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THE PROTEIN PRODUCTION POTENTIAL OF SOME MAIZE HYBRIDS

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Abstract

Maize hybrids, provided by Research and Development Agricultural Station-ARDS Suceava, were tested in comparative crop, under the specific conditions of the Western Plain of Romania. Field experiments were carried out in the ARDS Lovrin. Twenty maize hybrids were tested (SV_1 to SV_20, experimental codes). The protein content of the grains (Pro, %) was evaluated. The protein content varied between Pro = 9.45±0.09% (SV_13), and Pro = 12.40±0.12% (SV_17). Comparative analysis between hybrids (PHC), led to 190 combinations. There were 45 statistically significant positive differences; 13 differences with p<0.05 level (*), eight differences with p<0.01 level (**), and 24 differences with p<0.001 level (***). There were 19 negative differences with statistical certainty; two differences with p<0.05 level (o), three differences at the p<0.01 level (oo), and 14 differences at the p<0.001 level (ooo). In relation to the mean value (Pro_m = 10.69±0.18%), some hybrids presented higher values (nine hybrids), and other hybrds presented lower values (11 hybrids). Significant increase in protein growth was recorded by hybrid SV_17 (ΔPro = 1.71%), followed by hybrid SV_5 (ΔPro = 1.46%). Maize hybrids with genetic advantage for protein production have been identified, for breeding programs and agricultural practice.

Key words**:** *comparative analysis, maize genotypes, proteic crops, protein yield increase*

INTRODUCTION

Quality sources for protein intake in human nutrition, it is necessary to ensure a balanced supply of various nutrients such as dietary fiber, mineral elements, and vitamins [17].
Balanced protein consumption in human nutrition, in relation to age categories and the specifics of socio-economic activities, is necessary for human health [7, 17, 24].
Food and dietary approaches for the human population aim to promote health in relation to the age structure and dynamics of the human population [14]. The authors have studied the importance regarding high-quality protein intake in some recommended dietary. Plant proteins are of high interest as sustainable protein sources for human nutrition [14]. The demand for food resources increased in the context of human population growth, and proteins are of great importance [1]. For a balanced human diet, protein is a vital macronutrient [4].
Associated to the need for proteins in human nutrition, and the different diets that were adopted, there have been an increasing demand for plant-based proteins [11]. Proteins from plant sources have gained increasing demand for human nutrition, and growth trends are predicted for the coming decades [13]. Plant proteins represent a good source of essential amino acids, mineral elements, and nutritional principles for human diets [13]. Proteins from plant sources are increasingly promoted for various nutritional, human health, and environmental reasons [4].
There has been an increasing demand for plant proteins worldwide, which are considered a "key component" of balanced diets [2]. Different categories of crop plants, such as legumes, oilseeds, cereals, have been considered as protein sources, and different methods for extracting proteins from plant sources have been studied [2].
Various crop plants are important sources of vegetable protein, particularly through the high

protein content in their seeds [6]. Through the presence of different species of protein plants in the structure of crop plants, they contribute to increasing biological diversity and increasing the sustainability of agricultural ecosystems [6]. Three categories of crop plants are in focus as main sources of protein, namely legumes, oilseeds, and cereals [4].

The plant-based protein industry is experiencing a growing trend, and protein crops present a series of economic and ecological benefits in agricultural ecosystems [19]. Attention is paid to improving genotypes of plants cultivated for protein production, with the aim of benefiting farmers by cultivating these categories of plants [19].

Maize is a crop of interest for protein, and different genetic systems in maize are being studied to obtain quality proteins [15]. Maize is a multifunctional crop, with a major contribution to global agri-food systems [8]. In many countries, maize is a staple food for a significant part of the world's population [5]. Evaluating the influence of climatic conditions and optimizing crop technologies and management practices, associated with high-performance genotypes, are considered necessary to increase yields and quality indices in maize crop [3, 5, 10, 21, 22].

This research evaluated the protein content of seeds in a group of maize hybrids (20 hybrids) originating from ARDS Suceava, and tested in comparative crops under pedo-climatic conditions characteristic of the Western Plain, located at ARDS Lovrin, Romania.

MATERIALS AND METHODS

Experimental protocols and collaborations between research stations provide for the comparative testing of crop plant genotypes created within a research station under specific conditions in another area of the country. In the present study, twenty maize hybrids, provided from ARDS Suceava, were cultivated and tested under specific climate and soil conditions within ARDS Lovrin. The genotypes were noted with SV_1 to SV_20 trials codes.

The research was conducted in the 2023-2024 agricultural year, under non-irrigated crop conditions. Climatic conditions are presented in Figure 1.

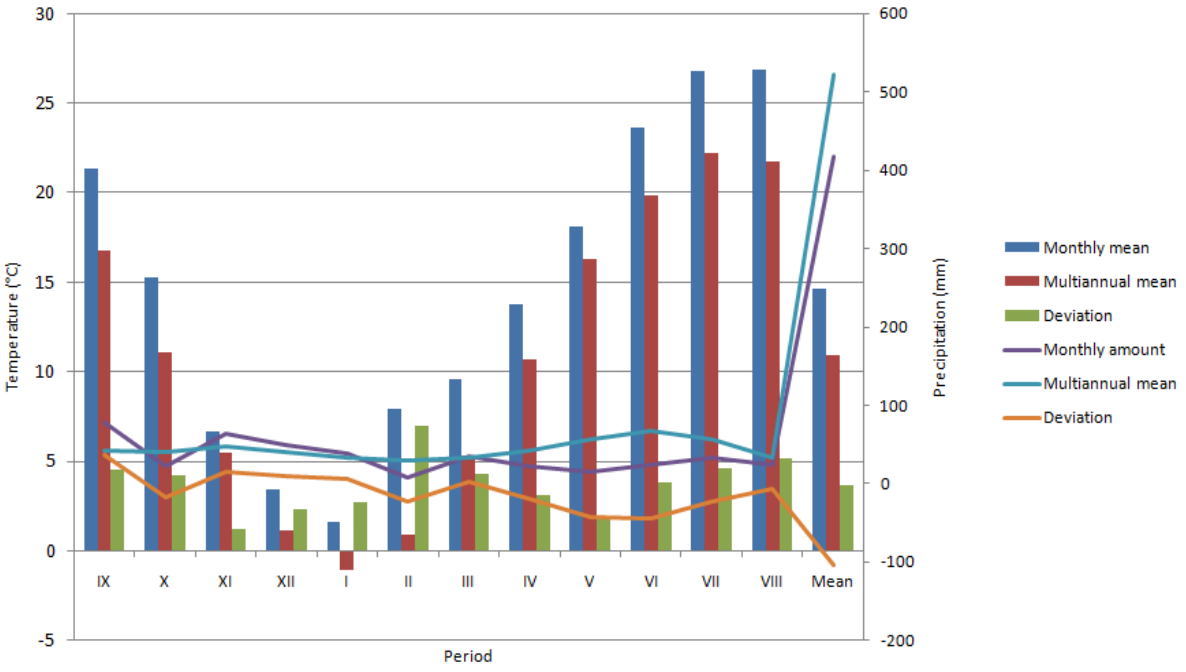

Fig. 1. Climatic conditions during the study period
Source: Original data, ARDS Lovrin Weather Station.

The location of the experiment was on a plot

with chernozem soil, with medium fertility. A classic soil working system was used (plowing, disk, combine harrowing) for land preparation. Complex mineral fertilizers (15/15/15) were applied for soil fertilization, before sowing (250 kg ha^{-1}). Additionally, in vegetation, ammonium nitrate was applied (200 kg ha^{-1}). In the first decade of April, corn hybrids were sown. Repetitions were provided for each hybrid. Protection of corn crops from weeds was done by pre-emergence herbicides and by mechanical and manual work during the vegetation period.

The grain production was harvested at plant maturity [16], on each hybrid and replicates. Protein content (Pro, %) was determined based on sub-sampling from kernels production, for each genotype.

For the comparative analysis of corn hybrids, in terms of grain protein content, the calculation module in EXCEL, the PAST software [9] and JASP [12] were used.

RESULTS AND DISCUSSIONS

The tested maize hybrids benefited from uniform soil conditions (cambic chernozem) and climate, and expressed the genetic potential for protein content. Protein content values between Pro = 9.45±0.09% (hybrid SV_13) and Pro = 12.40±0.12% (hybrid SV_17) were recorded (Table 1).

Table 1. Protein content values of the tested corn hybrids

Maize hybrid	Protein (%)	Std. Error (SE)	Maize hybrid	Protein (%)	Std. Error (SE)
SV_1	11.50	±0.35	SV_11	10.65	±0.09
SV_2	10.30	±0.29	SV_12	10.30	±0.12
SV_3	10.85	±0.32	SV_13	9.45	±0.09
SV_4	10.45	±0.38	SV_14	11.25	±0.14
SV_5	12.15	±0.03	SV_15	10.40	±0.12
SV_6	10.70	±0.06	SV_16	9.55	±0.14
SV_7	11.05	±0.09	SV_17	12.40	±0.12
SV_8	11.15	±0.43	SV_18	11.30	±0.17
SV_9	10.55	±0.03	SV_19	9.65	±0.09
SV_10	10.15	±0.03	SV_20	10.05	±0.09

Source: Original data.

The Anova test applied certified the presence of the variance, as well as the reliability of the experimental data (Table 2).

Table 2. Results of Anova Test

Cases	Sum of Squares	df	Mean Square	F	p
Trial	35.554	19	1.871	15.841	< .001
Residuals	4.725	40	0.118		

Source: Original data.

A comparative analysis of maize hybrids was performed, based on the protein content accumulated in the grains.

Each hybrid was analyzed against the other hybrids in the comparative crop (Post Hoc Comparisons - PHC), to find out how the hybrids position themselves among themselves, in relation to the protein content. 190 combinations of comparative analysis resulted. The results safety and the significance of differences are presented in Table 3.

For the reliability of the results, the thresholds $p<0.05$ (symbol * for positive differences; symbol o for negative differences), $p<0.01$ (symbol ** for positive differences; symbol oo for negative differences), respectively $p<0.001$ (symbol *** for positive differences; symbol ooo for negative differences) were considered.

Positive differences were recorded, with statistical safety, for some comparative analyses; thirteen differences at the $p<0.05$ level (*), eight differences at the $p<0.01$ level (**), and 24 differences at the $p<0.001$ (***) level. Negative differences, in conditions of statistical safety, were recorded in the case of nineteen comparisons; in two situations with $p<0.05$ level (o), in three situations with $p<0.01$ level (oo), and in fourteen situations at $p<0.001$ level (ooo). Differences without statistical safety (ns) were also identified, for 126 comparative analyses. Of the total number of analyses, those that marked hybrids with high protein content, which showed genetic advantages for this quality index, were considered important, compared to the other hybrids.

Considering the results of the PHC analysis, in which the positioning of the hybrids was found based on protein content, with statistically significant differences among the 190 comparative analyses, it was also considered appropriate to analyze the hybrids in comparison with the average value at the experiment level.

Table 3. Results of the comparative analysis between corn hybrids, in relation to protein content

	SV_2	SV_3	SV_4	SV_5	SV_6	SV_7	SV_8	SV_9	SV_10	SV_11	SV_12	SV_13	SV_14	SV_15	SV_16	SV_17	SV_18	SV_19	SV_20
SV_1	0.014	0.713	0.056	0.713	0.362	0.983	0.999	0.129	0.003	0.266	0.014	< .001	1.000	0.036	< .001	0.188	1.000	< .001	0.001
	*	ns	ns	ns	ns	ns	ns	ns	**	ns	*	***	ns	*	***	ns	ns	***	**
SV_2		0.9	1.000	< .001	0.995	0.473	0.266	1.000	1.000	0.999	1.000	0.266	0.129	1.000	0.473	< .001	0.086	0.713	1.000
		ns	ns	ooo	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ooo	ns	ns	ns
SV_3			0.995	0.005	1.000	1.000	1.000	1.000	0.594	1.000	0.900	0.002	0.995	0.983	0.005	< .001	0.983	0.014	0.362
			ns	oo	ns	ns	ns	ns	ns	ns	ns	**	ns	ns	**	ooo	ns	*	ns
SV_4				< .001	1.000	0.818	0.594	1.000	1.000	1.000	1.000	0.086	0.362	1.000	0.188	< .001	0.266	0.362	0.995
				ooo	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ooo	ns	ns	ns
SV_5					0.001	0.036	0.086	< .001	< .001	< .001	< .001	< .001	0.188	< .001	< .001	1.000	0.266	< .001	< .001
					**	*	ns	***	***	***	***	***	ns	***	***	ns	ns	***	***
SV_6						0.999	0.983	1.000	0.900	1.000	0.995	0.008	0.900	1.000	0.022	< .001	0.818	0.056	0.713
						ns	ns	ns	ns	ns	ns	**	ns	ns	*	ooo	ns	ns	ns
SV_7							1.000	0.953	0.188	0.995	0.473	< .001	1.000	0.713	< .001	0.003	1.000	0.002	0.086
							ns	ns	ns	ns	ns	***	ns	ns	***	oo	ns	**	ns
SV_8								0.818	0.086	0.953	0.266	< .001	1.000	0.473	< .001	0.008	1.000	< .001	0.036
								ns	ns	ns	ns	***	ns	ns	***	oo	ns	***	*
SV_9									0.995	1.000	1.000	0.036	0.594	1.000	0.086	< .001	0.473	0.188	0.953
									ns	ns	ns	*	ns	ns	ns	ooo	ns	ns	ns
SV_10										0.953	1.000	0.594	0.036	1.000	0.818	< .001	0.022	0.953	1.000
										ns	ns	ns	o	ns	ns	ooo	o	ns	ns
SV_11											0.999	0.014	0.818	1.000	0.036	< .001	0.713	0.086	0.818
											ns	*	ns	ns	*	ooo	ns	ns	ns
SV_12												0.266	0.129	1.000	0.473	< .001	0.086	0.713	1.000
												ns	ns	ns	ns	ooo	ns	ns	ns
SV_13													< .001	0.129	1.000	< .001	< .001	1.000	0.818
													ooo	ns	ns	ooo	ooo	ns	ns
SV_14														0.266	< .001	0.022	1.000	< .001	0.014
														ns	***	o	ns	***	*
SV_15															0.266	< .001	0.188	0.473	0.999
															ns	ooo	ns	ns	ns
SV_16																< .001	< .001	1.000	0.953
																ooo	ooo	ns	ns
SV_17																	0.036	< .001	< .001
																	*	***	***
SV_18																		< .001	0.008
																		***	**
SV_19																			0.995
																			ns

Source: Original data.

The protein content mean value ($\overline{Pro}$), at the experimental level, was $\overline{Pro} = 10.69 \pm 0.18\%$. Compared to calculated mean value, nine hybrids provided positive differences, with an increase in protein content (ΔPro) ranging between ΔPro = 0.01% (SV_6) and ΔPro = 1.71% (SV_17). Eleven hybrids recorded a negative increase in protein content, with values ranging between ΔPro = -0.04% (SV_11) and ΔPro = -1.24% (SV_13). Hybrids SV_5 and SV_17 presented a positive increase, at a $p<0.001$ level. In the case of some hybrids,

the differences fell within the limits of the standard error, SE = ±0.18% (e.g. SV_3, SV_6, SV_9, SV_11) (Figure 2).

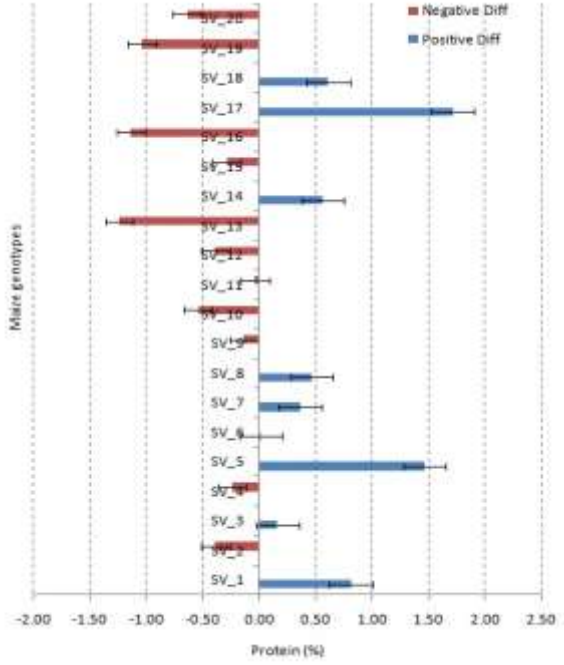

Fig. 2. Distribution of differences in protein content in corn hybrids, relative to the mean value of the experiment
Source: Original figure.

Based on the descriptive statistical analysis, quartile thresholds were generated and the corn hybrids were grouped by quartiles, in relation to the protein content in the grains (Figure 3). The upper quartiles included the hybrids SV_17, SV_5, SV_1, SV_18 and SV_14, with high protein content values. The lower quartile included the hybrids SV_10, SV_20, SV_19, SV_16, and SV_13, respectively, with protein content lower than the 10.99% threshold. The middle quartile included 10 hybrids, respectively SV_8, SV_7, SV_3, SV_6, SV_11, SV_9, SV_4, SV_15, SV_2, and SV_12.

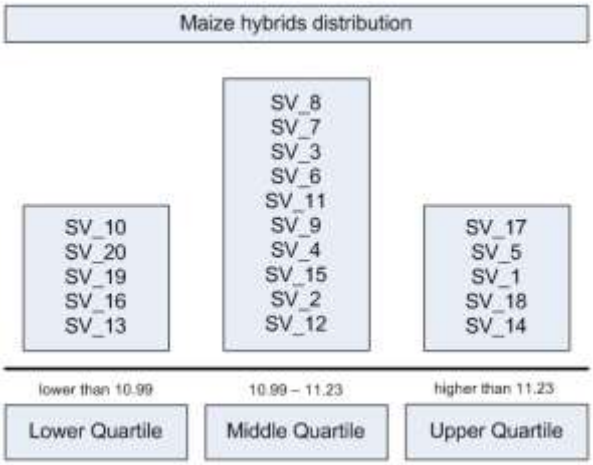

Fig. 3. Quartile distribution of maize hybrids, in relation to grain protein content
Source: Original figure.

A ranking of the maize hybrids was made based on the protein content of the kernels. The hierarchical diagram in Figure 4 resulted, with the distribution of the corn hybrids in the confidence interval in Figure 5, in the scattergram format.

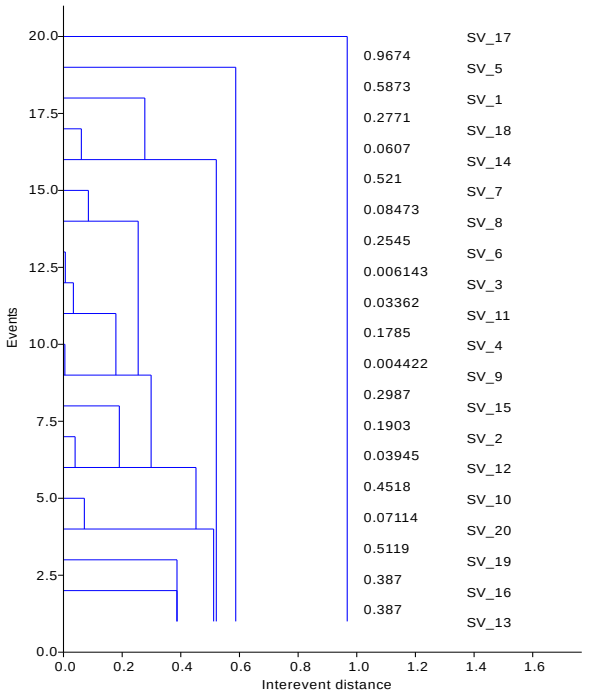

Fig. 4. Maize hybrid ranking chart based on protein content
Source: Original figure.

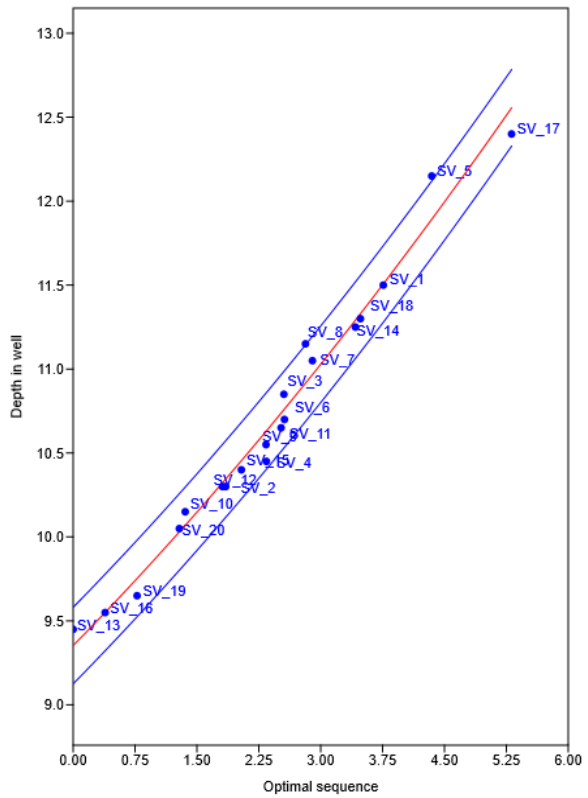

Fig. 5. Scattergrams of maize hybrids distribution
Source: Original figure.

The protein content in protein crops and the quality of proteins, especially in essential amino acids (Lys, Trp in cereals; Met in legumes) has presented and continues to present interest from economic and humanitarian perspectives [23]. The authors presented the importance of methods based on genetic approaches, on biotechnologies, which, complemented with technological measures, lead to a high and quality protein content in protein crops [23].

Associated with population growth and demand for food resources, there has been a need to find technologies to ensure accessible proteins for human consumption, and the production of vegetable protein represents a possible solution [1].

Vegetable proteins are found in varying proportions in different diets, and protein sources are represented by a wide range of plant species [18].

Maize protein yield was analyzed in relation to various agrotechnical and climatic elements [20]. The authors recorded the variation of protein content significantly with climatic conditions during the growing season in a seven-year study. Significantly lower protein content was recorded in drought years and high temperatures [20].

Nitrogen fertilization before sowing, and localized fertilization with NP complexes in the plant row, significantly contributed to increasing the protein content in corn kernels [20].

In the context of the present study, the genetic potential for protein production in the 20 hybrids in comparative culture was analyzed.

The hybrids in the upper quartile were analyzed and discussed both in terms of position within the quartile, as well as in relation to the other hybrids in the comparative crop.

The first position was occupied by the hybrid SV_17 with a protein content of Pro = 12.40±0.12%. Five hybrids were included in the upper quartiles (Figure 3). These five maize hybrids (SV_17, SV_5, SV_1, SV_18, and SV_14) showed genetic advantage for protein content, compared to the other hybrids tested.

Within the upper quartile, the hybrid SV_17 presented differences at the $p<0.05$ level compared to the hybrids SV_14 and SV_18. Compared to the hybrids SV_1 and SV_5, the differences did not present statistical significance. In the case of the other hybrids grouped in the upper quartile, differences were observed, but without statistical significance.

Across the entire collection of maize hybrids tested in comparative crop, maize hybrid SV_17 presented statistically significant differences, compared to the most of the hybrids tested, except for SV_1 and SV_5 hybrids. The SV_5 maize hybrid presented statistically significant differences, compared to 14 tested hybrids. The SV_1 maize hybrid registered statistically significant differences compared to eight tested hybrids. The SV_18 maize hybrid and the SV_14 maize hybrid presented statistically significant differences compared to six tested hybrids.

Ten hybrids were included in the middle quartile (Figure 2). Hybrid SV_8 (first position in the middle quartile) compared to the hybrids in the upper quartiles had a lower protein content, but with differences without statistical certainty (Table 3). Hybrid SV_7 (second position in the middle quartile) presented

differences at the $p<0.05$ level with hybrid SV_5, at the $p<0.01$ level with hybrid SV_17, and differences without statistical certainty with the other hybrids in the upper quartiles. Hybrid SV_3 (third position in the middle quartile) presented differences at $p<0.01$ levels compared to hybrid SV_5, at $p<0.001$ level compared to hybrid SV_17 and differences without statistical certainty compared to the other hybrids in the upper quartile. Hybrid SV_6 (fourth position in the middle quartile) showed differences at the $p<0.01$ level compared to hybrid SV_5, at the $p<0.001$ level compared to hybrid SV_17 and differences without statistical certainty compared to the other hybrids in the upper quartile. Hybrid SV_11 (fifth position in the middle quartile) showed differences at the $p<0.001$ level compared to hybrids SV_5 and SV_17, and differences without statistical certainty compared to the other hybrids in the upper quartile. These hybrids require attention in future studies, as they show differences in protein content, with statistical certainty, only compared to two hybrids in the upper quartiles, and differences without statistical certainty compared to three hybrids in the respective quartile. The other five hybrids in the middle quartile presented negative differences in protein content compared to three hybrids in the upper quartile, within statistical safety. Maize hybrids in the lower quartile recorded low protein content under the study conditions, but can be further evaluated for other morphological and physiological traits and agronomic characteristics.

CONCLUSIONS

By the protein content in the grains, the maize hybrids expressed differentiated protein production potential under uniform cultivation conditions, in terms of environmental and technological factors. Based on the protein content, five hybrids were positioned in the upper quartile, with values above the threshold of 11.23% protein, five hybrids were positioned in the lower quartile, with values lower than the threshold of 10.99% protein, and ten hybrids were positioned in the middle quartile. The highest protein content was recorded for the SV_17 hybrid (Pro = 12.40±0.12%), followed by the SV_5 hybrid (Pro = 12.15±0.03%).

The comparative analysis led to 190 combinations, of which 45 comparative analyses with positive differences and 19 analyses with negative differences, in conditions of statistical safety.

Compared to the average value at the experiment level ($\overline{Pro} = 10.69 \pm 0.18\%$), the nine hybrids provided positive differences, with an increase in protein content (ΔPro) ranging between $\Delta Pro = 0.01\%$ (SV_6) and $\Delta Pro = 1.71\%$ (SV_17).

Maize hybrids in the upper quartile are of high interest for the corn breeding program, as a source of valuable genotypes, but at the same time they are also important for agricultural practice for the purpose of comparative testing in different pedoclimatic conditions and promotion for farmers.

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REFERENCES

[1]Aimutis, W.R., 2022, Plant-based proteins: The good, bad, and ugly, Annual Review of Food Science and Technology, 13:1-17.
[2]Akyüz, A., Tekin, İ., Aksoy, Z., Ersus, S., 2024, Plant protein resources, novel extraction and precipitation methods: A review, Journal of Food Process Engineering, 47(10):e14758.
[3]Boiko, P., Kovalenko, N., Yurkevych, Y., Albul, S., Valentiuk, N., 2023, Maize production and trade and scientific technological solutions to mitigate climate change impact in Ukraine, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 23(4):103-112.
[4]Chandran, A.S., Suri, S., Choudhary, P., 2023, Sustainable plant protein: an up-to-date overview of sources, extraction techniques and utilization, Sustainable Food Technology, 4(1):466-483.
[5]de Bruyn, M., Nel, A., van Niekerk, J., 2024, The nutritional benefits of maize-soybean rotational systems in the North-Western Free State, South Africa, Agriculture & Food Security, 13:20.
[6]De Ron, A.M., Sparvoli, F., Pueyo, J.J., Bazile, D., 2017, Editorial: Protein crops: Food and feed for the future, Frontiers in Plant Science, 8:105.
[7]Elmadfa, I., Meyer, A.L., 2017, Animal proteins as important contributors to a healthy human diet, animal

proteins as important contributors to a healthy human diet, Annual Review of Animal Biosciences, 5:111-131.
[8]Erenstein, O., Jaleta, M., Sonder, K., Mottaleb K., Prasanna B.M., 2022, Global maize production, consumption and trade: trends and R&D implications, Food Security, 14:1295-1319.
[9]Hammer, Ø., Harper, D.A.T., Ryan, P.D., 2001, PAST: Paleontological Statistics software package for education and data analysis, Palaeontologia Electronica, 4(1):1-9.
[10]Haraga, L.-C., Szilagyi, L., Ion, V., 2022, Results regarding the effect of microgranulated fertilizers in hybrid seed maize production, Scientific Papers. Series A. Agronomy, LXV(2):216-221.
[11]Hertzler, S.R., Lieblein-Boff, J.C., Weiler, M., Allgeier, C., 2020, Plant proteins: Assessing their nutritional quality and effects on health and physical function, Nutrients, 12(12):3704.
[12]JASP Team, 2022, JASP (Version 0.16.2) [Computer software].
[13]Langyan, S., Yadava, P., Khan, F.N., Dar, Z.A., Singh, R., Kumar, A., 2022, Sustaining protein nutrition through plant-based foods, Frontiers in Nutrition, 8:772573.
[14]Lonnie, M., Hooker, E., Brunstrom, J.M., Corfe, B.M., Green, M.A., Watson, A.W., Williams, E.A., Stevenson, E.J., Penson, S., Johnstone, A.M., 2018, Protein for life: Review of optimal protein intake, sustainable dietary sources and the effect on appetite in ageing adults, Nutrients, 10(3):360.
[15]Maqbool, M.A., Issa, A.B., Khokhar, E.S., 2021, Quality protein maize (QPM): Importance, genetics, timeline of different events, breeding strategies and varietal adoption, Plant Breeding, 140(3):375-399.
[16]Meier, U., 2001, Growth stages of mono-and dicotyledonous plants e BBCH monograph, Federal Biological Research Centre for Agriculture and Forestry, 158 pp.
[17]Philips, S.M., Fulgoni, V.L.II., Heaney, R.P., Nicklas, T.A., Slavin, J.L., Weaver, C.M., 2015, Commonly consumed protein foods contribute to nutrient intake, diet quality, and nutrient adequacy, The American Journal of Clinical Nutrition, 101(6):1346S-1352S.
[18]Rolands, M.R., Hackl, L.S., Bochud, M., Lê, K.A., 2024, Protein adequacy, plant protein proportion, and main plant protein sources consumed across vegan, vegetarian, pescovegetarian, and semivegetarian diets: A systematic review, The Journal of Nutrition, Available online at: https://doi.org/10.1016/j.tjnut. 2024.07.033
[19]Singh, A.K., Elango, D., Raigne, J., Van der Laan, L., Rairdin, A., Soregaon, C., Singh, A., 2024, Plant-based protein crops and their improvement: Current status and future perspectives, Crop Science, https://doi.org/10.1002/csc2.21389
[20]Szulc, P., Ambroży-Deręgowska, K., Mejza, I., Kobus-Cisowska, J., Ligaj, M., 2020, The role of agrotechnical factors in shaping the protein yield of maize (*Zea mays* L.), Sustainability, 12(17):6833.
[21]Șimon, A., Ceclan, A., Haș, V., Varga, A., Russu, F., Chețan, F., Bărdaș, M., 2023, Evaluation of the impact of sowing season and weather conditions on maize yield, AgroLife Scientific Journal, 12(1):207-214.
[22]Tashikalma, A.K., Giroh, D.Y., 2024, Productivity and efficiency of maize (*Zea mays*) farmers in Adamawa State, Nigeria, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 24(1):979-990.
[23]Ufaz, S, Galili, G., 2008, Improving the content of essential amino acids in crop plants: goals and opportunities, Plant Physiology, 147(3):954-961.
[24]Wu, G., 2016, Dietary protein intake and human health, Food & Function, 7:1251-1265.

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STUDY ON THE CHARACTERISTICS OF THE VEGETAL AGRICULTURAL SECTOR IN ROMANIA COMPARED TO OTHER EU COUNTRIES

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Abstract

This paper proposes a detailed analysis of the performance of the Romanian vegetable agricultural sector, compared to the EU average, for the period 2018-2022. The aim of the paper is to highlight the relative position of Romania within the vegetable agricultural sector, by assessing some indicators that reflect the economic performance and competitive capacity of the sector. The research method was based on the analysis of certain technical-economic indicators such as: average farm size, agricultural area in relation to population, average production per hectare, income from the agricultural sector and productivity. The analysis was based on official statistical data provided by national and European reference institutions such as Eurostat, the National Statistical Institute and the Ministry of Agriculture and Rural Development. The results obtained show that Romania consistently ranks among the top six EU Member States in terms of crop production. From the point of view of economic performance, the values recorded by the Romanian agricultural crop sector are comparable with the EU average.

Key words**:** *agriculture, vegetable sector, potential, performance, productivity, Romania*

INTRODUCTION

The agricultural sector plays an important role in Romania's economy. It represents 3,8 percent of national GDP and 18,45 percent of employment (Bodescu et al., 2021) [3]. The crop sector, through the cultivation of cereals and oilseeds, is an important source of food and raw materials for the food industry (Burja et al., 2020) [2].

In a context marked by intensifying climate change, profound economic transitions and constant redefinition of the European agricultural policy framework, the analysis of the performance of the vegetable sector is of a particular strategic relevance (Popescu et al., 2023a) [12].

The issue is at the confluence of multiple interests: academic, institutional and practical, generating a complex framework of reflection and intervention for researchers, policy makers and farmers alike.

In this respect, understanding the dynamics of plant sector performance is not just a descriptive approach but a prerequisite for sustainable and competitive agricultural policies at European Union level

The literature highlights that the performance of the plant sector is influenced by factors such as: the structure of agricultural holdings, access to finance, the use of modern technologies and climate change (Andrei, 2019) [1]. Also, the analysis carried out by Eurostat, 2022, indicates that Romania, although it has an extensive agricultural area, has lower yields compared to other member states of the European Union [5].

In Romania, some researchers Jurjescu et al. (2020), Medelete et al. (2018), Panzaru and Medelete (2017, Popescu et al., 2023b [6, 7, 10, 11] pointed out that the main agricultural crops which dominate the vegetal sector are: maize, wheat and sunflower

At the beginning of the Common Agricultural Policy in 1962, farmers were encouraged to adopt measures of agricultural intensification by using large quantities of pesticides and fertilizers. These measures were aimed at increasing yields to achieve the European Union's strategic objectives of food self-sufficiency (Coca e tal., 2020) [4]. The agricultural sector in Romania plays a very

important role in the national economy and can represent a real source of competitive advantage within the European Union. This potential is supported by natural resources available, the extensive agricultural area and the growing number of specialists in the field (Ștefan & Coca, 2013) [13].

The study analyzes the performance of the agricultural vegetable in Romania sector in relation to the standards and developments in the European Union, using relevant technical and economic indicators. The research highlights the factors influencing productivity, the main structural challenges and development opportunities for the sector. Based on the results obtained, applied recommendations and align the sector with the current requirements of European agricultural policies.

MATERIALS AND METHODS

The purpose of this paper is to analyse the performance of the Romanian vegetable agricultural sector. The present study is based on the processing of relevant statistical data and consultation of specialized literature. This approach aims to provide a perspective that reflects the quantitative dimension of the agricultural phenomenon, its structural and contextual particularities. The data used in the research were processed from Eurostat [5] database for European level indicators, statistical data published by the National Institute of Statistics [9] for detailed data on national agricultural as well as data provided by the Ministry of Agricultural and Rural Development [8]. In addition to these sources, relevant scientific works were consulted to support a deeper understanding of the sector analysed.

The research methods applied were the following:

-Descriptive statistical analysis – used to analyze the evolution of cultivated areas, the distribution of the main crops and the variations in average production per hectare

-Comparative analysis – aimed at placing the performance of the Romanian agricultural sector in a European context, by comparing it with indicators from other European Union member states and identifying possible gaps in terms of efficiency and productivity**.**

By using these methods, this paper contributes to creating an overview of the current state of the Romanian plant sector**.**

RESULTS AND DISCUSSIONS

Utilized agricultural area is an important indicator for assessing a country's agricultural potential. The size of this area directly influences agricultural production and the competitiveness of the agri-food sector.

Comparative analysis of the agricultural area used in the EU Member States provides information about the differences between countries in terms of the organization and use of agricultural land. Romania is one of the countries with a large agricultural area, which is an advantage in terms of available resources, but also entails the responsibility for their efficient management. (Table 1) provides an overview of the agricultural area utilizes in the European Union and shows Romania's position in relation to the other Member States. During the analysed period, the total useful agricultural area in the European Union varied between 161.9 million hectares and 160.5 million hectares. In dynamics, the trend is decreasing. During this period, the total arable agricultural area decreased by 1,387,650 hectares (-0,86%). The causes of the decrease are the conversion of agricultural land into residential or industrial areas and soil degradation due to the effects of climate change.

In 2022, the largest useful agricultural areas were recorded in: France - 28 million hectares, Spain - 24 million hectares, Germany - 16 million hectares, Poland - 14 million hectares, Italy 12.9 million hectares, Romania 12.6 million hectares, Greece – 5,3 million hectares, Bulgaria 5.02 million hectares.

Table 1. Utilized agricultural area at European Union level (ha)

Country	2018	2019	2020	2021	2022
Austria	2,653,840	2,652,220	2,646,960	2,602,490	2,599,510
Belgium	1,356,080	1,358,700	1,367,080	1,368,310	1,361,910
Bulgaria	5,030,280	5,037,470	5,047,250	5,046,600	5,022,060
Cyprus	132,440	125,350	127,780	121,780	122,790
Croatia	1,485,650	150,450	1,506,210	1,476,350	1,447,920
Denmark	2,632,500	2,626,000	262,000	2,618,400	2,624,250
Estonia	981,830	984,670	985,460	986,670	986,210
Finland	2,271,900	2,273,800	227,000	226,800	2,266,400
France	29,020,160	28,689,860	28,697,570	28,697,570	28,597,500
Germany	16,645,100	16,666,000	16,595,000	16,591,500	16,594,900
Greece	5,288,050	5,153,380	5,267,520	5,204,090	5,371,560
Ireland	4,516,040	4,524,150	4,511,420	4,337,130	4,347,530
Italy	12,908,750	13,150,200	13,122,140	12,987,420	12,950,410
Latvia	1,937,900	1,959,400	196,900	1,970,100	1,970,400
Lithuania	2,947,230	2,974,990	2,942,780	1,937,470	2,911,300
Luxembourg	131,560	131,590	132,140	132,810	132,520
Malta	11,580	11,580	10,700	10,730	107,30
Netherlands	1,822,400	1,816,320	1,814,450	1,811,910	1,804,370
Poland	14,539,550	14,550,350	14,754,860	14,521,860	14,197,890
Portugal	3,752,980	3,966,670	3,970,410	3,981,220	3,935,910
Czech Republic	3,523,220	3,523,660	3,523,870	3,529,800	3,530,420
Romania	13,413,740	13,825,610	13,048,800	13,078,880	12,677,580
Slovakia	1,919,540	1,915,730	1,910,040	1,856,130	1,849,190
Slovenia	477,930	479,820	484,060	479,490	479,430
Spain	24,201,910	24,371,660	24,434,630	24,420,400	24,692,570
Sweden	300,390	3,004,780	3,005,540	3,002,910	2,995,180
Hungary	5,343,780	5,309,520	4,997,880	5,049,010	5,081,050

Source: processed based on the data from Eurostat [5].

In 2022, Romania ranks 6th compared to the European Union states. The useful agricultural area in Romania decreased by 5,8% during the analysis period.

The arable agricultural area has a direct impact on the production of basic crops such as wheat, maize, sunflower (Table 2). In dynamics, the trend is decreasing. In 2018, the total arable agricultural area was 9.01 million hectares. In 2022, the total agricultural area decreased to 7.72 million hectares. The total arable agricultural area during this period decreased by 1,790,940 million hectares. The causes of the decrease are conversion of arable land into permanent pastures or forest areas, soil erosion and desertification effect due to climate change.

In 2022, the largest arable agricultural areas were recorded in: France – 17.04 million hectares, Spain – 11.69 million hectares, Germany – 11.65 million hectares, Poland 11.1 million hectares, Romania (8.21 million hectares), Italy (7.01 million hectares), Hungary (4.15 million hectares).

In 2020, the number of farms in the European Union was 9,070,980 million with an uneven distribution between countries. Some countries have many farms: Romania 2,887,070 farms, Poland 1,302,330 farms, Italy 1,133,020 farms, Spain 914,870 farms, Greece 530,750 farms (Figure 1).

Other countries such as Germany, Denmark and the Netherlands have a consolidated agricultural system with a small number of farms. Romania had the highest number of farms in the European Union 2 times more than Poland - the country that ranks 2nd. The very large number of subsistence and small farms in Romania indicates that Romanian agriculture is fragmented. Romanian agriculture is dominated by small farms, farms that have a low performance, which limits competitiveness on the European Union market. Land fragmentation is one of the main problems of agriculture in Romania.

Table 2. Arable agricultural area at the European Union level (ha)

Country	2018	2019	2020	2021	2022
Austria	1,327,150	1,325,530	1,321,710	1,322,920	1,320,590
Belgium	856,830	863,550	869,340	870,420	868,410
Bulgaria	3,463,670	3,462,110	3,478,010	3,478,750	3,456,140
Cyprus	104,540	96,400	99,390	93,470	93,860
Croatia	803,900	822,810	888,930	856,740	851,470
Denmark	2,389,800	2,394,400	2,369,300	2,357,950	2,382,880
Estonia	679,150	685,940	685,940	693,640	698,880
Finland	2,242,600	2,244,900	2,242,700	2,242,800	2,240,800
France	18,229,910	18,210,620	17,044,030	17,072,010	17,045,660
Germany	11,730,900	11,713,700	11,663,800	11,657,900	11,657,000
Greece	1,849,640	1,815,810	1,764,950	1,753,140	1,755,180
Ireland	449,940	441,780	442,900	434,940	445,200
Italy	6,722,140	6,914,140	6,908,710	6,905,950	7,011,150
Latvia	1,294,800	1,318,600	1,333,500	1,362,200	1,356,700
Lithuania	2,113,280	2,209,900	2,247,330	2,277,030	2,290,440
Luxembourg	62,280	62,140	62,320	62,710	62,310
Malta	9,230	9,230	7,770	7,780	7,780
Netherlands	1,020,790	1,011,100	1,004,830	1,003,450	1,003,750
Poland	11,009,210	11,054,840	11,149,640	11,078,760	11,164,920
Portugal	960,440	997,760	972,910	967,770	932,560
Czech Republic	2,489,990	2,490,110	2,489,780	2,480,940	2,484,910
Romania	8,685,630	8,966,310	8,482,860	8,587,740	8,210,720
Slovakia	1,347,770	1,349,060	1,346,050	1,326,480	1,322,970
Slovenia	172,980	174,200	175,560	175,270	176,710
Spain	12,125,530	12,023,570	11,869,700	11,732,660	11,690,560
Sweden	2,541,990	2,540,120	2,242,700	2,242,800	2,240,800
Hungary	4,333,700	4,309,640	4,101,770	4,141,840	4,159,810
Total	99,017,780	99,508,260	97,569,970	97,494,560	97,226,840

Source: processed based on the data from Eurostat [5].

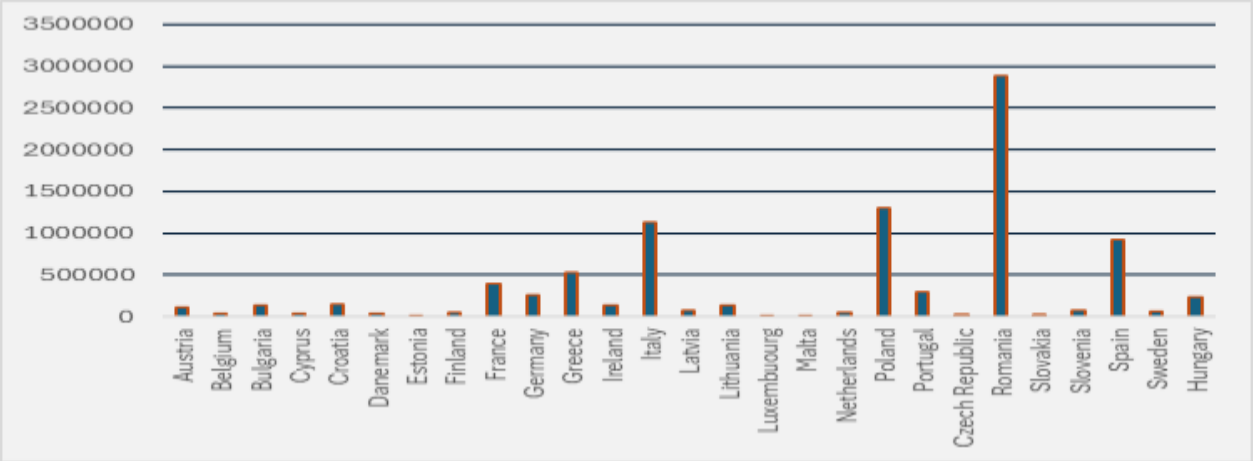

Fig. 1. Number of farms in the European Union in 2020 [5].
Source own results.

In this sense, decision-makers must adopt land consolidation policies and support for farmers association.

Western European countries have fewer farms, but they have a large area, are technologically efficient and economically efficient. Increasing the size of farms will make Romania a European leader not only in the number of farms, but also in economic efficiency.

The size of the agricultural holding, expressed in terms of the area of land under management, is a benchmark for analysing the performance of the agricultural sector and is correlated with the level of efficiency and productivity. Within the European Union, there is a wide variation in average farm size. The differences are due to the configuration of land tenure, the degree of technological modernization and agricultural regulations specific to each Member State.

According to 2020 data, the average farm size ranges from 1.02 hectares in Malta to 86.12 hectares in the Czech Republic (Figure 2). This consistent difference emphasizes the grouping of EU countries into two categories:

-Countries with large, technological farms, oriented towards economic efficiency and performance.

-Countries with small, fragmented farms based on subsistence agriculture.

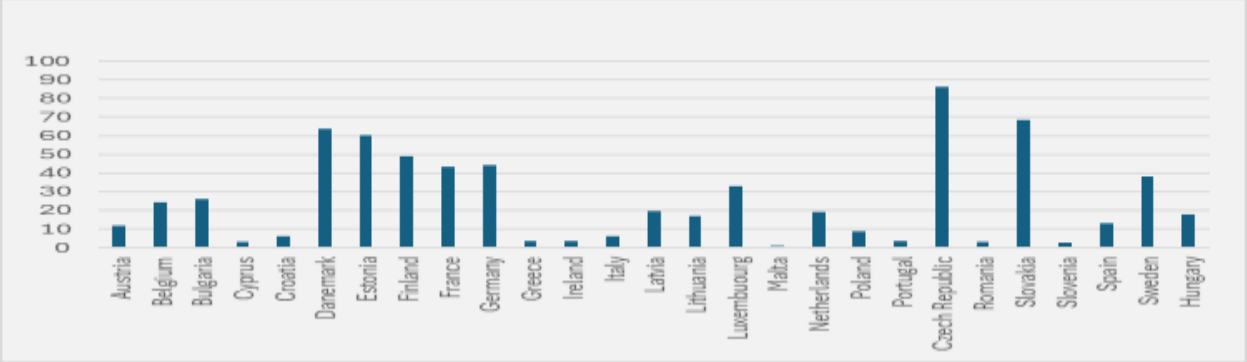

Fig. 2. Number of hectares/farm in the EU in 2020 [5].
Source: own results.

Among the countries of the European Union, a difference can be noted regarding the average farm size. The highest average areas per farm are found in the Czech Republic (86.12 ha/farm), Slovakia (68.57 ha/farm), Denmark (63.88 ha/farm), Estonia (60.33 ha/farm) and Finland (49.15 ha/farm).

At the opposite pole, the smallest farm sizes are found in Malta (1.02 ha/farm), Slovenia (2.42 ha/farm), Cyprus (2.92 ha/farm), Romania (2.94 ha/farm), and Greece (3.33 ha/farm) Romania is among the states with the smallest areas of farms. This area is 29 times smaller than in the Czech Republic and 21 times smaller than in Denmark.

The arable land area to population ratio is an indicator that describes a country's agricultural potential. This indicator is influenced by the size of the total arable area and the number of people residing in the country. At the EU level, during the period analysed, there is a general trend of decreasing arable area per capita. According to the data for 2022 (Table 3), the countries with the highest values of arable area per capita were recorded in: Lithuania has 0.81 ha/capita, Latvia has 0.72 ha/capita, Bulgaria has 0.53 ha/capita, Estonia has 0.52 ha/capita, Denmark has 0.40 ha/capita

Table 3. Arable area/capita in the EU (ha/capita)

Country	2018	2019	2020	2021	2022
Austria	0.15	0.14	0.14	0.14	0.14
Belgium	0.07	0.07	0.07	0.07	0.07
Bulgaria	0.51	0.52	0.52	0.53	0.53
Cyprus	0.12	0.11	0.11	0.10	0.10
Croatia	0.20	2.06	2.25	0.22	0.22
Denmark	0.41	0.41	0.40	0.40	0.40
Estonia	0.51	0.51	0.51	0.52	0.52
Finland	0.40	0.40	0.40	0.40	0.40
France	0.27	0.27	0.25	0.25	0.25
Germany	0.14	0.14	0.14	0.14	0.14
Greece	0.17	0.16	0.16	0.16	0.16
Ireland	0.09	0.08	0.08	0.08	0.08
Italy	0.11	0.11	0.11	0.11	0.11
Latvia	0.66	0.68	0.69	0.71	0.72
Lithuania	0.74	0.78	0.79	0.80	0.81
Luxembourg	0.10	0.10	0.09	0.09	0.09
Malta	0.01	0.01	0.01	0.01	0.01
Netherlands	0.05	0.05	0.05	0.05	0.05
Poland	0.28	0.29	0.29	0.29	0.30
Portugal	0.09	0.09	0.09	0.09	0.08
Czech Republic	0.23	0.23	0.23	0.23	0.23
Romania	0.44	0.46	0.43	0.44	0.43
Slovakia	0.24	0.24	0.24	0.24	0.24
Slovenia	0.08	0.08	0.08	0.08	0.08
Spain	0.25	0.25	0.25	0.24	0.24
Sweden	0.25	0.24	0.21	0.21	0.21
Hungary	0.04	0.44	0.42	0.42	0.43

Source: processed based on the data from Eurostat [5].

These countries have a relatively small population, a large agricultural area and agriculture plays an important role in the economy (export). The countries with the lowest arable areas per capita (2022) are: Malta 0.01 ha/capita, Netherlands 0.05 ha/capita, Belgium 0.07 ha/capita, Slovenia 0.08

ha/capita, Ireland 0.08 ha/capita. These countries are characterized by a dense population, limited agricultural areas, most of the land being used for industry and urbanization, the lack of an extensive area is compensated by the technology of farms achieving large productions per hectare.

Romania is in an average position in the European Union. During the analyzed period Romania recorded the following values: 2018: 0.44 ha/capita, 2019: 0.46 ha/capita, 2020: 0.43 ha/capita, 2021: 0.44 ha/capita, 2022: 0.43 ha/capita.

Wheat is an important agricultural culture both in Romania and in the European Union.

The evolution of the cultivated area in the analyzed period is increasing. In 2018, the agricultural area cultivated with wheat was 445 million hectares. In 2024, the agricultural area cultivated with wheat was 447 million hectares (Table 4) The countries with the largest wheat areas in 2022 are: Germany 2,980,900 ha, Poland 2,518,440 ha, Spain 2,172,700 ha, Romania 2,168,660 ha and Italy 1,778,730 ha. All these countries have a favourable climate for wheat cultivation, with fertile soils. In these countries there is a high demand for wheat flour products.

These data reflect the importance of wheat in national and European agriculture, underlining the essential role in ensuring food security but also in the national and European economy.

The total area devoted to maize in the European Union has shown a downward trend over the period analysed. This change is caused by restructuring in the crop sector influenced by factors such as: climate change, market orientation, agricultural policies, crop rotation. According to the data of 2019, the area planted with corn in the countries of the European Union was 9.81 million hectares while in 2022 it decreased to 8.83 million hectares. The differences from 2019 to 2022 were about 980,000 hectares(Figure 3).

Table 4. Area cultivated with wheat in the European countries (ha)

Country	2018	2019	2020	2021	2022
Austria	294,290	278,340	279,020	279,860	295,510
Belgium	195,690	203,760	194,660	209,180	204,460
Bulgaria	1,212,010	1,198,680	1,200,180	1,206,190	1,506,580
Cyprus	10,020	10,590	12,970	12,320	13,310
Croatia	138,460	143,150	147,840	147,390	161,830
Denmark	425,800	573,400	502,600	537,700	497,300
Estonia	154.580	166,980	168,040	180,000	1,800,970
Finland	177,800	197,600	198,800	212,400	219,640
France	5,234,090	5,244,250	4,519,780	5,276,730	494,840
Germany	3,036,300	3,118,100	2,835,500	2,939,000	2,980,900
Greece	404,490	350,490	355,880	411,010	412,490
Ireland	579,80	63,480	46,990	62,330	67,230
Italy	1,821,730	1,754,640	1,711,220	1,726,610	1,776,730
Latvia	417,200	492,700	498,200	537,300	537,500
Lithuania	772,890	895,760	893,510	994,170	945,720
Luxembourg	12,870	13,360	11,930	12,870	13,570
Malta	0	0	0	0	0
Netherlands	111,660	120,550	108,910	118,140	123,800
Poland	2,417,230	2,511,330	2,391,000	2,390,520	2,518,440
Portugal	27,030	28,530	30,140	28,660	31,050
Czech Republic	819,690	839,450	798,580	784,780	854,430
Romania	2,116,150	2,168,370	2,155,250	2,175,080	2,168,660
Slovakia	403,370	406,820	387,080	356,970	411,690
Slovenia	27,820	26,730	27,290	26,790	275,60
Spain	2,063,680	1,920,090	1,914,660	2,128,470	2,172,700
Sweden	372,500	469,490	449,170	479,130	461,570
Hungary	1,026,150	1,015,640	936,620	892,790	9790,10

Source: processed based on the data from Eurostat [5].

This decrease in area is caused by severe drought in some regions (corner is sensitive to lack of rainfall), alternation with other crops (some farmers have reduced areas cultivated

with maize in favour of wheat and oilseed plants with higher profitability), European Union agricultural policies

Countries with the largest areas cultivated with maize in 2022: Romania (2.43 million hectares), France (1,45 million hectares), Poland (1.19 million hectares), Hungary (816,640 hectares), Italy (563,700 hectares). Romania is the European leader in the area cultivated with corn.

In Romania, the area planted with maize has been constant during the analysed period 2018-2022 with very small fluctuations.

The recorded statistical data indicate the following values: in 2018- 2.44 million hectares were cultivated, which increased to 2.58 million hectares.

In the year 2021- 2.55 million hectares were recorded while 2.43 million hectares were cultivated in 2022.

This stability in the area cultivated with corn underlines the importance of this crop in Romanian agriculture.

Even if Romanian is in first place in the European Union in terms of area planted with maize, it is not the leader in total production.

Western European countries a have higher production per hectare due to the use of advanced technologies and the irrigation system.

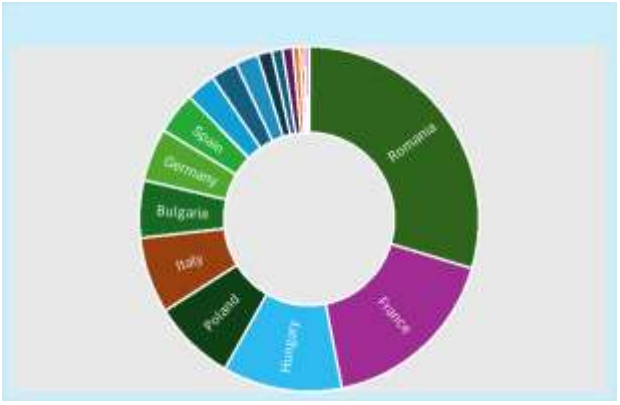

Fig. 3. Area cultivated with corn in 2022 [5].
Source: own results.

Romania needs to increase investment in irrigation infrastructure mechanization and technology. Investment in these areas will increase yields per hectare, reduce dependence on climatic factors and modernize the agricultural system.

The total area cultivated with sunflower in the European Union increased significantly in the analysed period. In 2018, the total area cultivated with maize was 4.02 million hectares. In 2022, the total area cultivated with sunflower was 4.93 million. (Figure 4). In dynamics growth was 18.35%. The factors that influenced the growth of the sunflower area were: high demand for sunflower oil, increased drought tolerance and European agricultural policies. The countries that had significant increases in sunflower area in 2022 compared to 2021 were: Spain (245,510 hectares), France (172,200 hectares), Bulgaria (80,490 hectares), Germany (43,300 hectares).

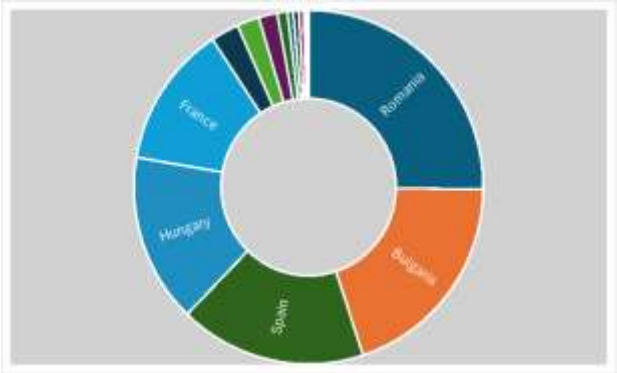

Fig. 4. Area cultivated with sunflower in 2022 [5].
Source: own results.

During the analysed period, Romania was the European Union leader in terms of sunflower area. In the years 2020 and 2022, the cultivated areas were smaller, negatively influenced by unfavourable climatic conditions and increased production costs. These decreases were largely because of the Covid-19 pandemic and the instability generated by the military conflict in Ukraine. The war affected supply chains and pushed up prices for fuel, fertilizers and seeds.

Total crop sector production in the European Union in 2018 was 218.3 billion euro. In 2022 total crop sector production was 290.2 billion euro (Table 5). In dynamics the trend is increasing 12.66%.

The evolution of the agricultural sector in Romania:

2018 - €13.15 million (5th place in the EU)
2019 - €13.26 million (6th place in the EU)
2020 - €10.91 million (7th in the EU)
2021 - €15.02 million (6th place in the EU)
2022 - €14.58 million (7th place in the EU).

Table 5. Production vegetables sector at basic prices (million euro)

Country	2018	2019	2020	2021	2022
Austria	3,174,320	3,157,640	3,289,560	4,031,880	5,060,750
Belgium	3,640,380	3,926,100	4,047,010	4,934,720	4,934,720
Bulgaria	2,882,070	2,880,510	2,678,210	4,146,820	4,959,480
Cyprus	273,820	285,920	279,670	291,110	324,530
Croatia	1,397,660	1,396,590	1,434,110	1,620,710	1,963,450
Denmark	3,510,280	3,758,230	4,000,920	4,542,110	5,551,750
Estonia	369,810	649,970	503,320	484,270	570,640
Finland	1,592,850	2,137,070	1,857,230	1,737,360	2,478,640
France	44,954,240	43,986,890	42,746,230	45,488,430	54,337,860
Germany	22,794,050	27,518,330	28,007,640	29,970,780	36,278,620
Greece	7,852,450	8,146,160	8,206,580	8,543,680	10,625,050
Ireland	2,656,000	2,150,890	1,957,370	1,885,000	2,125,240
Italy	32,464,720	31,712,300	32,824,790	34,999,240	40,994,940
Latvia	1,372,360	1,033,640	1,029,040	924,740	667,890
Lithuania	1,593,720	1,872,500	2,167,280	2,287,910	3,289,710
Luxembourg	166,110	157,990	152,740	207,150	219,030
Malta	45,440	49,050	43,550	44,350	49,290
Netherlands	16,510,120	17,199,660	16,580,500	18,627,560	19,262,600
Poland	10,884,080	11,798,490	12,925,060	13,620,870	19,754,080
Portugal	4,374,750	4,658,120	4,752,720	5,941,800	6,264,630
Czech Republic	2,964,330	3,112,670	3,302,550	4,044,020	4,644,980
Romania	13,153,460	13,269,410	10,914,360	15,028,320	14,583,450
Slovakia	1,236,370	1,211,620	1,288,880	1,485,070	1,776,230
Slovenia	797,890	734,800	786,150	724,270	832,690
Spain	31,405,760	30,108,330	30,484,600	35,229,220	37,203,110
Sweden	2,602,710	2,829,130	2,887,280	3,434,500	3,986,400
Hungary	4,873,020	4,868,080	4,939,010	5,821,490	5,916,780
Total	218,346,750	224,279,400	224,134,170	250,615,800	290,200,300

Source: processed based on the data from Eurostat [5].

The average production per hectare reflects the yield of the wheat harvest expressed in kg/hectares. In the analysed period, the average production of wheat in Romania was: 4,793kg/ha in 2018, 4,749 kg/ha in 2019, 2,966 kg/ha in 2020, 4,797 kg/ha in 2021 and 4,004 kg/ha in 2022 (Table 6). This variation is caused by climate conditions, technologies used and soil structure.

The decrease in 2020 and the return of production in 2021 highlight the dependence of agriculture on climatic conditions. In the dry years (2020), production losses are 37%. The year 2022 shows that although the drought affected the harvest, the decline was not as great as in 2020 due to technological improvements.

The average production of maize per hectare in Romania in the period 2018-2022 (Table 7), in evolution, decreased. In 2018 the average production was 7,644 kilograms per hectare. In 2022, the average production was 3,298 kilograms per hectare. The evolution shows a general decline in maize yield in the years 2020 and 2022.

Table 6. Wheat yield in Romania (kg/ha)

2018	4,793
2019	4,749
2020	2,966
2021	4,797
2022	4,004

Source: processed based on the data from the Ministry of Agriculture and Rural Development [8].

Table 7. Corn yield in Romania (kg/ha)

2018	7,644
2019	6,502
2020	3,977
2021	5,802
2022	3,298

Source: processed based on the data from the National Institute of Statistics [9].

Table 8. Sunflower yield in Romania (kg/ha)

2018	3,041
2019	2,783
2020	1,858
2021	2,530
2022	1,927

Source: processed based on the data from the Ministry of Agriculture and Rural Development[8].

The average production of sunflower per hectare in the analyzed period is decreasing. In

2018, the average production was 3,041 kg/hectare. In 2022, the average production of sunflower per hectare was 1,927 kg (Table 8).
Analysis of the three crops shows that wheat is the most stable crop, corn the most vulnerable, and sunflower has an intermediate behaviour. Drought is the main factor affecting productivity, and the long-term solution is the development of irrigation and the use of modern technologies.

CONCLUSIONS

Romania's agricultural production during the 2018-2022 period recorded decreases in the main crops analysed. Even if Romania has an extensive arable agricultural area, the production per hectare is lower compared to the production per hectare of the Member States of the European Union. Among the proposed solutions to increase productivity are major investments in irrigation infrastructure together with large-scale adaptation of modern technologies. The aim of these measures is to sustain long-term performance and reduce vulnerability to climate change. Romanian agriculture is facing problems. The biggest problem is the high degree of land fragmentation, for which Romania is at the bottom of the European rankings. Romania has very many farms, most of which are subsistence farms
The average size of a farm in 2020 in Romania was 2.94 hectares, positioning Romania at the bottom of the European ranking. Land fragmentation and the predominance of small farms are associated with low performance and low competitiveness in the agricultural sector. This difference highlights the need for farmers' association and land consolidation policies.
Romania occupies an important position in the European Union in terms of the total volume of agricultural production, consistently ranking in the top seven in this criterion. This encouraging result is largely due to the significant arable agricultural area, with our country ranking six on this indicator. In spite of the good raking on these indicators, the efficiency of the crop farming sector in terms of average productivity remains at the EU average. The lower productivity yields highlight a few limitations.
Performance increases through farm modernization and higher labour productivity. Romania can better exploit its advantage of large agricultural area. The development of irrigation systems is the solution for Romania to increase its agricultural production.
Romania is among the EU Member States with the highest production volume. However, in terms of the performance of crop agricultural sector, Romania’s position in close to the European average. This discrepancy shows the significant agricultural potential which is not being fully exploited highlighting the need for measures to modernize and increase productivity.

REFERENCES

[1]Andrei, J. V., 2019, The Common AgriculturalPolicyand Romanian Agriculture. NosworthyWay, Walllingfort, United Kingdom: CABI International.
[2]Burja, V.,Tamas-Szora, A., Dobra, I. B., 2020, Land Concentration. Land GrabbingandSustainableDevelopment of Agriculture in Romania. Sustenability, 12(5), 2137.
[3]Bodescu, D., Ștefan, G., Cazacu, D., Tudoran, A. S., Măgureanu, A., Coca, O., 2021, Considerationsregardingthedevelopment of a specific specimen for theanalysis of cost in agriculture. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 21(4), 49-58.
[4]Coca, O., Mironiuc, M., Pânzaru R. L., Ștefan G., 2020, Exploringthestatisticalassociationbetweenthe economic, environmentalandinnovativearea of performance: the case of European Union agriculture. Romanian agriculturalResearch, 37, 253-261.
[5]Eurostat, 2022, Agriculturalstatistics in the European Union: Trends and challenges. https://ec.europa.eu/eurostat/data/database,Accessed on 03 December 2024.
[6]Jurjescu, A.L.,Nan, A., Mateoc, T., Bacau, C., Mateoc-Sirb, N., 2020, Study on cultivated areas and productions in Romania in the main crops in an European context. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 20(3), 297-302.
[7]Medelete, D.M., Pânzaru, R.L., Vladu, M., Matei, G., 2018, Some considerations regarding the primary wheat supply in Romania and its composition (2014 – 2016). Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 18(1), 245-252.
[8]Ministry of Agricultureand Rural Development, 2022, Plant sector – overview.

https://www.madr.ro/agricultura.html,Accessed on 23 January 2025.
[9]National Institute of Statistic, 2022, Yearbook of Romania. Agriculture, http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table,Accessed on 05 March 2025.
[10]Pânzaru, R.L., Medelete, D.M., 2017, Some considerations concerning the Romanian production of maize in European context (2012 - 2014). Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 17(4), 237-242.
[11]Popescu, A., Stanciu, M., Stanciu, C., 2023a, Romania's vegetal production in the post access period to the European Union. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 23(1), 627-638.
[12]Popescu, A., Dinu, T.A, Stoian, E., Serban, V., 2023b, Climate change and its impact on wheat, maize and sunflower yield in Romania in the period 2017-2021. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 23(1) 587-602.
[13Ștefan, G., Coca, O., 2013, The Romanian agriculture- source of competitive advantage. Lucrări Științifice seria Agronomie, 56(1).

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EUROPEAN GREEN POLICIES' IMPACT ON FOOD PRODUCTION IN BULGARIA

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Abstract

The energy policy of the European Union (EU) aims to achieve a sustainable energy future by reducing carbon emissions, increasing energy efficiency and ensuring energy security. The EU's main objectives in this context include reducing dependence on external energy sources, shifting to renewable energy sources and creating an internal energy market that ensures efficiency and fair access for all Member States. The EU aims to achieve climate neutrality by 2050, which implies a significant reduction in carbon emissions, as well as a transition to cleaner and more sustainable technologies for energy production and consumption. Union policy has increasingly focused on transforming the energy production landscape of the continent towards a more sustainable future, with an ever-growing renewable energy sector. This process has also included the agricultural sector as it also has a high impact on the climate neutrality of the continent, with Green Deal policies focusing on reducing greenhouse gases produced by farms, the food supply chain and recourse producers (fertilizers, pesticides, etc.) and improving the food security of the continent. In this context, the aim of this study is to analyse the impact of European green policies on food production in Bulgaria. To achieve this goal, the following tasks must be completed: to highlight the most impactful European eco-policies regarding Bulgarian food production; to analyse the impact of these policies on the development of organic production in Bulgaria, as environmentally responsible, and to assess the possibilities for adapting Bulgarian agricultural practices to the new European green framework. This research uses data supplied by the Ministry of Food and Agriculture of the Republic of Bulgaria, though it's Agrostatistics branch. In order to achieve the goal of the study a policy review method was used, with the goal of highlighting the most impactful European policies for the organic production sector in Bulgaria. The main conclusion for the development of Bulgarian agriculture is that the concentration and specialization in production allows these larger-scale producers to be better positioned to leverage institutional support mechanisms. This is not without its challenges, as European green policies that promote sustainability require a more nuanced approach to policy implementation to succeed. The implementation of European green policies in Bulgaria must focus more on the support and promotion of internal markets and the shortening of food supply chains, by strengthening regional food supply.

Key words**:** *agriculture, sustainability, food security*

INTRODUCTION

The ability for Bulgaria's agricultural sector to produce food, based on high sustainability standards is highlighted by the European green deal (EGD) [8]. It is oriented towards the reduction of carbon emissions and transition to sustainable agriculture. As part of the European union, Bulgaria's agricultural policy is largely developed in regard to the Common agricultural policy of the Union and aims to achieve the same goals. The aim of this study is to analyse the policy mechanisms of the EDG and their application in the context of Bulgarian agriculture, paying attention to the opportunities for adapting local practices to these new requirements. The carbon neutral economy that the Green Deal is set to build in Europe by 2050 is relaying on the decarbonisation of its' industry as much as on improving the sustainability of food production. European policies had great impact on Bulgarian agriculture and have been shaping the sector since the accession of the country to the union in 2007. This process is ongoing with the main goal being the integration of the CAP and the European Green Deal into national development strategies for the sector.

Bulgaria should adapt its practices through more sustainable agricultural methods that respond to climate challenges and contribute to reducing environmental risks [4].

Although countries with more developed economies, such as Germany and France, have better access to resources and technology, Eastern European countries, including Bulgaria, face difficulties due to economic and infrastructure constraints (Hurduzeu, et.al., 2022) [20]. However, the Green Deal encourages the introduction of eco-schemes that incentivize farmers to adopt sustainable practices, such as growing legumes and using renewable energy sources (Testi, et.al., 2023) [32]. The differences in the level of participation between EU countries highlight the need for better information and financial support for Bulgarian farmers. The main policy action of the EU that seeks to increase the sustainability of food production and reduce its environmental impact are the Farm to fork strategy and the Biodiversity strategy that are closely related to the European green deal and CAP (Cagliero, et.al., 2021) [5].

Member States must implement national CAP strategic plans that include measures to reduce greenhouse gas emissions, increase organic areas and promote innovation in agricultural technologies. Despite the challenges associated with high initial costs and insufficient infrastructure, the successful implementation of these policies is essential to achieve the EU's sustainable agriculture objectives by 2030.

In this context, the purpose of the paper is to study the impact of current European green agricultural policy implementation in Bulgaria in order to identify any failings and propose pathways for improvement in the future.

MATERIALS AND METHODS

To analyse the impact of European Union's policies on the development of sustainable agricultural practices in Bulgaria we have focused on policy analysis and various policy documentation has been investigated and cited in this research.

Data from centralised statistical databases has been used, mainly the Agrostatistics database of the Ministry of Food and Agriculture of the Republic of Bulgaria [35].

The reference system of indicator used in this study includes pressure indicators as land use and livestock dynamics, as well as impact indicators for European policies. The data used in this study was processed through consolidation of crop types and animal species. The Agrostatistics database data was crosschecked for accuracy with the FAOSTAT database, and inaccuracies ware not found.

RESULTS AND DISCUSSIONS

European green policies, promote the building and reinforcing sustainable food production networks among member states, as within those states. The impact of these policies in Bulgaria so far is largely felt trough the Common Agricultural Policy (CAP) and its set of goals and measures. The CAP Strategic Plan for 2023-2027 [9] introduces a "green architecture" aimed at improving environmental conditions, but poses challenges for Bulgarian farmers, especially in terms of compliance with environmental standards.

The CAP is moving from quantitative to qualitative support, focusing on sustainable practices that meet consumer needs (Hulot, 2025) [19]. The European Union has long promoted sustainable agriculture through various policies and programmes that aim to reduce the environmental footprint of agriculture and improve its sustainability. Sustainable agriculture in the context of the EAC is advocated through various initiatives such as the European Biodiversity Strategy and the Soil Strategy (Boix-Fayos and de Vente, 2023) [3].

The Common Agricultural Policy includes environmental protection measures, agri-environment schemes, innovations for cleaner farming and environmental requirements for farmers. In Bulgaria, these policies play a central role in the modernisation of the sector by providing support for sustainable production and organic farming (Shukadarova, 2023) [29]. The CAP emphasises compliance with standards for good agricultural and environmental conditions, which has proven challenging for grain producers in Bulgaria (Shukadarova, 2023) [29]. Farmers face difficulties in maintaining minimum soil cover and setting aside arable land for unproductive areas, which leads to reluctance to apply for

support due to increased environmental requirements. The CAP for 2023-2027 emphasises environmental friendliness, competitiveness and social fairness, by promoting multifunctional agricultural production (Zinchuk and Kutsumus, 2023) [34].

Financial resources are directed towards eco-schemes and support for small and medium-sized farms, increasing food security and rural development (Oliinyk, 2022) [25]. Improvements in soil cultivation, soil cover and crop rotation are increasing, thanks to the introduction of conditioned practices. In addition, support for reduced use of targeted mineral fertilizers, as well as investments in precision agriculture, help reduce N_2O emissions. Overall, 35% of cultivated agricultural land in the EU should benefit from voluntary actions that will contribute to both carbon sequestration and N_2O emissions reduction.

These measures not only contribute to the sustainable management of agricultural resources (Pinta, 2024) [26] but also lay the foundation for further steps in reducing the environmental impact of agriculture (Smedescu, et.al., 2023) [30]. A significant part of the Farm to Fork Strategy is its goal to shrink the usage of chemicals (mainly pesticides, herbicides and fertilizers) by food producers in the EU by no less than 50% in a very short timeframe – by 2030. This ambitious goal is correlated to actions planned to be supported by multiple other EU initiatives.

The European Green Deal (Green Deal), which was introduced in 2019, sets ambitious goals for reducing carbon emissions and transitioning to a sustainable economy. One of the main focuses of the deal is sustainable agriculture, which is directly linked to food production. Among the main measures included in the EAA are reducing the use of chemical pesticides, promoting organic farming, and increasing biodiversity through agricultural land management. According to the strategy document, 25% of agricultural land in the EU should be organic by 2030. Some countries, such as Austria, have already exceeded this target, while others, such as Romania (Ionitescu, 2023) [21], have more modest goals due to lack of demand and limited subsidies. The European initiatives focus on reducing greenhouse gas emissions and promoting organic farming, which is in line with Bulgaria's agricultural practices (Prigoreanu, et.al., 2024) [27].

As a core component of the EES, the Farm Strategy this Fork focuses on transforming food systems in accordance with the main sustainability goals. This strategy encompasses the entire food chain from production to consumption, emphasizing reducing chemical inputs, reducing post-harvest losses, and promoting healthier diets (Vasiliu, 2022 and Guyomard, et.al., 2023) [33, 16]. Regarding the challenges to the EHS objectives, about 50% of agricultural crops in the EU suffer from pollination shortages, droughts have led to annual economic losses of €9 billion, and the fragmentation of agricultural land and the lack of modern infrastructure continue to be barriers for Eastern European member states such as Romania and Bulgaria to adopt renewable energy and sustainable practices (Shukadarova, 2023) [29].

The Common Agricultural Policy (CAP) can support the Farm to Fork Strategy [11] target of reducing the use and risks of harmful chemical agents currently used in agriculture. Mandatory crop rotations and other measures such as bans on pesticides in watercourses and keeping fallow land support integrated pest management (IPM) (Directive 2000/60/EU) [6]. Pesticide reduction will be reinforced through voluntary eco-schemes on 27% of EU farmland. Reinforced soil management rules and buffer strips, combined with voluntary nutrient management interventions, will help reduce nutrient losses by 50% by 2030. Fertiliser restrictions and support for soil improvement cover 15% of EU farmland.

Adapting Bulgarian agricultural practices to European green policies: Just Transition Mechanism (JTM)

The JTM is a policy that encourages the transformation of regions and industries dependent on carbon-intensive practices towards more sustainable production models, including in agriculture. This mechanism is relevant for Bulgarian regions, where

agriculture with a high environmental impact can be transitioned to sustainable agriculture through innovation and financial incentives (Balogh and Toth, 2021) [1].

Promoting the transition to organic farming, which is compatible with the EU's green goals of reducing pesticides and improving soil health. Bulgaria has huge potential to expand organic farming, which would significantly improve the sustainability of agriculture in the country (Hodge and Mullen, 2021) [18].

Supporting farmers in the transition to new green practices requires training in sustainable agricultural methods, the proper application of new technologies and techniques, consultations, and incentives for innovation in agriculture (Kusz and Kusz, 2024) [22].

The transition to a green economy is essential for Bulgaria, focusing on resource efficiency and waste minimization, which can improve the sustainability of agriculture.

While the CAP aims to promote sustainable practices, some farmers express concerns about the feasibility of meeting strict environmental standards, potentially leading to a reduction in agricultural output.

In support of sustainable agriculture and food production in Bulgaria, the CAP provides significant financial resources, including guidelines for reducing negative environmental impacts and incentivizing practices that minimize the use of chemicals and enhance biodiversity. However, in Bulgaria, despite the availability of strategic funds for environmental schemes, there is a need for a wider implementation of these practices, which are key to sustainable food production (Georgieva, 2024) [14]. Bulgarian farmers need to be motivated to switch to agro-ecological and organic production methods to meet the EU criteria for sustainable agriculture and achieve better results in food production.

Innovation and modernization of food production in Bulgaria

The European Commission stresses the importance of innovation for modernising agricultural practices and improving productivity. The CAP provides financial instruments for developing innovation in the agricultural sector, which includes the introduction of new technologies and sustainable solutions, such as precision farming and digitalisation. Although Bulgaria has many farms with great potential, the country needs to invest in research and the introduction of modern technologies that will help farmers improve the efficiency of food production and respond to changing climate conditions (EEA Report, 2020) [12, 28].

To achieve a successful transition to sustainable food production, Bulgaria needs to implement the CAP strategies for 2023-2027 [23], which emphasize economic sustainability and environmental requirements (Harizanova, 2024) [17]. It is important for the country to raise awareness among farmers about the new requirements and to invest in infrastructure to ensure the successful modernization of the sector. Forecasts indicate that Bulgaria can increase the production of organic products and increase its competitiveness on the sustainable food markets.

Organic farming in Bulgaria has improved greatly during the previous CAP planning period – prior to 2014, with the number of operators in the control system increasing from 214 to over 4,000. This process has a significant impact on the agricultural sector as a whole and thus needs to be further explained. The Ministry of Agriculture and Food of Bulgaria introduced Measure 11 "Organic Production" and promptly adopted Regulation No. 4 for its implementation to be included in the implementation of CAP in the country to support the growth of organic farming during the 2014 - 2020 period. Prepped up by the measure the sector continued to improve with an 18% increase in the number registered organic farmers in the first year of its implementation. Past 2016 the growth of the sector has been stifled by the difficulties producers encounter in the certification process. The lack of competition among the certification bodies in Bulgaria, led to market hegemony of large certification organization that increased the price for their services and made then inaccessible for small producers. Larger holding did not face the same issues and have increased their numbers, but they were mainly processers and traders of organic products.

Under the influence of market trends, a change in the production of organic products in Bulgaria is observed. The organic farms tripled their sizes up to 226 thousand hectares in 2019 (Table 1) compared to 2014. This process was also supported by the concertation of organic production in Bulgaria, as the number of farms overall decreased. The organic pasture areas did increase significantly and consequently provide the opportunity for growth for organic livestock breeding.

Table 1. Areas of agricultural crops grown organically in Bulgaria (ha)

Crops	2019	2020	2021	2022	2023
Grains, incl. rice	17,845.2	15,550.3	12,496.6	18,802.5	18,439.2
Technical crops	27,578	27,253.1	18,544	17,088.6	18,753.9
Vegetables, melons and strawberries	2,648.3	2,107.8	1,716.2	1,342	1,726.4
Perennial crops	26,502.9	24,829.3	23,124	22,592.6	22,503.6
Pastures	27,338.9	30,153.8	19,063.4	29,855.7	69,894.7
Fodder crops	436.1	468.7	841.5	1,905.3	1,171
Fallow land	2,510.1	3,191.8	3,216.9	12,108.9	7,243.3

Source: Agrostatistics of the Ministry of Agriculture [34].

During the period 2014-2019, there was an increase in the number of animals raised organically, but the relative share of organic livestock farms remained low – 2% for cattle breeding, 1.8% for sheep breeding and 4% for goat breeding in 2019. Only Bulgarian beekeeping achieved a significant share of organic production, reaching 27.6% of all apiaries in the country in 2019. Institutional support through the Rural Development Programme 2014-2020, expressed in Measure 11 "Organic Production", has a positive impact on the development of the sector in the initial stages of its operation. However, the problems faced by producers lead to a slowdown in growth rates.

After 2019 to 2021, we account a significant decline in the areas for growing organic cereals, as this decline is common to the sector and is also reported for technical crops, which continue to be produced on a smaller scale in 2022. This decrease in the production base of organic agriculture in Bulgaria for the period from 2019 to 2021, and for perennial crops until the very end of the research period, reflects the decreasing base for the production of food products from organic crop production in the country.

The areas on which organic cereals are grown increase in 2022 and 2023, with the values even exceeding the areas reported in 2019. Despite the increase in the areas used for technical crops in 2023, they are slightly less than 9 thousand ha. less than the values for 2019. A similar process is observed in the areas on which organic vegetables are grown, as the recovery in 2023, after the period of permanent decline, is insignificant and they are nearly 1,000 ha. less than at the beginning of the research period.

The organic pastures expansion has a meaningful implication for the development of organic livestock farming in the country - is very different and dynamic. Despite the significant decline of more than 11 thousand ha in 2021, the values quickly recovered the following year and in 2023, organic pastures in the country reached peak values of nearly 70 thousand ha. This increase of 130% compared to 2020 reflects the expansion of the production base of Bulgarian organic livestock farming and is a key factor for the future development of the entire sector.

Organic livestock farming in Bulgaria is a small part of the entire sector (Table 2), with the only exception being organic beekeeping, as at the end of the research period over 28% of the bee colonies raised in the country were included in organic production and were in the control system.

Organic cattle farming more than doubles its production base by 2023 compared to 2022. The same process is evident with organic sheep herding and to a lesser extend in organic beekeeping. The base for organic goat farming remained unchanged, due to the production specifics of these farms and their smaller size.

Table 2. Farm animals in the control system

	2019		2020		2021		2022		2023	
Cattle	10,914	2.10%	10,343	1.80%	10,408	1.70%	13,724	2.40%	30,494	5.30%
Sheep	22,982	1.80%	19,090	1.50%	19,873	1.70%	25,995	2.40%	39,497	3.70%
Goats	9,175	4.00%	8,296	3.30%	8,108	3.80%	7,333	4.00%	7,951	4.50%
Bee colonies	239,223	27.60%	223,151	25.80%	218,949	26.10%	214,183	26%	233,920	28.60%

Source: Agrostatistics of the Ministry of Agriculture [34].

In organic beekeeping, no significant changes were recorded during the study period, due to the earlier start of its development, as already in 2019, the sector reached its saturation point. Organic apiculture cannot benefit from the organic pastures expansion and the production base stayed relatively steady throughout the period.

The number of organic beekeeping farms was the lowest in 2022 (Table 3). During the last studied year - 2023 increases to a slightly higher values than in 2021.

Table 3. Operators in the organic farming control system in Bulgaria

	2019	2020	2021	2022	2023
Registered organic farms	6,405	5,844	4,913	4,863	5,026
Ratio of organic farms	7.30%	7.20%	6.40%	5.90%	6.40%

Source: Agrostatistics of the Ministry of Agriculture.

Throughout the studied period, the role of organic production as part of Bulgarian agriculture remained very low, with no more than 7.30% of producers choosing to join the control system and offer organic products to the market.

Organic crop farming in Bulgaria is lagging behind in its development compared to the organic livestock breeding in the country. The expansion of organic pastures alone is insufficient and to achieve the sustainable food goals of the union Bulgarian agriculture needs to continue developing its organic productions. The support farmwork will also have to be focused on diversification of organic farms with the inclusion of more traditional crops based on local market demands.

The current concentration of production in the sector is also reflected in organic farms, which may negatively affect these important factors.

Adapting Bulgarian agricultural practices to the new EU requirements requires the integration of sustainable agricultural methods. Efforts need to be directed in several main areas, related to the development and support of organic farming, changes in the agricultural structure, training and consulting of farmers, resource efficiency and waste minimization.

Modern agriculture is faced with a number of global environmental challenges related to population growth, limited arable land and fresh water, and climate change. In these conditions, conventional agriculture has led to excessive use of resources, labour is no longer abundant, and energy demand is constantly increasing (Gomiero, 2011) [15]. To respond to the EU's main green policies, the agricultural sector is successfully introducing smart farming technologies, which can be summarized in three categories: farm management information systems; precision farming systems; automation and robotics in agriculture.

Farm management information systems are basic software systems for collecting, processing, storing and distributing farm data necessary to perform farm operations and functions.

Precision agriculture uses technologies to monitor and measure spatial and temporal variability between and within crop fields with the aim of improving economic returns and reducing environmental impacts (Finger, 2019) [13]. Conventional agriculture has a serious negative impact on the environment, human health and can’t meet the sustainability goals of the population. Intensive agricultural practices lead to the loss of biodiversity - destruction of natural habitats, reduction of the population of wild animals and plants, destruction of local varieties of crops. The use of chemical fertilizers and pesticides leads to

water pollution, endangers aquatic flora and fauna, the health of agricultural workers and consumers.

Conventional agriculture is a cause of soil depletion, reduction of organic matter and erosion, which reduces soil fertility and resilience. Agriculture can become more sustainable and environmentally friendly by introducing regenerative agriculture practices.

Conservation agriculture is a concept of agriculture that promotes zero or minimal tillage, maintaining constant soil cover through cover crops, and crop rotation. (Northrup, et.al. 2021) [24]. Conservation agriculture contributes to reducing greenhouse gas emissions, increasing soil carbon storage, improving soil quality and biodiversity, and reducing soil compaction and erosion.

All of this can improve the environmental performance of the farm, but it can also have a negative effect if herbicides are used uncontrolled in the first years of the transition from conventional to conservation agriculture.

based on European Conservation Agriculture Federation (ECAF) 2018 data only 16.5 thousand ha of arable land are adhering to conservation practices. In a five-year period these areas have increased to 200 thousand ha.

Bulgarian agriculture's transition to more sustainable practices is supported through the EU's CAP. European policy is represented in local legislations through the Rural Development Programme (RDP), that provides financial incentives to Bulgarian farmers who commit to transitioning to biological and organic practices. Among the main measures included in the RDP are subsidies for the modernization of equipment, the introduction of innovations and sustainable technologies, as well as for the transition to organic farming practices. These incentives aim to reduce the use of chemical pesticides and fertilizers and promote environmentally friendly methods of growing agricultural crops (RDP, 2020).

The green architecture of the CAP, which has enrolled for the period 2023-2027[31], will introduce mandatory eco-schemes promoting sustainable agriculture. These schemes are part of the CAP reform, which aims to increase the environmental efficiency of agricultural practices and minimize their impact on natural resources. The implementation of mandatory eco-schemes will provide additional opportunities to improve the production base of organic farming in Bulgaria and stimulate the transition to sustainable agricultural production methods (EU, 2021) [10].

Despite significant support from the European Union, Bulgaria faces a number of challenges in implementing green policies in agriculture. In particular, in areas with limited resources and insufficient awareness, farmers face difficulties in transitioning to sustainable practices. Studies show that smaller farmers in Bulgaria have a lower ability to meet the new requirements for sustainable agriculture compared to larger farms, which have greater access to resources and investments, which gives them an advantage in the adaptation process (Beluhova-Uzunova, 2020) [2].

In addition, despite the positive results achieved in organic farming, the reduction of chemical fertilizers and pesticides does not always lead to short-term economic benefits for farmers. This raises the need for additional support and training for farmers to help them effectively implement new technologies and methods for sustainable production. The inclusion of such measures in future support plans for organic farming development in Bulgaria is paramount for their successful implementation (Eurostat, 2020) [36].

CONCLUSIONS

The analysis of the impact of European green policies on food production in Bulgaria highlights the need to adapt local agricultural practices to the new regulations. The successful integration of these policies in Bulgaria depends on the effectiveness of support for farmers who need to switch to sustainable and ecological production methods. Policy makers need to include all relevant parties when developing plans for the next planning period (Cagliero , R, 2021) [5]. Their success will rely on the accumulative actions of farmers, researchers, investors and innovators.

Throughout the study period, the role of organic production in Bulgarian agriculture

remained relatively limited, with only 7% of agricultural producers offering organic products on the market. Despite the significant development of organic livestock farming in Bulgaria towards the end of the study period, organic crop production progressed at a slower pace. The production of quality and clean food is a fundamental element of the green policies of the European Union, that will in term lead to the improvement of quality of life within it. Organic farming is a key developmental area for agriculture's environmental sustainability and impact capacity and improvement.

To achieve better results and accelerate the development of organic crop production in Bulgaria the increase of the number of organic farms must be supported through all available measures. This will lead to an expansion of the scope of organically grown crops and will contribute to increasing food security in the country. Despite the positive trends in the organic production sectors, the current concentration of farmers and farms in certain regions of the country may lead to limiting the potential for achieving wide-ranging environmental and economic benefits that can be realized through diversification of production and wider application of organic practices.

Encouraging the wider inclusion of farmers in the organic certification system is not only a key element for increasing the capacity of organic agriculture, but also for optimizing the opportunities for its sustainable development in Bulgaria, as an important component of the EU's green policies.

The development of organic production in Bulgaria in the future will be increasingly linked to the opportunities for the sale of the produced products on the national market. The introduction of measures to stimulate the consumption of Bulgarian organic products by local consumers is necessary for the sustainable development of the sector.

The sector is going through a phase of concentration and specialization of production, with the number of operators decreasing, but the area and number of animals raised per producer increasing. These larger producers are better able to take advantage of the institutional support opportunities provided and are creating a basis for the future development of the sector.

While European green policies aim to promote sustainability in Bulgarian agriculture, challenges to compliance and economic viability highlight the need for a nuanced approach to policy implementation.

The balance between economic growth and environmental protection remains a critical challenge, requiring continued support and adaptation of policies to ensure the viability of agriculture in Bulgaria.

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REFERENCES

[1]Balogh, J., Tóth, G., 2021, Impact of EU Green Deal on Agricultural Markets and Prices. European Review of Agricultural Economics, 48(2), 231-252.

[2]Beluhova-Uzunova, R., Hristov, K., & Shishkova, M. (2020). The common agricultural policy post 2020-farmers perception and policy implication. Scientific papers series management, economic engineering in agriculture & rural development, 20(2).

[3]Boix-Fayos, C., de Vente, J., 2023, Challenges and potential pathways towards sustainable agriculture within the European GreenDeal. Agricultural Systems, 207 (2023) 103634

[4]Building a sustainable future by implementing the green economy concept in Bulgaria and the Bulgarian agricultural sector. (2024). 2023(2). https://doi.org/10.37075/idara.2023.10

[5]Cagliero , R., Bellini, F., Marcatto , F., Novelli, S., Monteleone, A., Mazzocchi, G., 2021, Prioritizing CAP Intervention Needs: An Improved Cumulative Voting Approach. Sustainability 2021, 13, 3997.

[6]Directive 2000/60/EU of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (OJ L 327, 22.12.2000, p. 1) https :// eur - lex . europa . eu / legal - content / BG / TXT / PDF /? uri = CELEX :02000 L 0060-20141120

[7]EU Pollinators Initiative (COM (2018) 395). Brussels, 1.6.2018

[8]European Commission, 2020, Farm to Fork Strategy https://ec.europa.eu/info/food-farming-fisheries, Accessed on 24 February 2025.

[9]European Commission, 2021, Common Agricultural Policy (CAP), https://ec.europa.eu/info/food-farming-fisheries, Accessed on 24 February 2025.

[10]European Commission, 2021, General agricultural politics on The European union, Official website of the EU.
[11]European Commission. Farm to Fork and Biodiversity Strategies: A Comparative Analysis of the Green Deal Targets. 2022. https://agriculture.ec.europa.eu/system/files/2022-02/factsheet-farmtofork-comparison-table_en_0.pdf , Accessed on 24 February 2025.
[12]European Environment Agency, 2020, Transition to sustainable agriculture and climate change.
[13]Finger , R., Swinton , S.M., El Benni, N., Walter, A., 2019, Precision Farming at the Nexus of Agricultural Production and the Environment. Annual Rev. Resource. Econ. 11, 313–335.
[14]Georgieva, V., 2024, Subsidies and profitability in the agricultural sector: examining the relationship in Bulgaria. Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development, 24(1), 465-473.
[15]Gomiero, T., Pimentel, D., Paoletti, M.G., 2011, Is There is a Need for a More Sustainable Agriculture ? Crit . Rev. Plant Sci. 30, 6–23.
[16]Guyomard, H., Soler, L.-G., Détang-Dessendre, C., Réquillart , V., 2023, The European Green Deal improves the sustainability of food systems but has even economic impacts on consumers and farmers., Communications Earth and Environment 4, art. 358.
[17]Harizanova-Bartos, H., Kabadzhova, M., 2024, Development of Bulgarian agriculture production structures. Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development, 24(3), 411-42o
[18]Hodge, I., Mullen, J., 2021, Adapting agricultural practices to the EU Green Deal. Agricultural Systems, 183, 102857.
[19]Hulot, J.-F. (2025). Rethinking Food and Farming in Europe.
https://doi.org/10.3390/proceedings2025113001
[20]Hurduzeu, G., Pânzaru, R.L., Medelete, D.M., Ciobanu, A., Enea, C., 2022, The Development of Sustainable Agriculture in EU Countries and the Potential Achievement of Sustainable Development Goals Specific Targets (SDG 2). Sustainability 2022, 14, 15798
[21]Ionitescu, S., 2023, The role of agriculture in Romania's economy in the period 2013-2022. Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development, 23(4), 407-418.
[22]Kusz, D., Kusz, B., 2024, Farm size and technical efficiency of the agricultural sector in the European Union (EU-27). Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development, 24(2), 577-586.
[23]Ministry of Agriculture, Food and Forestry of the Republic of Bulgaria, 2022, National Strategic Plan for the CAP 2023-2027.
[24]Northrup, D.L., Basso, B., Wang, M.Q., Morgan, C.L., Benfey, P.N., 2021, Novel technology for emission reduction complement conservation agriculture this achieve negative emissions from row crop production. Proc Natl Acad Sci USA 118(28):e2022666118. https://doi.org/10.1073/pnas.2022666118
[25]Oliinyk , L., 2022, Peculiarities, and directions of implementation of common agricultural policy in EU. Ukraïns′kij Žurnal Prikladnoï Ekonomìki , 7(3), 223–227. https://doi.org/10.36887/2415-8453-2022-3-30
[26]Pință, I. M., 2024, Methods of optimizing the management of agricultural farms of medium economic dimensions-a review. Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development, 24(3), 629-634.
[27]Prigoreanu, I., Ungureanu, B.A., Ungureanu, G., Ignat, G., 2024, Analysis of Sustainable Energy and Environmental Policies in Agriculture in the EU Regarding the European Green Deal. Energies, 17(24), 6428. https://doi.org/10.3390/en17246428
[28]Report from the Commission to the European Parliament and the Council
[29]Shukadarova , N., 2023, Green conditionality and eco-schemes in the CAP Strategic Plan of Bulgaria. Agricultural Science. https://doi.org/10.22620/agrisci.2023.38.011
[30]Smedescu, C., Mărcuță, A., Mărcuță, L., Micu, M. M., Tudor, V. C., 2023, Bibliometric analysis of sustainability and profitability in conventional and ecological agriculture. Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development, 23(3), 831-841.
[31]Summary of CAP Strategic Plans for 2023-2027: joint effort and collective ambition.
[32]Testi, A., Zetti , I., Tarsi, E., Fontana, C., Gisotti, M.R., Rossi, M., 2023, Supporting Local Implementation of the European Green Deal through a Place-Based, Participatory Approach: Methodology for a Comprehensive Analytical Framework. Sustainability 2023,15, 15098.
[33]Vasiliu, C., 2022. Food Chains Transformation in the Context of EU Green Deal Strategy. Amfiteatru Economic, 24 (60), pp.305-307
[34]Zinchuk, T., Kutsmus, N., 2023, EU common agricultural policy for 2023–2027: ambitions and relevance to the sustainable development goals. Ekonomìka Ukraïni . https://doi.org/10.15407/economyukr.2023.11.076
[35]***Ministry of Food and Agriculture of the Republic of Bulgaria. Agrostatistics database.
[36]***Eurostat, https://ec.europa.eu/eurostat, Accessed on 24 February 2025.
[37]***Faostat database, https://www.fao.org/faostat/en/#home, Accessed on 24 February 2025.

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DYNAMICS OF THE AREAS, PRODUCTION, IMPORT AND EXPORT IN FRUIT AND VEGETABLES SECTORS AND LABOUR RESOURCES IN BULGARIA'S AGRICULTURE - TRYING TO ACHIEVE THE GOALS OF THE "FARM TO FORK" STRATEGY

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Abstract

The Farm to Fork Strategy is part of the European Union's ambitious Green Deal and aims to create sustainable and efficient food systems that reduce the negative impacts on the climate, the environment and public health. This strategy focuses on the transition to greener agriculture and food processes, aiming to provide enough food for a growing population without depleting natural resources and damaging ecosystems. The aim of this study is to analyse the ability of Bulgarian agriculture to achieve the goals set out in the Farm to Fork Strategy through assessment of the development of its production, trade and labour resources. To achieve this goal, the following points should be addressed: the key points of the Farm to Fork Strategy should be clearly stated; the production base and production of the agricultural sector should be valuated; labour as a significant factor should also be studied in regards to the development of new eco-policies in order to propose vectors for improvement. For the purpose of this study a policy review of the Farm to fork strategy was done. For analysis of the dynamics of production, trade and labour resources of Bulgarian agriculture data from multiple sources was used, mainly from the Agrostatistics database of the Ministry of food and agriculture and the National statistical institute of Bulgaria. The data from internal sources was aggregated and cross-referenced with the Eurostat database as well as UN databases – Comtrade and Faostat. As a result form this research we can conclude that Bulgarian fruit and vegetable markets rely heavily on imports and the local agricultural sector needs to increase its production to meet the consumer demands in order to achieve the goals set in the Farm to fork strategy of the European union.

Key words**:** *sustainability, food supply, agricultural labour*

INTRODUCTION

The European union's farm to fork strategy, is a key pillar in the transition to a sustainable food system in the union and has been launched in 2020. it provides a comprehensive plan for the transformation of the agricultural sector, focusing on shortening the distance between "farm" and "fork", with the aim of reducing carbon emissions, increasing food safety and ensuring sustainable agriculture (Schebesta, et.al., 2020) [21]. a key aspect of the strategy is the close link with the objectives of the eu's common agricultural policy (cap), which should play a key role in maintaining sustainable agriculture and reducing the environmental impact of agricultural production (Wesseler, 2022) [24].

In this context, the Farm to Fork strategy requires radical changes and shortening food supply chain, a key factor in achieving its goals (Mezzacapo, 2024) [12].

The Farm to Fork Strategy aims to create an efficient, fair and sustainable food system. It seeks to propose innovations in the agricultural sector (Harizanova and Kabadzhova, 2024) [8] that reduce the negative impact on the environment and climate, while ensuring food safety and quality (Marek and Tosun, 2023) [10]. Based on the global need to reduce carbon emissions and increase food security, the strategy calls for a strategic approach to reducing carbon footprints, with one of the main areas of focus being the shortening of food supply chains. By reducing the distance between food producers and consumers, the EU hopes to achieve several key objectives: reducing transport costs and pollution, ensuring more stable incomes for farmers (Omar and Thorsoe, 2024) [19] and protecting

biodiversity (Molitorisova, et.al., 2023) [16]. At the same time, shortening these chains leads to support for local economies and a reduction in dependence on globalized food supply chains, which are often vulnerable to economic shocks and natural disasters (Sniadach, 2024) [22]. The strategy therefore has profound social and economic dimensions, aiming to reduce trade inequalities and create conditions for a higher degree of social justice. The focus of the strategy is the transition to sustainable agriculture, which is not only a response to global climate challenges, but also a response to the growing need to reduce pollution associated with the use of chemical plant protection products in agriculture (Derunova, et.al, 2024) [5]. The EU has set itself the goal of significantly reducing the use of chemical fertilizers and pesticides, as one of the main measures for the transition to cleaner and environmentally sustainable production methods (Goulas and Papachatzis, 2024) [7]. A key part of the strategy is the promotion of biodiversity and the implementation of agroecological and organic practices, which not only reduce dependence on chemicals but also increase the resilience of agricultural systems to climate change.

At the same time, reducing the use of fertilizers and pesticides also leads to a significant reduction in the negative impact on water sources and soils, which are often polluted by nitrates and other chemical elements applied in traditional agriculture. In addition, the strategy includes innovations in agricultural resource management technologies, such as the use of sensors, drones and precision farming technologies, which can optimize the use of fertilizers and reduce their environmental footprint, as well as reduce waste generated by the activity (Bonciu, et.al, 2021) [2].

Changes in consumption habits can have important long-term benefits for public health, while reducing the carbon footprint of the food industry (Mensah, et.al., 2024) [11]. Promoting short supply chains is an important element of this process, as it enables consumers to choose healthier, local and seasonal products, which often have lower energy costs for transportation and better quality (Burgaz, et.al., 2024) [4].

Although sustainable agriculture strategies are often perceived as burdensome for producers, the Farm to Fork Strategy also places an emphasis on social justice by ensuring fair incomes for farmers who commit to the transition to sustainable practices (Stojanovic, 2021) [23]. This includes not only supporting small and medium-sized farmers but also stimulating direct trade relations between producers and consumers by shortening supply chains.

Reducing intermediaries in the food trade not only enables farmers to earn better incomes (Milev and Mutafov, 2024) [13], but also leads to a reduction in food waste and increases the resilience of local economies (Pinta, 2024) [20]. However, such transitions require targeted investments in innovation and the development of new business models that ensure the financial stability of small producers.

The Farm to Fork Strategy plays a crucial role in the transition to sustainable agriculture and food systems in the European Union. It combines environmental, social and economic aspects of the food chain and offers a holistic approach to solving global challenges facing the agricultural sector. By reducing the distance between producers and consumers, promoting local and sustainable production and processing methods, the strategy has the potential to create healthier, more efficient and socially just food chains. At the same time, its successful implementation requires innovation, close cooperation between different stakeholders and a commitment to creating sustainable practices at every level of the food chain.

In this context, the purpose of the paper is to analyze the dynamics of the horticultural sector regarding the surfaces covered by orchards by fruit tree types and fruit production by fruit sort as well as import of fruit and vegetables in order to identify the changes in the period 2020-2023.

Also, it was studied the dynamics of labour force and average net salary in agriculture and at the national level, in order to reflect the changes and differences in the period 2008-2023.

All these are destined to illustrate the efforts made by Bulgaria trying to align the EU's Farm to Fork strategy.

MATERIALS AND METHODS

In order to assess the ability of Bulgaria's agricultural sector to align to the goals of the "Farm to fork strategy" multiple points of interest were analysed. The data reflecting land use of Bulgarian agriculture was supplied by the Ministry of Agriculture and Foods' own statistical department – Agrostatistics [14]. The data needed for the analysis of the agricultural labour resources was sourced from the National Statistical Institute [17].

The period analysed in this study varied based on the relevant information for the analysis and points made in different sections [1].

The cultivated areas and productions for the fruit sector and vegetables sector was studied in the interval 2020-2023.

Labour resources based on their specifics and mobility needed to be studied for a longer period of time – 16 years, between 2008 and 2023, than the trade flows and land use.

To analyse the dynamics of production, trade, and labour resources in Bulgarian agriculture, data from various sources was utilized, primarily from the Agrostatistics database of the Ministry of Food and Agriculture and the National Statistical Institute of Bulgaria, which was aggregated and cross-referenced with the Eurostat database, as well as with UN databases, including Comtrade and FAOSTAT.

RESULTS AND DISCUSSIONS

Land use as the main production factor for agriculture

Bulgarian farmers' ability to maintain a steady food supply and comply to market demands is based on optimisations of land use, as the country has a various terrain, and areas are suited to different productions. These limitations are studied trough the current land use data and farmers production choices.

Orchards area and fruit production

The total area of fruit, nut and berry plantations in agricultural holdings in Bulgaria in 2023 was 59,904 ha, which is 5% below the level of the previous year [3]. In 2022 it was 63,327 ha, which is 3% below the level of the previous year, and in 2021 it was 65,497 ha, which is 1% above the level of the previous year (Table 1).

The largest share of the harvested area in 2023 was occupied by cherries - 23.6%, followed by plums - 22.7% and walnuts - 18.4%. Almost all major fruit crops recorded a decrease in harvested areas compared to 2022, ranging from 1.5% for plums to 41.5% for peaches and nectarines. An increase was observed only for raspberries by 0.4% and hazelnuts by 12.9%. These changes in the peaches and apricots harvested areas is alarming, due to the high local demand for these products and the long preparation period for such production.

Table 1. Orchards areas and fruit production

	Orchards by fruit tree type (ha)				Production by fruit type (tons)			
	2020	2021	2022	2023	2020	2021	2022	2023
Apples	3,555	3,778	3,720	3,562	37,874	44,030	46,403	34,933
Pears	503	545	575	468	2,830	3,038	3,100	2,511
Peaches	2,775	2,673	2,533	1,483	20,740	21,698	24,182	10,799
Apricots	1,838	3,064	3,049	2,199	9,516	20,701	19,040	10,855
Plums	8,573	9,275	9,398	9,556	60,024	65,123	56,650	57,737
Cherries	10,631	10,754	10,799	9,648	52,326	52,615	53,920	46,222
Sour cherries	1,101	1,183	1,111	934	4,809	4,414	4,260	3,274
Walnuts	7,097	8,066	8,327	7,509	4,750	4,731	4,035	3,450
Almonds	928	1,284	1,506	1,077	473	828	960	622
Hazelnuts	1,337	1,561	1,529	1,727	846	692	759	799
Raspberries	1,829	1,632	1,566	1,572	6,167	5,563	5,691	5,656

Source: MFA, Department "Agrostatistics" [14].

The labour shortage in some areas of the country impacted the producers decisions to move away from some of these highly labour intensive productions. The largest share of

harvested areas in 2022 was occupied by cherries - 23.7%, followed by plums - 20.6% and walnuts - 18.3%. Compared to 2021, the harvested areas of plums, walnuts, pears and almonds increased by between 1.3% for plums and 18.3% for rose hips, while the remaining observed crops recorded a decrease within 0.5% for apricots and 6.1% for sour cherries.

The largest share of harvested areas in 2021 cherries occupy 23.9%, plums 20.6% and walnuts 17.9%.

Almost all main fruit crops recorded an increase in harvested areas compared to 2020, ranging from 1.2% for cherries to 66.7% for apricots. There was a decrease only for peaches and nectarines by 3.7% and raspberries by 10.8%.

In 2023, a total of 179,613 tons of fruit were produced in the country - 19.2% less compared to the previous year, due to the unfavourable climatic conditions in the country as well as due to the reduction of the production base for some fruit cultures. An increase in production compared to the previous year was recorded for plums by 1.9% and hazelnuts by 5.3%. For the other fruit species, production is lower, with the largest decrease in peaches and nectarines by 55.3%, followed by apricots -43.0%, almonds -35.2% and apples -24.7%.

Almost all - 97% of the fruit produced in 2023 was sold on the local and international markets. The largest share of production intended for direct sales and in the trade network is 56%. The quantities for processing account for 37%. The local market has a high demand for locally produced foods and the "Farm to fork" strategy can be implemented to recover some of the lost ground by fruit producers. To achieve such goals, increase in the levels of public support for fruit production in some areas must be seriously considered by policymakers.

In 2022, the total production of fruit in agricultural holdings amounted to 222,177 tons - 1.7% below the previous year's level, mainly due to a decrease in plum production by 13%. The harvested quantities of sour cherries by 3.5%, apricots by 8% and walnuts by 14.7% were also lower than in 2021.

In 2022, the largest relative share of the total fruit production was formed by plums - 25.5%, followed by cherries - 24.3%, apples - 20.9% and peaches and nectarines - 10.9%.97% of the fruit produced in 2022 was sold. The largest share of production was intended for direct sales and in the retail network - 52%, and 41% was directed for processing.

In 2021, 226,118 tons of fruit were produced in the country, which is 11.6% more on an annual basis. The largest relative share of the total fruit production during the year was formed by plums - 28.8%, followed by cherries - 23.3% and apples - 19.5%.

Compared to 2020, there was a significant increase in the production of apricots and almonds - more than twice and by 75.1%, respectively. The harvested quantities of peaches and nectarines, pears, plums, apples and cultivated rose hips were also significantly larger - by between 4.6% and 37.3%.

At the same time, the production of sour cherries, raspberries and hazelnuts decreased from 8.2% to 18.2%. The production of cherries and walnuts is close to that reported in the previous year. Almost all - 98% of the fruits produced during the year were sold. The largest share of the production is intended for direct sales and in the retail network - 51%.

Cultivated area with vegetables and vegetables production

The total open areas with vegetables in 2023 are 28,988 ha - 1.2% less than in 2022. By crop groups, an increase in areas is observed for fruit vegetables by 9.6% and tuber and onion vegetables by 23.9%, and a decrease in potatoes by 23.4% (Table 2).

With the largest relative share of the total areas with vegetables during the year are those occupied by potatoes - 24.2%, watermelons - 12.8%, onions 10.4%, melons - 9.6% and tomatoes - 8.8%.

By types of vegetable crops, in 2023, a significant growth on an annual basis is reported in the areas with gherkins (more than double), cucumbers by 47.9%, melons by 34.3% and onions - mature by 30.1%.

The total production of vegetables in 2023 is 594 thousand tons - 5.6% less than the previous year, mainly due to a serious decline in the amount of potatoes harvested.

The production of open areas is shrinking by 6.5% on an annual basis, to 485.9 thousand

tons, and the greenhouse production - by 1.5%, to 108.1 thousand tons.

In 2023, the largest production is potatoes - 119.2 thousand tons (20.1% of the total vegetable production), tomatoes - 115.7 thousand tons (19.5%), watermelons - 80.1 thousand tons (13.5%), pepper - 52 thousand tons (8.8%), cucumbers - 50.1 thousand tons (8.4%).

Almost all groups of vegetables reported an increase in the quantities harvested from open areas compared to the previous year, reaching 30.4% in tuber and onion vegetables.

Table 2. Vegetable areas and production

	Cultivated area with vegetables (ha)				Vegetables production (Tons)			
	2020	**2021**	**2022**	**2023**	**2020**	**2021**	**2022**	**2023**
Tomatoes	2,587	2,427	2,488	2,540	115,790	116,418	126,455	115,650
Cucumbers	490	432	219	324	50,202	51,414	51,025	50,131
Gherkins	206	156	53	128	3,434	2,268	1,242	2,383
Eggplants	369	321	415	357	9,921	7,804	9,689	10,238
Zucchinis	220	131	165	154	4,315	2,094	3,659	3,049
Melons	2,242	2,952	2,080	2,794	25,453	29,203	21,493	29,487
Watermelons	4,421	4,747	3,338	3,714	87,251	107,342	79,978	80,130
Peppers	2,597	2,866	2,215	2,371	50,992	61,576	46,793	52,005
Onions	2,620	2,351	2,318	3,016	28,443	29,874	27,459	38,956
Carrots	591	459	359	446	8,702	12,056	9,544	9,707
Garlic	369	272	336	226	1,600	1,031	1,287	1,073
Potatoes	9,946	10,902	9,159	7,019	192,331	195,639	172,209	119,239

Source: MFA, Department "Agrostatistics" [14].

Among the more significant crops, a significant increase in the production obtained from open areas was observed in mature onions by 41.9%, melons by 37.2%, cucumbers by 32.4% and peppers by 9.3%, and a decrease in potatoes by 30.8% and tomatoes by 14.2%.

In 2022, the main areas used for vegetable production in agricultural holdings were 30,942 ha, which is 16.5% less on an annual basis. The open areas planted with vegetables shrank by 16.9%, to 29,869 ha. Greenhouse areas also reported a decrease, but to a lesser extent - by 3.1%, to 1,073 ha.

By crop groups, there was a decrease in areas for tuber and onion vegetables by 2.1%, potatoes by 16%, fruit vegetables by 24.9% and leaf or stem vegetables by 26.1%.

The areas with the largest relative share of the total area with vegetables in 2022 were the areas occupied by potatoes - 31.2%, followed by those with watermelons - 11.4%, tomatoes - 8.5%, peppers - 7.5%, melons - 7.1%.

The areas with eggplants and zucchini were also significantly higher - within 26% - 29.3%. On the other hand, the areas with gherkins are seriously decreasing by 66%, cucumbers by 49.3%, watermelons by 29.7%, melons by 29.5% and pepper by 22.7%.

The total production of vegetables - harvest 2022 is 629.2 thousand tons - 8.8% below the level of 2021. Production from open areas is shrinking by 10.7% on an annual basis, to 519.4 thousand tons, while greenhouse production is reporting a slight increase of 1.1%, to 109.7 thousand tons.

In 2022, the largest production is of potatoes - 172.2 thousand tons (27.4% of total vegetable production), tomatoes - 126.5 thousand tons (20.1%), watermelons - 80 thousand. tons (12.7%), cucumbers – 51 thousand tons (8.1%), pepper – 46.8 thousand tons (7.4%).

Among the more significant crops, a significant increase in the production obtained from open areas is observed for eggplants by 25.3% and tomatoes by 20.9%, and a decrease – for cucumbers by 42.7%, pumpkins by 32.5%, melons by 26.4%, pepper by 25.8%, watermelons by 25.5%, potatoes by 12% and ripe onions by 8%.

In 2021, the main areas used for vegetable production in agricultural holdings are 37,072 ha, which is 1.6% more than the previous year. The open areas planted with vegetables are 35,965 ha. Greenhouse areas increased by 23.3% on an annual basis, to 1,107 ha.

Open areas with vegetables during the year increased by 4.1% compared to 2020, with an

increase by crop groups in fruit vegetables by 6% and potatoes by 9.6%.

The areas with the largest relative share of the total open areas with vegetables in 2021 were the areas occupied by potatoes - 31.1%, followed by those with watermelons - 13.5%, melons - 8.4%, pepper - 8.2%, tomatoes - 6.9%, etc.

The total production of vegetables – harvested in 2021 amounted to 690.1 thousand tons - 5.9% above the level of the previous year. Production from open areas increased by 4% on an annual basis, to 581.6 thousand. tons, and greenhouse production – by 17.2%, to 108.5 thousand tons.

In 2021, the largest production was of potatoes – 195.6 thousand tons, tomatoes – 116.4 thousand tons, watermelons – 107.3 thousand tons, pepper – 61.6 thousand tons and cucumbers – 51.4 thousand tons

Among the more significant crops, a noteworthy increase in the production obtained from open areas was recorded for watermelons by 23%, pepper by 20.6%, melons by 14.6% and onions by 5%, and a decrease – for eggplants by 22.1%, tomatoes by 17.4% and cucumbers by 11.6%. Potato production increased by 1.7% on an annual basis.

Considerations on the dynamics of fruit trees and vegetables area and production

The dynamics of development of Bulgarian agriculture in recent years for different sectors of agriculture has been different – for grain and technical crops it is positive, and for various vegetable production it is negative (Mitova, 2024) [15].

In Bulgaria, the development of the fruit and vegetable market follows the trends in the EU, but at the same time is influenced by a number of other factors, such as the volume of local production and trade with neighbouring countries, including those that are not members of the Union, progressive technologies and the growing demand for direct sales. All this affects consumer demand.

According to Ivanov and Dimitrova (2018) [9], increased incomes in Bulgaria and the world are one of the factors for increasing the demand and consumption of food, and especially food that provides healthy nutrition. This contributes to the growth of the market and direct trade.

The type and quantity of food that is produced and consumed, as well as the amounts of food losses and waste generated, have a significant impact on the sustainable use of natural resources.

A huge economic cost, with a high social and environmental cost, is the loss and waste of food. From an environmental point of view, the loss of food leads to the waste of valuable natural resources. These foods contribute to the generation of a large percentage of greenhouse gas emissions. At the same time, damage is caused to the use, and arable land for the production of agricultural products. (Georgieva and Karavasileva, 2022) [6].

According to Nikolaeva (2022) [18], in order to increase and improve sustainable consumption of agricultural products, their demand and supply must be increased and they must be produced and delivered in a sustainable manner. But for this, it is necessary to coordinate policies and instruments in different areas - health, environment, social policy, regional governance and society as a whole.

For the period from 2022 to 2024, a decrease in the production of fruits and vegetables in the country was observed compared to previous years (Tables 1 and 2). Accordingly, the decrease was by 1.7% and 8.8% compared to 2021. And in 2023, compared to 2022, 19.2% less fruit and 5.6% less vegetables were produced. This trend in the reduction of the volume of fruit and vegetable production is influenced by climatic conditions (untraditionally low temperatures, leading to frosts in areas, heavy rains, prolonged summer droughts), increased production costs, shrinkage of the cropped areas for vegetables, changes in coupled support schemes. This is a prerequisite for the volume of production not to be large.

By the end of the studied period - 2023, on an annual basis, there is a serious decrease in the production amount of peaches, apricots by between 43% and 55%, and cherries, walnuts, pears, sour cherries and apples - by between 14.3% and 24.7%. Among vegetables, the most significant decrease on an annual basis is noted

in the production of potatoes by 30.8%, tomatoes (by 8.5%) and cucumbers (by 1.8%). In the other main types of vegetables, an increase in production is observed compared to 2022, with the largest growth in onions (by 41.9%) and melons (by 37.2%).

The areas for fruit and vegetable production in Bulgaria are largely influenced by targeted support, market realization, the lack of permanent irrigated fields, the lack of an insufficient policy to support producers, the different nature and size of producers, external pressure from large and competitive companies, and the introduction of innovations in production (Mitova, 2024) [15].

Bulgaria's trade with agricultural products

Bulgaria's agricultural trade in 2023 is in the amount of 14,142.2 million euro. This is 5.3% less than in 2022. Exports of agricultural goods are down by 4% compared to 2022, and imports are down by 7%(Table 3). The agricultural sector, which accounts for 15% of the total trade for the year, retains its importance in 2023 in the country's foreign trade. Bulgaria carries out a large part of its agricultural trade with the countries of the European Union.

Table 3. Import and export of fruits in Bulgaria (tons)

	Imports				**Exports**			
	2020	**2021**	**2022**	**2023**	**2020**	**2021**	**2022**	**2023**
Apples	52,933	51,157	60,825	53,782	1,590	269	104	108
Grapes	9,406	9,877	10,051	432	751	961	59	395
Peaches and nectarines	20,959	18,874	23,285	23,145	3,406	3,575	1,689	1,762
Apricots	3,916	2,907	5,618	5,547	453	725	1,570	219
Plums and sloes	1,135	423	2,463	1,231	660	1,290	255	80
Cherries	2,854	3,300	2,026	6,298	844	583	556	3,373
Strawberries	3,363	4,325	4,576	4,556	654	1,090	569	561
Watermelons	35,687	42,067	50,592	43,679	3,875	2,909	22,573	13,825
Other (incl. citrus and bananas)	228,681	253,042	234,478	249,753	39,414	47,999	49,438	49,034
Total fruits	**358,934**	**385,972**	**393,915**	**397,534**	**51,646**	**59,400**	**76,812**	**69,357**

Source: NSI and MAF [17, 14].

Table 4. Import and export of vegetables in Bulgaria (tons)

	Imports				**Exports**			
	2020	**2021**	**2022**	**2023**	**2020**	**2021**	**2022**	**2023**
Potatoes	44,327	46,242	48,010	49,932	25,600	2,557	2,819	1,977
Tomatoes	86,320	99,726	89,880	98,671	9,400	15,775	13,989	17,207
Onions	24,005	22,067	23,099	22,134	441	149	221	712
Cabbage	8,350	9,123	8,259	6,102	2,835	2,665	920	805
Carrots and turnips	17,206	16,300	17,749	17,080	291	263	153	186
Cucumbers	18,977	19,518	21,835	25,554	7,653	6,944	6,017	5,693
Gherkins	9,965	14,950	8,130	4,353	6,009	9,410	4,627	2,284
Pepper	25,999	33,162	26,443	30,193	5,753	6,273	3,967	5,523
Other	37,073	44,286	41,402	42,541	13,318	11,959	5,755	4,857
General vegetables	**272,221**	**305,374**	**284,806**	**296,599**	**48,261**	**55,995**	**38,469**	**39,245**

Source: NSI and MAF [17, 14].

In 2022, according to data from the National Statistical Institute and the Ministry of Agriculture, 393.9 thousand tons of fresh fruit were imported into Bulgaria, which is 2.1% more than in 2021.For the same period, 284.8 thousand tons of fresh vegetables were also imported, or 6.7% less than in 2021 (Table 4).

In 2023, the country imported 0.9% more fresh fruit (397.5 thousand tons) and 4.1% more fresh vegetables (296.6 thousand tons) than in 2022. This shows a significant increase in the import of fresh vegetables. In Bulgaria, the import levels of fruit and vegetables depend mainly on the level of fulfilment of domestic consumption with local production and the size of production (Tables 4 and 5).

The consumer attitudes create favourable conditions for the implementation of the “Farm to fork” strategies’ goals in the country. Bulgarian consumers will welcome the shortening of food supply chains and will choose to consume local products if given the opportunity to do so at competitive prices.

Table 5. Import and export value of fruits and vegetables in Bulgaria (thousand euro)

	Imports				Exports			
	2020	**2021**	**2022**	**2023**	**2020**	**2021**	**2022**	**2023**
Fruit; citrus or melon	228,486	275,166	303,981	353,097	104,476	127,849	168,793	154,242
Vegetables, plants, roots and tubers	191,646	221,165	251,857	299,756	114,674	141,289	166,677	170,197

Source: NSI and MAF [17, 14].

In 2022, the leading imported group of fresh fruits remained the import of citrus fruits and bananas, a total of 48.4% of all fresh fruit imports for the year, 9.3% below the level of the previous year. These products cannot be produced competitively in Bulgaria due to lack of absolute advantages of the country. In this regard the shortening of the supply chain of such products must focus on sourcing them from neighbouring, or closest countries that have those production advantages.

A relatively large share was also represented by the supplies of apples and watermelons, as well as grapes, strawberries, peaches and nectarines, which increased by 1.8% - 23.4% more compared to 2021. The quantities of cherries supplied in 2022 were 38.6% less compared to 2021.

In 2023, the total import of fresh fruits was again formed by citrus fruits and bananas, with supplies being 4.2% more compared to 2022. A relatively large share in imports was occupied by the supplies of apples (13.5%), which decreased by 11.6% (53.8 thousand tons). Imports of strawberries, peaches, apricots, grapes and watermelons are down by between 0.4% and 13.7% year-on-year. Imports of cherries are three times higher than in 2022, and plums are down by up to 50%.

The strongly negative trade balance for fruits and vegetables clearly shows that the local market actors rely broadly on imports and focus exclusively on their economic goals. To achieve its goals, the "Farm to fork" strategy has to create economic incentives for local market actors to promote or require the local production of fruits and vegetables, that the country can produce efficiently. These economic incentives can have a positive implication for the development of Bulgaria's agricultural sector by diversifying it and thus increasing its sustainability in the long term. These necessary changes to the agricultural sector will lead to changes in the modes of production in some areas of the country and the factor requirements for it. As the country has variable land resources, the main productive factor that must be studied in order to use its ability to adjust and comply to the new requirements of the "Farm to fork" strategy's goals is the labour resources.

Labour resources in Bulgaria's agriculture

Labour availability and use of labour resources by the agricultural sector in Bulgaria

The peculiarities of agriculture are associated with a high share of production costs, low wages, different purposes of finished products, seasonality and short shelf life of production, etc. Unlike other industries, the agricultural sector is largely dependent on natural and climatic conditions.

The research period is 16 years, respectively from 2008 to 2023, and it is notable that the number of employed persons in the agricultural sector decreases with each subsequent year, reaching 166.4 thousand in 2023.

This negative trend is evident in the 84 thousand people or 33.75% less employed in agriculture compared to the initial period taken as a base (Table 6).

At the same time, the total number of employed persons in Bulgaria is also decreasing, but by a smaller percentage or 12.76%, which is evidence of the lack of desire and attitude of persons of working age to prefer to work in this sector.

In agriculture, men predominate, who exceed the number of women more than twice.

The number of people employed in the agricultural sector in the period 2008 – 2013 varied in the range of 5 to 7% of the total number of employed persons in Bulgaria, with the lowest value calculated in the last year amounting to 5.68%.

Table 6. Number of employed persons in Bulgaria and in the "Agriculture, Forestry and Fisheries" sector in the period 2008 - 2023

	Number of employed in agriculture			Number of employed in Bulgaria	Share of employed in agriculture, %
	Overall	Male	Female		
2008	251,200	160,000	91,200	3,360,700	7.47
2009	230,700	149,000	81,800	3,253,600	7.09
2010	209,600	134,800	74,700	3,075,300	6.82
2011	201,000	133,800	67,300	2,965,200	6.78
2012	189,000	129,300	59,700	2,934,000	6.44
2013	195,500	133,800	61,700	2,934,900	6.66
2014	208,900	144,900	64,100	2,981,400	7.01
2015	207,900	146,200	61,700	3,031,900	6.86
2016	203,700	143,800	59,900	3,016,800	6.75
2017	221,000	154,400	66,600	3,150,300	7.02
2018	207,400	145,100	62,300	3,152,700	6.58
2019	214,100	149,500	64,600	3,233,100	6.62
2020	205,600	144,100	61,500	3,121,700	6.59
2021	178,100	124,200	53,800	2,877,200	6.19
2022	184,900	127,900	57,000	2,940,600	6.29
2023	166,400	117,100	49,300	2,931,900	5.68

Source: NSI and MAF [17, 14].

Table 7. Average monthly gross salary for the country and for the sector "Agriculture, forestry and fisheries" in the period 2008 - 2023

	Average monthly net salary (BGN)		Difference (BGN)	Ratio of difference (in %)
	Overall, for Bulgaria	in agriculture		
2008	538.33	373.67	164.67	44.07
2009	602.25	442.00	160.25	36.26
2010	645.42	476.08	169.33	35.57
2011	696.83	517.25	179.58	34.72
2012	735.92	582.08	153.83	26.43
2013	774.83	649.92	124.92	19.22
2014	818.33	677.58	140.75	20.77
2015	883.17	711.75	171.42	24.08
2016	944.83	784.75	160.08	20.40
2017	1,041.67	834.75	206.92	24.79
2018	1,130.58	933.58	197.00	21.10
2019	1,261.17	989.42	271.75	27.47
2020	1,374.08	1,005.33	368.75	36.68
2021	1,537.42	1,098.17	439.25	40.00
2022	1,739.17	1,279.92	459.25	35.88
2023	1,990.75	1,435.17	555.58	38.71

Source: NSI and MAF [17, 14].

Table 7 presents the data regarding the average monthly salary by year in agriculture, and again the same negative trend is observed related to the lower income from activities in the sector compared to the remuneration received in the country. The average gross salary in the agricultural sector is lower than the average salary for the country and varies approximately from 19% to 44%, with the highest values recorded at the end of the period. The labour as a production factor has a significant impact on the results of the functioning of the production system.

Maintaining information on the quantitative and qualitative characteristics of labour makes it possible to assess the production potential of this factor, and from there the production capabilities of the entire system.

Labor in agriculture is characterized by low attractiveness as a result of:

- The work performed in the industry is "outdoors" - under the direct influence of natural and climatic conditions.
- The presence of technological interruptions related to the seasonality of production, which implies short-term employment of labour for a partial working year, part-time work and, in particular, work under non-employment legal relationships and oral agreements.
- Weak organization of production caused by the lack of the necessary educational and qualification level.
- High labour intensity associated with insufficient equipment and modern technology in processing agricultural products.
- Low and uneven payment of the workforce in the sector and hence low social and health insurance, most often the minimum social security income and others. Most often, a piecework form of labour payment is applied.

All these characteristics describing Agriculture and the peculiarities of the labour force as the main production factor in the sector are a great challenge not only for entrepreneurs in this area but also for the state.

To overcome the labour resource shortages that are evident form the analysis and increase the number of employed in agriculture required for more labour-intensive fruit and vegetable production economic incentives must be created.

The vast difference between the average salary in the country and in the sector must be overcome to attract more of the local labour resources.

CONCLUSIONS

In Bulgaria, the development of the fruit and vegetable market is in line with trends in the European Union, while at the same time being influenced by several other factors, including the volume of local production, trade with neighbouring countries and the mounting demand for direct sales. These factors have a significant impact on consumer demand.

The consumption of fruit and vegetables in Bulgaria depends on the income of the population, the price levels of products, consumer preferences and cultural and educational qualifications. The increase in the standard of living and income of the population leads to changes in the consumption of fruit and vegetables, as well as in the trade channels.

When analysing labour resources, it is observed that the increase in remuneration from activities related to the agricultural sector is increasing at a much slower pace compared to those of workers in other sectors and in Bulgaria as a whole. It is interesting that the wage in agriculture for 2023 compared to 2008 increased by 284.07%, which is 14.27% more than the increase in remuneration in the country for the same period and amounts to 269.80%.

During the studied period labour resources in agriculture remained with lower remuneration values compared to the average for the country in terms of salary per number of employees, which again proves an unattractiveness in the sector.

Thus, people of working age are not interested and motivated to engage in activities related to agriculture.

An important aspect of the "From Farm to Fork" strategy is the promotion of healthy and sustainable diets.

The transition to plant-based foods and a reduction in the consumption of processed foods and meat not only has an environmental impact but is also a response to growing public health problems, such as diabetes, cardiovascular disease and obesity.

Promoting healthy foods involves both changes in production methods and information campaigns to raise consumer awareness of the importance of food quality.

New economic incentives must be implemented through Union-wide policies to address the labour resource deficiencies identified in the analysis and to increase the workforce in agriculture necessary for more labour-intensive productions. The significant disparity between the national average salary and those within the sector must be mitigated to attract more local labour resources. Additionally, the workforce demands posed by the “Farm to Fork” strategy’s short food supply chains may surpass the availability of local labour, necessitating the consideration of both internal and external migration to meet these requirements.

The significantly negative trade balance for fruits and vegetables for Bulgaria’s agricultural sector underscores the heavy reliance of local market actors on imports, with a predominant focus on economic objectives.

If Bulgaria aims to achieve the goals of the “Farm to Fork” strategy, it is crucial to establish economic incentives that encourage local market participants to prioritize or mandate the domestic production of fruits and vegetables that can be efficiently cultivated within the country. At the current state of resources available for local economic support for such actions, Bulgarian policy makers must rely on larger support from the EU. These incentives however could positively impact the development of Bulgaria’s agricultural sector by diversifying its production base, thereby enhancing long-term sustainability.

The necessary adjustments of the agricultural sector will require modifications in production practices across various regions and alterations in the factors of production.

Given the country's diverse land resources, the key factor that must adapt and meet the new requirements set forth by the “Farm to Fork” strategy is the availability and suitability of labour resources.

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REFERENCES

[1]Annual Report on the Status and Development of Agriculture (Agricultural Report) for the Period 2020 – 2024

[2]Bonciu, E., Păunescu, R. A., Roșculete, E., Păunescu, G., 2021, Waste management in agriculture. Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development, 21(3), 219-227.

[3]Bulletin on the situation of the fresh fruit and vegetable market in Bulgaria for the period 2020 - 2024

[4]Burgaz, C., Van-Dam, I., Garton, K., Swinburn, B. A., Sacks, G., Asiki, G., Vandevijvere, S., 2024, Which government policies to create sustainable food systems have the potential to simultaneously address malnutrition, obesity and environmental sustainability?. Globalization and health, 20(1), 56.

[5]Derunova, E., Vasilchenko, M., Voronov, A., 2024, Assessment of the degree of implementation of the results of scientific research and inventions in the agricultural sector of the economy. Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development, 24(1), 311-319.

[6]Georgieva, R., V. Karavasileva, 2022, Reducing Food Waste and Food Waste, Teaching Aid Erasmus+ Mobility Project, Key Action 1: Educational Mobility for Citizens 2022-1-BG01-KA122-VET-000076469 "Innovation in the Food Industry", pp. 1-30

[7]Goulas, A., Papachatzis, A., 2024, Farm to fork strategy: a sustainable solution for rural communities. Annals of the University of Craiova, Biology, Horticulture, Food products processing technology, Environmental engineering, 29(65).

[8]Harizanova-Bartos, H., Kabadzhova, M., 2024, Development of Bulgarian agriculture production structures. Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development, 24(3), 411-421.

[9]Ivanov, B., Dimitrova, D., 2018, Forecasts for the development of vegetable production. Center for Economic Analyzes in Agriculture (CAPA) at IAE, Sofia.

[10]Marek, C., Tosun, J., 2023, Tackling the Environmental and Climate Footprint of Food Systems: How "Transformative" Is the EU's Farm to Fork Strategy?. In Sustainability Transformations, Social Transitions and Environmental Accountabilities (pp. 265-297). Cham: Springer International Publishing.

[11]Mensah, K., Wieck, C., Rudloff, B., 2024, Sustainable food consumption and Sustainable Development Goal 12: Conceptual challenges for monitoring and implementation. Sustainable Development, 32(1), 1109-1119.

[12]Mezzacapo, E., 2024, Mind the Gap: Assessing Member States' Implementation of Farm to Farm-to-Fork Targets within the 2023–2027 Common Agricultural Policy. European Journal of Risk Regulation, 15(2), 265-279.

[13]Milev, O., Mutafov, E., 2024, Financial profitability of agriculture in Bulgaria. Scientific Papers Series Management Economic Engineering in Agriculture and Rural Development, 24, 661-666.

[14]Ministry of Agriculture and Food, MFA, Department "Agrostatistics". https://www.mzh.government.bg/en/ Accessed on 24.02.2025

[15]Mitova, D., 2024, Competitiveness of Bulgarian vegetable production in the world market Bulgarian Journal of Agricultural Economics and Management, 63 (3), pp.39-59.

[16]Molitorisová, A., Burke, C., 2023, Farm to fork strategy: Animal welfare, EU trade policy, and public participation. Applied Economic Perspectives and Policy, 45(2), 881-910.

[17]National Statistical Institute, NSI, http://nsi.bg, Accessed on 24.02.2025

[18]Nikolaeva, V., 2022, Sustainable Consumption of Vegetables - A Matter of Trust as Well. Nauchni trudove, (2), 305-318.

[19]Omar, A., Thorsøe, M.H., 2024, Rebalance power and strengthen farmers' position in the EU food system? A CDA of the Farm to Fork Strategy. Agriculture and Human Values, 41(2), 631-646.

[20]Pinţă, I. M., 2024, Methods of optimizing the management of agricultural farms of medium economic dimensions-a review. Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development, 24(3), 629-634.

[21]Schebesta, H., Bernaz, N., Macchi, C., 2020, The European Union farm to fork strategy. European food and feed law review, 15(5), 420-427.

[22]Śniadach, O., 2024, European Farm to Fork Strategy in the Time of Food Insecurity (No. Utvorone: 29.10. 2024). Department of European Law and Comparative Law.

[23]Stojanovic, N., 2021, European Green Deal and" Farm-to-Fork" Strategy for a Fair, Healthy and Environmentally-Friendly Food System. In Collection

Papers from Conf. Org. on Occasion Day Fac. L. (p. 130).
[24]Wesseler, J., 2022, The EU's farm-to-fork strategy: An assessment from the perspective of agricultural economics. Applied Economic Perspectives and Policy, 44(4), 1826-1843.

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ANALYSIS OF THE STATUS AND PROBLEMS FOR THE DEVELOPMENT OF BEEKEEPING IN BULGARIA

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Abstract

The present study is aimed at analysing the status, potential and problems in the development of beekeeping. The need for the study stems from the fact that despite the great opportunity for the development of beekeeping, which the country has had in recent years, the sector is not only not developing but is also facing a catastrophe. The main hypothesis is that beekeeping in Bulgaria, despite the good natural conditions for development, is far from its potential. Hence the main goal of the study. To identify the main reason or factor stopping the development of beekeeping. From the conducted research, we have reason to assert that the most significant factor influencing the development of beekeeping is the profitability of the bee colony. Since the low profitability in this case results from the adoption of poor legislative policies by the state and the EU, which are detrimental to beekeeping. The decisive role for the development of beekeeping remains in the hands of the state and the European administration and their legal and financial policies aimed at the sector.

Key words**:** *state of beekeeping, honey production, beekeeping problems, honey trade*

INTRODUCTION

The history of beekeeping in our lands begins long before the founding of the First Bulgarian State. According to various sources, the Slavs collected honey from nature long before the founding of the First Bulgarian State, and later, with the help of the skills of the Proto-Bulgarians, they began to cultivate the process. At a later stage, beekeeping developed as one of the main crafts in the First Bulgarian State. Even then, due to the good qualities of Bulgarian honey, it was an object of trade with other kingdoms and trade centers such as Byzantium, Genoa, etc. (Basheva-Nikolova H., 2023) [3]. This is one of the few crafts that has survived through the centuries and is still practiced today. This livelihood still contributes to the socio-economic and sustainable development of rural areas.

Over the years, the beekeeping sector of Bulgaria has been the subject of various research institutions and authors of scientific publications, such as the Bulgarian Academy of Sciences (BAS), the Ministry of Agriculture and Food (MAF) (MAF, 2024) [10], the Institute of Animal Sciences Kostinbrod and Troyan and researchers such as Simova (2007), Hristov (2016), Angelov (2017), Borisov (2020), Lyubenov (2020a and b), Garabedian (2023), Stanev (2018) [14, 7, 2, 4, 8, 9, 6, 13]. Their opinions, findings and conclusions are presented in various reports and articles. But their focus, besides being the subject of previous years and periods, also covered other aspects of beekeeping in Bulgaria. In Romania, researchers such as: Pirvutoiu and Popescu (2011), Popescu (2013), Chiurciu et al. (2024), etc pointed out the status of beekeeping and its performance and challenges [11, 12, 5].

The present study is specifically aimed at identifying the causes of the negative trends that have arisen in recent years in the beekeeping sector in Bulgaria, looking for possibilities for overcoming them and optimizing the state of the sector in this country.

The research thesis is that beekeeping in Bulgaria is very well equipped with natural and climatic conditions, but has not yet developed its full potential in Bulgarian conditions.

The aim of the study is to identify the problems and challenges hindering the development of beekeeping in Bulgaria and to propose

opportunities and solutions for optimizing the state of the sector.

To achieve the goal, the following tasks are set:

– To monitor and analyze the state of the beekeeping sector;

– To identify and analyze the main commercial practices in the sale of honey;

– To establish the external influence on the state of the sector;

– To derive solutions and recommendations for optimizing the development of beekeeping in Bulgaria.

MATERIALS AND METHODS

For the purposes of the study, primary and secondary sources of information were used. Primary sources are official documents, reports, statistical and analytical materials of the Ministry of Agriculture.

Secondary sources of information are scientific publications and interviews conducted with beekeepers and honey buyers and chairmen of beekeeping associations, on site and by telephone.

Traditional methods of scientific research were used: generally scientific - historical and logical; logical-theoretical - analysis, synthesis, comparison, induction, deduction.

During the course of the research, numerous operating beekeeping farms, beekeeping companies, markets and shops were visited and interviewed, with the aim of obtaining first-hand opinions from people on the ground who face the challenges of the sector every day. We were interested in learning about their views on good and bad government policies, so that they could be used by us as well. Meetings were held with traders and representatives of honey processing plants in Bulgaria, who are also the main buyers. All these conversations, shared experiences and accumulated impressions helped to achieve the results presented in the study.

RESULTS AND DISCUSSIONS

Prerequisites for the development of beekeeping in Bulgaria

The geographical location of Bulgaria and the very well-preserved ecosystem predispose the development of beekeeping in the country. About 25% of the territory is mountainous and semi-mountainous, combined with more than 1,100 species of pollinating plants, which are a source of an extremely diverse palette of pollen and nectar (Hristov, 2016) [7]. Taking into account the climate, the natural conditions of the country are some of the most suitable for raising bee colonies and producing high-quality ecological honey. The honeydew and nectar honey produced in Bulgaria is distinguished by its exceptionally high taste and healing properties. In addition to the incredible aroma, taste and smell, the biological value is also due to the bouquet of nutrients - 18 types of amino acids, enzymes, vitamins A, C, E, K, B1, B2, B3, B5, B6, B7, B9, trace elements (calcium, phosphorus, magnesium, chromium, etc.), natural antibiotic substances (Angelov, 2017) [2]. Due to these qualities, Bulgarian honey is a signature product for Bulgaria and finds a place in some of the most demanding markets in the world.

Despite the unique conditions for the development of beekeeping, the state of the sector remains far from its potential. The density of beekeeping farms in Bulgaria is not well balanced and is almost half of its possible capacity. According to a study by Simova (2007) [14], taking into account the ecological and geographical characteristics of the country, it is possible to increase the number of bee colonies almost twice and reach 1.3 million bee colonies.

According to the division of the country by statistical regions (NUTS 2), in 2023, there were 194,658 bee colonies in the North-Eastern region, 186,672 in the North-Central region, 124,633 in the North-Western region, 174,163 in the South-Eastern region, 96,557 in the South-Central region, and the least populated region was the South-Western region with 39,990 (Figure 1). As it can be seen from the data above, the difference between the regions of Northern Bulgaria and Southern Bulgaria is large, 505,963 to 310,710, almost half, and between the region with the most and the fewest bee colonies, the ratio is 5 to 1. Which is a great loss for the country and the population, considering the contribution of the

honey bee to the ecosystem, economy, and food security (Yordanova, 2023) [15].

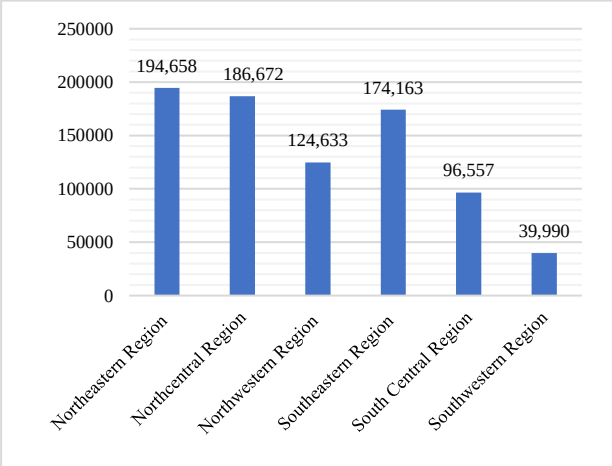

Fig. 1. Distribution of beekeeping farms by region for 2023.
Source: Based on data from the Directorate of Agrostatistics at the Ministry of Agriculture and food [10].

More bee colonies mean more plants, forests, higher crop yields, more employment for rural communities, economic contribution to processors and traders, increased Gross Domestic Product and many other contributions to the country.

Good practices from the EU and Bulgaria for the development of beekeeping

A good example of stimulating the development of the sector by the state and the European Union (EU) can be found by going back 13 years in time. With the help of the EU and the Ministry of Agriculture, bee colonies increased from 529,117 in 2012 to 867,561 in 2019. Honey production has also increased significantly from 9,186 tons to 11,518 tons (Table 1) and in 7 years with the right policies, the beekeeping sector managed to develop and increase bee colonies by 64% and honey production by 25%.

Table 1. Main indicators in the beekeeping sector for the period 2012 - 2019

Year	2012	2013	2014	2015	2016	2017	2018	2019
Number of bee farms	19,283	17,185	16,143	17,969	15,306	13,431	12,260	13,771
Number of bee colonies	529,117	541,564	577,304	747,434	754,105	765,772	783,348	867,561
Honey produced (tons)	9,186	10,065	9,268	11,388	10,218	11,388	10,388	11,518

Source: Based on data from the Directorate of Agrostatistics at the Ministry of Agriculture and food [10].

With Bulgaria's entry into the EU, new horizons are opening up for Bulgarian beekeeping. In addition to the huge European market, the sector, as a priority policy, is financed under various headings and is subject to various interventions by the state and the EU.

The sector receives support through various measures from:

- Rural Development Program (RDP). Registered beekeeping farms can use financial resources from the RDP 2014-2020, the most attractive measures for the sector are:

-Measure - 4. Investments in tangible assets,
-Measure 6. Development of the economy and economic activity,
-Measure 9. Establishment of groups and organizations of producers,
-Measure 11. Organic farming,
-Measure 16. Cooperation.

For the period from 2014 to the end of 2019, a total of 74.85 million BGN were absorbed under the measures of the RDP 2014-2020, with the largest share being measure 11 with 65 million BGN.

- The National Beekeeping Program (NBP) funds the sector for three years. Four such programs were implemented for the period 2008-2019. Financial resources in Bulgarian beekeeping from the implementation of the NBP from 2008-2019 are 74% of the financial resources provided, i.e. 40.4 million BGN out of 54.6 million BGN. Financial assistance is provided for investments, costs or projects in the following areas - measures: technical assistance for beekeepers and beekeeping associations; medicines to combat varroa; measures to support laboratories carrying out physico-chemical analysis of honey; measures to support the renewal of beehives in the

Community; cooperation with specialized bodies for the practical implementation of applied research programs in the field of beekeeping.

-Beekeeping farms can also benefit from state aid under the de minimis scheme (minimum aid) on the basis of Regulation (EU) No. 1408/2013. It is granted to support in dealing with unstable climatic conditions, to compensate for part of the costs of raising bee colonies and for their destruction as a result of plant protection measures (chemical spraying).

In addition to sector financing measures, the EU has also established a mechanism to maintain markets within the Union (Borisov P. H., 2020) [4]. The EU Common Organization of Agricultural Markets aims to stabilize them, ensure a better standard of living for the population employed in the agricultural sector, and offer quality and safe food at affordable prices. It covers market support measures, regulatory measures related to the quality control of agricultural products, recognition of producer organizations, issuance of quotas, duties and import and export licenses, etc. Market measures are key instruments of the CAP and play the role of a "safety net" in conditions of market instability. Market instability poses a threat to the sustainable development of beekeeping, which can prevent the achievement of effective management of production resources (Borisov, 2020) [4]. Other good practices from the EU and the State are Bulgarian and international exhibitions, fairs, promotional campaigns to advertise and increase the recognition of Bulgarian bee products. Such as the campaign launched in schools in 2017, with the support of Bulgarian beekeepers, "Honey Breakfast" under the motto: "Eat honey, be healthy!". These initiatives, in addition to advertising, also help build brands and direct marketing of Bulgarian bee products (Lyubenov, 2020) [8, 9]. National agricultural policies are important for expanding the scope of communication policies of beekeeping farms at the national and international level. They improve the recognition of Bulgarian bee products, as well as the opportunities for entering new markets and expanding and preserving old ones.

As can be seen from the data presented above, with appropriate policies from the EU and the state, investing in the sector is yielding results and Bulgarian beekeeping has managed to develop to levels it has not reached in many years.

The state of the beekeeping sector in recent years

- **Beekeeping**

The negative trends in Bulgarian beekeeping began at the end of 2019. Since the beginning of 2020, there has been a decline in interest in the sector, which has been on the rise for the past seven years. In one year, 2019/2020, beekeeping farms decreased by 15.6%.

In the following years, the decline continues, albeit at a lower rate (Figure 2): 7.1% for 2020/2021, 5.3% for 2021/2022, 7.7% for 2022/2023 and 5.4% for 2023/2024. For the period under review, by counting, 4,848 beekeeping owners have ceased operations or 35% compared to 2019. This is more than a third of beekeepers in Bulgaria, according to the Ministry of Agriculture, and a decline of at least 5% is expected for 2025. These data are, to put it mildly, worrying, especially the sustainability of the process and the speed at which it is happening.

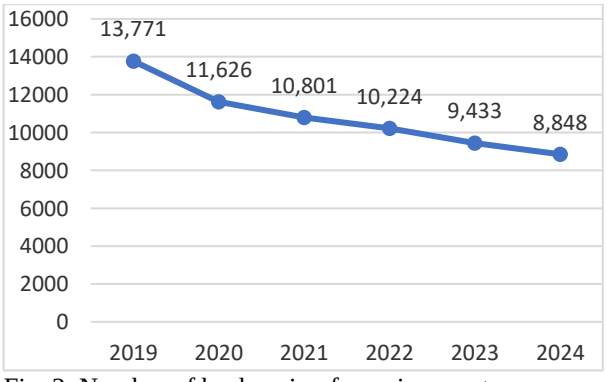

Fig. 2. Number of beekeeping farms in recent years
Source: Based on data from the Directorate of Agrostatistics at the Ministry of Agriculture and food [10].

If we take as an example, neighboring Romania with an area of 238,397 km², by 2022 its beekeepers are 32,277, compared to 2019 they have an increase of 39.4% (Chiurciu et al., 2024) [5]. On the other hand, Bulgaria with an area of 110,994 km² and 10,224 beekeepers by

2022 and with a permanent decline of 34% compared to 2019. Romania is only twice as large in area but with three times more beekeepers and with an upward development trend, unlike Bulgaria which has fewer beekeepers compared to its area and with a negative development trend.

- **Bee colonies**

When reviewing this indicator in Figure 3, it is seen that its condition is significantly better than the previous one.

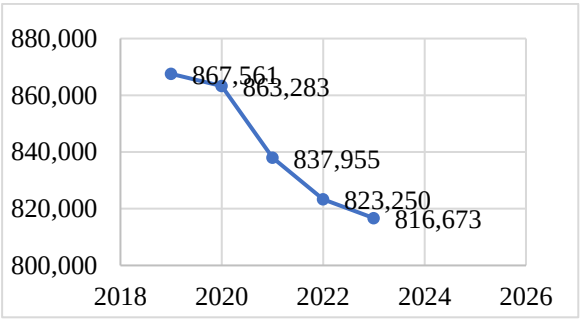

Fig. 3. Number of bee colonies in recent years
Source: According to data from the Directorate of Agrostatistics at the Ministry of Agriculture and food [10].

Here for 2019/2020 the decline in bee colonies is 0.5%, but for the next year 2020/2021 the decline in bee colonies reaches 2.9%, for 2021/2022 it is 1.8%, for 2022/2023 it is 0.8% for the period under review bee colonies have decreased by 6.3% compared to 2019. The predicted decline for 2024 is about 3%.

Logically, with the decrease in bee colonies, the colonies from which honey is extracted also decrease (Table 2). From 702,851 bee colonies from which honey was extracted in 2019, they decreased to 659,002 in 2023, by 43,849 colonies or by 6.6% in 5 years.

- **Honey produced**

The results of honey production managed to remain relatively good. The sector's honey production for 2019 was 11,518 tons, in 2020 there was a significant drop to 9,066 tons, but in the remaining years the honey extracted ranged from 11,638 tons to 11,944 tons, see Table 2.

Table 2. Bee colonies from which honey was extracted and their production for the period 2019 - 2023.

Indicators	Number of bee colonies from which honey was extracted	Produced honey (tons)
2019	702,851	11,518
2020	680,266	9,066
2021	672,163	11,638
2022	665,020	11,944
2023	659,002	11,189

Source: According to data from the Agrostatistics Directorate at the Ministry of Agriculture and food [10].

Against the background of the decreased production units, this is a good achievement for those employed in the sector. If we take the average yield of bee colonies that vary between the lowest yield of 13.3 kg. in 2020, and the highest in 2022 with 17.9 kg., we will get an average yield of 15.6 kg. for the five years.

- **Structure of bee farms**

The only indicator with a permanent positive trend is the average number of bee families per farm, for 2024 it is 93.9 bee families per farm, compared to 2019 the average number of families per farm is 63, for 2020 it is 74.3, for 2021 the number is already 77.6, and for 2022 it is 80.5. and for 2023 it is 86.6. The increase in the average number is mainly due to the increase in farms with over 150 hives, they are the only segment of the structure of bee farms that has increased by 16.1% compared to 2019, at the expense of the other three groups that have decreased their share of the total number of bee farms in the country (Table 3). In order to understand the level of consolidation of beekeeping farms, data was extracted from the results in Romania, where the average number of families for 2022 is 73, in our country it is 80.5, and for the EU this number is only 29.

Table 3. Structure of beekeeping farms for the period 2019 - 2024

Structure of beekeeping farms	Bee colonies					
	2019	2020	2021	2022	2023	2024
From 1 to 9	1.2%	1.2%	0.7%	0.7%	0.5%	0.4%
From 10 to 49	15.1%	10.6%	11.2%	9.6%	9%	7.3%
From 50 to 149	43.3%	44.5%	41.4%	36.2%	34%	35.4%
150 and above	40.4%	43.7%	46.7%	53.5%	56.5%	56.8%
Average number of bee colonies per farm	63	74.3	77.6	80.5	86.6	93.9

Source: According to data from the Agrostatistics Directorate at the Ministry of Agriculture and food [10].

A As can be seen from Table 3, the consolidation of farms is a sustainable process, which turns an increasing number of those employed in beekeeping from a source of additional income into a main activity. Beekeeping farms are increasingly taking on the form of professional and commercial enterprises.

ll these lead to the thought that the Bulgarian beekeeper has become convinced of the advantages of large-scale production and perhaps the moment is approaching when we will be ripe for unification into strong cooperatives in the beekeeping sector.

- **The sale of honey**

The main source of income for beekeeping farms is the sale of honey (Lyubenov L., 2020) [8, 9]. Due to the low purchase prices in recent years, the most significant problems and dissatisfaction in beekeeping come from the low profitability in the sector.

In this section, we will briefly introduce the prices and sale of honey in Bulgaria.

According to some authors and institutions, the trade of honey in Bulgaria is carried out mainly through four channels.

- ✓ Direct sales to end consumers;
- ✓ Direct sales to retailers;
- ✓ Sales to processing plants;
- ✓ Sales to industry;
- ✓ For own consumption and feeding of bees.

But according to the beekeepers participating in the study, honey is sold mainly through three channels. As for the two groups "Sales to processing plants" and "Sales to industry", for them there is only one - Sales to wholesalers.

In practice, over the years, the following groups have emerged as the structure of the distribution of honey produced (Table 4).

The share of sales in the group "Direct sales to end consumers" for the period under review ranged from 15.4% to 23.8%, with their trend increasing.

This means that the share of short sales chains, producer-consumer, is increasing, which is what we all strive for, with this sales channel all the added value remains in the hands of the producer.

According to data from the Ministry of Agriculture, the average price for the period is 8.04 BGN, with an upward trend and the highest value being 8.96 for 2023, according to data from the Ministry of Agriculture [10].

Table 4. Distribution structure of produced honey

Distribution of honey produced	2019	2020	2021	2022	2023	2024
Direct sales to end users	15.4%	19.8%	16.7%	17.8%	23.8%	21.5%
Direct sales to retailers	2.6%	4.9%	2.3%	3.8%	4.8%	4.5%
Direct sales to wholesalers	36.3%	60.3%	50.4%	41.4%	57.1%	74%
For own consumption and feeding of bees	13.5%	15%	13.2%	12%	14.2%	0%
In stock	32%	0%	17.4%	25%	0%	0%

Source: According to data from the Agrostatistics Directorate at the Ministry of Agriculture and food [10].

The smallest share of all sales channels is sales to retailers, where the percentage varies from 2.3% to 4.9% in 2020.

Prices are slightly lower than those in direct sales, but the quantities in a transaction are larger, in most cases ranging from 100 kg to 500 kg.

For the period, the highest price is in 2023, 8.45 BGN. and the lowest 5.90 BGN. in 2020.

The main channel for honey sales, on which profitability in the sector depends, is sales to wholesalers.

The share of these sales varies from 36% in 2019, when, due to beekeepers' refusal to sell due to low purchase prices, nearly 32% of the year's production remained in warehouses, to 74% in 2024, with full sales of the honey produced in 2024.

As can be seen from the sales made through this channel, most of the sector's production passes through it.

The bad thing in this case is that the price at which it is purchased is too low, well below the cost of the honey produced.

For 2023, the average price between organic and conventional honey according to the Ministry of Agriculture is 4.36 leva, for 2024 the price is even lower, 4.23 leva.
This negative trend has been going on for years, which is detrimental to the sector.
At first glance, the stated selling prices in the first two channels do not seem low.
But let us not forget that in order for these sales to happen, the producer must have gone through the investments/costs not only in production, but also in processing, packaging, logistics and trade, which costs not only money but also time, which not everyone has at their disposal.
Due to these circumstances, the main part of the honey produced goes through wholesalers (Angelov, 2024) [1].
According to the study, the following companies stood out as some of the most significant buyers of honey for Bulgaria: "YOT GI VAL BULGARIA" OOD - Targovishte, Apimel OOD - Rakovski, Apitrade - Plovdiv, RAM Commerce OOD - Maslarevo.
Over the years, the prices offered by these traders have differed to some extent from those indicated by the Ministry of Agriculture, in a negative direction.
Against the backdrop of the general increase in commodity prices and double-digit inflation in the country in recent years, honey prices are not only not stagnant but have also fallen by about 30%.
From Table 5, it is clearly seen that prices are steadily decreasing for all four companies.
For conventional honey for 2024, the average price among the four buyers is 3.9 leva or 2 euros, for organic honey the price is 4.4 or 2.20 euros.
The low purchase prices come mainly from the decline in prices at the European level and uncontrolled imports into the EU.

Table 5. Purchase prices of honey in BGN/kg

Wholesale honey buyers	October 2022		October 2023.		December2024		decline in %	
	conventional	organic	conventional	organic	conventional	Organic	conventional	organic
"YOT GI VAL BULGARIA" EOOD, city of Targovishte	5.5 .	6.5 .	4	4.5	3.8	4.5	-31%	-31%
Apimel EOOD, town of Rakovski	5.2 .	6.2.	3.9	4.5 .	4	4.6	-24%	-26%
RAM Commerce Ltd. Maslarevo village	5 .	6.	3.8	4.3	3.8	4.3	-24%	-29%
Apitrade, city of Plovdiv	5.5	6.3	3.9	4	4 .	4.5.	-28%	-29%

Source: Own calculations, Based on data from honey traders.
Note: Euro 1= 1.94 BGN, 23 April 2025.

Challenges facing beekeeping in Bulgaria

After reviewing data and results from reports and analytical documents from various authors and institutions, we listened to and analyzed the opinions of people on the ground (beekeepers, traders and experts from various institutions) who face problems in the sector on a daily basis, and we united around the following significant problems in the beekeeping sector: Strong competition at the international level; Rising costs of all kinds; Problems with spraying to combat plant pests; High mortality of bee colonies from diseases and aggressors in beehives; Deteriorating environment, climate and too many forage crops and lack of grazing; Lack of financial capital, Low level of competence, Small bee farms, but **the most significant according to everyone is the profitability and profitability of beekeeping**. And as stated above, the main source of income is the sale of honey. The income received from the sale of honey depends on two components, the amount of honey and the price at which it is sold. From what has been stated so far, it can be seen that the average yield from a bee colony varies plus or minus one to two kilograms up or down, for a relatively normal year without cataclysms. Which means that a down option, or to say in a bad year, in a farm of 100 bee families, the

yield will be 100 to 200 kg. less. This is not good, but on an annual basis it will not be of great importance. The situation is similar in a good year, with an increase of 100, 200 kg., it is good, but it is not of great importance. This is actually a variation in the yield by 5% to 10% up or down. But in terms of price, **the march is significantly greater**, on the one hand the value of money is reduced by double-digit inflation, on the other hand the price itself is reduced by 30%, which is detrimental to beekeeping in Bulgaria.

If we do a quick calculation, as we said above, the average number of bee colonies in a farm for 2024 is 94, the average honey yield per hive is 15kg. Or the yield of an average farm is 1,410kg. at a price of honey of 3.9 BGN is 5,499 BGN, annual turnover. This profitability would cause a smile if the situation were not tragic, because in Bulgaria every registered beekeeper pays insurance. For 2024, the insurance of a beekeeper is about 350 BGN per month (compared to 2019, the monthly insurance is 95 BGN) or 4,200 BGN per year. If we subtract 4,200 BGN from the annual turnover, 1,300 BGN remains. disposable income and when other expenses are added and taking into account that a large part of the farms have under 90 hives, the account will certainly have a negative balance. **There is no other issue as significant as profitability** that has such an impact on the sector. It is no coincidence that, according to beekeeping companies, there will be many bankruptcies in the sector. Most beekeepers say that they did not give up the craft only because of their love for beekeeping. Also, many of them have contracts under various programs and are subject to sanctions in the event of cessation of activity, but these incomes will not last long.

External factors influencing beekeeping

Despite the benefits of honey consumption and its accessibility in Bulgaria, its consumption remains very low, about 0.3/0.4 kg. per person per year, compared to Germany's consumption of 1.1 kg. For this reason, production covers demand 100 percent and about 60%/70% of the honey produced is export-oriented. Globally, Bulgaria, despite its small size, has about 2% of the world's honey exports, which range from 300,000 tons to 400,000 tons. The largest producer is China, followed by the USA and Argentina, but as a union the EU is the second largest producer and the largest importer in the world. Every year the EU has a production deficit of about 150,000t. to 200,000t. which it imports from third countries. The problem is that there is a conflict of policies, on the one hand the EU strives, **as a priority, to increase the income of agricultural producers, on the other hand to reduce the prices of food products**. Which leads to confusion and imbalance in markets and production.

In Slovenia, there is a minimum price of honey of 10 euros, while honey is imported from China at 1.29 euros/kg. Imports from Ukraine are at 1.74 euros/kg, from Russia it is even cheaper at 1.42 euros/kg, on which there are many trade restrictions due to the war, but honey is traded. In 2023, the imported quantity from Ukraine is 45,822 tons, from China – 60,177 tons, and from Argentina – 20,450 tons. However, in the first 5 months of 2024, Ukraine displaced China from the first position as a key importer of honey into the EU. Honey imports into the EU have occurred before, but **market mechanisms** have worked that have not allowed such a drop in prices. The main problems with the trade in honey began with the EU's permission to import Ukrainian honey into the EU. In addition to the fact **that imported honey directly undercuts the price** of European producers, large quantities of it are also imported into Bulgaria where they are repackaged and exported as produced in the EU or Bulgaria

Another significant problem is fake honey. Much of this so-called honey not only lacks its beneficial and healing properties, but also contains products such as glucose-fructose syrup, which is a prerequisite for various diseases. Honey is one of the most counterfeited products. In an investigation by the European Commission, out of 320 honey samples tested, 147 were counterfeit, most of which were from countries outside the EU. Almost 40% of imports come from China, and it is not uncommon for imported honey to be mixed with sugar syrup from rice, wheat or sugar beets and coloring. In recent years, beekeepers in Europe have been increasingly exposed to unfair competition and enormous

price pressure due to cheap fake honey, which often comes to the market from outside the EU.

CONCLUSIONS

As a result of the research, it can be argued that the appropriate natural climatic and ecological conditions and the traditions we have in beekeeping are not a guarantee for the development of the sector in Bulgaria, but are only a prerequisite for this. The most significant factor in a negative sense and a major obstacle to development was the profitability of beekeeping. It is accordingly a function of poor management policies on the part of the EU and the country, as a result of which the price of honey is subjected to serious dumping by unfair competition from countries importing, to a large extent, low-quality and in many cases, fake honey. Since the main source of income for Bulgarian beekeepers comes from the sale of honey, low purchase prices are detrimental to Bulgarian beekeepers. All these data confirm that the sector is facing a permanent and deepening crisis, which will seriously affect honey production, crop pollination and the overall ecological balance in Bulgaria.

Bulgarian beekeepers alone will not be able to cope with the situation they are in. In this case, there is a need for intervention at the state and European level regarding changes in the legislative and regulatory framework, at the EU level.

As a result of the study, **several recommendations** have been made that could help the financial condition and development of the sector:

-When importing honey from third countries, honey and other bee products must be subjected to laboratory analysis, including nuclear magnetic resonance, to ensure compliance with EU standards. And to prevent the import of low-quality and fake honey.

-To require mandatory labeling of honey and bee products with data on quality, composition, origin and the enterprise in which it is packaged. Also, synchronization of packaging legislation with all EU member states. To avoid fraud by malicious packers and traders who mix low-quality and counterfeit honey;

-To ensure the survival and stability of the beekeeping sector, it is necessary to take urgent measures aimed at strategically expanding and strengthening financial support. But they should be based on scientifically sound analysis. Any form of payment, be it subsidy, compensation or direct aid – should be determined on the basis of empirical data and objective criteria, in order to avoid insignificant support imitating concern on the part of the institutions;

-There should be a minimum price for the EU, which should be linked to various market mechanisms such as tariffs, quotas, licenses, etc., which, when the price falls or increases too much, should limit or allow imports of honey and bee products from third countries. In this way, beekeepers throughout the EU will feel much more secure and protected.

Beekeeping, besides being an agricultural sector and a livelihood for thousands of people, is also strategically important for the country and for the food security of Bulgaria and the entire EU.

REFERENCES

[1]Angelov, G., 2024, Status and trends in the development. Conference Proceedings "Innovative development of agricultural business and rural areas, pp. 282-290. Sofia: UNWE Academic Publishing House.

[2]Angelov, G., 2017, Problems in the production and sale of honey in Bulgaria. Annual doctoral Research Almanac, 643-654 pp.

[3]Basheva-Nikolova, H., 2023, Beekeeping in Bulgaria and the Bulgarian Lands until the Liberation. Bulgarian Science, pp. 103-116.

[4]Borisov, P. H., 2020 (2 March), Effects of the application of the CAP on the development of bee farms and profiling of their needs in the future. Journal of Bio-Based Marketing, pp. 39-51.

[5]Chiurciu, I.A., Zaharia, I., Soare, E., 2024, Aspects related to the honey market and the ethics of the beekeeping environment in Romania. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 24(2), 295-304.

[6]Garabedian, H., 2023, Assessing the impact of the CAP on the profitability of bee farms in Bulgaria. Bulgarian Journal of Agricultural Economics and Management, 68(2), 3-11 (Bg).

[7]Hristov, P., 2016, Organic beekeeping in Bulgaria - nature, status and prospects. Agricultural Academy/Animal Sciences/3-6/, 20-29.
[8]Lyubenov, L., 2020a, Development of the Bulgarian markets for bee products. Society and Health, 92-100.
[9]Lyubenov, L., 2020b, (1 June), Communication Policies of Bulgarian Beekeeping Farms in the Context of the Common Agricultural Policy of the EU. Business Management, pp. 79-98.
[10]Ministry of Agriculture and Food, 2024, (15 August), Beekeeping in Bulgaria in 2023. Ministry of Agriculture - Directorate "Agrostatistical Beekeeping": www.mzh.government.bg/media/filer_public/2024/03/01/ra234_beeshoney2023-29022024.pdf, Accessed on 5 February 2025.
[11]Pirvutoiu, I., Popescu, A., 2011, Analysis of Romania's honey market, Scientific Papers Animal Science and Biotechnologies, 44(2), 500-503.
[12]Popescu, A., 2013, Research concerning apiary size, honey yield and beekeepers' income in Teleorman county, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol. 13(1), 293-300.
[13]Stanev, Y., 2018, Entrepreneurship as an opportunity for employment (self-employment) and development of small towns in Bulgaria. Dialogue, 35-48.
[14]Simova, A., 2007, Honey production in Bulgaria - state and prospects for development. Economics and management of agriculture, 52(5), 58–63.
[15]Yordanova, E., 2023, Management Aspects in Modern Agriculture. Svishtov: Domino Publishing House.

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ASSESSMENT OF THE APPLICABILITY OF FINANCIAL INSOLVENCY MODELS

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Abstract

This article aims to develop criteria for classifying the most commonly used financial diagnostic models based on the scientific literature related to the theoretical and methodological assumptions of financial insolvency. On this basis, we assess the models' applicability by considering the specifics of Bulgarian conditions - difficulties, limitations in their application, advantages and disadvantages. The practical study focuses on enterprises operating in the agricultural sector which allegedly have been the subject of bankruptcy proceedings. The authors attempt to reveal to what extent the diagnostics using financial sustainability analysis methods provide an accurate forecast of the risk of insolvency and, hence, bankruptcy. The present study seeks answers to the following questions: are there any methodologies that stand out with a highest degree of coincidence of the forecast with the actual status quo of "declared bankruptcies"? Which indicators are characteristic of the agricultural sector, and what makes the applicability of the methods in which they participate most suitable for testing?

Key words**:** *insolvency, classification bankruptcy prediction models - advantages and disadvantages, agriculture*

INTRODUCTION

Forecasting future bankruptcies always raises the question whether the choice of methodology is correct and to what extent financial analysts can trust it. It is no coincidence that the literature abounds with models for the *ex ante* detection of bankruptcy risk as developed by Altman (1968) [1], Altman (2000) [2], Yang (1999), [29], Kasarova (2010) [12], Mohammadi (2016) [22], Huo (2006) [10], Valashkova (2020) [27]. Each subsequent author looks for their application in a specific economic sector, explores national specificities, scope of analysis, etc.

The study of insolvency risk models is of key importance for agriculture, as it takes into consideration certain specifics. The sector has traditionally been regarded as high risk, with low creditworthiness of producers. To a large extent, agricultural activity is characterised by low profitability as affirmed Kuhmonen and Siltaoja (2022) [16]; European Commission, 2020 [7] and a high proportion of loss-making enterprises Lubenova (2012) [20]; Prisacaru, and Strainu (2023) [24]. These factors favour higher indebtedness of agricultural enterprises and the risk of deterioration of financial health and insolvency. Due to its importance and the need to satisfy the debts to creditors, the insolvency procedure is statutory.

Insolvency in Bulgarian legislation is governed by the Commercial Law. It states that "the purpose of insolvency proceedings is to ensure fair satisfaction of creditors and the possibility of reorganising the debtor's undertaking (Commercial Law, 1991) [5]. It is opened by application by the debtor company or its creditor. Where there is a debt to the State or the municipalities, it is also opened at the request of the National Revenue Agency. Applications to initiate insolvency proceedings is also published in the Commercial Register. Although the majority of companies are in insolvency proceedings, they continue to be active in trade.The aim of this study is to propose a classification of analytical models for bankruptcy risk assessment and by using real data to identify which of the selected models has the highest degree of forecast matching with the actual *status quo* of "declared bankruptcies".

Review of the Criteria classification

The variety of models provides grounds to classify them and to indicate their advantages and disadvantages.

After a thorough literature review: Kulchev, (2023) [17], Balina et al. (2021) [4], Valaskova and Gajdosikova (2021) [28], Milić et al. (2021) [21], Dorohan-Pysarenko, L. et al. (2021) [6], Korol (2019) [14], Popescu (2014) [23], Table 1 lists some of the more important criteria for classifying analytical models for bankruptcy risk assessment. Each of the plethora of models has its advantages and disadvantages over the others. For example, discriminant analysis models are distinguished by a high level of interpretability of the results, accuracy and simplicity (Kanapickienė, R., 2023)[11]. Artificial neural network models, on the contrary, are said to be more difficult and require more modelling skills (Zhang, 2016) [30]. The latter are used to model quite complex nonlinear dependencies, using a computer program that selects those indicators that have the greatest impact on bankruptcy (Haas, C., 2023) [9].

Table 1. Criteria for classifying analytical models for bankruptcy risk assessment

Criteria	Types	Criteria	Types
1. According to the methodology used	- discriminant analysis; - logistic regression; - artificial neural networks, etc.	6. According to the individual indicators included in the model	- liquidity - profitability - capital structure - others
2. By economic sector of application	- for the industry sector; - onstruction; - agricultural sector; - trade, etc.	7. According to the technique used to process the results	- statistically; - intelligent (artificial intelligence models)
3. According to the scope	- global (applicable to all countries); - applicable at national level	8. According to the nature of the information they use	- on the basis of micro data (most often on the basis of annual financial statements) - based on macro data (by reflecting market factors)
4. By enterprise size	- micro - small; - medium; - large	9. According to the time order of the forecast	- for long-term forecasts; - for short-term forecasts
5. According to the number of indicators involved in the model	- bifactor; - trifactorial; - tetra-factorial, etc.		

Source: own contribution.

Other studies rely on the better classification abilities of logistic regression models compared to those of discriminant analysis (Kovacova, Kliestik 2017) [15]. Another disadvantage of the linear discriminant analysis model is that microeconomic factors are analyzed without considering the macroeconomic environment (Kiyak, 2012) [13].

What matters when choosing a model is the affiliation to a certain economic sector. According toValashkova (Valashkova, 2020) [27], models developed in a particular economic sector significantly outperform the predictive capabilities of other models adopted in the same country or abroad. For example, the peculiarities of the construction sector inevitably affect the performance of the model. Balina, R. argues that in order to remain solvent, firms in the construction industry need to maintain their level of profitability of current assets above the construction industry average. This is explained by the fact that firms in this sector use a significant amount of working capital in their daily operations (Balina, 2021) [4]. The agricultural sector stands out for its specificities, caused by the seasonal nature of its production. Its production and financial performance are also subject to weather and climatic conditions, as well as the length of the production cycle. The above factors can impact important financial indicators, such as

turnover, liquidity, profitability and solvency. For example, the agricultural sector is characterized by low levels of profitability (Letyagina et al., 2020) [19]. At the same time, the subsidization of agricultural producers is reflected in the small number of firms that have declared insolvency.

The size of the enterprises whose data are analysed is also relevant for the results of the method applied. It turns out that, expressed in percentages, the predictive capabilities of insolvency risk assessment models are higher for enterprises that are classified as large or medium-sized, compared to small and micro-enterprises (Kanapickienė, R., 2023) [11]. One of the reasons is that in the case of micro-enterprises, for example, annual financial statements are simplified and the data contained in them is minimised - for example, they give information only on the sections, with none available for groups, items or analytical accounts. Therefore, for this group of companies it is difficult, and sometimes impossible, to apply any of the bankruptcy prediction models.

The use of financial ratios to determine the financial health of a company are a common tool in practice. Long-term solvency ratios involve equity, leverage, total capital, etc. Their purpose is to establish the participation of sources external to the firm to finance its activities. The ratio between equity capital and capital employed is relevant for the financial autonomy of the firm. According to Kasarova (Kasarova, 2010) [12] capital structure ratios, reveal the financial stability and independence of the company from its creditors. However, too high a proportion of equity may lead to a decrease in the profitability of equity.

The capital structure of a firm is also influenced by its size. It appears that smaller firms have more difficulty in accessing external financing than larger firms.

In this context, the purpose of the paper is to develop criteria for classifying the most commonly used financial diagnostic models based on the theoretical and methodological assumptions of financial insolvency offered by literature in the field. Also, we aim to assess the applicability of these models in the specific conditions of Bulgaria.

MATERIALS AND METHODS

The study includes anonymised micro data from sector "A" - Agriculture, Forestry and Fisheries from the Annual Enterprise Accounts for the period 2014-2023. They belong to the group of small and micro enterprises based on the attribute of number of employees. For the purpose of tracking over time, the enterprises included in the sample are coded for the whole period with the same identifier - from 1 to 14. By 2024, seven of them have been involved in insolvency proceedings and the remaining seven operate normally. According to the National Statistical Institute, there are no large or medium-sized enterprises in this sector that have declared insolvency as of this reporting period.

In order to investigate which models are applicable for establishing insolvency in agriculture, the authors focus on three models. The first of these is the Springate model, which they have already studied in previous publications and found that it predicts very high values of correctly classified enterprises in the group of "Financial Crisis and Bankruptcy" businesses (Stoyancheva and Angelova, 2024) [25]. It is also very sensitive to the deterioration of the financial health of firms in the agricultural sector and it will be appropriate to resort to some of the Eastern European models for greater certainty of the claim of bankruptcy (Angelova and Stoyancheva, 2023) [3]. This recommendation has been applied in this study by using two more models (both from Eastern European countries, Croatia and Bulgaria, respectively). The Croatian model is that of Kliestik, which is found in a publication by Valashkova (Valashkova, 2020) [27].

The above-mentioned model refers to a study on the risk of bankruptcy for enterprises in the agricultural sector classified as "small". The aim is to find as much consistency as possible in terms of national, sectoral and group affiliation within the analysed sample. Such is the motive for choosing the Kulchev model (Kulchev, 2023) [17],which was developed for Bulgarian conditions.

The financial ratios used and the corresponding bankruptcy risk estimates of the Springate,

Kliestik and Kulchev's models have been presented in Table 2.

Table 2. Insolvency risk forecasting models

X	Springate	Kliestik	Kulchev
X1	WK/TA	NI/E	TA/TL
X2	EBIT/TA	(NCL+CL)/TA	E/TL
X3	EBT/CL	WK/S	(NI+AM)/TL
X4	S/TA	EBT/E	EBIT/TA
X5	-	-	E/TA
X6	-	-	(CA-I)/CL
X7			CA/CL
	Z<0.862	Z>0	Z<12.546

Source: own contribution.

where:
WK - Working Capital;
TA - Total Assets;
EBIT - Earnings Before Interest and Taxes;
TL - Total Liabilities;
S - Sales;
EBT - Earnings Before Taxes
CL - Current Liabilities
NCL - Non-current Liabilities
CA - Current Assets
NI - Net Income
E - Equity
I - Inventories
DE - Depreciation Expenses

Springate's test model contains four variables (Todorov, 2014) [26]:

$$Z = 1.03 * X1 + 3.07 * X2 + 0.66 * X3 + 0.4 * X4$$

Kliestik's Model (Valashkova, 2020) [27] proposes four other financial ratios specifically aimed at the valuation of small businesses.

$$Z\ S\ NACE\ A = -1.412 - 1.512 * X1 + 2.504 * X2 - 0.06 * X3 + 1.256 * X4$$

Kulchev's Model (Kulchev, 2023) [17] uses seven financial ratios to identify the risk of insolvency.

$$Z = 9.3187 * X1 + 9.3021 * X2 + 9.1257 * X3 + 6.1674 * X4 + 2.6852 * X5 + 0.38308 * X6 + 0.32977 * X7$$

Data description

We used data from the financial statements of the companies which allows us to track and compare some indicators relevant to their financial health. All the enterprises insolvent in 2023 and 2024 had higher total assets for the period 2014-2020 (Table 3).

In the following years, the assets of the enterprises decreased sharply, coinciding with the insolvency of a large number among them. Financially healthy enterprises showed a smooth and steady increase in average assets.

Over the period under review, we observed a number of changes in financial data and ratios indicating unfavourable trends for enterprises with poor financial health (Table 3).

– The average total liabilities exceed more than twice the financially healthy companies. At the same time, we observe that their value has doubled - from BGN 1,076 thousand to BGN 2,230 thousand. The results are also applicable when distinguishing between long-term and short-term liabilities. Liabilities up to one year increased more gradually, but in the last 3 years they rose sharply in value. Bankrupt firms maintained a higher level of borrowed capital.

– Significant differences are observed when comparing working capital data. Its magnitude is more than three times the working capital of financially sound enterprises until 2019. This result corresponds to a sharp increase in short-term liabilities. By 2020, the insolvent 2023 enterprises can no longer pay their liabilities with current assets, and signs of deteriorating financial health and delayed payments emerge.

– The contraction in working capital is manifested in two directions - a reduction in inventories and receivables from suppliers and customers. By 2019, insolvent companies disclose a significant volume of inventories exceeding those of financially sound companies. The subsequent deterioration in financial health indicates that this volume exceeds a healthy level of inventories and maintaining it has adverse consequences.

– The comparison of the average size of claims highlights some differences. For both groups of enterprises, receivables are increasing in size, but for financially healthy enterprises, the increase is slower and somewhat uneven over the years. However, for insolvent firms, claims increase sharply until 2019, signaling a delay in payments and the

presence of inter-firm indebtedness.

Table 3. Selected indicators from the financial statements of enterprises

State	2014	2016	2018	2020	2022	2023
Total Assets						
1	4,105	4,043	4,325	2,300	1,221	1,056
2	1,646	2,282	2,561	2,990	4,110	4,639
Total liabilities						
1	1,076	1,002	1,919	2,134	1,935	2,230
2	527	639	712	620	523	680
Working capital						
1	1,608	1,739	2,102	-389	-745	-758
2	551	510	498	711	2,030	1,216
Inventory						
1	982	850	1,019	222	229	216
2	538	452	492	732	901	1,271
Receivables						
1	41	79	243	82	26	23
2	21	16	83	78	187	95

Source: own calculations.
where: 1 - bankrupt companies; 2 - financially sound enterprises

Table 4 presents financial leverage ratios commonly used in practice and theory (Kulchev, 2023a) [18], Valaskova and Gajdosikova, 2021) [28] Gajdosikova, D. et al, 2023 [8]).

Table 4. Debt ratios of insolvent firms

2014	2016	2018	2020	2022	2023
Current assets/Short-term Liabilities					
6.57	4.68	4.64	5.78	1.01	42.28
(Current assets-Inventory)/Short-term Liabilities					
3.60	3.13	3.02	1.15	.64	1.59
Equity/Total liabilities					
1.12	2.17	1.88	.25	-.25	-.60
Equity/Total assets					
.35	.42	.35	.08	-2.09	-3.28
Gross profit/Short term liabilities					
2.70	.46	.20	.19	.07	0
Total liabilities/Equity					
2.97	2.54	7.27	4.62	14.93	-7.10
Total liabilities/Assets					
.61	.50	.63	.93	3.11	4.18

Source: own calculations.

The liquidity indicators attest to elevated values above the recommended ones throughout the period.
The results show that the enterprises have frozen funds in the form of a significant amount of inventories.
The corresponding values of the ratios are - quick ratio above 1, and current ratio - above 2.
The financial leverage ratios signal that insolvent firms finance their activities mainly with borrowed capital. The total liabilities to equity ratio remained above 2 in all years, reaching extreme values of 9 and 14.
The total liabilities to assets ratio shows that the share of liabilities exceeds the recommended 30-60% of total assets, except for the years 2015-2017.

RESULTS AND DISCUSSIONS

The results of the analysis using the Springate model are shown in Table 5.
The data in Table 5 are arranged horizontally by years from 2014 to 2023 and vertically by the coded name of the enterprise from 1 to 14.
After the calculations, the results are sorted against the year 2024, for which there is information that the indicated enterprises are undergoing insolvency proceedings.
For the period 2014-2023, for all the analysed enterprises, the risk of insolvency is reported as "F", and the risk of insolvency as "No". The Springate model succeeds in capturing the bankruptcy risk in the longer term for all enterprises that are in insolvency proceedings. Since it is very sensitive to the financial health of firms, it gives indications even for firms that are not in such a procedure and are developing normally.
As mentioned above, the data refer to micro and small enterprises in the agricultural sector. The provision of subsidies in this sector manages to blur the picture of the analysis, especially for micro-enterprises, which have already been mentioned as using simplified financial statements. In the short term, for the last two years, the forecast of insolvency coincides 100% with the actual *status quo* for enterprises that have declared bankruptcy.
The results of the analysis using the Kliestik model are shown in Table 6.

Table 5. Results - Bankruptcy risk determined by the Springate's model

AE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
2	F	F	F	F	F	F	F	F	F	F	Ins
3	H	H	H	H	H	F	F	F	F	F	Ins
5	F	F	F	F	F	F	F	F	F	F	Ins
6	F	F	F	F	F	F	F	F	F	F	Ins
7	H	H	F	F	H	H	F	F	F	F	Ins
10	H	F	H	F	F	F	H	H	F	F	Ins
11	H	F	F	F	F	F	F	F	F	F	Ins
1	H	H	H	H	H	H	H	H	H	H	
4	H	H	F	H	F	F	F	F	H	H	
8	F	F	F	F	F	F	F	F	F	F	
9	F	F	F	F	F	H	H	H	H	H	
12	H	H	H	F	H	H	H	F	H	H	
13	F	F	H	F	F	F	F	F	H	H	
14	F	F	F	F	F	F	F	H	H	F	

Source: own contribution
where: F – failed; H – Healthy; AE - Agricultural Enterprises; Ins - Insolvency

Table 6. Results - Bankruptcy risk determined by the Kliestik's model

AE	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
2	H	F	F	F	F	F	F	F	F	F	Ins
3	H	H	H	H	H	H	F	F	F	F	Ins
5	F	F	F	F	F	F	F	F	F	F	Ins
6	F	F	F	F	F	F	F	F	F	F	Ins
7	H	H	H	H	H	H	H	H	F	F	Ins
10	H	F	H	F	F	H	F	F	F	F	Ins
11	F	F	H	H	F	F	F	F	F	F	Ins
1	H	H	H	H	H	H	H	H	H	H	
4	H	H	H	H	H	H	H	H	H	H	
8	F	F	F	F	F	F	F	F	H	F	
9	F	F	F	F	F	F	H	H	H	H	
12	F	H	H	H	H	H	H	H	H	H	
13	F	F	F	F	F	F	F	H	H	H	
14	H	H	H	H	H	H	H	H	H	H	

Source: own contribution
where: F – failed; H – Healthy; AE - Agricultural Enterprises; Ins - Insolvency

Table 7. Results - Bankruptcy risk determined by the Kulchev's model

AE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
2	H	H	H	H	H	H	F	H	F	H	Ins
3	H	H	H	H	H	H	H	F	F	F	Ins
5	H	H	H	F	F	H	F	H	F	F	Ins
6	H	H	H	H	H	H	H	F	F	F	Ins
7	F	H	H	H	H	H	H	H	F	F	Ins
10	H	H	H	H	H	H	H	H	H	F	Ins
11	H	H	H	H	H	H	H	H	H	F	Ins
1	H	H	H	H	H	H	H	H	H	H	
4	H	H	H	H	H	H	H	H	H	H	
8	H	H	H	H	H	H	H	H	H	H	
9	H	H	H	H	H	H	H	H	H	H	
12	H	H	H	H	H	H	H	H	H	H	
13	H	F	H	H	H	H	H	H	H	H	
14	H	H	H	H	H	H	H	H	H	H	

Source: own contribution
where: F – failed; H – Healthy; AE - Agricultural Enterprises; Ins - Insolvency

The results on the Kliestik model are also identical to the Springate model.
Again, we see a 100% match of the short-run forecast with the actual picture in terms of firms in bankruptcy. Again, this model is responsive to some of the fluctuations in financially sound firms, although in the short run they show a higher degree of predictability.
The results of the analysis using the Kulchev model are given in Table 7.
Kulchev's model offers a 100% accurate forecast for financially sound companies, and about 85.7% for those in bankruptcy.
The forecast is fully consistent with the summary recapitulation of the predictive capabilities of the analytical models with information for the last year of the analysis period (Kulchev, 2023 [17]).
This allows us to recommend combining this model, which was developed for Bulgarian conditions, with some of the other two models.

CONCLUSIONS

This study compares the accuracy of default risk estimates of the Springate, Kliestik and Kulchev models for their application in the agricultural sector.
A number of available models produce inconsistent results when tested for the insolvency risk of agricultural enterprises. Our results show that these three models provide correct predictions, exhibiting different estimation sensitivities and allowing for a deeper financial analysis.
Springate's model exhibits the greatest valuation sensitivity and classifies firms as potentially risky several years before actual insolvency occurs.
Very close to these forecasts are the Kliestik model estimates. Both models manage to predict 100% of the insolvent firms in the last two years - 2022-2023.
Kulchev's model also shows very high forecast accuracy for both years, failing to forecast insolvency for only one firm.
Overall, Kulchev's model is less sensitive to the temporal variation of financial ratios across years, but with high forecast accuracy.
In conclusion, the obtained results prove with sufficient confidence that the proposed three models correctly classify agrarian businesses in bankruptcy and it is appropriate to use them simultaneously for higher forecast certainty.

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REFERENCES

[1]Altman, E.I., 1968, Financial Ratios, Discriminant Analysis and the Prediction of Corporate Bancruptcy. The Journal of Finance, 23(4). 589-609.
[2]Altman, E.I., 2000, Predicting financial distress of companies: revisiting the Z-score and ZETA models. - Stern School of Business, New York University Working paper, p.1-54. http://pages.stern.nyu.edu/~ealtman/zscores.pdf. Accessed on 17.01.2025.
[3]Angelova, R., Stoyancheva, D., 2020, Digitalization, Financial Insolvency and Bankruptcy Risk Forecasting of Bulgarian Agricultural Enterprises. Scientific Papers-Series Management Economic Engeneering in Agriculture and Rural Development. 23(2), 29-35.
[4]Balina, R., Idasz-Balina, M., Achsani, N.A., 2021, Predicting Insolvency of the Construction Companies in the Credit worthiness Assessment Process-Empirical Evidence from Poland. Journal of Risk and Financial Management 14: 453. https://doi.org/10.3390/jrfm14100453
[5]Commercial Law Act, https://lex.bg/laws/ldoc/-14917630, Accessed on 10.01.2025.
[6]Dorohan-Pysarenko, L., Rębilas, R., Yehorova, O., Yasnolob, I., Kononenko, Z., 2021, Methodological Peculiarities of Probability Estimation of Bankruptcy of Agrarian Enterprises in Ukraine. Agricultural and Resource Economics: International Scientific E-Journal 7(2)
[7]European commission, 2020, Financial needs in the agriculture and agri-food sectors in Sweden. PDF www.fi-compass.eu. Accessed on 17.02.2025.
[8]Gajdosikova, D., Valaskova, K., Kliestik, T., Kovacova, M., 2023, Research on Corporate Indebtedness Determinants: A Case Study of Visegrad Group Countries. Mathematics 2023, 11, 299. https://doi.org/10.3390/math11020299;
[9]Haas, C., Radovanovich, J., 2023, The evaluation of bankruptcy prediction models based on socio-economic costs. Expert Systems with Application. 227, https://doi.org/10.1016/j.eswa.2023.120275
[10]Huo, H.Y., 2006, Bankruptcy Situation Model in Small Business: The Case of Restaurant Firms. Hospitality Review 24(2), Article 5.

[11]Kanapickienė, R., Kanapickas, T., Nečiūnas, A., 2023, Bankruptcy Prediction for Micro and Small Enterprises Using Financial, Non-Financial, Business Sector and Macroeconomic Variables: The Case of the Lithuanian Construction Sector. Risks 11, 97. https://doi.org/10.3390/ ;
[12]Kasarova, V., 2010, Models and indicators of analysis of the company's financial stability. NBU. https://eprints.nbu.bg/id/eprint/637/1/FU_1_FINAL.pdf Accessed on 3 February 2023.
[13]Kiyak, D., Labanauskaitė, D., 2012, Assessment of the Practical Application of Corporate Bankruptcy Prediction Models. Economics and Management: 2012. 17 (3)
[14]Korol, T., 2019, Dynamic bankruptcy prediction models for European enterprises. Journal of Risk and Financial Management 12: 185;
[15]Kovacova, M., Kliestik, T., 2017, Logit and Probit application for the prediction of bankruptcy in Slovak companies. Equilibrium. Quarterly Journal of Economics and Economic Policy, 12(4). 775–791. https://doi.org/10.24136/eq.v12i4.40
[16]Kuhmonen, I., Siltaoja, M., 2022, Farming on the margins: Just transition and the resilience of peripheral farms. Environmental Innovation and Societal Transitions, 43. 43-357
[17]Kulchev, K., 2023, Assessment of the Insolvency Risk of Enterprises. Economic World Collection "Tsenov "Academic Publishing House, "D.A.Tsenov" Academy of Economics - Svishtov, Bulgaria;
[18]Kulchev, K., 2023a, Key Elements of Models for Analysis of The Financial Sustainability of Enterprises. e-Journal VFU; 20; 445-452.
[19]Letyagina, E., Dadayan, E., Storozheva, A., 2020, Features and modern approaches to the analysis of the financial condition of the debtor as a necessary element of the bankruptcy procedure of agricultural enterprises. IOP Conf. Series: Earth and Environmental Science 548 (2020) 022002 IOP Publishing doi:10.1088/1755-1315/548/2/022002;
[20]Lubenova, A., 2012, Analysis of the financial condition of agricultural enterprises in Bulgaria. Nauchnitrudovena Rusenski Univwrsitet-2012, 51, 5.1.
[21]Milić, D., Tekić, D., Zekić, V., Novaković., T., Popov, M. Mihajlov, Z., 2021, Bankruptcy prediction models for large agribusiness companies in AP Vojvodina. Ekonomika poljoprivrede 68(3). 805-822.
[22]Mohammadi, S., 2016, Studying the Efficiency and the Power of Predicting Bankruptcy of Firms Listed on the Stock Exchange using Springate, Fulmer, and Zavgren Models. Mediterranean Journal of Social Sciences 7(4)4 S2.
[23]Popescu, A., 2014, Research regarding the use of discriminant analysis for assessing the bankruptcy risk of agricultural companies. Scientific Papers Series "Management, Economic Engineering in Agriculture and Rural Development". 14(4), 193-200.
[24]Prisacaru, V., Strainu, O., 2023, Implementation of the Innovative Management in the Food Industry Enterprises in the Republic Of Moldova - Current State, Barriers, Possible Solutions. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Vol. 23(1), 659-668.
[25]Stoyancheva, D., Angelova, R., 2024, Financial Diagnostics of Bancruptcy Risk in Agriculture. Scientific Papers Series Management, Economic Engeneering in Agriculture and Rural Development 24(2), 893 - 900.
[26]Todorov, L., 2014, Modern Business Evaluation Models. Nova Zvezda. Sofia.
[27]Valashkova, K., Durana, P., Adamko, P., Jaros, J., 2020, Financial Compass for Slovak Enterprises: Modeling Economic Stability of Agricultural Entities. MDPI Journal of Risk and Financial Management 13(5), 1-16.
[28]Valaskova, K., Gajdosikova, D., 2021, The impact of debt management on corporate earnings: Indebtedness and its effects on the financial performance of selected Visegrad group enterprises.SHS Web of Conferences 129.
[29]Yang, Z., Platt, M.H., 1999, Probabilistic Neural Networks in Bankruptcy Prediction. Journal of Business Research 44. 67-74.
[30]Zhang, F., Tadikamalla, P., Shang, J., 2016, corporate credit-risk evaluation system: integrating explicit and implicit financial performances. International Journal of Production Economics 177: 77-100.

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THE ROLE OF ECOTOURISM START-UPS IN DEVELOPING A SUSTAINABLE ECONOMY. CASE STUDY THE DANUBE DELTA

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Abstract

The purpose of this article is to examine ecotourism's potential as a sustainable model of economic growth in the Danube Delta, beginning with consumer attitudes and comparing them to real-world examples of best practices. The research aims were to identify tourist values and preferences connected to ecotourism, determine the degree of availability for the consumption of sustainable services, and assess the Danube Delta's viability as an ecotourism destination. Methodologically, the study was based on the use of a structured questionnaire, given to a sample of respondents interested in sustainable tourism. The instrument included questions regarding ecotourism values (environmental protection, community involvement, ecological education), travel behaviors, preferences for types of activities and willingness to pay for eco-certified services. The results were statistically analyzed and correlated with concrete examples of ecotourism in the Danube Delta. The results obtained highlight a clear consumer orientation towards responsible tourism: 92% of respondents support environmental protection as a fundamental value, 76% would pay more for ecological services, and 73% are interested in visiting the Delta. Activities such as bird watching, eco-lodging or kayaking were strongly preferred, confirming the relevance of the existing offer in the region. The examples analyzed, sustainable guesthouses, guided tours, community projects, demonstrate the applicability of these preferences in the field. The research conclusions support the idea that ecotourism in the Danube Delta has real potential for scaling and can simultaneously contribute to the conservation of ecosystems and the economic development of local communities. The recommendations aim to strengthen this model through institutional support, digitalization, transparent ecological certification and the promotion of green entrepreneurship as a viable strategy for natural areas with high ecological value.

Key words**:** *ecotourism, environmental, social and economic sustainability, ecotourism market, the Danube Delta*

INTRODUCTION

Ecotourism is a rapidly expanding segment of the global tourism business that is distinguished by a dedication to environmental protection, community engagement, and education [11]. As demand for sustainable travel grows, entrepreneurs are looking for new ways to develop lucrative and ethical tourism enterprises [6].
Ecotourism is a type of sustainable tourism that emphasizes responsible travel to natural areas, environmental protection, and increasing communities' well-being [6]. Effective governance is a key requirement for an effective sustainable tourism [2, 16]. Unlike mass tourism, ecotourism promotes low-impact experiences, environmental education, and active engagement in conservation initiatives [14, 17]. It operates under the basic principles of minimizing negative impacts on the environment and local culture, generating financial benefits for local community conservation, and promoting ecological awareness [4, 9].
In this perspective, ecotourism business is more than just exploiting a niche market; it embodies a comprehensive vision of social, economic, and environmental responsibility [1]. An ecotourism company is founded not only on the appeal of a natural area, but also on the following values: transparency, community participation, carbon footprint reduction, and educating tourists about local ecosystems [13, 23]. Thus, the goal and vision of an ecotourism firm are essential aspects in engaging a target audience concerned about sustainability.
Several elements combine to provide market prospects for ecotourism entrepreneurs. First,

worldwide trends indicate a growing demand in genuine and sustainable experiences, particularly among Generation Y and Z travellers [3, 8]. Second, European and worldwide policies that promote sustainable development enable access to funds, collaborations, and mentorship for green ventures [15, 18, 22]. Important investigations and researches on the remarkable ecotourism potential of the Danube Delta were made by [11, 25].

Strategically, developing an ecotourism startup requires a careful analysis of local resources, establishing partnerships with environmental authorities and NGOs, as well as a business model that combines profitability with social and ecological impact [12]. Planning activities must include a clear identification of the target audience (international tourists with ecological values, families, schools, etc.), the development of integrated tourism packages (accommodation, guiding, educational experiences), as well as adapting to seasonal demand.

Another essential aspect is the integration of digitalization in the promotion of the startup. Online presence through an interactive website, reviews on responsible tourism platforms and storytelling on social networks can ensure not only visibility but also credibility in front of a demanding audience [24]. Also, the integration of eco-friendly reservation systems, transparent communication of the impact on the local community and the periodic publication of sustainability reports can differentiate the startup in the market [5, 20].

Financially, launching an ecotourism startup involves moderate initial investments, with the possibility of progressive scaling. Sources of financing can include European funds, green tourism grants, partnerships with conservation foundations or crowdfunding campaigns [19].

The impact of ecotourism startups is reflected not only in economic terms, but also in social and environmental dimensions, as they can contribute to the conservation of natural landscapes, the revitalization of local traditions and the education of tourists about the fragile balance of ecosystems. In addition, the involvement of the local community in tourism activities (guides, traditional gastronomy, artisan workshops) can create sustainable jobs and reduce the phenomenon of migration [10, 21, 23].

Therefore, considering all these aspects, this paper aims to investigate the development of an ecotourism startup, exploring the values, market opportunities, strategic actions and financial requirements necessary for success.

MATERIALS AND METHODS

A quantitative, descriptive approach was used to conduct the research, based on the application of a structured questionnaire. The main objective of the chosen method was to collect relevant data from the perspective of consumers interested in ecotourism, in order to identify strategic directions, fundamental values and necessary conditions for the development of an ecotourism startup.

The central research instrument was the questionnaire, which included both closed and open questions, in order to capture the attitudinal and motivational nuances of the respondents. The questionnaire was structured into several thematic sections, including:

- values and principles perceived as essential in ecotourism;
- preferred ecotourism activities and services;
- level of awareness and education regarding sustainability;
- willingness to pay for environmentally friendly services;
- perceptions regarding the impact of ecotourism on local communities;
- importance of ecological certification and local partnerships.

The sample consisted of respondents, recruited through online distribution of the questionnaire on social networks, thematic groups and forums focused on tourism, nature and sustainability.

The selection was non-probabilistic, snowball type, but the diversity of responses was sought according to age, gender, educational level and previous experience in ecotourism. A significant percentage of participants (over 65%) was represented by people aged between 20 and 35, a demographic segment recognized

for its increased interest in responsible tourism and the digitalization of the tourist experience. The collected data were centralized and statistically processed. The answers to the open questions were analyzed through thematic coding, in order to identify recurring ideas and emerging strategic perspectives. Thus, the methodology combines a quantitative vision with elements of interpretative qualitative analysis, for a more complete understanding of the phenomenon studied.

In parallel, relevant secondary sources were analyzed, in order to consolidate the analysis framework and compare the results obtained with existing global trends.

At the same time, exploratory interviews were conducted with experts in the field of ecotourism and green entrepreneurship, in order to validate the interpretations and obtain more realistic estimates regarding the budgets necessary to launch an ecotourism business, the cost structure and sustainable financing sources. These qualitative data were integrated into the analysis to provide depth to the economic dimension of the research.

By choosing this mixed methodology, quantitative supported by qualitative components, the aim was to obtain the most detailed and applicable picture possible of the real potential of the development of ecotourism startups, in accordance with market requirements, consumer values and sustainability objectives.

RESULTS AND DISCUSSIONS

The Danube Delta not only provides a spectacular natural backdrop, but it also fully meets the criteria for sustainable tourism: minimal impact, ecological education, local engagement, and biodiversity preservation. Simultaneously, the region plays an important role in the macro-regional development of ecotourism as part of the Black Sea riparian states' cooperation. Romania receives European funding for the development of tourism infrastructure and initiatives that promote sustainable attractions, such as the Danube Delta., creating an institutional and financial environment suitable to entrepreneurial enterprises.

Furthermore, shared regional development strategies encourage integrated tourist packages (beach tourism, ecotourism, cultural and adventure tourism), and the Delta plays an important part in these initiatives due to its distinctive characteristics and worldwide appeal.

Given the Danube Delta's outstanding ecological and economic potential, the current study sought to assess consumer attitudes and expectations of ecotourism practices in this area. The goal was to better understand the sustainable consumer's behavior, degree of information, and readiness to support existing ecotourism businesses through purchasing decisions.

The research was guided by the desire to answer questions like as: *How popular is the Danube Delta as an ecotourism destination? What kind of ecological experiences do tourists want while picking this region? What is the willingness to pay for eco-certified services?* In this sense, the questionnaire was created in such a manner that it captures both the ecotourism values of consumers and their choices for activities, accommodation, cultural experiences, and modes of transportation.

The research results highlight a high level of ecological awareness among respondents, along with a favorable attitude towards the principles of ecotourism. Thus, 92% of participants believe that environmental protection should be a fundamental value in any ecotourism business, while 88% support the importance of minimizing the ecological footprint in carrying out tourism activities. Other strongly supported values include respect for local culture (79%) and the involvement of communities in the management and sharing of economic benefits (85%). Also, 64% of respondents believe that ecological education should be integrated into the experiences offered to tourists.

The data is equally relevant to consumption intentions and tourism habits. 73% of respondents were interested in visiting natural reserves in Romania, such as the Danube Delta, and 41% had previously participated in ecotourism activities in the previous two years. This indicates the existence of an active and receptive market, which not only aspires to a

sustainable tourism model, but also practices it in practice.

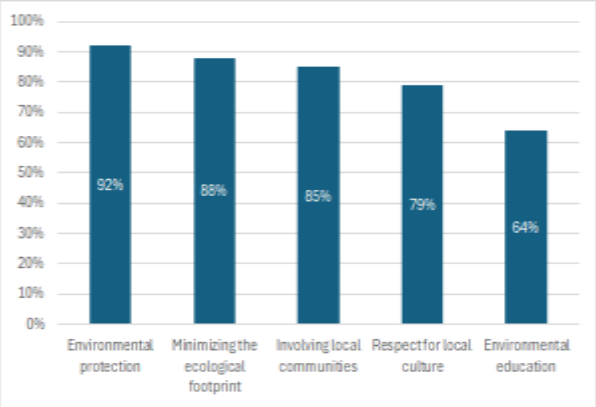

Fig. 1. Ecotourism values and principles
Source: own processing.

Regarding willingness to pay, 76% of respondents said they were willing to pay 10–20% more for certified ecotourism services, which highlights a positive elasticity of demand in relation to sustainability. At the same time, 61% say that sustainability influences the decision to choose a destination, and 83% prefer accommodation units that use renewable energy or serve local, organic food.

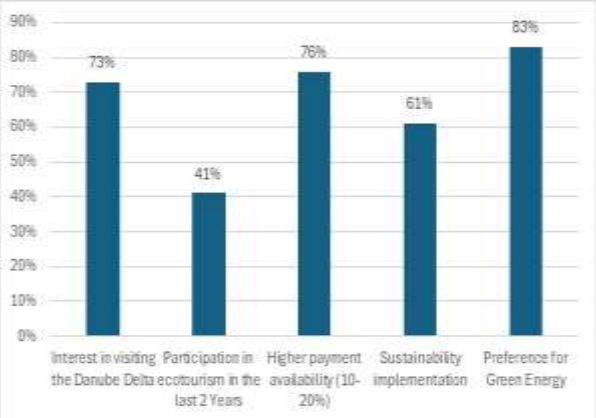

Fig. 2. Ecotourism behaviors and intentions
Source: own processing.

Regarding tourist preferences related to specific activities, respondents indicated increased interest in: wildlife and bird watching (67%) – a representative activity for the Danube Delta; authentic cultural experiences (58%) – such as craft workshops or traditional gastronomy; eco and sustainable accommodation (53%); nature and adventure-based activities, such as kayaking, hiking or guided tours (49%).

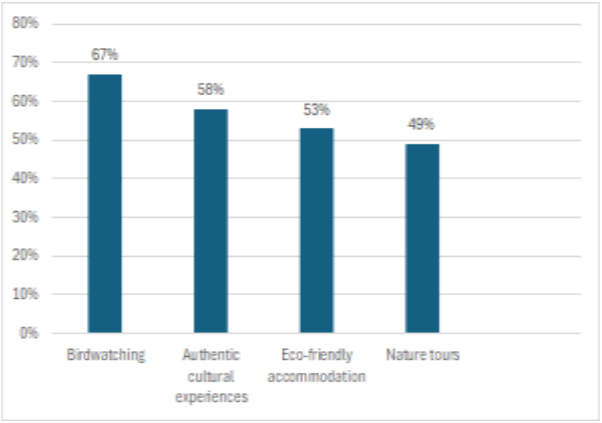

Fig. 3. Ecotourism values and principles
Source: own processing.

All these options coincide with the real offer in the Danube Delta, which validates both the feasibility and practical attractiveness of ecotourism in this area.

The integrated interpretation of these data demonstrates that the target audience is already aware of environmental issues and receptive to sustainable tourism models.

Furthermore, the Danube Delta offers an ideal setting for the concrete application of ecotourism principles, being an example of a balance between biodiversity conservation, local community involvement and sustainable economic development. In localities such as Sfântu Gheorghe, Mila 23 and Crișan, there are eco-friendly guesthouses built with traditional materials, using solar panels, rainwater harvesting and local food ingredients. These enterprises provide travellers with real experiences, such as fishing workshops and deltaic gastronomy, which directly benefits the local economy.

At the same time, guided bird watching trips that focus on protected species like the Dalmatian or the White-tailed Seabird adhere to stringent wildlife protection requirements and contain educational components, meeting the expectations of conservation-minded travellers. Kayaking or canoeing excursions provide a sustainable alternative to motorized transport, safeguarding vulnerable habitats and providing a deep connection to nature. Furthermore, local non-governmental organizations (NGOs) and ecotourism operators work together on ecological restoration and environmental education programs that are funded by visitor donations.

These examples closely corroborate the choices revealed by survey respondents, who highly supported environmental conservation, community participation, ecological education, and low-impact tourism. Thus, the Danube Delta not only demonstrates the genuine implementation of the ecotourism idea, but also provides a repeatable example for other locations with significant natural potential.

Fig. 4. Ecotourism map of the Danube Delta
Source: taken from [7].

The ecotourism map of Deltei Dunării (Figure 1) includes 15 approved water routes for canal and lake tourism, including Tulcea - Gârla Şontea - Mila 23 - Crişan - Tulcea, Murighiol - Dranov Canal - Gura Portiţei - Dunavăţ Canal - Murighiol, Sulina - Cardon Canal - Periprava - Musura Bay - Sulina, and 9 land hiking routes, including ecologically protected Letea and Caraorman forests.
The questionnaire responses, together with examples of successful Danube Delta practices, form a solid foundation for the expansion of Romania's ecotourism industry. On the one hand, customers are becoming more aware and interested in the environmental impact of their journeys. On the other hand, the Danube Delta demonstrates that it is feasible to construct a sustainable tourist strategy, combining economic growth with natural resource protection and the valorisation of local heritage. For entrepreneurs, this convergence between sustainable demand and viable local offers translates into a clear business opportunity. An ecotourism startup in the Danube Delta can directly respond to the preferences expressed in the research – authentic experiences, low-impact activities, eco-accommodation, ecological education – while benefiting from the advantage of a unique natural setting, European financial support and international visibility. In addition, consumers' willingness to pay more for eco-certified services (76%) and their preference for establishments that use renewable resources (83%) indicate a potential for sustainable monetization of these values.
For these initiatives to become scalable and sustainable, an integrated entrepreneurial vision is needed, combining innovation (green technologies, digital marketing), ethics (transparency, respect for the community) and adaptation to local specificities. Initial investments, although moderate (50,000–120,000 euros), can be supported by European funds, partnerships with NGOs or green investors, thus reducing financial risks.
Therefore, the Danube Delta is not only an exceptional ecotourism destination, but also a real platform for testing and implementing sustainable entrepreneurship. The present study demonstrates that the values promoted by ecotourism are shared by consumers, already present in the field and scalable in the future. Strengthening this type of entrepreneurship can contribute not only to protecting natural heritage, but also to the economic revitalization of rural regions and to positioning Romania as a regional leader in sustainable tourism.

CONCLUSIONS

The growing public interest in sustainability, coupled with the accelerated degradation of natural ecosystems, has led to a profound change in consumer preferences in tourism. This transformation has created the necessary

premises for the development of ecotourism as the dominant form of conscious and responsible travel. Thus, against the backdrop of a growing demand for authentic, educational and environmentally friendly experiences, ecotourism entrepreneurship is becoming not only possible, but necessary.

The survey data showed that respondents consistently value environmental protection, local community involvement and minimizing the ecological footprint. As a result, startups that align with these principles are more likely to be accepted and supported by the target audience. Furthermore, the indicated readiness to pay extra for eco-certified services is a direct result of increased awareness of the harmful effects of mass tourism, which has transformed sustainability into a clear competitive advantage.

Applying these ideals in the context of the Danube Delta, one of the most significant wetlands in Europe, reveals that ecotourism is not a theoretical concept, but a realistic model with tangible impacts. Investments in eco-lodges, guided wildlife tours, low-footprint activities and community-based conservation initiatives have demonstrated that, when there is harmony between the natural resource, local actors and market demand, ecotourism can function as a mechanism for sustainable rural development. In conclusion, when public policies, consumer behaviour and entrepreneurial initiatives align around sustainability values, the conditions for a structural transformation of tourism are created. The Danube Delta provides a clear example of applied ecotourism, and the results of this research support the idea that expanding this model can produce positive effects on both biodiversity conservation and the economic revitalisation of local communities. Therefore, ecotourism should no longer be seen as a niche alternative, but as a sustainable development strategy with broad applicability.

REFERENCES

[1]Asadi, A., Kohan, M. F. Z., 2011, The role of Entrepreneurship on Ecotourism development, 2011 International Conference on Sociality and Economics Development, Singapore, pp. 38-39.

[2]Bramwell, B., Lane, B., 2011, Critical research on the transition to sustainability in tourism systems. Journal of Sustainable Tourism, 19(4-5), 491-502. https://doi.org/10.1080/09669582.2011.561097, Accessed on 11.03.2025.

[3]Butnaru, G. I., Niță, V., Melinte, C., Anichiti, A., Brînză, G., 2022, The nexus between sustainable behaviour of tourists from generation z and the factors that influence the protection of environmental quality, Sustainability, 14(19), 12103.

[4]El Moslem Badr, D. M., 2022, Challenges and Future of the development of sustainable ecotourism, International Journal of Modern Agriculture and Environment, *2*(2), 54-72.

[5]Gössling, S., Scott, D., Hall, C. M., 2021, Pandemics, tourism, and global change: A rapid assessment of COVID-19, Journal of Sustainable Tourism, 29(1), 1–20.

[6]Honey, M., 2008, Ecotourism and sustainable development: Who owns paradise? Island Press.

[7]Gastecu P., 2025, Tourist routes within the Danube Delta Biosphere, https://www.researchgate.net/figure/Tourist-routes-within-the-Danube-Delta-Biosphere-Reserve_fig14_337894657, Accessed on 11.04.2025

[8]Kędziora, M., 2024, Customer perspective from Generation Z on Sustainable Tourism Initiatives, https://www.proquest.com/openview/dc12f7a2bdf08916b1c1c951827bb4a4/1?cbl=2026366&diss=y&pq-origsite=gscholar, Accessed on 11.03.2025.

[9]Marcuta, A., Marcuta, L., Popescu, A., Tindeche, C., Tudor, V., Smedescu, D., 2020, Possibilities of development of the slow tourism concept in Romania, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol. 20(4), 331-338.

[10]Marcuta, L., Onea, M. G., Marcuta, A., 2022, Study on the impact of COVID-19 on experiential tourism and transformative tourism, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol. 22(3), 403-410.

[11]Popescu, A., Stanciu, M., Tindeche, C., Marcuta, A., Marcuta, L., Hontus, A., 2024, Ecotourism in the Danube Delta. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 24(4), 645-660.

[12]Rigatti, V., 2016, How can an ecolodge become a sustainable and successful business model: Environmental, social, and economic perspectives, Unpublished Thesis, Modul University, Austria, https://gileboom.info/wp-content/uploads/2018/02/Become-ecolodge.pdf, Accessed on 11.03.2025

[13]Spenceley, A., Rylance, A., 2021, Ecotourism and the sustainable development goals, Routledge handbook of ecotourism, pp. 9-22.

[14]Stem, C. J., Lassoie, J. P., Lee, D. R., Deshler, D. D., Schelhas, J. W., 2003, Community participation in ecotourism benefits: The link to conservation practices and perspectives, Society &Natural Resources, 16(5), 387-413.

[15]Stefan, P, Cretu, R.C., Micu, M.M., 2012, Economic crisis and the implications on rural tourism and sustainable development in Calarasi County, Revista Economică, 799

[16]The International Ecotourism Society, 2015, The International Ecotourism Society (TIES). What is ecotourism?

[17]Ting, D. H., Cheng, C. F. C., 2017, Developing pro-environmental behaviour: Ecotourism fieldtrip and experiences, International Journal of Sustainability in Higher Education, 18(7), 1212-1229.

[18]Tonea, E., Butnariu, M., 2009, European rural development policy-implications on Romania, Proceedings of the 37th International Symposium "Actual Tasks on Agricultural Engineering", Opatia, Croatia, 10-13 February 2009, Vol. 37, pp. 319-323.

[19]Tonea, E., 2009, How can be sustainable investments efficient from economical point of view, Proceedings of the 37th International Symposium "Actual Tasks on Agricultural Engineering", Opatia, Croatia, 10-13 February 2009, Vol. 37, pp. 325-328.

[20]Uyar, A., Koseoglu, M. A., Kılıç, M., Mehraliyev, F., 2021, Thematic structure of sustainability reports of the hospitality and tourism sector: A periodical, regional, and format-based analysis, Current Issues in Tourism, 24(18), 2602-2627.

[21]United Nations World Tourism Organization, 2021, International tourism and climate action.

[22]UNWTO, 2023, United Nations World Tourism Organization (UNWTO), Financing sustainable tourism projects.

[23]Utama, I. G. B. R., Laba, I. N., Junaedi, I., Krismawintari, N. P. D., Turker, S. B., 2021, Exploring key indicators of community involvement in ecotourism management, Journal of Environmental Management and Tourism, 12, 808-817.

[24]Zainol, N. R., Abdullah, F. A., Rahman, M. K., 2023, Exploring digitalization-driven in innovative eco-tourism sector, Social Entrepreneurship and Social Innovation in Eco-Tourism (pp. 61-84), Singapore: Springer Nature Singapore.

[25]WWF Romania, 2022, WWF Romania. Ecotourism development in the Danube Delta, wwf.ro, https://rewildingeurope.com/news/rewilding-europe-and-wwf-romania-join-forces-in-danube-delta/, Accessed on 11.03.2025.

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FAMILY LIVESTOCK FARMS IN BULGARIA: THEIR COOPERATION – A NEW DEVELOPMENT HORIZON

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Abstract

The family farm is one of the leading organizational forms of agricultural production in the economies of many countries. It plays a crucial role in the production and satisfaction of market needs with agricultural products. Family business in the livestock sector of Bulgaria is represented by market-oriented farms (open systems), which through the production of animal products satisfy not only the needs of the owner and his family, but are mainly intended for market implementation. The purpose of the study is to analyze the features of the family livestock farm with a market orientation, specializing in the production of sheep products based on its own empirical study of typical Bulgarian family farms. Our own empirical research of 9 typical for Bulgaria sheep family farms is conducted through a survey method in the period 2021-2023. Their main problems and difficulties in development are identified. The possibilities of cooperation in solving the problems and overcoming the difficulties of family livestock farms are revealed. The benefits of cooperation of family farms are presented, which offer a new horizon for their development.

Key words**:** *family farm, family economy, livestock farming, open system, cooperation, benefits*

INTRODUCTION

The family farm is one of the leading organizational forms for implementing agricultural production in the economies of developed countries.
This makes it the main structural unit for the production of agricultural products. It is where part of the working population finds professional fulfilment.
This form of agrarian business provides opportunities for personal expression and freedom in making management decisions.
The total number of functioning agricultural farms in Bulgaria, established during the 2020 census, is 132,742. Of these, 47.8% raise productive animals.
Their relative share is highest in the South Central region – 33.6%, followed by the South Western – 19.8% and the North Western - 13.8%. In the other three regions – the South Eastern and North Eastern – it is smaller – 11.3% each and the smallest - 10.2% is in the North Central region.
The census found that nearly 31 thousand family livestock farms raise an average of 20 cattle, 2 thousand - 58 sheep, and 12 thousand - 21 goats.
In Bulgaria, family farms of market type have an average size of usable land of 6,3 ha with a tendency to slowly increase, of which 2/3 is leased. Their main economic activity is the production of plant and animal products intended for market sale. The head of the family, with the help of the other family members, carries out the activity. The annual employment in the family farm is about 1.4 work units. The age of the person managing the family business is over 50, in rare cases under it. The durable material assets on average of a family farm are around 27,333 €, and the short-lived ones around 10,620 € [9, 10].
The aim of the study is to analyse the characteristics of family livestock farming with a market orientation, based on our own empirical research of family farms in Bulgaria specializing in the production of sheep products; to identify their main difficulties and reveal the possibilities of cooperation to solve their problems.
Due to the broad scope of the researched issues in this paper, the analysis is limited to market-

oriented family farms with sheep breeding specialization.

To achieve the goal of this study, we assume that the family business in the livestock sector in Bulgaria is mainly represented by a market-oriented, family farm, which we consider to be an open, market-oriented system. In it, through the production of animal products, not only the needs of the farmer and his family are satisfied, but the resulting animal products are mainly intended for market realization.

MATERIALS AND METHODS

The classification of family farms utilized in this study is: part-time farms, subsistence farms (including semi-market farms), small market-oriented and large commercial farms (Davidova et al., 2009) [6]. According to general systems theory, every system is made up of functional elements, which we refer to as "subsystems." There is an interrelation between the elements of the system, due to which its integrity and development is possible (Steffen, Born., 1987) [13]. A similar understanding can be applied to the market-oriented family livestock farm. The need to present it as an open system is also determined by the peculiarities of its cost structure and the specifics of management (Bodmer et al., 1993) [5]. A family business is not only an independent, organized, hierarchical unit, but also a living system that grows or shrinks, changes and adapts (Kolhlus et al., 1978) [8]. In Bulgarian literature, the family farm is viewed as a set of three subsystems: production, economic and legal (Stankov, 1997) [12]. Based on the understandings of the aforementioned authors and on our previous studies (Atanassova, 2003, 2016, 2019a, 2019b) [1, 2, 3, 4], we accept the thesis that the market-oriented family livestock farm with sheep breeding specialization is an open system.

It has its own input through which it supplies/purchases food, medications, etc., as well as an output expressing the volume and value of the sold sheep's milk, lambs, etc. The internal environment of this system is made up of four subsystems: production, economic, legal, and social.

In study have been used the data from 9 family farms with sheep breeding specialization. (Map 1).

Map. 1. Territorial positioning in Bulgaria of the studied family farms
Source: Own research, 2021-2023.

The farmers are members of the National Sheep and Goat Breeding Association (NOKA) [11] and participated at the interview in the period 2021 - 2023, and based on their responses, the characteristics of the production, economic, legal and social subsystems of the family farm have been established.

RESULTS AND DISCUSSIONS

The production subsystem of the family livestock farm represents the totality of the available production factors: used agricultural land, buildings and facilities, agricultural machinery, number, type and breed of productive animals, varietal composition of crops, determining the structure of the produced output. This subsystem forms the framework for the implementation of production processes. The size and potential of the factors of production largely determine the results obtained. The needs of society (market demand) determine the size of this subsystem and determine the type and quantity of animal products produced (production specialization). For the system as a whole, it is important to produce such a volume and quality of animal products (forming the income, i.e. its output) that they receive a market price that recovers the input production costs and the largest possible surplus (profit). The realization of higher profit requires planning, organization and control of livestock production in order to

utilize the available production factors and their functional qualities.

Photo 1. Mother sheep (production subsystem) in one the studied farms
Source: Original.

Otherwise, they represent an expense (input) for the family farm, but not a sufficient income (output). The characteristics of the production subsystem of the nine family livestock farms studied are presented in Photo 1 and Table 1. The economic subsystem of the family livestock farm - market type, reflects the value of the realized production or the income received (forming the output of the system) and the amount of the expenses incurred (forming the input of the system).

The difference between the output and the input (income - cost) measures the amount of profit/loss. The ratio of output to input (income/cost) measures the economic efficiency of the input production costs (Table 2). The state of the production and economic subsystems is mutually conditioned.

The income received and the expenses incurred contribute or hinder the expansion of the production capacity of the family farm.

Table 1. Characteristics of the production subsystem of the studied farms

Farm №	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Land (ha)	60	-	-	14,5	-	-	20	30	202
Pastures	-	-	-	-	-	-	-	45	160
Sheep	200	1,000	170	145	120	500	220	150	530
Milking parlor	+	+	+	+	-	+	+	+	+
Agricultural equipment	3	3	-	1	-	1	-	1	3
Milk productivity per sheep (liter)	110	110	128	135	130	133	110	110	150
Fertility of the sheep (number of lambs/year)	1.4	1.3	1.4	1.2	1.5	1.4	1.3	1.3	1.3

Source: Own research, 2021-2023.

Table 2. Characteristics of the economic subsystem of the studied farms*

Farm №	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Price of sheep's milk (€/liter)	0.83	0.94	0.81	0.82	0.79	0.81	0.81	0.80	0.81
Income from milk of a mother sheep (€)	91	103	104	110	103	107	89	88	121
Price per 1 kg. live weight of lamb (€)	3.21	4.10	3.33	3.85	3.33	4.10	4.10	3.49	3.85
Income from lambs sold (€)	88	118	113	106	126	133	123	101	120
Total income (€)	179	221	216	215	229	241	212	188	241
Subsidy for 1 sheep (€)	37	35	38	33	39	35	37	38	34
Gross average annual income per 1 sheep (€)	216	256	254	248	268	277	250	226	277
Total production costs/1 sheep (€)	211	241	237	239	264	258	234	238	258
Effectiveness ratio (income/cost)	1.02	1.06	1.07	1.04	1.01	1.07	1.07	0.95	1.08

Source: Own research, 2021-2023.
*Note: Calculated based on the productivity of one ewe –mother.

The legal subsystem of the family livestock farm reflects its legal and organizational status. Most often, it is a registered agricultural producer - non-trader, and in rare cases it may

be aSole trader(ST) or Single-member limited liability company (Single-member LLC). The organizational form chosen by the farmer legalizes the economic activity on the farm. This subsystem determines the rules for management, complying with the current laws (Table 3).

The legal one subordinates the economic and production subsystems to the requirements of the macroeconomic environment. The type of the legal subsystem determines the rights and responsibilities of the owners (limited or unlimited), who are subject to the established legal norms. The type of this subsystem determines the possibilities for financing, the trust of financial institutions in lending, as well as tax obligations and/or reliefs.

The social subsystem of the family livestock farm symbolizes the trinity of the figure of the farmer, who is simultaneously the owner of the farm, its entrepreneur-manager and worker. This is also confirmed by the empirical studies presented in Table 4.

Table 3. Characteristics of the legal subsystem of the studied farms

Farm №	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Status	Registered agricultural producer under Ordinance No. 3 of 29.01. 1999 on the establishment and maintenance of a register of agricultural producers (Title amended - SG, issue 31 of 2015, effective 28.04.2015)								
Identification	The farmer is a natural person entered in the register with a registration number corresponding to his/her personal identification number.								
Year of registration	2005.	2010	2012.	2019.	2011	2012	2016	-	2009 .
Responsibilities	The registered farmer submits annually, from 01.10 to 28.02., up-to-date information about his/her activities, based on the information submitted, the regional directorate "Agriculture" certifies his/her registration card for a period until 28.02. of the following business year.								
Rights	Registered agricultural producers have the right to apply for and receive: 1) financial support under schemes and measures from the European Agricultural Funds through the State Fund "Agriculture"; 2) funds from the state budget in the form of state aid such as: a) free advice from the National Agricultural Advisory Service; b) free information, analyses and forecasts from the Agricultural Advisory Service; c) information on prices and markets for agricultural products from the National Agricultural Advisory Service; d) to trade in the agricultural products they produce in accordance with Art. 55 of the Agricultural Advisory Service Act and Art. 10a of the Agricultural Advisory Service Act.								

Source: Own research, 2021-2023.

The complex characteristic of the figure of the farmer, combining in one the rights and obligations of otherwise three separate figures in other legal and organizational forms of the agrarian business, provides certain advantages to the management of the family business, but at the same time there are some difficulties.

In the role of the owner of the family farm, the farmer owns part or all of the available production factors (land, machinery, animals, etc.). As such, he is motivated to use his property rationally, to manage it so that it increases and develops. The income from the economic activity of the farm is entirely for him and his family. This is an important condition for achieving higher economic efficiency of the family business. With the freedom to materialize his business ideas, the owner-farmer faces and must overcome a number of difficulties and risks. The significantly smaller size of his property compared to large lease farms makes him highly vulnerable to the suppliers of raw materials and materials (food, seeds, fuels, etc.) and to the companies buying his market production (milk, lambs). His opportunities for obtaining project financing are more limited and the amounts of subsidies are smaller. One can also add the significant production risks caused by natural disasters and cataclysms, pandemic animal diseases, etc. The losses for the farmer in many of these cases are significant. The farmer in the role of entrepreneur-manager takes an active position as the helmsman of the family business. His main function is to deal with uncertainty in the

dynamic and imperfect market environment, in which profit is a return on the risk inherent in farm management (Kalchev, 2013) [7].

Table 4. Characteristics of the social subsystem of the studied family farms

Farm №	1	2	3	4	5	6	7	8	9
Age of the farmer (years)	45	61	48	39	42	38	54	55	34
Education	High school								
Motives for activity development	Family traditions	Family traditions	Family traditions	Animal husbandry experience	Family traditions	Animal husbandry experience	Animal husbandry experience	Animal husbandry experience	Family traditions
Family workforce	The farmer, his brother	The farmer and his father-in-law	The farmer, helped by his daughter	The farmer and his mother	The farmer, the father and the mother	The farmer,	The farmer,	The farmer,	The farmer, his wife and his father
Hired workforce (number of workers)	2	9	-	-	-	3	1	2	3
Method of management	Equal management	Dominant management	Sole management	Sole management	Equal management	Sole management	Sole management	Sole management	Equal management

Source: Own research, 2021-2023.

The personal fate of the farmer is strongly linked to the economic goals of the family business, as he receives the result of the production activity (entrepreneurial profit), motivating him to rationally organize production and management of the farm, to seek opportunities for innovation. The risk for the entrepreneur-farmer is the greatest and to minimize it, he needs to act promptly and professionally. In the role of a worker, the farmer is daily engaged in raising animals, cultivating the land, and is assisted in the work by his family. Very often, he does not provide for his own labor a remuneration (salary), which is due to an employed worker, but pays his monthly insurance premiums based on the minimum wage in the country, because he is a registered agricultural producer.

CONCLUSIONS

From the interpretation of empirical research on family livestock farms with sheep production specialization, some important conclusions can be synthesized: A family livestock farm of market type is an open system, the internal environment of which is composed of four functionally related elements or subsystems. The model of their functional connectivity is an individual/single-family organizational form, which implies the independence of the individual in making management decisions. This model is an "engine" of economic initiative in combination with high material responsibility, accompanied by daily labour engagement of the farmer and his family in raising animals.

The achieved production and economic results of the family livestock farm with sheep breeding specialization are mainly due to the high work motivation of the entire family and the farmer's desire to continue the family traditions. In order to meet modern market requirements and achieve sustainable growth of the livestock farm, the owner needs managerial knowledge and skills, since his social destiny is directly related to that of the family business and affects the standard of living of the family members.

In order to preserve the family traditions of raising animals inherited from his parents/grandparents and to ensure a good standard of living for the family, the main task of the sheep farmer in managing the family business is to organize his production activities in such a way as to obtain animal products (milk and lambs) for which there is a profitable market demand. The production of sheep products is a specific process that requires organization in such a way as to ensure the usability of the created production capacity of land, animals, buildings and facilities, etc. It must cover the input production costs and guarantee the farm a profit.

Current good practice among the investigated family sheep farms is their voluntary membership in the National Sheep Breeders' Branch Association. For now, it assists farmers mainly in the selection and reproduction of animals, in the sale of the produced sheep milk and protects some of their economic interests.

Cooperation between Bulgarian family farms with sheep breeding specialization is imperative. Successful cooperation is a real opportunity that opens up a new horizon for individual producers, who can join their efforts to achieve a common goal - modern and effective sheep breeding in Bulgaria. The cooperative form of organization of production in the difficult sheep breeding sector can lead to a number of benefits and advantages for farmers, expressed in:

-*Access to new markets*– through the collective offering of sheep breeding products, farmers can increase their visibility and reach a wider customer group;

-*Better negotiating power*– through their cooperation, farmers can have greater leverage in negotiations with suppliers and traders, which will guarantee better prices and conditions for the supply of raw materials and the sale of their products;

-*Training and exchange of experience*– through cooperation between farmers, knowledge and experience can be shared, which will contribute to the improvement of their production practices;

-*Resource sharing*– promoting the sharing of resources, such as machinery and equipment, which can reduce costs for the individual farmer and increase production efficiency;

-*Financial access*– through cooperation, farmers will have guarantees and easier access to financing, which is currently very difficult for individual producers;

-*Participation in projects*– receiving support for inclusion in joint projects between farmers that support innovation, smart livestock farming and environmental protection;

-*Implementation of modern technologies and innovations* in sheep production – ensuring access to new technologies and innovations when farmers are members of one or more cooperatives.

In conclusion, the benefits for farmers of their membership in branch organizations, regional and national cooperatives in various forms can be numerous. There is a slow but steady awareness among farmers of such an opportunity, which will open up new horizons for the development of the Bulgarian, family sheep farming business.

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REFERENCES

[1]Atanassova, T., 2003, Forms of agricultural enterprises and financial conditions for their development.Monograph. Stara Zagora, BG: Litera Print.

[2]Atanassova-Kalaydzhieva, T., 2016, Development of agricultural holdings in Bulgaria and the influence of the EU CAP on them, collection "EU CAP and agribusiness in the Republic of Bulgaria - economic and legal problems", SA "D.Tsenov", Svishtov, 77-82.

[3]Atanassova-Kalaydzhieva, T., 2019, Small farms in Bulgaria: realities and prospects. Management and Sustainable Development (2), 31-36.

[4]Atanassova-Kalaydzhieva, T., 2019, Agricultural enterprises in Bulgaria: structural features and development, Trakia Journal of Sciences, 17(1), 334-343.
[5]Bodmer, Ul., Heißenhuber, Al., 1993, Rechnungswesen in der Landwirtschaft. Stuttgart, DE: UTB.
[6]Davidova, S., Fredriksson, L., Gorton, M., Mishev, P., Petrovici, D., 2009, Comparative Analysis of the contribution of subsistence production to household incomes in five EU New Member States: Lessons learnt. Structural change in Europe's rural regions - Farm livelihoods between subsistence orientation, modernisation and non-farm diversification. Studies on the Agricultural and Food Sector in Central and Eastern Europe, Halle (Saale), DE: IAMO.
[7]Kalchev, E., 2013, Profit as an indicator of sustainable development of the enterprise. Management andSustainable Development, (5), 55-59.
[8]Kolhlus, J., Waldburger, H., 1978, Informatik fuer EDV-Benuetzer. Stuttgart, DE: Ulmer.
[9]Ministry of Agriculture, Sofia. Agrostatistics, Basic data on the structure of agricultural holdings in 2020,
[10]Ministry of Agriculture, Food and Rural Affairs, 2021, Census of agricultural holdings in 2020 - preliminary results, (2021). Bulletin No. 390, 5-6.
[11]NOKA, The largest livestock industry organization in Bulgaria, https://noka.bg/, Accessed on 26-th November 2024.
[12]Stankov, Wl., 1997, Theoretische Thesen ueber Unternehmen in der Landwirtschaft und ihre Verwirkungen in der Agrarreform in Bulgarien. Privatisierungsprozess, Rechtsformen und Betriebsstrukturen in Agrarbereich der Mittel- und Osteneuropaeischen Laender., Halle (Saale), DE: IAMO., 125-131.
[13]Steffen, G., Born, D., 1987, Betriebs- und Unternehmensfuehrung im der Landwirtschaft., Stuttgart, DE: Ulmer.

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FROM CHALLENGES TO COMPETITIVE ADVANTAGE: A MATRIX FOR RESOURCE OPTIMIZATION, MARKET ACCESS, POLICY COHERENCE AND TECHNOLOGICAL ADVANCEMENT IN ROMANIAN AGRICULTURE

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Abstract

The Romanian agri-food sector faces significant challenges related to economic resource allocation and policy formulation. The study aims to explore these issues through a comprehensive case study of Romania, highlighting the interplay between economic policies and agri-food market dynamics. Following a research approach centered on administering questionnaires to key stakeholders, our findings reveal persistent inefficiencies in resource allocation, influenced by historical legacies, market fragmentation, and inconsistent policy frameworks. In addition, there were identified critical deficiencies in infrastructure and technology adoption that are impeding market efficiency. Overall, the study emphasizes the need for integrated policy reforms to increase the efficiency of resource allocation, support sustainable agricultural practices, and improve farmers' market access. The findings suggest that addressing these challenges requires a coordinated effort between policymakers, industry stakeholders, and the farming community to promote a resilient and competitive agri-food sector in Romania. Moreover, the matrix of challenges and opportunities provides the basis for turning these obstacles into competitive advantages through strategic optimization of resources, improved market access, coherent policy frameworks, and technological advances.

Key words**:** *agri-food sector, policy formulation, market dynamics, development matrix*

INTRODUCTION

The Romanian agri-food sector presents a compelling paradox due to its dual role as both a cornerstone of the national economy and a domain fraught with challenges that impede its full potential. This sector, which plays a pivotal role in employment and contributes significantly to Gross Domestic Product (GDP), stands at a critical juncture [20]. On one hand, Romania benefits from fertile lands, a skilled agricultural workforce, and a deep-rooted tradition in food production. Conversely, enduring legacies of historical events, market fragmentation, and inconsistent policy implementations have intertwined to create a complex maze of barriers that obstruct efficient resource management and market dynamism [28]. Recognizing the intricate interplay between resource allocation and policy formulation is crucial for nurturing sustainable growth and enhancing market efficiency within Romania's agri-food sector. The historical backdrop underscores how past developments have shaped the current landscape, where the legacy of land collectivization followed by privatization has resulted in a fragmented pattern of land

ownership. This fragmentation poses substantial challenges to contemporary farming practices, constraining economies of scale and impeding the widespread adoption of advanced agricultural methodologies. In essence, the Romanian agri-food sector embodies both promise and predicament [6], embodying potential for growth alongside systemic hurdles that necessitate strategic interventions and cohesive policy frameworks to unlock its full economic and agricultural potential.

Market fragmentation further complicates the sector's efficiency and competitiveness. The Romanian agri-food market, characterized by numerous small-scale producers operating independently [14], struggles with barriers that prevent small farmers from accessing broader markets. The role of cooperatives, or the absence of such entities, significantly exacerbates these issues, resulting in the inefficient allocation of resources and severely limiting the dynamism of the market. These structural inefficiencies serve as substantial barriers, hindering the sector's ability to effectively integrate into global supply chains and compete on a larger, more competitive scale. Additionally, the inconsistent implementation of policies and the frequent changes in regulations create an environment characterized by uncertainty [8], [37]. This pervasive uncertainty deters long-term investments, thereby stymying growth and preventing the sector from achieving its full potential. The existing policy frameworks, marked by inconsistencies and short-term focus, fail to provide the necessary support for sustainable development [20], [17], [25]. This policy instability not only impacts resource distribution but also affects market dynamics, further entrenching the sector's challenges.

Addressing these multifaceted challenges requires a comprehensive approach that takes into account the intricate interplay between historical legacies, market structure, and policy decisions. Understanding this interplay is essential for formulating effective solutions. Potential policy reforms must concentrate on creating a stable and supportive policy environment, which is crucial for fostering investor confidence and encouraging long-term investments [34]. Simultaneously, enhancing market integration is vital for ensuring that the agri-food sector can compete on a larger scale, facilitating smoother entry into global supply chains [9]. Furthermore, fostering technological adoption and infrastructure development is key to modernizing the sector, improving efficiency, and increasing productivity [35]. By holistically addressing these core issues, Romania can unlock the full potential of its agri-food sector, transforming it into a vibrant and competitive force within the global agricultural landscape.

By providing a detailed and evidence-based analysis, this research aims to contribute to the formulation of policies that ensure the Romanian agri-food sector's growth and sustainability in the years to come. Understanding the sector's complexities and addressing its challenges head-on can lead to the development of a robust and resilient agri-food industry [19]. Such an industry would be capable of significantly contributing to Romania's economic prosperity and ensuring food security for its population [22]. By taking a comprehensive approach to reform and modernization, this research seeks to offer valuable insights and practical recommendations that can guide policymakers in creating an environment where the agri-food sector can thrive. This will ultimately result in a more dynamic, competitive, and sustainable agri-food industry that can stand strong in the face of global challenges and opportunities [3].

This paper undertook a comprehensive investigation into the challenges hindering Romania's agri-food sector [27] by employing a mixed-methods approach. This approach combined qualitative and quantitative analyses to provide a holistic understanding of the sector's current state. By examining stakeholder perceptions, the research aimed to identify key issues and gaps that are impeding progress. The study pinpointed problems such as inefficient resource allocation, market fragmentation, inconsistent policy frameworks, and deficiencies in infrastructure and technology.

The ultimate purpose of this research is to utilize these findings to formulate evidence-

based policy recommendations. These recommendations are designed to address the identified challenges and lay the groundwork for transformative changes within the sector. By implementing these strategic policies, the Romanian agri-food sector can be steered towards a path of enhanced competitiveness and sustainable growth. This involves creating a stable policy environment, fostering market integration, promoting technological adoption, and developing robust infrastructure.

In essence, this research aspires to contribute significantly to the formulation of effective strategies that will bolster the long-term development and resilience of Romania's agri-food industry. By addressing these complex challenges head-on, the sector can evolve into a vibrant and competitive force within the global agricultural landscape, ultimately contributing to Romania's economic prosperity and food security.

MATERIALS AND METHODS

The primary objective of this study was to explore and understand the perceptions of active participants within the agri-food sector regarding the phenomena [7]. Specifically, it aimed to gather field data that could sustain the development of policies destined to promote agri-food products.

Given this goal, this research work is deliberately focused on capturing real-world insights and perspectives directly from stakeholders rather than engaging in a legislative or regulatory analysis. This methodological choice was grounded in the necessity to bridge the gap between theoretical insights and practical policy formulation [10], [16].

Justification of the Methodological Approach

The decision to center this study on field data collection and stakeholder perceptions stems from several foundational considerations. First and foremost, policy development in the agri-food sector necessitates a deep understanding of how industry stakeholders perceive existing challenges and opportunities [4]. By engaging directly with these stakeholders through the questionnaire method, the study aimed to uncover nuanced perspectives that legislative analyses might overlook. Moreover, this research sought to prioritize the experiences of those actively involved in the agri-food sector. These individuals possess invaluable firsthand knowledge that is indispensable for crafting effective and contextually relevant development policies. Through qualitative inquiry, the study aimed to elucidate the complex interplay of factors influencing the sector, including economic dynamics, consumer behavior trends [31], technological advancements, and environmental considerations.

Research Design and Data Collection

To achieve the research objectives, it was employed a qualitative research design characterized by the distribution of structured questionnaires to stakeholders across various segments of the agri-food sector. This methodological approach aimed to comprehensively understand stakeholder perspectives on critical issues impacting the sector's development.

In order to gather data from an assortment of stakeholders, including legislators, agricultural specialists, farmers, and business representatives, we developed a questionnaire especially for the study on Romania's agri-food sector. In order to guarantee a balanced representation of all groups, we proceeded by asking demographic details to divide participants by role, experience, geography, and age.

Significant issues such as resource allocation and land fragmentation were the primary objectives of the questionnaire, that asked respondents to rate the degree of fragmentation and mention issues like poorer productivity, greater operating costs, and diminished economies of scale. We additionally asked for recommendations for possible adjustments, such as cooperative arrangements or land consolidation.

After examining market fragmentation and access constraints, we questioned about issues including inadequate infrastructure, expensive transportation, a lack of market knowledge, and a lack of negotiating position and improvement suggestions were requested from the respondents.

Evaluating the effectiveness of current agricultural policies was the goal of the policy framework and implementation part. Participants evaluated the coherence of policies and identified issues such as poor coordination, bureaucratic inefficiencies, and insufficient budget. We also gathered recommendations for improving policy by asking about the efficacy of support and subsidy programs.

We also looked at the adoption of technology and infrastructure, asking participants to provide feedback on the level of technology adoption in the rural areas and the infrastructure in those regions. Respondents offered ways of addressing the barriers to technology adoption, such as high costs, ignorance, and aversion to change.

We were able to collect both quantifiable data and in-depth insights by combining quantitative and qualitative questions in the questionnaire. The findings were significant in enabling us to create targeted policy suggestions that would improve the competitiveness, efficiency, and sustainability of Romania's agri-food industry.

The sampling strategy was meticulously designed to ensure representation from farmers, processors, distributors, policymakers, and consumer advocacy groups. By targeting a diverse range of participants, we sought to capture a broad spectrum of viewpoints and experiences, thereby enhancing the robustness and applicability of our findings to policy formulation.

The sample of 56 participants was specifically purposefully selected to ensure representation from key stakeholders in Romania's agri-food sector, including policymakers, agricultural scientists, farmers, and industry. Although the sample might seem small when first considered, it should be interpreted in light of the primary goal of our study, to obtain richly contextualized insights into challenges and perspectives of these stakeholders, rather than perform wide statistical generalization.

They were purposively sampled to adequately represent each of the seven major stakeholder groups. Policymakers, agricultural experts, farmers, and industry representatives all bring different and valuable perspectives, so the sample was fielded to capture this diversity. Given that 36% of those that attended were farmers, who form the backbone of the agri-food sector, followed by 27% being policymakers, we consider the distribution to be very well placed to provide a holistic insight on the challenges the sector faces. Given the nature of this sample, we do not claim full generalizability to the population of those working in these domains, but we do believe this is a sufficiently large and representative subset of stakeholders from which to derive meaningful conclusions about the sector. A diverse sample provides a holistic understanding of issues, reducing biases toward any demographic, providing insights covering many spectrums. Furthermore, the results provide a solid foundation for identifying systemic problems and patterns, that can subsequently direct future research with potentially larger sample sizes or influence recommendations for policy. Finally, the quality of insights gathered is arguably more important than the number of participants who took part in studies like this one, including when the objective is to inform the development of policy and the improvement of sector-specific strategies. Hence, although the sample is relative small, it is representative for a core range of stakeholders involved in Romania’s agri-food sector and the qualitative insights this brings are valuable for understanding the fundamentals.

Ethical Considerations

Throughout the research process, ethical guidelines were strictly adhered to, with measures implemented to protect participant confidentiality and ensure informed consent. Clear instructions were provided to participants regarding the purpose of the study, voluntary participation, and the use of data solely for research purposes. Ethical considerations also included the respectful representation of stakeholder perspectives in the analysis and reporting of findings.

Limitations

While questionnaires provided valuable quantitative data on stakeholder perceptions, it is important to acknowledge inherent limitations. Responses may be influenced by respondent bias or limited to the scope of

questions asked, potentially constraining the depth of qualitative insights compared to more interactive methods like interviews. Despite these constraints, the structured nature of questionnaires facilitated efficient data collection and analysis, offering valuable insights into stakeholder viewpoints on agri-food sector issues.

Proposal for a Matrix Supporting Agro-Food Product Development Policy

The questionnaire aimed to explore and analyze the current state of economic resource allocation [24] and policy challenges within Romania's agri-food sector, gathering comprehensive data on critical aspects such as resource allocation, market fragmentation, policy frameworks, and infrastructure and technological adoption [5], [11], [29], [36]. These aspects were identified as pivotal for their relevance and importance in understanding the sector's dynamics and obstacles. This initiative aligns with the proposed research goal of developing a robust matrix to support the creation of effective policies aimed at promoting Romania's agri-food products.

1. Resource Allocation

Efficiency and Productivity

Understanding how resources are currently allocated is crucial for identifying inefficiencies that could be hindering productivity [23] and profitability for Romanian agriculture. Fragmented land ownership, for example, it can limit economies of scale and access to resources.

Targeting Support

Examining resource allocation helps to ensure that support programs and subsidies reach the farmers who need them most [32]. Misallocated resources can have a limited impact on overall sector development.

2. Market Fragmentation

Market Access

A fragmented market with limited access to larger markets for small-scale farmers can stifle their growth and competitiveness. Analyzing this aspect helps identify barriers like poor infrastructure, high transportation costs, and lack of market information [33].

Fairness and Equity

Market fragmentation can create an uneven playing field, disadvantaging small-scale farmers [18]. Examining this aspect helps ensure fair access to markets and opportunities for all stakeholders within the sector.

3. Policy Frameworks

Effectiveness of Policies

Analyzing policy frameworks helps to determine if the existing policies are achieving their intended goals [12], [15]. Inconsistency and incoherence in policy design can lead to confusion and hinder implementation [2].

Targeted Interventions

Understanding policy frameworks allows for the development of more targeted interventions that address specific challenges faced by the sector. Policies need to be clear, well-communicated, and efficiently implemented to be successful [21].

4. Infrastructure and Technological Adoption

Modernization and Efficiency

The adoption of modern technologies and infrastructure improvements are critical for enhancing productivity and promoting sustainable agricultural practices [13]. Analyzing this facet facilitates the identification of sectors requiring investment for modernization.

Knowledge and skills

For farmers to effectively embrace new technologies, training and knowledge development are frequently necessary [30]. With the help of this research, support initiatives may be established in place to provide farmers the tools they need to make the most of these developments.

A matrix was created to rigorously assess the crucial elements that were determined to be the basic foundations in the creation of food products. Together, these four interrelated elements provide a thorough analytical framework that is essential for analyzing the potential and difficulties facing Romania's agri-food industry. By focusing on these aspects, this study hopes to provide important information for decision-makers. These understandings will be essential in formulating successful plans to encourage the industry's expansion and raise the level of competition for its goods.

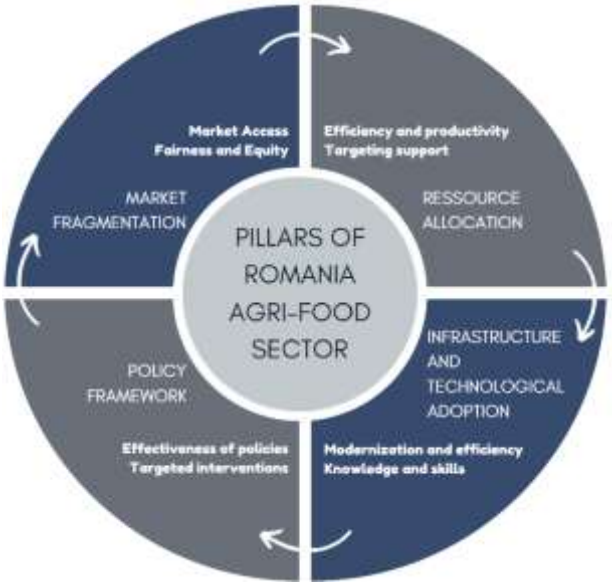

Fig. 1. Interrelated connections in the agri-food sector in Romania
Source: Authors' own work.

The relationships and reciprocal effects between these four elements are illustrated in Figure 1. Better market access, well-informed policy, and technical breakthroughs are all driven by efficient resource allocation. Fair possibilities are guaranteed for all farmers by tackling market fragmentation, and important information is obtained for the creation of infrastructure and policies. In turn, efficient policy frameworks influence the allocation of resources and aid in modernization initiatives. Technology adoption and infrastructure development, which are influenced by resource allocation and policy, increase sustainability and productivity. Developing comprehensive strategies to promote the Romanian agri-food sector requires an understanding of these interdependencies.

The hypothesis of the research

To establish the credibility of the matrix outlined earlier, there were formulated several hypotheses. These hypotheses are designed to be validated through the in-depth analysis of the questionnaire results. By scrutinizing the data gathered from the survey, we aim to substantiate the accuracy and reliability of the matrix we have put forward. This approach allows us to systematically test and confirm the theoretical framework we have proposed, ensuring that it effectively reflects the real-world phenomena under investigation.

(1) Resource Allocation - Land fragmentation in Romania's agri-food sector leads to inefficient resource allocation.
(2)Market Fragmentation - Poor infrastructure and high transportation costs significantly hinder market access for small-scale farmers.
(3) Policy Framework - Inconsistent and poorly designed policy frameworks hinder the effectiveness of subsidy and support programs.
(4) Infrastructure and Technological Adoption - Inadequate infrastructure and low technological adoption impede the efficiency and productivity of Romania's agri-food sector.

RESULTS AND DISCUSSIONS

The agri-food sector in Romania holds a crucial position within the national economy, contributing significantly to food supply, employment generation, and rural development. Despite its importance, the sector encounters various challenges that impede its efficiency, productivity, and sustainability.
To address these issues, it was employed the questionnaire method which is the most effective approach for obtaining pertinent information for our research. This method will facilitate the collection of relevant data, enabling a thorough analysis and informed recommendations to enhance the sector's performance.

Demographic Considerations of Participants

The study successfully garnered responses from a diverse range of stakeholders within Romania's agri-food sector, with a total of 56 participants.
Policymakers comprised the largest group, representing 27% (15 respondents) of the sample. This significant participation ensures a strong foundation for understanding policy perspectives and challenges. Agricultural experts formed the second-largest group at 21% (12 respondents), providing valuable insights into technical aspects and best practices within the sector. Farmers, the backbone of the agri-food sector, constituted 36% (20 respondents) of the participants, offering firsthand experiences and perspectives on the ground-level realities. Industry

representatives rounded out the sample at 16% (9 respondents), contributing their knowledge of market dynamics and value chain operations. This well-balanced distribution of participants across stakeholder groups fosters a comprehensive understanding of the challenges faced by the Romanian agri-food sector from various vantage points.

Key findings of resource allocation

Overwhelming Consensus on Fragmentation: A staggering 80% of respondents (45 out of 56) indicated that land ownership in Romania's agri-food sector is "very fragmented." This is further supported by the minimal representation of those who perceive fragmentation as moderate (18%, 10 respondents) or slight (2%, 1 respondent).

Challenges Observed:

The severe fragmentation of land ownership translates into a multitude of challenges, as reported by the participants:

(i)Reduced Economies of Scale: The most prevalent challenge identified by 70% of respondents (39 respondents) is the limitation of economies of scale. Small, fragmented farms struggle to compete with larger operations in terms of cost efficiencies, hindering their ability to invest in advanced machinery, negotiate better prices for inputs, and access lucrative markets.

(ii)Lower Productivity: Land fragmentation can lead to inefficiencies in land use practices and pose obstacles to adopting modern agricultural technologies. As noted by 66% of respondents (37 respondents), this translates into lower overall productivity for the sector.

(iii)Higher Operational Costs: Fragmented landholdings often incur higher operational costs due to the logistical complexities of managing scattered plots. This challenge was reported by 59% of respondents (33 respondents).

(iv)Resource Management Difficulties: Scattered landholdings pose significant challenges in managing resources effectively. Half of the respondents (28 respondents) highlighted this difficulty, which can encompass issues like coordinating labor, equipment usage, and irrigation practices across fragmented plots.

The overwhelming consensus on land fragmentation, coupled with the observed challenges, underscores the significant impact this issue has on inefficient resource allocation within the Romanian agri-food sector. Historical legacies and the resulting land fragmentation create a scenario where small and fragmented landholdings severely limit economies of scale. This, in turn, reduces productivity and profitability for Romanian agriculture. Addressing land fragmentation through policy interventions aimed at promoting land consolidation or cooperative structures is crucial to optimize resource allocation and enhance the sector's competitiveness.

Key findings of market fragmentation

Barriers to Market Access: The research identified several significant barriers hindering small-scale farmers' access to larger markets within Romania's fragmented agri-food sector. A concerning 75% of respondents (42 respondents) highlighted poor infrastructure, such as inadequate roads and storage facilities, as a major obstacle. This sentiment is echoed by the 68% (38 respondents) who identified high transportation costs as a significant barrier. (i)Limited access to efficient and affordable transportation due to poor infrastructure directly translates into higher costs for farmers, further squeezing their profit margins.

(ii)Furthermore, a lack of market information emerged as a critical challenge, reported by 63% of respondents (35 respondents). Without access to reliable information on market prices, trends, and potential buyers, small-scale farmers struggle to make informed decisions and secure profitable opportunities. (iii)Adding to these challenges, 55% of respondents (31 respondents) pointed to their limited bargaining power as a disadvantage. (iv)Fragmented markets with a multitude of small producers often leave them vulnerable to lower prices dictated by larger players in the market chain.

Impact of Logistical Challenges: The combined effect of these barriers manifests in the significant impact logistical challenges have on market access, as reported by the participants. A resounding 64% of respondents

(36 respondents) stated that logistical challenges significantly affect market access for small-scale farmers. This highlights the urgency of addressing these issues to ensure a more level playing field and empower smaller producers to reach wider markets. While a quarter of respondents (14 respondents) felt the impact was moderate, and a small portion (6 respondents) perceived a slight effect, it's noteworthy that no participants indicated no impact.

The findings paint a clear picture of a highly fragmented agri-food market in Romania, characterized by limited access to larger markets for small-scale farmers. Poor infrastructure, high transportation costs, lack of market information, and weak bargaining power all contribute to logistical challenges that significantly hinder market access and reduce competitiveness. Addressing these issues through targeted policies and infrastructure development initiatives is crucial to creating a more efficient and equitable market environment for all stakeholders within the Romanian agri-food sector.

Key findings of the policy framework

Consistency and coherence of policies: The research exposes a critical issue within Romania's agri-food sector: policy frameworks that lack consistency and coherence. A staggering 82% of respondents (46 respondents) rated existing policies as "not consistent or coherent." This highlights a significant disconnect between policy design and implementation, potentially leading to confusion and inefficiencies for stakeholders. Concerns over policy coherence were further accentuated by the fact that only a small percentage of participants thought that policies were either fairly consistent (14%, 8 respondents) or moderately consistent (4%, 2 respondents). Surprisingly none of the respondents believed that the policies were "very consistent and coherent."

Implementation difficulties: According to the participants, the lack of consistency in the policy results in specific difficulties during implementation. The most significant barrier was found to be bureaucratic inefficiencies, which were mentioned by 71% of respondents (40 respondents). Potential beneficiaries may be deterred from accessing support programs by the time-consuming nature of navigating intricate bureaucratic procedures. 66% of respondents (37 respondents) expressed serious concern about inadequate funding for policy initiatives, suggesting a possible discrepancy between the goals of policy and the resources at hand. Additionally, 31 respondents, or 55% of the sample, mentioned that personnel in charge of carrying out policies needed proper training. This may result in misunderstandings and inconsistent application, which would ultimately reduce the programs' effectiveness. In addition to these challenges half of the respondents (28 respondents) noted a lack of coordination between government agencies involved in agriculture, which could lead to inconsistent signals and duplication of effort.

Effectiveness of subsidies and support programs: The study analyzed in further detail the effectiveness of particular policy tools, such as subsidies and support programs. The results show that 39 respondents, or 70% of the sample, believe that current initiatives are ineffective at reaching their stated objectives. The low percentage of respondents who believe these initiatives are just moderately effective (7%, 4 respondents) or somewhat effective (23%, 13 respondents) supports this view even further. Once again, none of the respondents thought they were "very effective."

The research provides compelling evidence that inconsistent and poorly designed policy frameworks are a significant challenge hindering the Romanian agri-food sector. The lack of coherence in policy design coupled with implementation challenges such as bureaucratic red tape, inadequate funding, and insufficient training all contribute to a scenario where subsidy and support programs fall short of their intended impact. Addressing these issues through policy reforms that prioritize consistency, clear communication, and efficient implementation is crucial to ensure that policy frameworks effectively support the growth and competitiveness of the Romanian agri-food sector.

Key findings of infrastructure and technological adoption

State of rural infrastructure: A stark picture emerges regarding rural infrastructure, with 64% of respondents (36 respondents) rating it as "poor." This highlights a critical gap in essential infrastructure that hinders efficient operations and market access, particularly for farmers in rural areas. Only a small fraction of participants found rural infrastructure to be fair (27%, 15 respondents), good (7%, 4 respondents), or excellent (2%, 1 respondent).

Technological adoption: The level of technological adoption within the sector remains concerning. A significant majority (57%, 32 respondents) indicated a "very low" level of adoption, further corroborated by 30% (17 respondents) reporting a "low" level. While a small portion observed moderate adoption (11%, 6 respondents) and only 2% (1 respondent) noted a high level, it's clear that the sector lags in embracing modern technologies.

Barriers to technological adoption: The research identified several key barriers hindering the widespread adoption of modern agricultural technologies:

(i)*High Cost*: The perceived high cost of technology was a major concern for 75% of respondents (42 respondents). Limited financial resources can act as a significant barrier for farmers, particularly those in small-scale operations.

(ii)*Lack of Knowledge and Training*: A significant knowledge gap emerged as another critical obstacle, with 66% of respondents (37 respondents) highlighting the lack of training and knowledge as a major deterrent to adopting new technologies. Farmers may be hesitant to invest in technologies they don't fully understand or lack the skills to operate effectively.

(iii)*Limited Access*: Physical limitations in accessing new technologies were also a concern for 55% of respondents (31 respondents). This could encompass issues like lack of local vendors, limited distribution networks, or inadequate infrastructure hindering access to these technologies.

(iv)*Resistance to Change*: A more intangible barrier identified by 50% of respondents (28 respondents) is the resistance to change among some farmers. Traditional mindsets and established practices can create inertia and reluctance to embrace new technological advancements.

The findings reveal a critical need to address the substantial gaps in infrastructure, particularly in rural areas. Additionally, a major obstacle in improving productivity and encouraging sustainable practices in the Romanian agri-food sector is the poor adoption of contemporary agricultural technologies. Targeted interventions are required to address the high prices of technology, provide farmers access to information and training opportunities, increase their affordability, and promote an open attitude toward accepting innovations in order to overcome these obstacles. By addressing these problems, the manufacturing sector may reach its maximum potential and advance toward a future that is more productive, efficient, and sustainable.

Hypothesis demonstration and matrix validation

Our hypotheses, which are supported by empirical findings from a structured questionnaire distributed to stakeholders in Romanian agriculture, are thoroughly summarized in Table 1. The results reveal widespread problems that obstruct effective resource distribution, market integration, coherent policy, and technical development. These challenges are a reflection of larger systemic issues that impact the sustainability and competitiveness of the industry. This study offers insights into the complex nature of the challenges faced by small-scale farmers, governments, and industry stakeholders by methodically analyzing these variables.

Four important hypotheses have been confirmed by the thorough questionnaire research used to validate the Matrix Supporting Agri-Food Product Development Policy. This validation demonstrates the matrix's applicability in addressing important issues in the agri-food industry in Romania. First, the matrix's focus on resolving land fragmentation in relation to resource allocation is consistent with research showing its negative effects on efficiency. Proposed solutions include advocating for land consolidation and cooperative frameworks. Secondly, addressing market fragmentation, the matrix's recommendations, such as infrastructure

enhancements and improved transportation access, directly respond to identified barriers like inadequate infrastructure and high costs. Thirdly, regarding policy frameworks, the matrix advocates for reform to streamline bureaucratic processes and enhance program effectiveness, aligned with research revealing current inconsistencies. Lastly, tackling infrastructure and technological adoption challenges, the matrix promotes targeted investments in infrastructure and technological training, crucial for optimizing productivity. These validated insights highlight pathways to enhance resource allocation, expand market access, improve policy implementation, and foster technological advancement within Romania's agri-food sector. By advocating for the matrix's adoption and crafting detailed action plans based on its recommendations, stakeholders can collaboratively drive positive change, ensuring a more competitive and prosperous future for Romanian agri-food products [1].

Table 1. Hypothesis demonstration and matrix validation

Analyzed Aspect	Hypothesis	True / False/ Not applicable	Demonstration
Resource Allocation	Land fragmentation in Romania's agri-food sector leads to inefficient resource allocation.	True	80% of respondents indicated land ownership is "very fragmented." Reduced economies of scale (70%). Lower productivity (66%). Higher operational costs (59%). Resource management difficulties (50%). The overwhelming consensus on fragmentation and the reported challenges demonstrate how land fragmentation leads to inefficient resource allocation in Romania's agri-food sector.
Market Fragmentation	Poor infrastructure and high transportation costs significantly hinder market access for small-scale farmers.	True	Poor infrastructure (75%). High transportation costs (68%). 64% of respondents stated that logistical challenges significantly affect market access. The identified barriers and their impact on market access indicate that poor infrastructure and high transportation costs are significant hindrances for small-scale farmers.
Policy Framework	Inconsistent and poorly designed policy frameworks hinder the effectiveness of subsidy and support programs.	True	Policies rated as "not consistent or coherent" by 82% of respondents. Bureaucratic inefficiencies (71%). Inadequate funding (66%). Lack of adequate training (55%). 70% of respondents view current programs as ineffective. The inconsistency and poor design of policy frameworks, coupled with implementation challenges, hinder the effectiveness of subsidy and support programs in the agri-food sector.
Infrastructure and Technological Adoption	Inadequate infrastructure and low technological adoption impede the efficiency and productivity of Romania's agri-food sector.	True	Poor rural infrastructure (64%). Very low technological adoption (57%). Barriers to Technological Adoption: High cost (75%); lack of knowledge and training (66%); limited access (55%); resistance to change (50%). The poor state of rural infrastructure and low levels of technological adoption, along with the identified barriers, show how these factors impede the efficiency and productivity of the sector.

Source: own elaboration based on the result of the questionnaire.

Policy Framework Proposal for Agro-Food Product Development

This analysis underscores the urgent need for targeted interventions and policy reforms aimed at addressing the identified barriers. Such initiatives are essential for fostering resilience, enhancing productivity, and promoting equitable growth within Romania's agri-food sector. Understanding these dynamics is crucial for developing strategies that can unlock the sector's potential and contribute to its long-term viability in a globalized economy.

Based on the results of this research and the validation of the matrix, it was proposed a policy framework that aims to address the systemic challenges identified in Romania's agri-food sector, focusing on improving policy coherence, enhancing support mechanisms, and promoting sustainable development. This framework is designed to foster innovation, efficiency, and competitiveness across the sector (Table 2).

Table 2. Policy framework proposal for agro-food product development

1. Enhancing policy coherence and alignment
Objective: *Improve consistency and coherence in policy frameworks to provide clarity and stability for stakeholders.*
Activities:
1. Conduct a comprehensive review of existing agricultural policies to identify inconsistencies and gaps.
2. Develop a unified policy approach that integrates agricultural, economic, and environmental objectives.
3. Establish mechanisms for regular stakeholder consultation to ensure policies meet sectoral needs and adapt to evolving challenges.
2. Strengthening support mechanisms
Objective: *Enhance the effectiveness of subsidy and support programs to better assist small-scale farmers and agri-food businesses.*
Activities:
1. Increase funding allocation for agricultural support programs while ensuring efficient utilization.
2. Simplify application procedures and reduce bureaucratic barriers to accessing subsidies and grants.
3. Provide targeted support for technology adoption, infrastructure development, and market access improvements.
3. Promoting sustainable practices and innovation
Objective: *Encourage the adoption of sustainable farming practices and foster innovation in agro-food production.*
Activities:
1. Implement incentives for farmers adopting sustainable agriculture practices, such as organic farming and integrated pest management.
2. Encourage research and development projects with the goal of enhancing agriculture yields, climate resilience, and resource efficiency.
3. Encourage partnerships between academic institutions, research centers, and businesses to speed up the spread of innovations and technology transfer.
4. Developing skills and competence
Objective: *Fill in the knowledge gaps and improve the abilities of farmers and other agri-food stakeholders.*
Activities:
1. Increase the number of workshops and vocational training programs to enhance technical proficiency in contemporary agriculture technology and practices.
2. Create networks and venues for knowledge sharing to promote information sharing about industry trends and best practices.
3. Encourage training in business management and entrepreneurship to provide farmers with the abilities necessary to produce and market value-added agro-food.
5. Market access and infrastructure development
Goal: Expand small-scale farmers' and rural communities' access to markets while enhancing rural infrastructure.
Activities:
1. To reduce transportation costs and improve market connectivity, invest in infrastructure projects like roads, storage facilities, and cold chain logistics.
2. To assist farmers make more informed choices and reach wider markets, improve digital infrastructure, and market information system accessibility.
3. Encourage agri-food clusters and cooperative structures to help small-scale farmers increase their market presence and negotiation leverage.

Source: author's elaboration.

In order to solve major issues and encourage resilience, competitiveness, and sustainable growth, the suggested policies for Romania's agri-food industry are needed. Promoting policy alignment and coherence promotes stability and clarity, enabling stakeholders to make well-informed choices and encouraging sustained investment in sustainable practices. Strengthening support mechanisms through increased funding and simplified procedures enhances accessibility to resources, promoting technological adoption and market competitiveness. Encouraging sustainable practices and fostering innovation not only boosts productivity but also enhances resilience to climate change and environmental challenges [26]. Capacity building and skills development among farmers and stakeholders equip them with essential tools to adapt to modern agricultural practices and market demands. Additionally, investing in infrastructure development and enhancing market access connects farmers to broader markets, reduces logistical costs, and strengthens their bargaining power. These integrated efforts will unlock the sector's full potential, driving inclusive and equitable growth across Romania's agricultural landscape.

CONCLUSIONS

Based on the comprehensive analysis and findings obtained from our research, we are now in a position to summarize several key conclusions that are pertinent to the study. These conclusions are derived from the data collected, the methodologies employed, and the thorough examination of the results. They highlight significant insights, trends, and implications that have emerged throughout the research process. The validated Matrix Supporting Agri-Food Product Development Policy serves as a roadmap for policymakers and stakeholders to address key challenges. Land fragmentation, a significant barrier to efficient resource utilization, can be tackled through initiatives that encourage land consolidation or the formation of cooperatives. Similarly, the fragmented market environment hindering small-scale farmers can be addressed by targeted investments in rural infrastructure and improved transportation access. The research also underscores the need for clear and well-designed policy frameworks, achievable through streamlining bureaucratic processes and enhancing communication strategies. Finally, the identified gaps in infrastructure and technology adoption can be bridged by directing investments toward rural areas and developing comprehensive training programs for farmers. By implementing these pragmatic solutions, stakeholders can work collaboratively to unlock the immense potential of the Romanian agri-food sector. The proposed policies not only address immediate challenges but also lay the foundation for a more sustainable and prosperous future for Romanian agriculture, ensuring a thriving sector that produces high-quality agri-food products that can compete effectively on a global scale. This research also opens doors for future endeavors. A focus on policy coherence and alignment alongside strengthened support mechanisms and infrastructure development will create a stable environment for long-term investment and market competitiveness. By equipping farmers and stakeholders with the tools they need to succeed, we can unlock the full potential of Romania's agri-food sector, driving inclusive and equitable growth for a prosperous agricultural future.

REFERENCES

[1]Arion, F. H., Bardea, F., Chifor, Diana C., Maier, L. C., 2023, The analysis of a complex collaborative value chain. Case of AgroTransilvania cluster, in Scientific Papers-Series Management Economic Engineering in Agriculture and Rural Development, Vol. 23(2), 37-49, https://managementjournal.usamv.ro/pdf/vol.23_2/Art4.pdf, Accessed on 23.05.2024

[2]Bachev, H., Ivanov, B., 2024, Framework for a Holistic Assessment of the Quality of Agri-Food Governance in Bulgaria. Sustainability, 16(5), 2177, https://www.mdpi.com/2071-1050/16/5/2177, Accessed on 06.05.2024

[3]Beia, S.I., Constantin, M., Deaconu, E.M., Beia, V.E., Nicolaie, F.C., Smedescu, D., Smedescu, C., 2024, Elasticity Dynamics and Trade Balance Performance as Metrics for Food Security - An Assessment of Romania's Swine Meat Market, in Scientific Papers-Series Management Economic Engineering in Agriculture and Rural Development, Vol. 24(1), 107-116, https://managementjournal.usamv.ro/pdf/vol.24_1/Art10.pdf, Accessed on 24.05.2024

[4]Borsellino, V., Schimmenti, E., El Bilali, H., 2020, . Agri-food markets towards sustainable patterns. Sustainability, 12(6), 2193, https://doi.org/10.3390/su12062193

[5]Brunori, G., 2023, Towards a new generation of (agri) food policies. Bio-based and Applied Economics, 12(2), 103-113, https://www.torrossa.com/en/resources/an/5562960#page=25, Accessed on 17.05.2024

[6]Castillo-Díaz, F. J., Belmonte-Ureña, L. J., López-Serrano, M. J., Camacho-Ferre, F., 2023, Assessment of the sustainability of the European agri-food sector in the context of the circular economy. Sustainable Production and Consumption, 40, 398-411, https://doi.org/10.1016/j.spc.2023.07.010

[7]Chiciudean, D.I., Bruma, I.S., Cuibus, L., Arion, I.D., Chiciudean, G.O., 2023, Consumer Perception on the Local Gastronomical Points in Agriculture and Rural Development, Vol. 23(4), 185-194, https://managementjournal.usamv.ro/pdf/vol.23_4/Art18.pdf Accessed on 23.05.2024

[8]Chu, L. K., Doğan, B., Dung, H. P., Ghosh, S., Alnafrah, I., 2023, A step towards ecological sustainability: how do productive capacity, green financial policy, and uncertainty matter? Focusing on different income level countries. Journal of Cleaner Production, 426, 138846, https://www.sciencedirect.com/science/article/abs/pii/S0959652623030044, Accessed on 16.06.2024

[9]Constantin, M., Sapena, J., Apetrei, A., Pătărlăgeanu, S. R., 2023, Deliver smart, not more! Building economically sustainable competitiveness on the grounds of high agri-food trade specialization in the

EU. Foods, 12(2), 232, https://doi.org/10.3390/foods12020232
[10]Cook, L. D., Moore, S., Haynes Brown, T., McCalla, R., Thwaites, K., Weaver, L., Williams-McBean, C., Weaver, S., McCarthy Curvin, A., 2019, A Methodological Review of Mixed Methods Research Studies from Selected Journals in the Caribbean. International Journal of Multiple Research Approaches, 11(3), 10.29034/ijmra.v11n3a3, Accessed on 23.05.2024
[11]Cricelli, L., Mauriello, R., Strazzullo, S., 2024, Technological innovation in agri-food supply chains. British Food Journal, 126(5), 1852-1869, https://www.emerald.com/insight/content/doi/10.1108/BFJ-06-2022-0490/full/html, Accessed on 22.05.2024
[12]de Oliveira, G. M., Miranda, B. V., Saes, M. S. M., Martino, G., 2023, Opening the "black box" of food safety policy implementation: The efficiency-enhancing role of a private meso-institution. Food Policy, 121, 102528, https://www.sciencedirect.com/science/article/abs/pii/S0306919223001264, Accessed on 21.05.2024
[13]Derakhti, A., Santibanez Gonzalez, E. D., Mardani, A., 2023, Industry 4.0 and beyond: a review of the literature on the challenges and barriers facing the Agri-Food supply chain. Sustainability, 15(6), 5078, https://www.mdpi.com/2071-1050/15/6/5078 Accessed on 25.05.2024
[14]Dumitru, E. A., Sterie, C. M., Rodino, S., Butu, M., 2023, Consumer preferences in the purchase of agri-food products: Implications for the development of family farms. Agriculture, 13(8), 1478, https://doi.org/10.3390/agriculture13081478
[15]Figurek, A., Thrassou, A., 2023, An Integrated Framework for Sustainable Development in Agri-Food SMEs. Sustainability, 15(12), 9387, https://www.mdpi.com/2071-1050/15/12/9387 Accessed on 03.06.2024
[16]Froehlich, D. E., Rehm, M., Rienties, B. C., 2020, Mixed methods social network analysis. Mixed methods social network analysis: Theories and methodologies in learning and education, Routledge, 1-10.
[17]Ibinceanu Onica, M.C., Cristache, N., Dobrea, R.C., Florescu, S.M., 2021, Regional development in Romania: Empirical evidence regarding the factors for measuring a prosperous and sustainable economy. Sustainability, 13(7), 3942, https://www.mdpi.com/2071-1050/13/7/3942, Accessed on 30.11.2024
[18]Hermesse, J., Vankeerberghen, A., Lohest, F., Truyffaut, A., 2023, Co-creative research for transitioning toward a fair and sustainable agri-food system in Brussels, Belgium. Frontiers in Sustainable Food Systems, 7, 868982, https://www.frontiersin.org/journals/sustainable-food-systems/articles/10.3389/fsufs.2023.868982/full Accessed on 12.06.2024
[18]Kalimuthu, T., Kalpana, P., Kuppusamy, S., Sreedharan, V. R., 2024, Intelligent decision-making framework for agriculture supply chain in emerging economies: Research opportunities and challenges. Computers and Electronics in Agriculture, 219, 108766, https://www.sciencedirect.com/science/article/abs/pii/S0168169924001571 Accessed on 26.05.2024
[20]Kastelli, I., Mamica, L., Lee, K., 2023, New perspectives and issues in industrial policy for sustainable development: from developmental and entrepreneurial to environmental state. Review of Evolutionary Political Economy, 4(1), 1-25, https://link.springer.com/article/10.1007/s43253-023-00100-2 Accessed on 23.05.2024
[21]Mishra, D., Muduli, K., Sevcik, L., Jana, S. K., Ray, M., 2023, Combating of associated issues for sustainable agri-food sectors. Sustainability, 15(13), 10096, https://www.mdpi.com/2071-1050/15/13/10096 Accessed on 13.06.2024
[22]Morna, A. A., Brata, A. M., Tirpe, O. P., Muresan, I. C., Arion, F. H., Fora, A. F., ... & Bacter, R. V. 2023, Analysis of the factors and barriers influencing the consumption of organic products. Case of Bihor county, Romania. Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development, 23(3), 605-616, https://managementjournal.usamv.ro/pdf/vol.23_3/Art63.pdf, Accessed on 29.05.2024
[23]Nedelcu, A., Murărasu, I. C., Bulgaru, I. A., 2023, The competitiveness of the Romanian agri-food sector in comparison with European countries. Romanian Economic Journal, 26(86), 101-106, https://ideas.repec.org/a/rej/journl/v26y2023i86p101-106.html, Accessed on 03.06.2024
[24]Nijloveanu, D., Tita, V.D., Bold, N., Dinu, T.A., Fîntîneru, G., Smedescu, D., Peticila, A.G., Smedescu, C.A., Fîntîneru, A., Mihalascu, C., Stoian, M., 2024, Developing a Model Based on a Statistical Analysis of Food Loss And Waste Patterns, in Scientific Papers-Series Management Economic Engineering in Agriculture and Rural Development, Vol. 24(2), 705-712, https://managementjournal.usamv.ro/pdf/vol.24_2/Art78.pdf Accessed on 15.06.2024
[25]Ning, L., Abbasi, K. R., Hussain, K., Alvarado, R., Ramzan, M., 2023, Analyzing the role of green innovation and public-private partnerships in achieving sustainable development goals: A novel policy framework. Environmental Science and Pollution Research, 1-17, https://link.springer.com/article/10.1007/s11356-023-26414-6 Accessed on 09.06.2024
[26]Oltean, RC., Chifor, C., Isarie, V.I., Arion, I.D., Muresan, I.C., Arion, F.H., 2023, Environmental and Agrifood Cultural Tradition Preservation as Part of Rural tourism. A Systematic Literature Review in Romania, in Scientific Papers-Series Management Economic Engineering in Agriculture and Rural Development, Vol. 23(2), 501-516, https://managementjournal.usamv.ro/pdf/vol.23_2/Art57.pdf Accessed on 03.06.2024
[27]Poponi, S., Arcese, G., Ruggieri, A., Pacchera, F., 2023, Value optimisation for the agri-food sector: A circular economy approach. Business Strategy and the

Environment, 32(6), 2850-2867, https://onlinelibrary.wiley.com/doi/full/10.1002/bse.3274 Accessed on 28.05.2024
[28]Rațu, R. N., Veleșcu, I. D., Stoica, F., Usturoi, A., Arsenoaia, V. N., Crivei, I. C., Postolache, A.N., Lipsa, F.D., Filipov, F., Florea, A.M., Chitea, M.A., Brumă, I. S., 2023, Application of Agri-Food By-Products in the Food Industry. Agriculture, 13(8), 1559, https://doi.org/10.3390/agriculture13081559
[29]Royer, S., Simon, M., 2023, Small but powerful—local value chains and sustainability-oriented approaches in the agri-food sector. Business and Society Review, 128(2), 331-366, https://onlinelibrary.wiley.com/doi/full/10.1111/basr.12315 Accessed on 21.06.2024
[30]Ryan, M., 2023, Labour and skills shortages in the agro-food sector, OECD Food, Agriculture and Fisheries Papers, No. 189, OECD Publishing, Paris, https://doi.org/10.1787/ed758aab-en
[31]Smedescu, D., Tudor, V., Smedescu, C., Panait, R., Fintineru, A., 2024, Market Trends in The European Union Beverage Industry, in Scientific Papers-Series Management Economic Engineering in Agriculture and Rural Development, Vol. 24(2), 857-864, https://managementjournal.usamv.ro/pdf/vol.24_2/Art94.pdf Accessed on 28.05.2024
[32]Stads, G. J., Nin-Pratt, A., Wiebe, K., Sulser, T. B., Benfica, R., 2023, Public investment in agri-food system innovation for sustainable development. Frontiers of Agricultural Science and Engineering, 10(1), 124-134, https://journal.hep.com.cn/fase/EN/abstract/article/2095-7505/34292 Accessed on 16.06.2024
[33]Stanton, J., Caiazza, R., 2023, Trends Shaping the Future of Agrifood. In Agricultural Value Chains-Some Selected Issues. IntechOpen, https://www.intechopen.com/chapters/87074 Accessed on 22.05.2024
[34]Sugozu, I. H., Yasar, S., Verberi, C., 2023, The relationship between long-term portfolio investments and growth in the context of asset characteristics and development level. Borsa Istanbul Review, 23(1), 34-43, https://www.sciencedirect.com/science/article/pii/S2214845022000692, Accessed on 09.06.2024
[35]Ungureanu, A. V., 2020 (August), The transition from industry 4.0 to industry 5.0. The 4Cs of the global economic change. In 16th Economic International Conference NCOE 4.0 2020 (pp. 70-81). Lumen, Publishing House, https://www.ceeol.com/search/chapter-detail?id=971682 Accessed on 25.05.2024
[36]Vachanelidou, O., Karelakis, C., Loizou, E., Zafeiriou, E., 2024, Relationships and Interdependencies of the Agri-Food Sector in a Regional Economy: Employing an Input-Output Model. Journal of International Food & Agribusiness Marketing, 36(1), 23-46, https://www.tandfonline.com/doi/abs/10.1080/08974438.2023.2281327 Accessed on 21.06.2024
[37]Xing, M., Cao, J., Cao, D., 2023, Impacts of policy mix comprehensiveness on BIM implementation: Moderating effects of environmental state and response uncertainty. Journal of Construction Engineering and Management, 149(2), 04022171, https://ascelibrary.org/doi/abs/10.1061/JCEMD4.COENG-12716 Accessed on 21.06.2024

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GLOBALIZATION OR GLOCALIZATION? A COMPARATIVE ANALYSIS OF AGRI-FOOD SYSTEMS IN NIGERIA AND DEMOCRATIC REPUBLIC OF CONGO AMID GLOBAL CRISES

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Abstract

The study analyses the impact of recent global crises on the agri-food systems from Nigeria and the Democratic Republic of Congo (DR Congo), exploring vulnerabilities generated by globalization, and to adopt glocalization principles as solution to increase resilience and sustainability. Through a comparative approach, the research identifies the main challenges, such as high dependence on imports, poor agricultural infrastructure, and significant post-harvest losses, and highlights the potential of traditional crops, such as cassava and sorghum, in reducing food insecurity. The study proposes measures for crop diversification, infrastructure investments, and the adoption of sustainable agricultural practices, adapted to local conditions, as well as the need for regional collaboration and international partnerships to reduce structural vulnerabilities, concluding that a balanced integration of globalization and glocalization, adapted to local specificities, is a solution to strengthen food security. This analysis contributes to understanding the interdependence between global and local factors, providing insights to develop more resilient agri-food systems.

Key words**:** *DR Congo, Nigeria, food security, globalization, glocalization*

INTRODUCTION

Nigeria, the most populous country in Africa, and DR Congo, a country with vast natural resources, are emblematic cases for analyze the impact of globalization and glocalization on food security. With rapidly growing populations – more than 220 million in Nigeria and more than 100 million in DR Congo – both countries face significant challenges in feeding their populations (Anyanwu & Jukes, 1991; Karume et al., 2022) [7, 17]. Globalized agri-food systems, while bringing economic benefits through efficiency and access to expanded markets, have proven vulnerable to recent global crises, such as the COVID-19 pandemic and the conflict between Russia and Ukraine (Andam et al., 2020; Manyong et al., 2022) [6, 18].

Globalization - Opportunity and vulnerability

Globalization, defined as the process of worldwide economic, cultural and social interconnection, has been essential for the development of international trade and increased access to food resources (Folorunso et al., 2024; FAO, 2024) [12, 13]. In the context of agriculture, globalization has facilitated access to advanced technologies, fertilizers, and export markets for producers, transforming agriculture from a local activity into a complex global system. By creating extensive and interdependent supply chains, globalization has enabled the growth of large-scale food production and distribution, thereby reducing costs and giving consumers access to a diverse range of products.

However, over-reliance on these globalized systems has demonstrated major vulnerabilities to external disruptions (FAO, n.d.a; FAO, n.d.b) [14, 15]. In case of Nigeria, massive wheat imports from Russia and Ukraine – which account for around 30% of global wheat trade – have been severely affected by the conflict between the two countries (World Bank, 1. n.d.; World Bank, 2. n.d.) [30, 31]. This led to significant price increases on the domestic market and reduced food affordability for the poor people. In DR Congo, where the agricultural and logistics infrastructure is much less developed, the effects of the COVID-19 pandemic have been amplified by difficulties in transport and distribution, isolating many regions from the supply with basic food products (Chiarini, 2021; Manyong et al., 2022) [11, 18]. These crises have demonstrated that while globalization offers substantial benefits, exclusive reliance on global markets amplifies the risks associated with disruptive events.

Glocalization - Solution for sustainable future

In contrast to globalization, glocalization combines the advantages of global interconnectedness with adaptations at local level. The concept of glocalization involves customizing global products, services, and strategies to meet local needs and preferences (Folorunso et al., 2024) [12]. In agriculture, glocalization can mean promoting traditional crops, supporting small farmers, increasing farmers' income and their living standard, reducing dependence on imports and strengthening regional markets (Adebisi et al, 2021) [1].

In Nigeria, glocalization can play a critical role in reducing vulnerabilities and increasing resilience. By growing wheat locally or replacing it with alternatives better suited to the region's climate, such as cassava or sorghum or fish, the country could significantly reduce its dependence on foreign markets (Bradley et al., 2020; FAO, 2024; Akinkunmi et al., 2024) [8, 13, 3]. Also, the implementation of localized distribution networks and agricultural cooperatives could increase access to markets and better incomes for farmers, while supporting the rural economy.

In DR Congo, promoting subsistence agriculture by capitalizing on local crops such as cassava, yam and maize can ensure better food security. Although poor infrastructure limits access to international markets, glocalization could support local farmers by stimulating regional trade and reducing dependence on imports. Thus, DR Congo can turn current challenges into opportunities for a growth and sustainable adaptation.

Interdependence between globalization and glocalization

Although globalization and glocalization are often considered opposite approaches, they can be complementary. Glocalization does not imply the complete rejection of globalization, but the selective integration of global elements that can support local development. For example, Nigeria can use global agricultural technologies to improve the productivity of local farmers and increasing domestic production, while reducing the dependence on imports (Busari and Kehinde, 2021) [9].

Globalization has favored migration from the developing countries to the developed ones looking for jobs and a better life, and this has affected the local labour force and the economic growth (Iheke, 2016) [16], especially in Nigeria where agriculture has an important contribution to GDP (Okezie and Ihebuzoaju, 2017 [23].

Also, the alignment to UN SDGs in Nigeria is another form of glocalization connected to globalization for reducing poverty (Akpan et al, 2024) [4].

On the other hand, the adoption of glocalization requires well-thought-out public policies and significant investments in agricultural infrastructure, farmer education and access to finance. In addition, supporting local production must be accompanied by measures to reduce the impact of climate change, such as use of sustainable technologies and promotion of regenerative agriculture.

The paper analyzes the impact of recent global crises, such as the COVID-19 pandemic and the conflict between Russia and Ukraine, on the agri-food and agro-industrial sectors in Nigeria and DR Congo. The main objective is to assess how globalization and glocalization influence food security in these two countries,

highlighting both the vulnerabilities created by integration into global markets and the opportunities offered by harnessing local resources.

Through this approach, the study aims to:

-identify the key findings from the global crises in relation to the agri-food systems of Nigeria and DR Congo;

-explore the complementarity between globalization and glocalization to ensure food security;

-propose strategies adapted to local conditions to increase the resilience and sustainability of the agri-food systems in the two countries.

The comparative analysis between Nigeria and DR Congo provides a framework to understand how different policies and strategies can influence the response to global crises. Through this approach, our study contributes to the development of solutions applicable not only to Nigeria and DR Congo, but also to other African countries facing similar challenges. Not at least, our goal is to support the formulation of effective policies to ensure long-term food security in the context of an increasingly volatile global environment.

MATERIALS AND METHODS

This study uses a systematic documentary approach to analyze the influence of globalization and glocalization on food security in Nigeria and DR Congo, with a specific focus on the impact of recent global crises such as the COVID-19 pandemic and the conflict between Russia and Ukraine. The methodology adopted is based on literature review and use of relevant secondary data.

Data collection and selection criteria. For the comparative analysis, data sources from following categories were selected:

-*International databases*. FAOSTAT, World Bank Data and United Nations Food and Agriculture Organization (FAO) reports;

-*Scientific literature*. Peer-reviewed articles available in Scopus and Web of Science covering topics such as globalization, glocalization and food security;

-*Government reports.* National strategies and documents published by the authorities of Nigeria and DR Congo on agriculture and food security;

-*Regional case studies.* Empirical analyzes of local agriculture in the two countries, with focus on their responses to global crises.

Analyzed indicators. To highlight the differences and similarities between Nigeria and DR Congo, the analysis included following indicators:

-*Dependence on imports*. Share of food imports in total consumption;

-*Local production*. Yields for staple crops (wheat, cassava, rice, sorghum);

-*Impact of global crises.* Food price fluctuations and household accessibility to essential products;

-*Role of glocalization.* Local agricultural practices and the adoption of sustainable strategies,

-*Agricultural infrastructure.* Availability of storage, irrigation and transport.

Data analysis approach. The analysis followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) (Moher, 2009) [21]. The guideline was followed to ensure a rigorous and replicable selection of sources.

Selection criteria. To ensure a systematic and transparent selection process, the study applied the PRISMA guidelines, with the following inclusion and exclusion criteria:

- *Inclusion criteria:*

-Studies published in peer-reviewed journals from 2010 to 2023;

-Reports and datasets from FAO, World Bank, UN focusing on Nigeria and DR Congo;

-Empirical studies, case studies, and systematic reviews relevant to agri-food systems.

- *Exclusion criteria:*

-Articles without full-text access or not written in English;

-Studies focused on food security outside Africa, unless they provide comparative insights;

-Opinion pieces, editorials, and articles lacking empirical data.

Keywords used were: "Globalization", "Glocalization", "Food security", "Nigeria", "DR Congo", "COVID-19", "Russia-Ukraine Conflict".

Period analyzed. 2010–2023.

Data synthesis. The information was organized into three main dimensions:
- *Impact of global crises.* Evaluation of how the COVID-19 pandemic and the Russia-Ukraine conflict disrupted food systems in Nigeria and DR Congo;
- *Opportunities of glocalization.* Assessment of local agricultural strategies that can enhance food security and reduce dependency on imports;
-*Diversification and resilience strategies.* Analysis of policy measures, infrastructure investments, and sustainable agricultural practices that can strengthen agri-food systems.

Comparative methodology. To emphasize the main insights of this study, a comparative method was applied, analyzing the following aspects:
-the different levels of global integration of Nigeria and DR Congo;
-the local strategies used to deal with agri-food vulnerabilities;
-the potential to adopt glocalization as a sustainable solution for both countries.

This methodological framework provides a solid basis to analyze the impact of globalization and glocalization, as well as to identify solutions adapted to local conditions.

RESULTS AND DISCUSSIONS

Impact of global crises on supply chains in Nigeria and DR Congo

Agri-food supply chains in Nigeria and DR Congo have been deeply affected by two recent global events: the COVID-19 pandemic and the conflict between Russia and Ukraine. These two crises have exposed significant vulnerabilities of the food systems on this two countries, which rely heavily on global markets for the supply of staples. Analysing the impact of these crises in Nigeria and DR Congo highlights both country-specific challenges and common vulnerabilities.

The COVID-19 pandemic and the effects on imports and prices

The COVID-19 pandemic has significantly disrupted global supply chains, with severe consequences on access to food in Nigeria and DR Congo. Transport restrictions, logistical bottlenecks and labor cuts have limited the flow of essential imports. In Nigeria, imports of wheat, widely used to make bread, fell by 25% from 2020 to 2022, caused by international transport restrictions and rise of global wheat prices (FAO, 2024; World Bank b, n.d.) [13, 31]. As a result, prices of bakery products have increased by over 40%, disproportionately affecting vulnerable urban households.

In DR Congo, the pandemic has exacerbated already existing infrastructure and logistics problems (FAO, 2024; World Bank a, n.d.) [13, 30]. Isolated regions, which depend on imports to supply their food needs, faced acute shortages of corn and vegetable oils. Due to transportation restrictions and poor infrastructure, many rural communities were completely cut off from food supply (Chiarini, 2021; Manyong et al., 2022) [11, 18]. In addition, transport costs have risen significantly, contributing to rise of food prices by up to 35%.

The conflict between Russia and Ukraine, a catalyst for food insecurity

The conflict between Russia and Ukraine, which erupted in 2022, amplified already existing vulnerabilities, having a profound impact on grain and fertilizer global markets (Amare et al., 2024; FAO, 2024) [5, 13]. Russia and Ukraine are responsible for about 30% of global wheat exports, and the disruption of this flow has led to a massive increase in prices at global level. In Nigeria, this dependence on wheat imports from the Black Sea region has led to an acute food crisis (Wuepper et al. 2024) [29]. Rise of wheat prices had a domino effect on other staple foods, further limiting households' access to adequate nutrition (Matemilola, 2017; Onilogbo, 2024) [19, 25].

In DR Congo, the effects of the conflict were mainly felt through increased prices of fertilizers and other agricultural inputs. Congolese farmers, who already faced financial difficulties, could no longer afford to purchase fertilizers, leading to lower yields for essential crops such as cassava and maize (Chiarini, 2021; Rossi et al. 2006) [11, 27]. This decline in domestic production has exacerbated food insecurity in rural areas,

where subsistence agriculture is the main source of food.

Common issues: infrastructure and access to markets

Although the pandemic and conflict have affected Nigeria and DR Congo differently, there are common challenges that have amplified the effects of these crises. Poor infrastructure is one of the main barriers in both countries. In DR Congo, the lack of roads and efficient transport networks makes food distribution a challenge, especially in isolated regions. In Nigeria, although infrastructure is better developed, congested ports and inadequate storage infrastructure have exacerbated post-harvest delays and losses (Table 1).

Table 1. Impact of global crises on supply chains (2019–2022)

Indicator	Nigeria	DR Congo
Decrease in imports (%)	-25% (wheat)	-30% (maize)
Price increase (%)	+40% (bread)	+35% (vegetable oil)
Food accessibility	Reduced in urban areas	Severely affected in rural areas

Source: Our World in Data, 2023 [26].

Key findings from global crises

Recent crises have highlighted the need for strategic changes in agri-food systems in Nigeria and DR Congo to reduce vulnerabilities and increase resilience. On the base the key findings, three main directions of action were identified.

Diversification of supply sources. A key lesson derived from the COVID-19 pandemic and the conflict between Russia and Ukraine is the need to reduce dependence on grain imports. Nigeria and DR Congo, like many other African states, are significantly dependent on global markets for products such as wheat, maize and rice. This dependence makes them highly vulnerable to disruptions in global supply chains.

Diversification can be achieved by stronger domestic production, promotion of traditional crops adapted to local climates, such as cassava and sorghum, and support for small farmers to accessible technologies and local resources. Also, increasing rice production in Nigeria through national programs such as the "Rice Revolution", is a positive example that could be replicated and expanded to other sectors and regions.

Infrastructure improvement

Agricultural infrastructure plays a critical role in supply chains, and its lack has amplified the impact of crises in both countries. The development of transport networks, including more efficient rural roads and ports, is essential to ensure faster and more reliable food distribution.

In Nigeria, overburdened ports and inadequate storage infrastructure have caused significant delays in processing imports and considerable post-harvest losses. In DR Congo, the lack of adequate roads has isolated entire communities, preventing access to domestic and regional markets. Developing modern warehouses and cold storage facilities can reduce food losses, thereby increasing the efficiency of supply systems and reducing pressures on local farmers.

Creation of regional trade networks

Intra-continental cooperation and the stimulation of regional trade represent another essential direction to reduce vulnerabilities. Economic integration among African countries can provide viable alternatives to dependence on foreign markets. Developing regional trade networks such as the African Continental Free Trade Area (AfCFTA) [2], countries can harness local resources and boost regional production.

In the context of DR Congo, this could mean expanding trade with neighboring countries to facilitate distribution of agricultural products, while in Nigeria, expanding access to regional markets could strengthen incomes of small and medium farmers. These initiatives not only reduce exposure to global risks but also provide a platform for sustainable economic development.

By implementing these measures, Nigeria and DR Congo can reduce the risks associated with global shocks, ensure a more sustainable agri-food system and increase the population's resilience to future crises. The key findings emphasize the need for a balance between food autonomy and integration into global markets, a strategic approach that can transform current vulnerabilities into opportunities for development.

Opportunities offered by glocalization

Glocalization offers a strategic and sustainable alternative to reduce agri-food vulnerabilities in Nigeria and DR Congo (Folorunso et al., 2024; Omotoso & Omotayo, 2024) [12, 24].This concept involves the adaptation of global resources to local needs and conditions, emphasizing the use of traditional cultures and the development of the local economy. Facing recent global crises, such as COVID-19 pandemic and conflict between Russia and Ukraine, glocalization has emerged as a viable solution to strengthen food security and increase resilience.

Capitalizing on traditional cultures

A central aspect of glocalization is the promotion of traditional cultures (Bradley et al., 2020; FAO, 2024) [8, 13]. These are better adapted to local conditions and more resistant to climate change (Table 2).

Table 2. Yield, Drought resistance, and Costs of local vs. Imported crops in Nigeria and DR Congo

Culture	Local yield (tons/ha)	Drought resistance	Production cost ($/ha)	Main use
Cassava	15 (Nigeria)	High	350	Staple foods (fufu, gari)
	14 (DR Congo)	High	300	Staple foods (kwanga, chikwangue)
Imported wheat	3 (Nigeria)	Low	800	Bakery products
	2.5 (DR Congo)	Low	850	Bakery products
Sorghum	10 (Nigeria)	High	400	Animal feed, beer and traditional food
	7 (DR Congo)	High	380	Animal feed and traditional food

Source: Our World in Data, 2023 [26].

In Nigeria, cassava, sorghum and yam are staple crops used for both human and animal food (Figure 1).

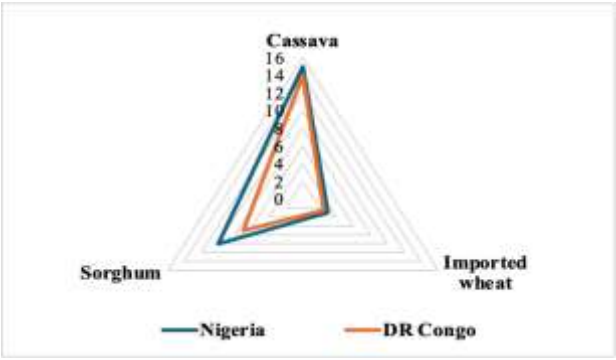

Fig. 1. Local yield (tons/ha)
Source: by authors based on the data from Our World in Data, 2023 [26].

Initiatives such as the "Rice Revolution" have demonstrated the effectiveness of strategies to promote domestic production. During 2017–2021, Nigeria managed reduce of rice imports by 30%, partially replacing them with domestic production (Figure 2).

In DR Congo, cassava plays a crucial role, being widely consumed in traditional forms such as kwanga and chikwangue. Yams and maize are also grown on a small scale in households and agricultural cooperatives (Figure 1). These crops have the potential to replace imported products, thereby reducing costs and dependence on foreign markets.

However, high post-harvest losses caused by poor infrastructure limit the efficiency of these crops (Figure 2).

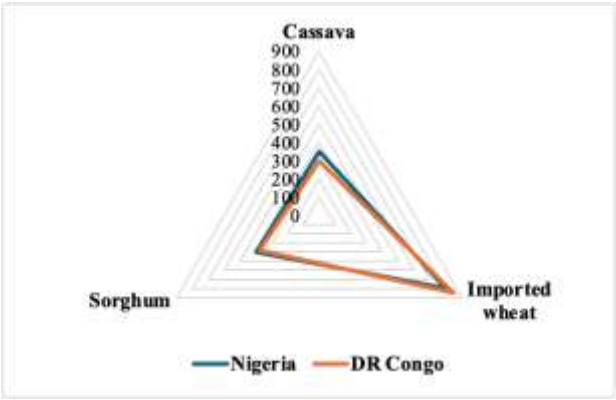

Fig. 2. Production cost for cassava, sorghum, and imported wheat (USD/ha)
Source: by authors based on the data from Our World in Data, 2023 [26].

Supporting small farmers

In both countries, small farmers are the backbone of agriculture. In Nigeria, financial support programs and access to inputs such as

fertilizers and seeds have helped increase productivity. Examples include the subsidized distribution of agricultural inputs through government programs. In addition, creation of agricultural cooperatives and local markets facilitated the sale of surplus production, boosting farmers' incomes.

In DR Congo, small farmers are responsible for about 80% of agricultural production. However, limited access to agricultural technologies and financial resources represent significant obstacles. Glocalization can contribute to the creation of local support networks and promotion of agricultural cooperatives. They can reduce production costs, facilitate access to markets and ensure more efficient distribution of agricultural products.

Development of regional markets

Another element of glocalization is the creation and expansion of regional markets to reduce dependence on global imports. In Nigeria, the promotion of trade between West African states has enabled the development of better integrated local and regional markets. This helped increase exports of products such as sorghum and rice.

In DR Congo, the lack of road infrastructure and organized markets limits regional trade. However, the potential to expand local markets through regional cooperation networks is significant. By developing infrastructure and connecting farmers to larger markets, DR Congo could reduce post-harvest losses and increase farmers' incomes.

Key findings from applying glocalization

The experiences of Nigeria and DR Congo highlight the importance of glocalization as a strategy to reduce vulnerabilities associated with global supply chains and enhance food security. Recent crises have demonstrated that the integration of local solutions adapted to the specific needs of each country can bring significant benefits. Analysis key findings from the application of glocalization principles reveal three essential directions of action: promoting traditional cultures, supporting small farmers and developing regional markets.

Promotion of traditional cultures

One of the most important key findings from the application of glocalization is the relevance of traditional cultures in strengthening food security. Local plants such as cassava, sorghum and yam in Nigeria and cassava, maize and bananas in DR Congo are adapted to the climate and soils specific to each region. These crops offer significant advantages compared to wheat or other imported crops, which require expensive inputs and are more vulnerable to climate change.

For example, in Nigeria, cassava is widely used in staple food preparations such as gari and fufu, being an essential source of calories for the rural and urban population (Sambo &Sule, 2024) [28]. Similarly, in DR Congo, cassava is processed into products such as kwanga and chikwangue, which are staple foods for rural households. These crops not only reduce dependence on imports, but also contribute to food diversification, increasing communities' resilience to global crises.

In addition, the use of traditional crops has a positive economic impact on local farmers, reducing production costs by using local inputs and limiting the risks associated with global price fluctuations. Promoting traditional crops, along with introduction of modern agricultural practices adapted to them, can become a long-term solution to increase the resilience of agri-food systems.

Supporting small farmers

Another crucial lesson is the need to support small farmers, who are the backbone of agriculture in Nigeria and DR Congo. Despite their critical contribution to food security, smallholder farmers face numerous challenges, including limited access to inputs, modern technologies and markets. Investments in agricultural cooperatives and infrastructure can change this dynamic, increasing production efficiency and farmers' incomes.

In Nigeria, programs such as subsidized distribution of seeds and fertilizers have had a positive impact on agricultural productivity. However, limited access to finance remains a barrier for many small farmers. By creating well-organized agricultural cooperatives, farmers can benefit from shared resources, including storage facilities, agricultural technologies and logistical support. This model not only reduces individual costs, but also

facilitates access to local and regional markets. In DR Congo, where small farmers produce more than 80% of the food consumed locally, support for agricultural cooperatives is extremely important. Through them, farmers can access cheaper agricultural inputs, share transport costs and get better prices for their products. Developing the infrastructure such as rural roads and collection centers is essential to integrate these farmers into local and regional supply chains.

Regional integration

Another essential element of glocalization is regional integration, which can help to reduce the dependence on global markets and create sustainable economic opportunities. Currently, many African states, including Nigeria and DR Congo, depend on imports for a wide range of food products, exposing them to risks associated with global price fluctuations and supply chain disruptions. Developing regional markets can provide a viable alternative, creating a more resilient intra-continental trade network (Folorunso et al., 2024; Omotoso & Omotayo, 2024) [12, 24].

In Nigeria, regional trade within the Economic Community of West African States (ECOWAS) has facilitated the expansion of local markets for agricultural products such as sorghum and rice. This integration has helped increase farmers' incomes and reduce post-harvest losses. Similarly, DR Congo could benefit from expanding regional trade by facilitating agricultural exports to neighboring countries. However, this requires significant investment in transport infrastructure and market organization.

Regional integration also provides opportunities to promote traditional crops on a larger scale, boosting production and increasing farmers' incomes. In addition, cooperation between African states can facilitate the transfer of technology and resources, thereby supporting development of a more resilient and sustainable agri-food system.

By capitalizing on traditional crops, supporting small farmers, and regional integration, glocalization can transform the current vulnerabilities of agri-food systems in Nigeria and DR Congo into sustainable opportunities. These key findings highlight the importance of a balance between adapting to local needs and using global resources, offering a promising path to strengthen food security in the long term.

Strategies for diversification and resilience of agri-food systems

Transforming agri-food systems to make them more diverse and resilient is a next important priority for both Nigeria and DR Congo, two countries that face common challenges but also offer valuable key findings through their responses to recent global crises. Diversifying agricultural crops, improving infrastructure and adopting sustainable practices are essential elements to strengthen agri-food resilience facing climate change, global market fluctuations and other disruptive factors (Morgan &Fanzo, 2020; Mekonnen et al., 2021) [22, 20].

Diversification of agricultural crops

Diversification is one of the most important pillars of resilience. In Nigeria, crop diversification has begun to be promoted through government programs that encourage farmers to adopt traditional plants adapted to local conditions, such as cassava, sorghum and yam (Bradley et al., 2020; FAO, 2024) [8, 13]. These crops are not only more drought resistant, but also reduce dependence on imported crops such as wheat. For example, the "Rice Revolution" managed to increase domestic rice production by 20% between 2017 and 2021, while reducing imports by over 30%.

In DR Congo, crop diversification is mainly based on use of indigenous plants such as cassava, maize and bananas. However, productivity is limited by lack of access to quality seeds, agricultural inputs and irrigation infrastructure. A promising program is the promotion of vegetable crops in small households, which has improved the diversification of diet and income in certain rural regions. However, these initiatives must be supported by better-structured public policies and substantial funding.

Improving infrastructure and logistics

Agricultural infrastructure plays a key role to reduce post-harvest losses and improve access to markets. In Nigeria, the government has

invested in upgrading silos and creating collection centers for farmers. For example, upgrading storage infrastructure reduced post-harvest losses for cassava by about 10% in the southeastern regions. However, the lack of adequate rural roads remains a major challenge, limiting farmers' access to regional markets.

In DR Congo, the infrastructure deficit is much more severe. Lack of roads and storage centers causes post-harvest losses of up to 30% for crops such as cassava and maize (Table 3).

Table 3. Impact of infrastructure improvements on post-harvest losses in Nigeria and DR Congo

Measure implemented	Losses without infrastructure (%)	Losses with infrastructure (%)
Modern Silos (Nigeria)	25	15
Modernized rural roads	20	10
Collection Centers (DR Congo)	30	20

Source: Our World in Data, 2023 [26].

Investments in rural roads and storage facilities could greatly increase the efficiency of supply chains and farmers' incomes.

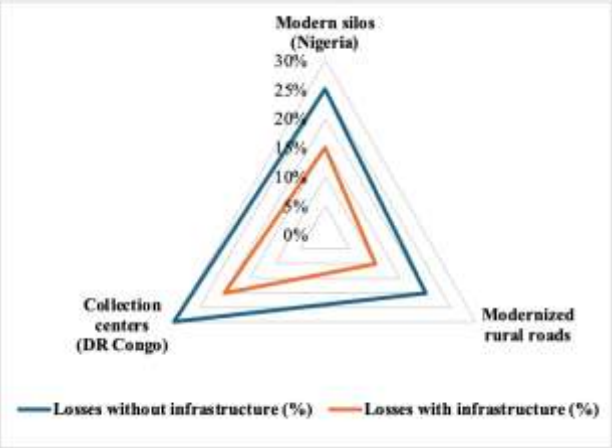

Fig. 3. Comparison of post-harvest losses with and without infrastructure implementation

Source: by authors by authors based on the data from Our World in Data, 2023 [26].

In addition, the development of river transport infrastructure, which is an essential resource in DR Congo, could improve market access for isolated regions (Figure 3).

Adoption of sustainable agricultural practices

Sustainable agricultural practices are fundamental to increase resilience to climate change and protect natural resources. In Nigeria, crop rotation and the use of organic compost have started to be adopted on a large scale, thanks to the support provided through training programs for farmers. Also, the introduction of cover crops, which reduce soil erosion, has helped improve long-term yields.

In DR Congo, organic farming is starting to be promoted in rural areas, where farmers use natural inputs and traditional methods for soil conservation. These practices, although effective in the long term, are still limited by a lack of resources and limited access to modern technologies.

Implementing agricultural education programs that promote regenerative practices could significantly contribute to increasing productivity and reducing dependence on imported chemical fertilizers.

Key findings from the diversification and resilience of agri-food systems

The experiences of Nigeria and DR Congo offer valuable key findings for understanding and applying the principles of glocalization in response to vulnerabilities in agri-food systems. These *key findings* highlights the importance of integrated public policies, infrastructure investments and the promotion of sustainability for the creation of a more resilient and diversified agri-food system.

Integrated public policies

A fundamental pillar of the development of agri-food systems is represented by integrated public policies, which respond to the needs of farmers and support the transition to modern and sustainable agricultural practices. In Nigeria, seed and fertilizer subsidies have supported farmers to increase productivity and diversify crops grown. However, the distribution of subsidies remains uneven, and small farmers' access to these benefits is sometimes limited by complex administrative procedures.

In DR Congo, the lack of a coherent policy framework limits farmers' access to necessary resources, amplifying vulnerabilities. Public policies must include programs that support small farmers by reducing production costs, access to finance and technical training. These measures will not only boost agricultural production, but will also contribute to increasing incomes in rural communities, where agriculture is the main source of livelihood.

Investments in infrastructure

Another important lesson is related to the need for significant investment in agricultural infrastructure. The lack of adequate roads, modern warehouses and efficient transport networks limits farmers' ability to capitalize on their production and contributes to significant post-harvest losses. In Nigeria, infrastructure investments such as modern silos and collection centers have reduced post-harvest losses for cassava and sorghum by up to 10% in some regions. However, these advances are uneven, and an expansion of the infrastructure is also needed in the less accessible areas.

In DR Congo, the impact of the lack of infrastructure is much more severe. Post-harvest losses for cassava and maize can reach up to 30%, due to lack of warehouses and roads to facilitate transport to markets. Infrastructure development, including the use of river transport, represents a unique opportunity for DR Congo, a country characterized by a vast network of navigable rivers. This type of infrastructure could connect isolated regions to larger markets, reducing losses and improving farmers' access to resources.

Promoting sustainability

Adopting sustainable agricultural practices is an essential lesson for reducing the impact of climate change and protecting natural resources. In Nigeria, crop rotation, use of organic compost and planting of cover crops are promoted through educational programs for farmers, with positive results on soil fertility and agricultural yields. However, these practices are mainly adopted by larger farms, with small farmers needing more support to implement them.

In DR Congo, organic farming is often the only viable option for farmers due to limited access to chemical fertilizers and industrial inputs. Traditional methods such as the use of mulch and agroforestry are widely used to conserve soil and reduce moisture loss. However, the effectiveness of these practices can be improved by the introduction of modern technologies adapted to local needs, as well as by access to additional training and resources.

These key findings emphasize the importance of local adaptation of agricultural policies, infrastructure and practices, using the principles of glocalization to address the structural vulnerabilities of agri-food systems in Nigeria and DR Congo. Implementation of these measures requires strong commitment at the national level, as well as international support, to ensure long-term sustainability and resilience.

Policy Recommendations and Strategic Priorities for Agri-Food Resilience

Based on the analysis presented in this study, a set of strategic recommendations emerges as crucial for enhancing the resilience and sustainability of agri-food systems in Nigeria and the Democratic Republic of Congo.

Globalization has played a key role in facilitating technological progress in agriculture, access to international markets, and economic growth (Folorunso et al., 2024; FAO, 2024). In Nigeria, for example, farmers have benefited from imported fertilizers, modern technologies, and foreign investment, which have contributed to increased agricultural productivity (FAO, 2024) [13]. However, these benefits have come at a high cost. Dependence on imports of wheat, maize, and rice has made the country highly vulnerable to global price fluctuations, trade restrictions, and geopolitical crises. In the DR Congo, where infrastructure is poorly developed, globalization has failed to generate significant improvements in food security because local farmers have no access to either global or regional markets (FAO, n.d.a.) [14].

In contrast, glocalization offers a more sustainable solution by capitalizing on local resources and strengthening domestic agricultural production. Promoting traditional crops such as cassava, sorghum, and yams is a viable strategy for reducing import dependence and improving food security at the community level. These crops, already adapted to the local climate, require fewer imported inputs and provide a more stable food supply. In addition, supporting local agricultural cooperatives and creating regional markets can reduce post-harvest losses and increase economic stability.

An important lesson from this analysis is that glocalization does not imply a rejection of globalization, but rather the selective integration of global elements that support local development while avoiding the

vulnerabilities associated with excessive dependence on international markets. For example, Nigeria can adopt modern agricultural technologies, but at the same time it must prioritize domestic food production so that it is not solely dependent on imports. Similarly, the DR Congo needs to invest in infrastructure – roads, warehouses, distribution centers – to reduce post-harvest losses and improve access to local and regional markets.

From an agricultural policy perspective, governments should adopt proactive strategies to support farmer resilience and reduce supply chain vulnerabilities. Key measures can include:

Expanding financing programs and microcredit for small farmers, so that they can invest in production, agricultural equipment, and irrigation. In Nigeria, programmes such as the Anchor Borrowers' Programme have demonstrated that access to finance can increase agricultural productivity (Central Bank of Nigeria, 2024) [10].

Supporting local agricultural cooperatives and regional markets, to facilitate access to more stable commercial opportunities for small farmers.

Investments in agricultural and logistics infrastructure, such as upgrading rural roads, building storage depots and developing agricultural production collection centres.

Promoting sustainable and climate-adapted agriculture, through innovative technologies and training for farmers.

Stimulating intra-regional trade, through integration into the African Continental Free Trade Area (AfCFTA) (African Union, n.d.) [2].

International organizations and NGOs can play a crucial role in implementing these measures. FAO, the World Bank and regional development agencies should support local initiatives through infrastructure projects, farmer financing and knowledge transfer programs.

For a better understanding of the long-term impact of glocalization strategies, further research on the effects of these policies on food security is needed, particularly comparative studies of various government interventions and regional initiatives, providing valuable insights into the most effective solutions for integrating global and local markets.

CONCLUSIONS

The comparative analysis of Nigeria and the DR Congo reveals the scale of the challenges facing agri-food systems in fragile economies in the context of global crises. The COVID-19 pandemic and the conflict between Russia and Ukraine have demonstrated how external shocks can have a severe impact on food supply chains, especially in countries with high import dependence, weak infrastructure and limited institutional capacity. In this context, the choice between globalization and glocalization becomes not a dichotomy but an opportunity for strategic integration.

The study showed that while globalization brings undeniable benefits, such as technological innovation, access to international markets and economic growth, it also creates critical vulnerabilities when local systems are not resilient. Glocalization, on the other hand, offers a more adaptive framework by encouraging the use of traditional crops, strengthening local production systems and promoting regional trade alliances. These elements are not mutually exclusive but must be combined in a way that supports long-term sustainability.

For Nigeria and the DR Congo, the way forward must include a mix of targeted infrastructure investments, support for smallholder farmers, crop diversification, and the creation of robust intra-regional trade networks. Improving food security in both countries requires not only technical solutions, but also inclusive public policies that empower rural communities and reduce structural inequalities.

Moreover, the comparative perspective adopted in this research offers valuable lessons for other African countries with similar socioeconomic and agroecological conditions. The findings emphasize that resilience must be rooted locally, even as countries engage in the global food economy. This means prioritizing policies that adapt international best practices to specific realities on the ground, while

drawing on indigenous knowledge and resources.

The future of food security in Nigeria, the DR Congo, and beyond, therefore, depends on finding the right balance between global integration and local empowerment. Glocalization does not emerge as an alternative to globalization, but as a complement to it - a strategy that turns vulnerabilities into strengths and builds food systems that are not only efficient, but also equitable, inclusive, and prepared for future disruptions.

REFERENCES

[1]Adebisi, O.A., Adebisi, L.O., Oludare, O.T., Daotu, T.O., Owolabi, M.T., 2021, Effect of farm income on the lifestyle factors of farmers in Kwara state, Nigeria. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 21(1), 15-20.

[2]African Union. n.d. The African Continental Free Trade Area. Flagship Projects of Agenda 2063. https://au.int/en/agenda2063/flagship-projects, Accessed on 7 December 2024

[3]Akinkunmi, J. A., Fasina, O. O., Smith, M. A. K., Ekeleme, F., 2024, Factors associated with adoption of sustainable Cassava weed management technology for Cassava systems in Nigeria. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", 24(4). 25-32.

[4]Akpan, S.B., Patrick, I.M.V., Essien, C.A., 2024, The attainment of the United Nation sustainable development goal (SDGs) number two: assessment of some indicators in Nigeria. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 24(1), 25-38.

[5]Amare, M., Abay, K. A., Hatzenbuehler, P., 2024, Spatial market integration during a pandemic: Evidence from food markets in Nigeria. Agricultural Economics, 55(1). 86-103.

[6]Andam, K., Edeh, H., Oboh, V., Pauw, K., Thurlow, J., 2020, Impacts of COVID-19 on food systems and poverty in Nigeria. Advances in food security and sustainability, 5. 145-173.

[7]Anyanwu, R. C., Jukes, D. J., 1991, Food systems and food control in Nigeria. Food policy, 16(2). 112-126.

[8]Bradley, B., Byrd, K. A., Atkins, M., Isa, S. I., Akintola, S. L., Fakoya, K. A., ... & Thilsted, S. H., 2020, Fish in food systems in Nigeria: A review. Penang, Malaysia: WorldFish. Program Report: 2020-06.

[9]Busari, A.O., Kehinde, A.L. 2021, Macro economic variables and Nigeria agricultural trade flows: a gravity model analysis approach. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 21(4), 95-100.

[10]Central Bank of Nigeria. 2024. Anchor Borrowers Programme https://www.cbn.gov.ng/DFD/agriculture/ABP.html, Accessed on 7 December 2024

[11]Chiarini, A., 2021, Effective strategies to eradicate poverty and hunger: Addressing food insecurity-the case of DR Congo. Agenda. https://www.un.org/development/desa/dspd/wp-content/uploads/sites/22/2021/07/Chiarini-final.pdf Accessed on 8 December 2024

[12]Folorunso, G. I., Duruji, M. M., Chidozie, F. C., 2024, Appraisement of glocalisation in the context of Nigeria's foreign policy: A concentric approach. Cogent Arts & Humanities, 11(1), 2286735.

[13] Food and Agriculture Organization of the United Nations (FAO), 2024, Nigeria Country Programming Framework 2023–2027, Abuja, Nigeria, https://openknowledge.fao.org/items/04e693a9-bf50-4071-b7b2-0818eeec929b, Accessed on 8 December 2024

[14]Food and Agriculture Organization of the United Nations (FAO). (n.d.) (a). Country profile Democratic Republic of the Congo https://www.fao.org/countryprofiles/index/en/?iso3=COD, Accessed on 6 December 2024

[15]Food and Agriculture Organization of the United Nations (FAO). (n.d.). (b). Country profile Nigeria https://www.fao.org/countryprofiles/index/en/?iso3=NGA, Accessed on 7 December 2024

[16]Iheke, O.R. 2016, Remittance and th economy: The Nigerian Experience: A review.. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 16(3), 145-152.

[17]Karume, K., Mondo, J. M., Chuma, G. B., Ibanda, A., Bagula, E. M., Aleke, A. L., Ndjadi, S., Ndusha, B., Ciza, P. A., Cizungu, N. C., Muhindo, D., Egeru, A., Nakayiwa, F. M., Majaliwa, J. -G. M., Mushagalusa, G. N., Ayagirwe, R. B. B., 2022, Current Practices and Prospects of Climate-Smart Agriculture in Democratic Republic of Congo: A Review. Land, 11(10). 1850.

[18]Manyong, V., Bokanga, M., Nyamuhirwa, D. M. A., Bamba, Z., Adeoti, R., Mwepu, G., ... & Nguezet, P. M. D., 2022, COVID-19 outbreak and rural household food security in the Western Democratic Republic of the Congo. World development perspectives, 28. 100469.

[19]Matemilola, S., 2017, The challenges of food security in Nigeria. Open Access Library Journal, 4(12). 1.

[20]Mekonnen, D. A., Trijsburg, L., Achterbosch, T., Brouwer, I. D., Kennedy, G., Linderhof, V., ... & Talsma, E. F., 2021, Food consumption patterns, nutrient adequacy, and the food systems in Nigeria. Agricultural and Food Economics, 9(1). 16.

[21]Moher, D., Liberati, A., Tetzlaff, J., Altman, D.G., 2009, Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement, Journal of Clinical Epidemiology, 62(10). 1006-1012.

[22]Morgan, A. E., Fanzo, J., 2020, Nutrition transition and climate risks in Nigeria: moving towards food

systems policy coherence. Current environmental health reports, 7. 392-403.
[23]Okezie, C.R., Ihebuzoaju, O.D., 2017, Sectoral contribution to Gross Domestic Product (GDP) in Nigeria economy (1970 – 2012). Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 17(3), 231-238.
[24]Omotoso, A. B., Omotayo, A. O., 2024, Enhancing dietary diversity and food security through the adoption of climate-smart agricultural practices in Nigeria: a micro level evidence. Environment, Development and Sustainability, 1-18.
[25]Onilogbo, O. N., 2024, Improving food systems for healthy diets and nutrition in Nigeria: Policies and actions. https://hdl.handle.net/10568/151895, Accessed on 7 December 2024
[26]Our World in Data team, 2023, End hunger, achieve food security and improved nutrition and promote sustainable agriculture. OurWorldinData.org. 'https://ourworldindata.org/sdgs/zero-hunger', Accessed on 6 December 2024
[27]Rossi, L., Hoerz, T., Thouvenot, V., Pastore, G., Michael, M., 2006, Evaluation of health, nutrition and food security programmes in a complex emergency: the case of Congo as an example of a chronic post-conflict situation. Public Health Nutrition, 9(5). 551–556.
[28]Sambo, U., Sule, B., 2024, Impact of climate change on food security in Northern Nigeria. Green and
[29]Wuepper et al., 2024, processed by Our World in Data. “Intensity of agricultural-environmental policies” [dataset]. Wuepper et al. (, “agricultural_policies_wuepper” [original data]. https://ourworldindata.org/grapher/agri-environmental-policies-intensity?tab=chart&country=NGA, Accessed on 7 December 2024
[30]World Bank. (n.d.). (a). DR Congo Overview. https://www.worldbank.org/en/country/drc/overview, Accessed on 8 December 2024.
[31]World Bank. (n.d.). (b). Nigeria Overview https://www.worldbank.org/en/country/nigeriahttps://www.worldbank.org/en/country/nigeria, Accessed on 8 December 2024.

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FOOD SYSTEM APPROACH IN ROMANIA: CHALLENGES AND OPPORTUNITIES

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Abstract

This paper investigates the implementation of a food system approach in Romania, focusing on its potential to enhance the resilience and sustainability of the food system, particularly for small producers. Drawing on existing literature, the study identifies key actors and themes within the Romanian food system. The findings highlight the crucial role of collaborative partnerships—as emphasized in the EU's Food 2030 strategy—in achieving inclusive growth and building a resilient agricultural framework. The research concludes that aligning with European directives necessitates fostering partnerships and implementing systemic changes through well-funded research and inclusive strategies to overcome challenges faced by small producers and build a more robust and equitable food system in Romania. The study emphasizes the interconnectedness of food processes for security and sustainability, underscoring the need for a holistic approach to address the specific challenges faced by small-scale producers.

Key words**:** *food production, food consumption, governance, small producers, sustainability*

INTRODUCTION

The agri-food system is a complex and interconnected network essential for ensuring food security, sustainability, and economic stability. Currently, we face unprecedented challenges, including the climate crisis, conflicts like the recent war in Ukraine, resource scarcity, inequality, food insecurity, malnutrition, and environmental degradation - particularly impacting marginalized rural communities and the urban poor. After decades of decline, the global hunger rate, which reversed in 2015, has stagnated below 11 percent, leaving over 820 million people hungry in 2018 (FAO, 2018) [19]. Presently, more than 110 million people are experiencing food crises, and this situation is likely to worsen if current trends continue.

These challenges stem from three main drivers:

- **Socio-economic factors**: demographic changes, urbanization, increasing inequality, limited resource access, unhealthy eating habits, and poverty.
- **Environmental factors**: climate change, soil degradation, over-exploitation of natural resources, and water scarcity.
- **Peace and security issues**: armed conflict, governance challenges, and violations of fundamental rights.

The EU, through frameworks such as the European Green Deal, the Farm to Fork Strategy, and the Biodiversity Strategy, aims to address these complexities by shaping agricultural and food policies that align with global sustainability goals. However, the current EU food system, including Romania's, primarily focuses on short-term economic gains and food safety, often neglecting broader sustainability aspects. A necessary paradigm shift is required to move from a short-term "productivist view" to a long-term commitment to inclusive food security that does not harm the environment or undermine food systems elsewhere (Bock, A.K., Bontoux, L., Rudkin, J., 2022) [6].

This transition necessitates simultaneous changes across multiple areas of the food system, supported by integrated policies tailored to Romania's specific context. Urgent action is required due to the significant challenges posed by climate change and biodiversity loss, with a limited timeframe to avert irreversible damage. While voluntary measures may initiate change, binding rules are

essential for establishing ambitious goals and providing reliability.

Key actors within Romania's food system-such as primary producers, food and drink manufacturers, retailers, and financial entities must be empowered to promote sustainability alongside collective consumer actions. Transparency and accountability are critical, particularly in addressing sustainability impacts at both production and consumption levels. Thus, Romania should shift its focus from immediate economic growth to sustainable and equitable food security, aligning with broader EU objectives. To address these dynamics, the EU, in collaboration with the FAO, organized the High-Level Event "Food & Agriculture in Times of Crisis: Working Better Together for Long-Term Solutions" on April 1-2, 2019, emphasizing the urgent need for a sustainable food systems approach to tackle interconnected issues effectively.

Food production, while supporting many livelihoods, is also associated with numerous sustainability challenges: poverty affects the potential of food production by triggering high levels of agricultural employment; practices such as land clearing lead to the increase of greenhouse gas emissions and to loss of biodiversity; yields in already at-risk areas are reduced due to climate change; demand for nutritious food increases although malnutrition from unhealthy diets remains a global health concern (IPBES, 2019; Springmann et al., 2018; Swinburn et al., 2019; Willett et al., 2019) [33, 46, 47, 51]. The connection between food security, environmental sustainability, and social equity does not receive sufficient attention in addressing these challenges (IPCC, 2019) [35]. Tackling one issue may unintentionally exacerbate others, emphasizing the need for a balanced approach to managing sustainability trade-offs across the various dimensions of the food system (Béné et al., 2019) [3, 4].

A food systems approach (FSA) analyzes the interconnectedness of food-related components and their impacts on sustainability, resilience, and equity. This holistic perspective is increasingly recognized as essential for addressing the multifaceted challenges facing global food systems.

This research explores the potential of adopting an FSA in Romania, focusing on implications for small-scale producers, who constitute a significant proportion of the country's agricultural sector. It aims to examine the current EU policy landscape regarding the adoption and implementation of FSA, review the existing literature on food system resilience and sustainability, and identify challenges and opportunities for adopting it at the national level. The study outlines the necessary steps for implementing a sustainable FSA in Romania, leveraging (points of interventions for maximizing the benefits) an analysis of the policy environment, the Romanian agri-food sector, and the transition from a productivity-centred model to a systems-oriented approach. Given the current limited information and research on Romania's agri-food system, this article seeks to clarify strategies to address these challenges while emphasising the absence of a clear definition and conceptualization of the FSA in the existing literature.

The research is structured around three key questions:

1. Why is adopting the FSA important?
2. What is the policy context for adopting an FSA?
3. What key aspects should be considered when implementing the "FSA" in Romania?

MATERIALS AND METHODS

To analyse the policy context for implementing the Food System (FS) approach and to understand how to identify key aspects for its application in Romania, this research employed a mixed-methods approach.

This approach included a comprehensive literature review, qualitative analysis of policy documents, secondary data analysis, and in-depth interviews.

Additionally, insights were gained from observations made during relevant workshops and conferences, further enhancing the depth of the findings.

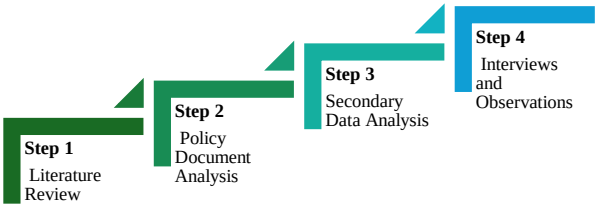

Fig. 1. Methodological steps for responding to the research questions
Source: Own design of the methodological steps.

These four methodological steps are described below, conducting the research.

Literature Review

A comprehensive literature review was undertaken, concentrating on key themes such as food systems, sustainability, resilience, governance, and the application of the FSA in diverse contexts. Databases such as Scopus, Web of Science, and Google Scholar were accessed to review both academic and grey literature. To address the research questions, search keywords included "food system approach", "food system sustainability," "food system transformation", "food system resilience", "smallholder farmers in the food system", and "agri-food system in Romania".

From this search, 24 records were identified in Scopus and 27 in Web of Science and Google Scholar. After removing duplicates, 12 articles remained. Article titles, keywords, and abstracts were then screened to ensure they aligned with the research aims and met quality standards.

The exclusion criteria applied were as follows:

- articles that did not primarily focus on FS, even if terms such as “food system” or “governance” appeared in their abstracts. For example, studies focused on “nutrition”, “water governance”, or “data use in FS”, rather than on FS themselves, were excluded.
- articles unrelated to the “transformation”, “governance”, or “EU policy context” dimensions were excluded. This included studies where key search terms appeared only in problem statements or conclusions, without serving as central points for discussions on “FS sustainability” or “FS governance”. Examples of such topics include “nutritional resilience”, “food policies”, and “rural dynamics”. As a result of this rigorous selection process, a refined set of literature was identified, enabling a focused analysis aimed at understanding the nuances and intricacies of FS implementation in diverse settings, particularly within the Romanian context.

Policy Document Analysis

An in-depth analysis was conducted on essential policy documents relating to agriculture, food security, and rural development in Romania. For this purpose, a range of national strategic plans and relevant EU directives and studies were covered, including the F2F Strategy, the Common Agricultural Policy, the Food 2030 Pathways for Action, and the EU Food System Dashboard. The aim was to identify key policy goals, strategies, and support mechanisms that encourage the adoption of a sustainable FS. These documents were systematically reviewed to evaluate their implications for FS governance and its implementation. Each policy was examined for its alignment with overarching contributions to the SGDs, sustainability objectives, the integration of stakeholder interests, and its potential impact on fostering a resilient agricultural ecosystem. Furthermore, the review sought to uncover gaps and challenges within the existing policy framework, highlighting areas that may require further development or reform. Additionally, specific attention was given to the indicators available for the Romanian food system at the EU level, especially the ones on governance, as well as the inclusivity of smallholder farmers and local communities, analyzing how policies address their needs and contributions to the food system. The findings from this analysis aim to provide actionable insights for policymakers, stakeholders, and researchers, ultimately contributing to a more effective and equitable food system in Romania. By synthesizing these various elements, this research endeavours to offer a comprehensive understanding of the current policy landscape and its role in advancing FS sustainability and resilience.

Secondary Data Analysis

Data from authoritative sources, such as the Romanian National Institute of Statistics (INSSE) [31], the Ministry of Agriculture and

Rural Development (MADR) [36], and the Food and Agriculture Organization (FAO), were utilized. This data provided insights into the structure of the Romanian FS, the role of small-scale producers, and various socio-economic indicators relevant to the study.

Interviews and Observations

Qualitative interviews were conducted with key stakeholders, including policymakers, researchers, academics, and practitioners. Observations were also gathered from workshops and conferences, particularly those associated with research and innovation projects like FoodSHIFT2030, CleverFood, and the Food2030 Network.

To assure a comprehensive understanding, the following categories were considered for the data extraction and analysis of each article:

- Aim and objectives of the research presented in the articles.
- Summary of the results:
  - FS definitions
  - FS sustainability and resilience.
  - elements of the concept framework of the FS.
- current challenges revealed in the agri-food system in Romania.
- Main conclusion.
- Proposals for further actions.

RESULTS AND DISCUSSIONS

Why is adopting the FSA important?

A sustainable FS *is "*a food system that delivers food security and nutrition for all in such a way that the economic, social, and environmental bases to generate food security and nutrition for future generations are not compromised" (HLPE, 2014) [28].

Analysing food systems (FS) at a territorial level enables the creation of policies. It is expected that such policies to enhance economic efficiency, foster social cohesion, and reduce environmental impact.

According to FAO (2018), a comprehensive FSA contributes to:

(i)boosting productivity while safeguarding the environment,

(ii)elevating the added value of territories and promoting short food supply chains,

(iii)increasing local product consumption while enhancing urban-rural interactions (FAO, 2018) [18].

The definition refers to all aspects and elements that contribute to the flow of products from farm to table, namely the environment, people, inputs, processes, infrastructure, and institutions (IFPRI, 2016) [32]. FS plays a crucial role in shaping diets by determining which foods are produced, their physical and economic accessibility, and influencing food preferences. The components of FS include food supply chains, food environments, and individual factors.

FS also encompasses crosscutting issues and drivers (factors that push or pull at the system, some being exogenous to FS) (Figure 2).

The components, crosscutting issues, and drivers all shape FS and can lead to both positive and negative outcomes. The reviewed literature reveals a spectrum of findings, ranging from food to more than just nutrition; it is a vital component of societal stability. Traditional practices such as gathering, hunting, fishing, and agriculture have historically supported rural livelihoods (Frison, E.A. & IPES-Food, 2016) [22]. As urbanization progresses, these activities—along with food processing and marketing—have become essential sources of income. Food not only meets biological needs but also fosters social interaction through shared meals, serves as a creative outlet in cooking, and reflects personal identity. It connects individuals to their environment, as food production shapes landscapes and engages with nature.

Regardless of food security, societies prioritize the origins and quality of their food, underscoring its importance for well-being and community cohesion.

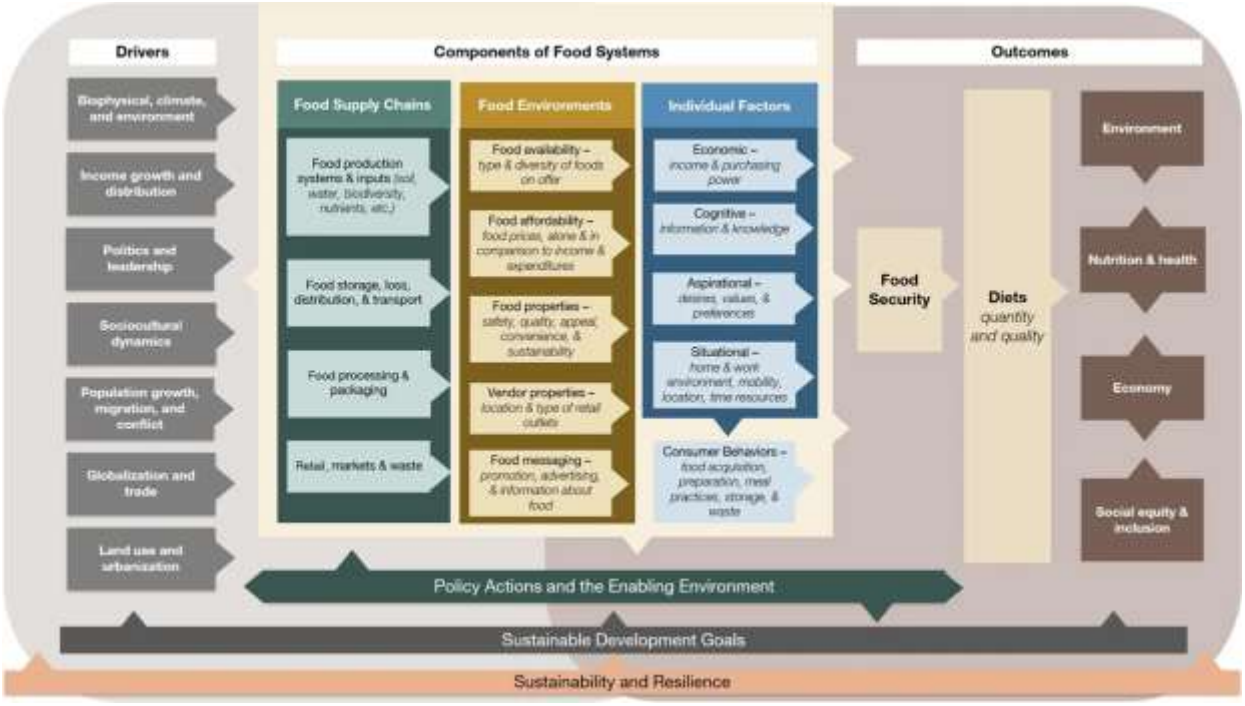

Fig. 2. Food System Framework.
Source: FSCI, 2023 [48].

Food security, food systems, and food resilience are interconnected but distinct concepts, each with its own intellectual and policy background (Barrett, 2024) [2].

Food security is considered a "wicked problem," characterized by paradoxes like the existence of both high rates of stunting and obesity, as well as persistent child malnutrition despite functioning FS. This complexity leads to challenging policy decisions, such as balancing food prices for producers versus consumers and determining whether to focus on maximizing agricultural yields or minimizing yield volatility, particularly in the context of climate change

Food systems encompass a broader range of actors, often highlighting food producers and consumers while neglecting processors, distributors, and urban FS. The COVID-19 pandemic underscored the vulnerabilities in food processing and highlighted the precarious access to food faced by urban poor populations, indicating a need for more comprehensive analysis across various components and demographics.

Food resilience involves robust producers, processors, distributors, and consumers who can adapt to shocks and stressors. It emphasizes continual adjustment rather than maintaining the status quo, requiring innovation and political commitment. While global FS have shown resilience with advancements in agriculture and institutional support, progress toward zero hunger is uneven, and concerns persist regarding access to nutritious and affordable diets.

Overall, despite the improvements in FS, the fragmented understanding of food security and resilience underscores the necessity for a balanced approach that addresses both food production and equitable access.

Food Systems Approach (FSA): a holistic view

FS has evolved from traditional household practices to specialized commercial operations, enhancing product quality for long-term storage and transport, and thereby improving food accessibility in urban areas. As urbanization rises, these culturally rooted activities are crucial for job and income generation. The food sector employs over 2 billion people globally, making it the largest employment sector; agriculture composed 68% and 39% of employment in low-income and lower-middle-income countries in 2016 (ILOSTAT, 2019) [30]. The focus on post-harvest processes has expanded to comprehensive FS, which include transportation, processing, waste management, and regulation (adapted from Pothukuchi and Kaufman, 2000; FAO, 2018) [42,19]. Viewing these systems as interconnected sub-systems provides insights into their interactions and impacts, supporting a

bioeconomy that produces food, energy, and raw materials, where changes in one part affect the whole system.

Food Systems: transformation and inclusive development

Transforming food systems is crucial for a sustainable future, contributing to poverty reduction, improved health, economic growth, and supporting the Sustainable Development Goals (SDGs). This transformation can eradicate hunger, enhance nutrition, ensure food security, reduce greenhouse gas emissions, and promote environmental protection (Benton et al., 2021) [5].

With approximately 1.23 billion people employed in FS and 3.83 billion linked to food-based livelihoods, this transformation holds significant potential for job creation and poverty alleviation, especially in rural areas By adopting innovative practices, we can enhance farmers' productivity and income, which is vital for addressing rural poverty and mitigating climate change while aiming to keep global warming below 1.5 degrees Celsius. Economically, transforming FS could yield benefits of "USD 5 to 10 trillion" annually, representing 4 to 8 percent of global GDP in 2020 (FAO, 2011) [17]. Aligning investments across agriculture, health, and environmental conservation helps tackle interconnected challenges like hunger and malnutrition while maximizing impacts and advancing the SDGs.

Despite sufficient global food production, access remains limited due to barriers in production capacity and affordability. The commercialization of post-harvest activities is altering income distribution, particularly impacting gender equity (Enete, Nweke, and Tollens, 2004; Harriss-White, 2005) [13, 26]. Access to land and resources is crucial, as inequalities are exacerbated by industrialization. Traditional food knowledge remains essential for preserving diversity and culture. FS also significantly impacts environmental sustainability, affecting landscapes, biodiversity, and energy use. Adopting alternative production methods can enhance sustainability through recycling and carbon capture (Frison and IPES-Food, 2016; Mason and Lang, 2017) [22, 37].

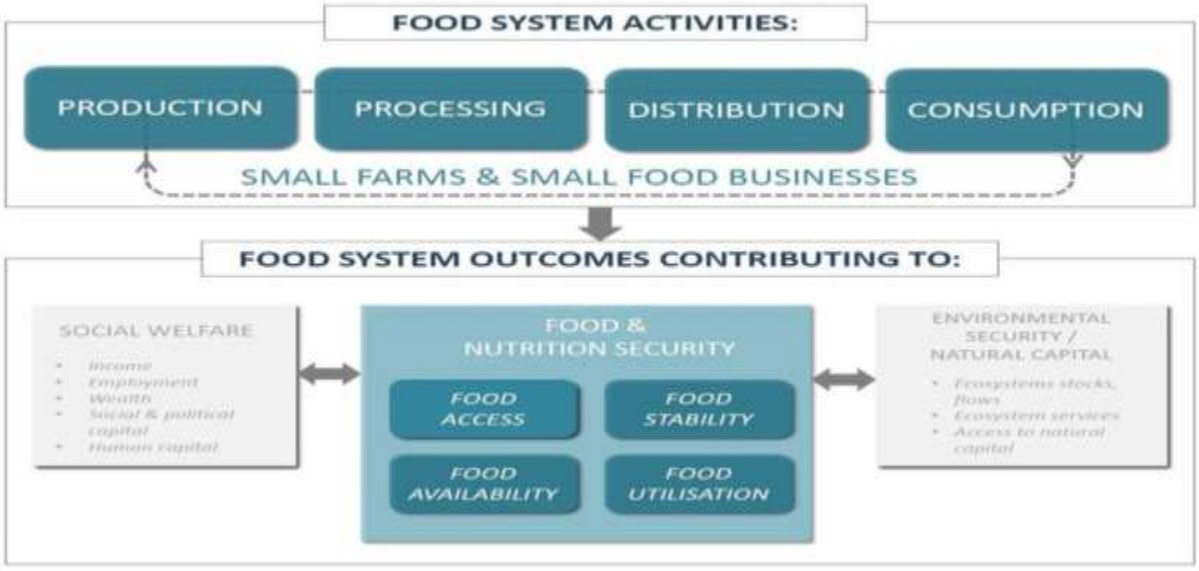

Fig. 3. Food-system-conceptualisation
Source: Adapted after Ericksen, P. J. (2008) [14].

Small farmers are key to local food production and rural economies in developing countries (FAO, 2014) [18] and provide insights into sustainable practices. Understanding their challenges, such as limited resource access, is vital for promoting inclusivity and social equity (Reardon et al., 2019) [43]. Their roles in building resilience to climate change through adaptive strategies inform policies that enhance agricultural practices (Dercon and

Gollin, 2014) [10]. FS comprises interconnected actors and activities that produce various outcomes, including food and nutrition security (Ericksen, 2008a) [14].

The effectiveness of small farms largely depends on their market connections, which enable the efficient distribution of surplus (HLPE, 2013) [27]. By assessing these contributions, we can better understand their role in local food security and the broader FS (Figure 3).

Food system at risk

According to the Food and Agriculture Organization (FAO) in 2014 [18], rapid population growth, urbanization, rising wealth, and changing consumption patterns are straining FS' ability to sustainably provide nutritious food and support livelihoods. FS both contribute to and suffer from climate change, land degradation, and biodiversity loss. The joint FAO, CIRAD, and EC report, "Food Systems at Risk: New Trends and Challenges" (Dury et al., 2019) [12], outlines several reasons for adopting a sustainable FSA:

1. **Climate impact**: strong evidence links food production, transport, and marketing to climate change, with increased animal product consumption contributing significantly to deforestation (Swinburn et al., 2019) [47].
2. **Health concerns**: current FS are associated with rising obesity and non-communicable diseases, indicating a need for systems that promote better health outcomes.
3. **Cumulative risks**: the complexity and interconnections of FS complicate risk prediction and impact measurement, necessitating a systematic management approach.
4. **Interconnected drivers**: the interaction among economic, environmental, and demographic factors highlights the need for a framework to address these interdependencies.
5. **Inequality and inclusion**: trends within FS threaten the inclusion of marginalized groups, such as women and minorities. A sustainable approach aims to promote equity.
6. **Environmental degradation**: existing FS led to resource over-exploitation, biodiversity loss, and pollution. A sustainable approach can mitigate these environmental impacts.
7. **Economic viability**: sustainable FS can create jobs and support prosperity in low- and middle-income countries, while neglecting these trends risks economic stability.
8. **Food and nutrition security**: achieving food security relies on addressing environmental and social/economic outcomes and ensuring stable markets and healthy diets.

The urgency for a sustainable FSA has intensified due to recent crises, such as the war at Romania's border and the COVID-19 pandemic, worsening food insecurity. This approach addresses health and environmental challenges by acknowledging the interconnectedness of agriculture, processing, distribution, retail, and consumption. For low and middle-income countries, this approach is crucial as the increase in food production was not sufficient to eradicate hunger.

The emphasis on rural-urban linkages and food supply chains has prompted the development of a framework for analyzing trade-offs among nutrition, environmental sustainability, and equity. Aligning health, environmental, and equity objectives with context-specific solutions is essential. Although FS frameworks receive more attention, their practical applications and the level of stakeholder engagement remain largely unexplored.

A FSA differentiates between the drivers and outcomes of transformation, identifying strategic leverage points for policy innovations (HLPE, 2017) [29]. The leverage points are specific areas in a system where small and strategic changes may result in significant impacts (Meadows, 1999) [39]. Good communication among stakeholders can facilitate the identification of the leverage points. In the same way, understanding the dynamics between formal and informal arrangements can facilitate adaptive change and, also, promote social progress (Geels, 2002) [24]. Changes in one area, for example, energy policies, can profoundly impact the entire FS, which *encompasses all actors and activities related to food production, processing, distribution, consumption, and disposal, influenced by broader economic, social, and natural contexts.*

It is essential to identify the diverse pathways for FS transformation and to highlight their

practical implications for policymakers. For effective governance of FS transformation processes, a well-structured and consistent analytical framework is necessary. Such a framework will provide insights into stakeholder interests, interactions, and their behavioral responses to incentives, innovations, and uncertainties. This understanding is crucial for adding value to different stakeholders and ensuring their active involvement in transformative FS processes.

A **sustainable and resilient FS** ensures food security and nutrition without compromising the economic, social, and environmental resources needed for future generations. This involves being economically viable, socially beneficial, and environmentally positive or neutral. Since 2015, when the United Nations' Sustainable Development Goals (SDGs) were set, sustainable FS has become a central element of SDGs, aiming to end hunger, secure food, and improve nutrition by 2030. Achieving the SDGs requires transforming global FS to be more productive, inclusive of marginalized groups, environmentally sustainable, resilient, and capable of providing healthy diets. This necessitates coordinated actions at local, national, regional, and global levels to tackle these complex and systemic challenges. A FS requires a comprehensive view that encompasses rapid demographic changes, urbanization, wealth increase, shifting consumption patterns, globalization, climate change, and resource depletion (Nguyen, H., 2018) [40]. Recent developments in FS, notably in developing countries, have boosted employment and food diversity, catering to consumer preferences. However, these changes bring challenges such as the prevalence of highly processed foods, unequal market access for small producers, and increased environmental impacts. Addressing these issues mandates a holistic and coordinated approach that transcends traditional sectoral boundaries. Currently, the systems often focus narrowly on food production, overlooking the wider interactions and feedback loops that impact food security and nutrition. Approaches like value chain and market systems development provide systemic perspectives but can still be limited by narrow focuses. Therefore, a FSA is expected to consider the entire system, its interactions, and broader impacts to foster systemic transformations. This encourages **multi-stakeholder collaboration, and** Policy coordination is essential for identifying synergies across key FS priorities, such as poverty reduction, productivity, nutrition, and sustainability, while effectively managing trade-offs to maximize positive outcomes. Although trade-offs among these priorities are inevitable, this approach promotes the alignment of efforts to achieve multiple goals simultaneously.

Research on **FS sustainability and resilience** underscores the importance of biodiversity, climate change mitigation, resource efficiency, and social equity. While global studies have explored these aspects, targeted research specific to Romania remains limited. Existing literature highlights the vulnerability of Romanian agriculture to climate change, alongside challenges related to water resources, soil degradation, and market access for small producers. Much of the available research focuses on resilience at the farm level rather than addressing systemic FS resilience.

What is the policy context for adopting a FSA?

Food system sustainability in the global and EU political agenda

A sustainable FS is "*a food system that delivers food security and nutrition for all in such a way that the economic, social, and environmental bases to generate food security and nutrition for future generations are not compromised*" (FAO, 2018) [19]. Economic sustainability covers profitability and affordability throughout the system. Social sustainability means wide-scale benefits including health, cultural drivers, and just and fair outcomes (SAPEA, 2020) [44]. Environmental sustainability means FS that have a neutral or positive environmental climate and biodiversity footprint (EC, 2020) [15]. In other words, FS are expected to contribute to SDGs established by the international community in 2015, and to do so, they must operate within planetary boundaries. A systems-based approach is crucial for effectively tackling these challenges, allowing for a holistic

consideration of the complexities involved in achieving sustainability (FAO, 2014) [18]. While FS have traditionally focused on increasing production, often leading to social inequalities and environmental degradation, they have the potential to significantly contribute to 14 out of the 17 SDGs (Caron et al., 2018; FAO, 2017, 2018b) [9, 20, 19] (see Figure 4). These contributions can be grouped into three main objectives: (a) ensuring food security and improved nutrition, (b) fostering inclusive development, and (c) promoting a sustainable environment and combating climate change. These goals are interconnected, as food and nutritional security cannot be attained without addressing poverty and environmental degradation.

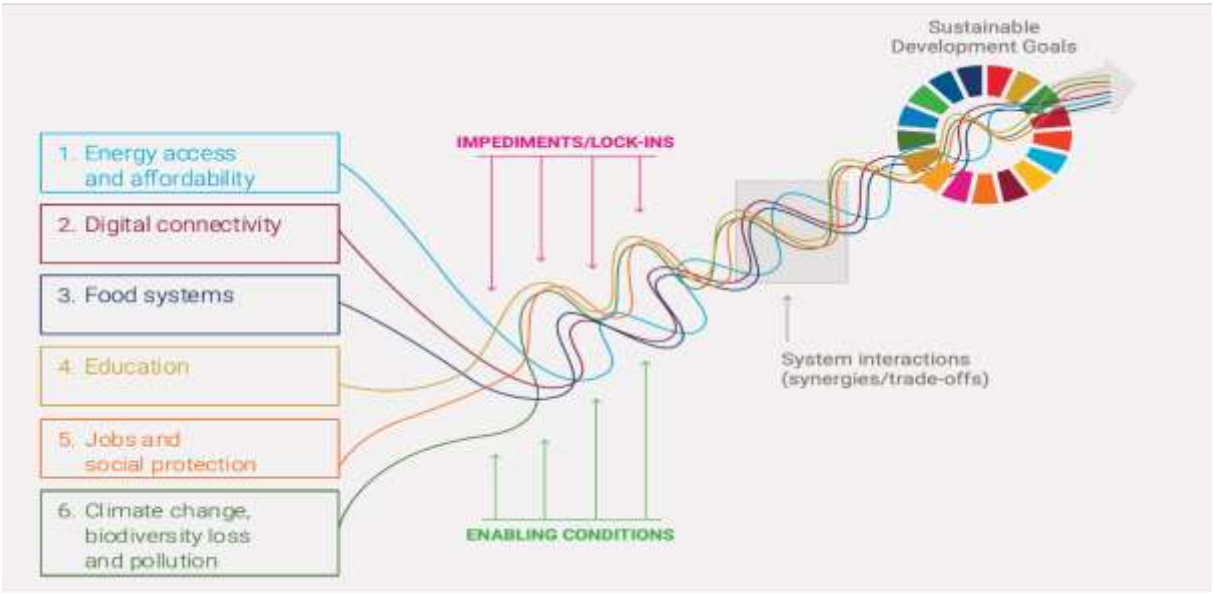

Fig. 4. The six key transitions that can have catalytic and multiplier effects across the SDGs
Source: Adapted by a Group of scientists appointed by the Secretary General, 2023.

FS have also been shown to significantly contribute to environmental degradation and exacerbate social and economic inequalities (Garnett, 2011; Foley et al., 2011 [23,21]; McKeon, 2015; UNEP, 2016) [38, 49]. The urgent need for systemic change toward more sustainable FS is widely recognized (IPES-Food, 2015; Milan Expo, 2015; Brunori et al., 2017; Gordon et al., 2017) [34, 8, 25] as reflected in global initiatives such as the SDGs and the Paris Agreement. These initiatives highlight the complex interrelationships between FS and critical issues such as malnutrition, obesity, climate change, poverty, biodiversity loss, and social injustice (Development Initiatives, 2017; Abarca-Gómez et al., 2017) [11, 1].

The EU FS is designed to align and contribute to commitments established under global initiatives, including the SDGs, the United Nations Framework Convention on Climate Change (UNFCCC), and the Global Biodiversity Framework (Borchardt et al., 2024) [7].

Therefore, the **European Green Deal** (EGD) aims to achieve climate neutrality and resource efficiency within the EU while also promoting economic growth and respecting planetary boundaries.

To achieve this vision, it requires fundamental changes across key economic sectors, particularly in the FS. The EGD introduces a new and inclusive growth strategy that highlights the importance of a comprehensive, cross-sectoral approach that integrates considerations for climate, environment, agriculture and forestry, fisheries and aquaculture, energy, transport, industry, and sustainable finance (European Commission, 2020, Green Deal) [15]. Central to the EGD is the Farm-to-Fork (F2F) Strategy, which thoroughly addresses the challenges of creating a sustainable FS while acknowledging the vital connections between healthy individuals, thriving societies, and a healthy planet

(COM(2020) 381 final). While food produced within the EU and imported into it already adheres to the highest standards of food safety and security, the current challenge is to expedite the transition toward sustainability, ensuring that planetary boundaries and societal well-being are upheld.

In the EU context, once the priority of food safety is effectively ensured, initiatives and interventions aimed at enhancing the sustainability of the FS should focus on the environmental, economic, and social dimensions, aligned with common policies across all EU Member States. Key policies, including the **Common Agricultural Policy** (CAP), the Common Fisheries Policy (CFP), the Zero Pollution Action Plan (ZPAP), the Circular Economy Action Plan (CEAP), the proposed Nature Restoration Law, and the Biodiversity Strategy, contain provisions that support the sustainability of the EU FS in both the short and medium term. Moreover, the EU committed to leveraging resources such as **Horizon Europe and the European Agricultural Fund for Rural Development** (EAFRD) to support research and innovation in the fields of sustainable agriculture, climate adaptation, and biodiversity conservation.

To achieve sustainable FS, the European Commission has launched the Research and Innovation (R&I) initiative through Horizon Europe, establishing the **Partnership for Sustainable Food Systems (P-SFS) for People, Planet, and Climate** (SCAR-FS) [45]. This initiative outlines a framework for contributing to EU policies and international efforts by addressing four key **thematic R&I areas** essential for developing sustainable food systems in the EU (Figure 5):

-R&I 1 ‘Change the way we eat’

-R&I 2 ‘Change the way we process and supply food’

-R&I 3 ‘Change the way we connect with food systems’

-R&I 4 ‘Change the way we govern food systems’.

The guiding document emphasizes the urgent need for member states to form partnerships to enhance governance for sustainable FS. It calls for a shift from a fragmented approach to address challenges related to climate, sustainability, health, and livelihoods (EC, 2020) [15]. Governance, defined as the processes by which society confronts its issues, is influenced by the interactions among various actors with differing, often conflicting, goals and interests. Research and innovation (R&I) areas aim to deepen understanding of governance patterns and provide practical solutions for achieving sustainability. Key governance challenges include fragmentation, slow adaptation, and difficulties in prioritizing urgent FS issues (EC, 2020) [18].

In December 2023, the “New Report: Food 2030 Research and Innovation – Pathways for Action 2.0” was released by the EC to guide future R&I policies related to Horizon Europe, the Farm to Fork (F2F) Strategy, the European Green Deal, and implementation of the FSA. It outlines eleven action pathways for R&I to deliver co-benefits in nutrition, climate, circularity, and community well-being:

1. Governance for Food Systems Change.
2. Urban Food Systems Transformation.
3. Food from Ocean and Freshwater Resources.
4. Alternative Proteins for Dietary Shifts.
5. Food Waste and Resource-efficient Systems.
6. The Microbiome World.
7. Nutrition and Sustainable Diets.
8. Advanced Food Safety Systems.
9. Food Systems Africa.
10. Data & Digital Transformation.
11. Zero Pollution Food Systems.

The report emphasizes the importance of a systemic, interdisciplinary approach to R&I for improved impact.

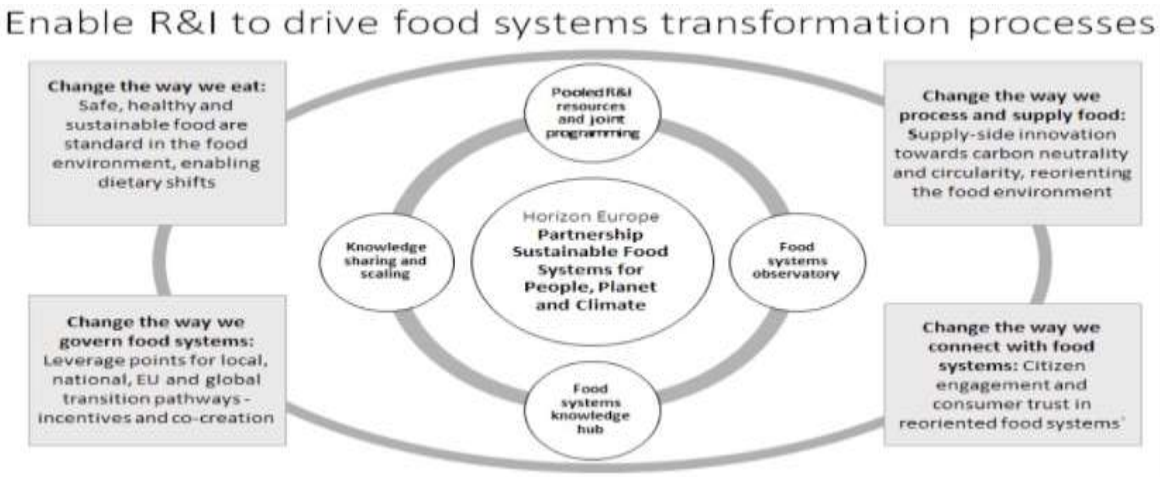

Fig. 5. The four R&I Areas and four Activity Areas of the Partnership SFS, all interconnected.
Source: SCAR-FS [45].

The **Food Systems Countdown Initiative** (FSCI) [48] monitors the global performance of FS toward achieving the 2030 Sustainable Development Goals (SDGs) through over 100 key indicators. Addressing challenges like food insecurity and environmental degradation, the initiative advocates for comprehensive assessments to guide necessary transformations. The primary objective of FSCI is to provide policymakers with evidence to foster sustainable, equitable, and resilient FS. To achieve this, the EC has developed the **Food System Dashboard**, a comprehensive monitoring framework for the EU FS's sustainability, which spans the entire food supply chain, from pre-production to disposal. This dashboard includes over 230 indicators across environmental, economic, and social dimensions, with a focus on quality assessment and normalized comparability. It enables users to interact with data on different sustainability aspects and will continually evolve to address data gaps and new policy priorities.

The FSCI data for Romania presents a mixed picture of FS indicators, revealing both strengths and significant weaknesses. Based on own interpretation and analysis of the main indicators for Romania, the situation is as follows:

1. Diets, Nutrition, and Health

-*Unaffordability of Healthy Diets*: a concerning 60% of the population is unable to afford a healthy diet, indicating widespread food insecurity.

-*Suboptimal Fruit and Vegetable Consumption*: fruits (293.8 g/capita/day) and vegetables (424.6 g/capita/day) are available; however, there is no data on whether actual consumption meets recommended levels, necessitating further investigation.

-*Inadequate Access to Safe Drinking Water*: only 67% of the population uses safely managed drinking water services, underscoring a need for improved sanitation infrastructure.

-*High Consumption of Ultra-Processed Foods*: the retail value of ultra-processed foods is relatively high at 183.4 current PPP dollars per capita per year, indicating a dietary shift that requires attention.

-*Missing Data on Dietary Diversity*: the absence of data on minimum dietary diversity for women and the overall consumption of all five food groups prevents a thorough assessment of dietary quality.

2. Environment, Natural Resources, and Production

-*Moderate Nitrogen Use Efficiency*: scoring 68%, this figure suggests room for improvement in sustainable agricultural practices.

-*Low Crop Yields*: yields for cereals (0.4 tonnes/ha), fruits (0.8 tonnes/ha), and vegetables (1.4 tonnes/ha) are low compared to their potential, requiring further analysis to determine underlying causes.

-*High Greenhouse Gas Emissions*: Significant emissions are observed across various agricultural sectors, indicating a critical need for strategies to mitigate climate change impacts.

3. Livelihoods, Poverty, and Equity

-*Low Agricultural Contribution to GDP*: agriculture accounts for only 4% of GDP. While diversification may be beneficial, this low figure

suggests challenges for the agricultural sector and rural communities.

-*High Rural Unemployment*: the unemployment rate in rural areas stands at 9%, which is a concern.

-*Social Protection Coverage*: a relatively high 81% of the population has social protection coverage. However, the adequacy of this protection is questionable, as only 54% of beneficiaries experience sufficient welfare.

4. Governance

-*Low Government Effectiveness*: there is currently no measure of governance effectiveness related to FS, and no data exist for a national FS transformation pathway.

-*Limited Governance Data*: the absence of data on various governance indicators, including civil society participation, hampers a comprehensive evaluation of governance in the FS.

5. Resilience

-*Limited Data Availability*: A significant number of resilience indicators lack data, preventing a complete analysis of the FS's capacity to withstand shocks.

According to the monitoring data, and compared with the Eastern European levels, Romania's FS faces substantial challenges, particularly in areas of diet affordability and quality, environmental sustainability, and the economic well-being of rural populations.

While positives such as social protection coverage exist, comprehensive improvements are crucial across various sectors.

The lack of data for numerous indicators highlights the urgent need for improved data collection and monitoring to facilitate informed policymaking and strategic interventions.

Engaging experts in food security, agriculture, and public health is recommended for a deeper understanding and the development of effective strategies to enhance Romania's FS.

What key aspects should be considered when implementing the "FSA" in Romania?

Beforehand, it is important to understand the characteristics of the Romanian agri-food sector. Based on an analysis of data available from national statistics (INSSE) [31], (Eurostat) [16], and the information collected in the SWOT analysis for Romania's National Strategic Plan for Agriculture (NSP-2021-2027) [41], several key insights regarding the structure of the sector have emerged:

-The Romanian agricultural landscape is characterized by a high number of small farms, primarily those under 5 hectares, which tend to focus on subsistence farming rather than market-oriented production.

-This situation has resulted in significant polarization within the sector, creating a considerable gap in size and economic performance between small farms and larger commercial operations.

-Other key findings include:

(a)Farm Size Distribution: a large proportion of farms are small, with less than 2 hectares (2,480,770 holdings,72% of the total), collectively utilizing only 1.53 million hectares (12.24% of the total utilized agricultural area - SAU) [50]. Farms with less than 5 hectares make up 91.8% of all holdings, but account for just 28.7% of SAU. In contrast, larger farms (>100 hectares) represent only 0.36% of total holdings and utilize 48% of SAU. The average size of smaller farms is merely 2.34 hectares, compared to the average size of 2,024.79 hectares for farms larger than 1,000 hectares. All these numbers indicate significant disparities in farm sizes.

(b)Economic Polarization: many farms exhibit low economic output. About 94.57% earn less than 8,000 euros in standard output (SO), below the EU average, indicating potential inefficiencies within the sector. Also, the agricultural income per worker is significantly lower than compared of other sectors.

(c)*Land Use*: arable land has the largest share of agricultural land use in Romania (63.47%), followed by pastures and hayfields (33.44%) and permanent crops (2.34%). The total SAU decreased in 2016 to 12.502 million hectares as compared to 2010 when where 12.502 million hectares. The changes indicate shifts in land use patterns or agricultural practices.

(d)Challenges for small farms: small farms face numerous obstacles, including limited access to markets, technology, finance, and information, as well as vulnerability to climate change impacts. Over half (50.02%) of the total SAU is affected by unfavourable environmental conditions due to biophysical factors, with mountainous regions (15.09% of

SAU) and significantly constrained areas (33.56%) impacting productivity.

(e)Consolidation trends: despite various schemes aimed at supporting small farms, there is evidence of land consolidation and a reduction in the number of farms, which dropped by 11.3% from 2010 to 2016, with the total requested area for surface payments growing from 9,177,354 hectares in 2016 to 9,748,666 hectares in 2019. This indicates a shift toward larger, more economically viable operations. The fragmented structure of small farms, characterized by *low economic performance*, hinders the competitiveness of the Romanian agri-food sector. While there are signs of consolidation, significant challenges persist regarding profitability, resource efficiency, and modernization of practices. The data underscores the *urgent need for effective policies to address these issues and enhance the sector's overall performance*, while the *lack of available data on several key* indicators remains a notable concern.

Table 1. Challenges and Opportunities for adopting the food system approach in Romania

Challenges:	**Opportunities:**
1. Fragmentation of Agricultural Holdings: a significant proportion of Romanian farms (72% are under 2 hectares) leads to low economies of scale, reducing their competitiveness and limiting access to market opportunities, finance, and technology, exacerbates existing inefficiencies in production and distribution. **2. Economic Polarization**: most small farms exhibit low economic output, with 94.57% earning less than 8,000 euros in standard output—far below the EU average. This economic disparity hampers the ability of smallholders to invest in modern practices and technologies, perpetuating a cycle of low productivity. **3. Vulnerability to Environmental Factors**: over half (50.02%) of the utilized agricultural area is affected by unfavourable environmental conditions, complicating agricultural practices and reducing yields. The impact of climate change represents an additional vulnerability, with increasing extreme weather events further threatening agricultural productivity. **4. Aging Agricultural Workforce**: the aging demographic of the workforce contributes to a shortage of skilled labor and presents challenges in attracting younger generations to the sector, hindering innovation and adaptability. **5. Limited Access to Resources**: small farms face significant barriers in accessing markets, finance, and technological advancements. The lack of investment in infrastructure and support services limits their growth potential and sustainability. **6. Data Gaps**: the absence of comprehensive data on various indicators, including dietary diversity and governance effectiveness, inhibits informed policymaking and strategic planning. **7. Poor Infrastructure -** inadequate infrastructure, including roads, irrigation systems, and storage facilities, limits efficiency and market access. Low innovation and technology adoption foster reliance on traditional farming methods, while weak farmer organization reduces bargaining power and minimizes value addition from agricultural outputs. **8. An Inefficient Food Supply Chain** restricts profitability and raises consumer prices, alongside significant food waste occurring at various points in the supply chain.	**1. Rural Development Potential**: with 207,633 km² of rural land and a rural population of 8,959,096, Romania has significant potential for rural development initiatives that support sustainable practices and enhance local economies. **2. Support from EU Policies**: access to EU funding programs aimed at rural development, innovation, and technology adoption provides an opportunity to bolster the agricultural sector and improve productivity. **3. Consolidation Trends**: evidence of land consolidation suggests a shift toward larger, more economically viable farms, which can enhance operational efficiency and competitiveness. Strategic policies that support this transition could foster sustainable growth. **4. Investment in Modern Agricultural Practices**: investment in modern agricultural techniques, such as precision farming and digital technologies, which can help bridge the gap between small and large farms, increasing production efficiency. **5. Growing Consumer Demand**: rising demand for high-quality, locally produced food presents an opportunity to promote short food supply chains and regional specialties, enhancing market access and profitability for smallholders. **6. Promotion of Sustainable Practices**: increasing interest in sustainable and environmentally friendly agricultural practices allows Romania to align its agricultural policies with EU standards, potentially promoting organic and eco-friendly products that attract consumer interest. **7. Development of Cooperative Structures**: enhanced cooperation among farmers through cooperative models can improve market access and bargaining power, enabling smallholders to compete more effectively. **8. Attracting Young People** to farming and advancing digital technologies will address workforce challenges and improve agricultural efficiency. Evidence of land consolidation suggests a shift toward larger operations that, with strategic policy support, can enhance productivity and competitiveness.

Source: Own contribution based on INSSE and Eurostat data analysis [31, 16].

With a **rural area of 207,633 km² (87.09% of total land)** and a **rural population of**

8,959,096 (46.14% of total), Romania has significant rural development potential, emphasizing the *need for strategic initiatives to leverage agricultural resources and address urban-rural disparities.*

Based on the FS framework, monitoring indicators for Romania (EU FS dashboard), and the analyzed data regarding the Romanian agri-food sector, the main challenges and opportunities for implementing a FSA in Romania are shown in Table 1.

As illustrated by both the FSCI indicators for Romania and the analysis of the statistical data, Romania's agri-food sector faces considerable challenges, such as dietary affordability and quality, environmental sustainability, and the economic well-being of rural populations.

It equally offers numerous opportunities for transformation.

A FSA that harnesses the development potential of rural areas, supports small farmers, and promotes sustainable practices, enhanced by data collection, could pave the way for a more resilient and competitive agricultural sector.

Engaging stakeholders across agriculture, public health, and food security will be crucial for developing effective strategies to facilitate this transition.

CONCLUSIONS

To develop effectively sustainable FS in Romania and fulfil its commitments and obligations under the EU's Farm to Fork Strategy and the Food2030, several key priorities must be addressed.

These should concentrate on enhancing governance, sustainability and resilience within the Romanian agri-food sector:

1.Strengthening Governance and Policy Frameworks

- establish a national FS transformation pathway with specific targets, timelines, and responsibilities.
- enhance inter-institutional coordination by fostering collaboration among government bodies, local authorities, and stakeholders.
- improve data collection and monitoring through investments in infrastructure to support informed policymaking.

2. Promoting Sustainable Agricultural Practices

- incentivize sustainable farming techniques, such as agroecology and organic farming.
- facilitate access to modern agricultural technologies for small farmers.
- increase research and development focused on sustainability and climate resilience.

3.Fostering Economic Viability of Agriculture

- enhance access to finance with tailored instruments for small farmers.
- support the formation of cooperatives to improve market access and bargaining power.
-promote diversification of crops and value-added products.

4. Improving Food Security and Nutrition

- implement programs to ensure access to healthy, affordable food for vulnerable populations.
- encourage the development of short supply chains connecting local producers to consumers.
- invest in public education campaigns promoting healthy dietary practices.

5. Enhancing Environmental Sustainability

- develop strategies to reduce greenhouse gas emissions from agriculture.
- promote policies for conserving biodiversity and protecting natural resources.
- provide resources and training for farmers to adapt to climate change.

6.Engaging Stakeholders and Raising Awareness

- ensure active participation of all stakeholders in policymaking processes.
- foster public-private partnerships for innovation and sharing best practices.
- implement educational programs to raise awareness of sustainability issues in FS.

Beyond aligning with EU standards, Romania should focus on enhancing the resilience of its FS while ensuring the right to food for all social groups.

This comprehensive approach prioritizes effective governance, promotes sustainable practices, and fosters collaboration among stakeholders, enabling Romania to strengthen food security and cultivate resilient rural economies while addressing climate change and globalization challenges.

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REFERENCES

[1]Abarca-Gómez, L., Abdeen, Z. A., Hamid, Z. A., Rmeileh, N. M. A., Cazares, C. A., Acuin, C., Adams, R. J., 2017, Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: A pooled analysis of 2416 population-based measurement studies in 128.9 million children, adolescents, and adults. The Lancet, 390, 2627–2642.

[2]Barrett, C. B. (Ed.)., 2024, Resilience and Food Security in a Food Systems Context. Palgrave Studies in Agricultural Economics and Food Policy. Cornell University, Ithaca, NY, USA.

[3]Béné, C., Oosterveer, P., Lamotte, L., Brouwer, I. D., Haan, S. D., Prager, S. D., Talsma, E. F., Khoury, C. K., 2019, When food systems meet sustainability – Current narratives and implications for actions, World Development, 113, 116–130, https://doi.org/10.1016/j.worlddev.2018.08.011.

[4]Béné, C., Prager, S. D., Achicanoy, H. A. E., Toro, P. A., Lamotte, L., Cedrez, C. B., Mapes, B. R., 2019, Understanding food systems drivers: A critical review of the literature. Global Food Security, 23(April), 149-159. https://doi.org/10.1016/j.gfs.2019.04.009.

[5]Benton, T.G., Bieg, C., Harwatt, H., Pudasaini, R., Wellesley, I., 2021, Food system impacts on biodiversity loss - Three levers for food system transformation in support of nature. London: Chatham House.

[6]Bock, A.K., Bontoux, L., Rudkin, J., 2022, Concepts for a sustainable EU food system, EUR 30894 EN, Publications Office of the European Union, Luxembourg; doi:10.2760/381319, JRC126575.

[7]Borchardt, S., Barbero Vignola, G., Listorti, G., Fronza, V., Guerrieri, V., Acs, S., Buscaglia, D., Maroni, M. and Marelli, L., 2024, Cultivating sustainability: the role of European Food Systems in advancing the SDGs, European Commission, Joint Research Centre, Publications Office of the EU, Luxembourg, JRC137661.

[8]Brunori G., Schmitt E., F. Galli, D. Menozzi, D. Maye, JM. Touzard, A. Marescotti, J. Six, 2017, Comparing the sustainability of local and global food products in Europe, Volume 165, Journal of Cleaner Production, 346-359.

[9]Caron, P., Ferrero y de Loma-Osorio, G., Nabarro, D. et al. 2018, Food systems for sustainable development: proposals for a profound four-part transformation. Agron. Sustain. Dev. 38, 41, https://doi.org/10.1007/s13593-018-0519-1

[10]Dercon, S., Gollin, D., 2014, Agriculture in the global economy: The role of smallholder farms. The State of Agricultural Commodity Markets 2018.

[11]Development Initiatives, 2017, UN, Department of Economic and Social Affairs, Sustainable Development, https://sdgs.un.org/goals

[12]Dury, S., Bendjebbar, P., Hainzelin, E., Giordano, T., Bricas, N., 2019, Food Systems at risk: new trends and challenges. FAO, CIRAD, and European Commission.

[13]Enete, A.A., F.I. Nweke, and E. Tollens. 2004. Gender and cassava processing in Africa. Quarterly Journal of International Agriculture, Vol. 43 (1): 57-69.

[14]Ericksen, P. J., 2008, Conceptualizing food systems for global environmental change research. Global Environmental Change, 18(1), 234-245.

[15]European Commission, 2020, Green Deal, https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en, Accessed on February 2021

[16]Eurostat, European Statistical System, European Commission, https://ec.europa.eu/eurostat

[17]FAO, 2011, Guide for policy and programmatic actions at the country level to address high food prices. FAO's Initiative on Soaring Food Prices. Rome, www.fao.org/fileadmin/user_upload/ISFP/revisedISFP_guide_web.pdf

[18]FAO, 2014, The State of Food and Agriculture: Innovation in family farming. Food and Agriculture Organization of the United Nations. Retrieved from http://www.fao.org/publications/sofa/2014/en/, Accessed on June 2021

[19]FAO, 2018, The future of food and agriculture: Alternative pathways to 2050. Food and Agriculture Organization of the United Nations. http://www.fao.org/3/I8429E/i8429e.pdf, Accessed on November 2023

[20]FAO, IFAD, UNICEF, WFP, & WHO, 2017, The State of Food Security and Nutrition in the World: Building resilience for peace and food security (No. 978-92-5-109888–2; pp. 1–109).

[21]Foley, J. A., DeFries, R., Asner, G. P., Barford, C., Bonan, G., Carpenter, S. R., Chapin, F. S., Coe, M. T., Daily, G. C., Gibbs, H. K., Helkowski, J. H., Holloway, T., Howard, E. A., Kucharik, C. J., Monfreda, C., Patz, J. A., Prentice, I. C., Ramankutty, N., Snyder, P. K., 2005, Global consequences of land use. Science, 570–574.

[22]Frison, E.A.; IPES-Food, 2016, From uniformity to diversity: a paradigm shift from industrial agriculture to diversified agroecological systems, Belgium, 96 p.

[23]Garnett T., 2011, Where are the best opportunities for reducing greenhouse gas emissions in the food system (including the food chain)?, Food Policy, Volume 36, Supplement 1, S23-S32,

[24]Geels, F. W., 2002, 'Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and case-study', Research Policy, 31 (8-9): 1257-1274.

[25]Gordon Line, J. et al, 2017, Rewiring food systems to enhance human health and biosphere stewardship, Environ. Res. Lett. 12 100201.

[26]Harriss-White, B., 2005, Commercialisation, commodification and gender relations in post-harvest systems for rice in South Asia, Economic and Political Weekly, 40(25): 2524. Frison, E.A.; IPES-Food, 2016,

From uniformity to diversity: a paradigm shift from industrial agriculture to diversified agroecological systems. Louvain-la-Neuve (Belgium): IPES, 96 p.
[27]HLPE, 2013, Investing in Smallholder Agriculture for Food Security. A report by the High-Level Panel of Experts on Food, Security and Nutrition of the Committee on World Food Security, Rome.
[28]HLPE, 2014, Food losses and waste in the context of sustainable food systems. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome..
[29]HLPE, 2017, Nutrition and food systems. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome.
[30]ILOSTAT, 2019, International Labour Office, World Employment and Social Outlook: Trends 2019 Report, Geneva
[31]INSSE, National Institute of Statistics, http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table, Accessed on 15 February 2025.
[32]International Food Policy Research Institute (IFPRI), 2016, Global Food Policy Report, Washington, DC: International Food Policy Research Institute.
[33]IPBES, 2019, Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. E. S. Brondizio, J. Settele, S. Díaz, and H. T. Ngo (editors). IPBES Secretariat, Bonn, Germany. 1148 pages, https://doi.org/10.5281/zenodo.3831673
[34]IPES-Food, 2015, The New Science of Sustainable Food Systems: Overcoming Barriers to Food Systems Reform, Louvain-la-Neuve: International Panel of Experts on Sustainable Food Systems
[35]IPCC, 2019, Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems [P.R. Shukla, J. Skea, E. Calvo Buendia, V.
[36]MADR Ministry of Agriculture and Rural Development, Romania
[37]Mason, P., Lang, T., 2017, Sustainable Diets: How Ecological Nutrition Can Transform Consumption and the Food System (1st ed.). Routledge. https://doi.org/10.4324/9781315802930
[38]McKeon, Nora, 2015, Food Security Governance: Empowering communities, regulating corporations, New York: Routledge.
[39]Meadows, D., 1999, Leverage Points: Places to Intervene in a System. Hartland: The Sustainability Institute
[40]Nguyen, H., 2018, Training course "Introduction to sustainable food systems and value chains." The course was developed and piloted under FAO Strategic Programme 4 (SP4) and executed by the Agricultural Development Economics Division (ESA) with broad consultation from other FAO Divisions and decentralized offices.
[41]NSP 2021-2027, Romania's National Strategic Plan for Agriculture 2021-2027
[42]Pothukuchi K., Kaufman J.L., 2000, The Food System, Journal of the American Planning Association, 66:2, 113-124, DOI: 10.1080/01944360008976093
[43]Reardon, T., Barrett, C. B., Berg, T., Swinnen, J., 2019, Agrifood systems and rural development in the 21st century: A global perspective. In Handbook on the Globalization of Agriculture (pp. 1-23). Edward Elgar Publishing.
[44]SAPEA, 2020, European Commission, Directorate-General for Research and Innovation, Group of Chief Scientific Advisors, Towards a sustainable food system: moving from food as a commodity to food as more of a common good: independent expert report, Publications Office.
[45]Standing Committee on Agricultural Research-Food System, SCAR-FS, 2024, https://scar-europe.org/food-main-actions/food-systems-partnership, Accessed on: December 2024,
[46]Springmann, M., Clark, M., Mason-D'Croz, D., Wiebe, K., Bodirsky, B. L., Lassaletta, L., de Vries, W., Vermeulen, S. J., Herrero, M., Carlson, K. M., Jonell, M., Troell, M., DeClerck, F., Gordon, L. J., Zurayk, R., Scarborough, P., Rayner, M., Loken, B., Fanzo, J., ... Willett, W., 2018, Options for keeping the food system within environmental limits, Nature, 562(7728), 519–525, https://doi.org/10.1038/s41586-018-0594-0
[47]Swinburn BA, Kraak VI, Allender S, Atkins VJ, Baker PI, Bogard JR, Brinsden H, Calvillo A, De Schutter O, Devarajan R, Ezzati M, Friel S, Goenka S, Hammond RA, Hastings G, Hawkes C, Herrero M, Hovmand PS, Howden M, Jaacks LM, Kapetanaki AB, Kasman M, Kuhnlein HV, Kumanyika SK, Larijani B, Lobstein T, Long MW, Matsudo VKR, Mills SDH, Morgan G, Morshed A, Nece PM, Pan A, Patterson DW, Sacks G, Shekar M, Simmons GL, Smit W, Tootee A, Vandevijvere S, Waterlander WE, Wolfenden L, Dietz WH., 2019, The Global Syndemic of Obesity, Undernutrition, and Climate Change: The Lancet Commission report, Lancet, 791-846.
[48]The Food Systems Countdown Initiatives, FSCI, 2023.
[49]UNEP, 2016, Food Systems and Natural Resources. A Report of the Working Group on Food Systems of the International Resource Panel. Westhoek, H, Ingram J., Van Berkum, S., Ozay, L., and Hajer M.
[50]Utilized Agricultural Area – SAU
[51]Willett, W., Rockström, J., Loken, B., et al., 2019, Food in the Anthropocene: The EAT-Lancet Commission on Healthy Diets from Sustainable Food Systems. The Lancet, 393, 447-492, https://doi.org/10.1016/S0140-6736(18)31788-4

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THE ECONOMIC IMPACT OF LOCAL FOOD PRODUCERS ON RETAILERS IN ROMANIA

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Abstract

The paper aimed to present the actions undertaken by the retail sector to support local producers in Romania. The study is based on statistical data provided by representatives of the "Profi" food retailer, which has the largest number of employees in the Romanian market. Through documentary research, we analyzed the presence of local producers in the retailer's stores and how it facilitates the relationship between consumers and producers. At the same time, the scientific endeavor examines the presence of local producers nationwide, focusing on the number and diversity of categories to assess how the products available in the retailer's stores meet consumers' needs and desires. Based on the statistical data, we made forecasts regarding the evolution of local producers in the stores. The results showed an upward trend, supported by the percentage of local products sold in the total sales of the analyzed retailer.

Key words**:** *local producers, traditional producers, economic impact, Food Retail, Romanian market*

INTRODUCTION

At a global level, producers play a fundamental role in the economy, ensuring the supply of products necessary to meet market demand (Illeris, 1989) [10].
In recent years, the way producers are perceived has undergone certain changes, with local producers securing a significant share of the market supply.
Initially promoted at fairs and community-organized events, their presence has become increasingly visible, as in recent years they have established partnerships with major retailers.
Through these partnerships, they have gained access to stores, reaching a broader audience (Bejan et al., 2025) [4].
Although they were initially found mainly at fairs specific to winter holidays (Preda & Cretu, 2024) [13].
The visibility of local producers has increased both at the European and local levels in recent years. They are now more widely recognized, a process facilitated by partnerships with major retailers.
Of course, the benefits have also been numerous for consumers, who now have access to local agricultural and food products. This has led to increased competitiveness and the development of the agricultural sector (Timofti &Timofti, 2015) [19].
Research conducted in recent years has shown that individuals have developed a preference for local, healthy, and eco-friendly products (Petre & Draghici, 2021) [12], and for it, they are willing to pay more. As a result, in recent years, consumer concerns have transcended visual aspects (such as recyclable packaging) and have placed greater emphasis on the quality of the product and its source. The ultimate goal of consumers is to support local producers and family businesses, believing that they are more „faithful" to sustainable principles, incorporating them into their production or sourcing processes.
Initially, local producers primarily opted for direct distribution channels (local markets or direct deliveries to customers) (Cetina et al., 2020; Caratus Stanciu, 2018) [6, 5]. However, this approach has changed in recent years. The main drawback (limited reach to a large

number of consumers despite sufficient production capacity) has been overcome through partnerships with retailers operating in the market (Stein & Santini, 2022) [18].

Depending on the level of market development and the products they offer, local producers can be categorized into numerous groups. This classification takes into account factors such as the complexity of the economy, sustainability practices implemented in their activities, and food security in cases where they operate in this sector.

Some authors (Giller et al., 2021) [9] argue that the category of local producers should also include small traditional farmers and companies that use advanced technologies. The advantage of this segmentation lies in a greater ability to respond to climate change while accommodating the needs of a growing global population. At the same time, it helps preserve food diversity and implement sustainable practices. Essentially, by including companies that adopt modern technological practices within the group of local producers, the needs of a larger number of individuals could be met, increasing production capacity. However, some opinions suggest that local producers are characterized by lower production volumes and a greater focus on product quality. Industrializing these tasks could be seen as a loss of essence for local producers.

Regarding the scale of their operations, Davis et al. (2021) [7] argue that small farmers, as part of the local producer segment, struggle to adapt to environmental shocks but contribute to supply chain development by diversifying food sources. Medium and large-scale producers support them by combining traditional methods with technological innovations, thus enhancing efficiency and facilitating access to regional and global markets.

Some researchers (Enthoven & Van den Broeck, 2021) [8] believe that the spectrum of local producers is much broader, encompassing everything from individual farms to cooperatives and family enterprises. Given this diversity, it becomes easier to adapt to the needs of the communities where they operate, ensuring consumer satisfaction and trust. Essentially, the benefits are twofold. Companies benefit because they support the community, which contributes to their growth while selling their stock efficiently. Consumers benefit by knowing the origin of their products and ensuring they receive high-quality goods produced sustainably.

In recent years, many local producers have aimed to engage consumers in the production process. This is most commonly seen in fruit and vegetable farms, where customers can pick their produce for a small fee. This approach allows producers to reduce labor costs while increasing consumer trust, as they feel more involved in the supply chain (Wu et al., 2021) [20].

When analyzing the diversity of local producers, an essential factor to consider is the economic and social structure of the region in which they operate. For example, Malizia et al. (2021) [11] state that in some regions, small producers focus on subsistence agriculture, while others specialize in premium products such as organic foods or traditional products with geographical indications. These producers cater not only to national market needs but also serve international consumers, thereby promoting the regions they come from.

Based on these considerations, this research aims to analyze the importance of local producers within the communities where they operate and to determine the measures retailers implement to support them.

The research novelty of this study lies in the analysis of the economic impact of actions taken by the retailer with the largest number of employees in collaboration with local producers.

MATERIALS AND METHODS

In conducting this research, we analyzed the Fast-Moving Consumer Goods (FMCG) sector.

We chose this field because it includes goods with low prices, short shelf life, and high purchase frequency, which are considered essential or moderately necessary products.

At the same time, another factor behind this choice was the composition of the shopping basket.

Regardless of income level or financial situation, consumers tend to cut back on discretionary expenses (such as vacations, recreational services, and entertainment) in favor of purchasing food products necessary to meet their physiological needs.

Thus, we sought to establish a partnership with the business sector to facilitate the collection of information regarding relationships with local producers.

Following our documentary research, we selected the retailer with the largest number of employees, based on the premise that a company's care for its internal customers (employees) is likely to be reflected in its relationship with consumers as well (Profi.ro, 2025) [15].

The research questions were:

Q1- „*What is the impact of local producers on the economy?*",

Q2-„*What actions does the selected retailer implement in support of local producers?*" and

Q3- „*What is the geographical distribution of the producers collaborating with the selected retailer?*".

To answer these questions, we conducted a documentary analysis tracking the evolution of the number of producers between 2022 and 2024, considering the entire territory of Romania.

The starting year represents the first year when the selected retailer established contracts with local producers, making their products available in stores.

RESULTS AND DISCUSSIONS

The information provided by the retailer allowed us to identify a classification of local producers used by the company. Based on their distance from the company and their coverage area, the retailer collaborates with local, regional, national, and artisanal producers (Bejan et al., 2025) [4].

At the end of 2022 (the first year observed), there were 7 active stores listing 27 local producers. The high sales volume of these products encouraged the retailer to expand its collaboration with them. As a result, by the end of 2023, 122 producers were present in 28 stores. One year later, their number had nearly doubled, with 49 stores promoting 186 local producers (Figure 1).

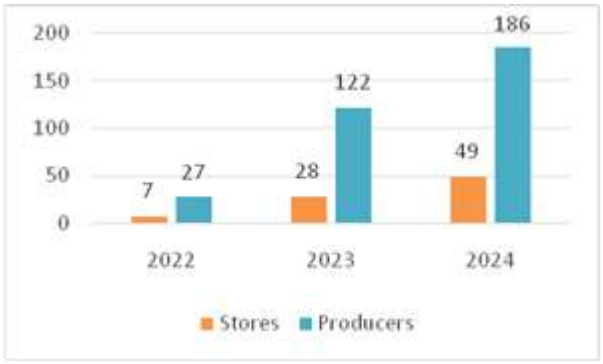

Fig. 1. The presence of local producers in stores
Source: Authors' Research based on the data from the retailer analyzed.

Of course, it is important to distinguish between listed producers and active producers. The first category includes producers considered by the retailer, with whom collaboration contracts have been signed, allowing them to sell their products in the retailer's stores. The second category consists of producers who are physically present in stores, already benefiting from the opportunity to sell their products (Figure 2).

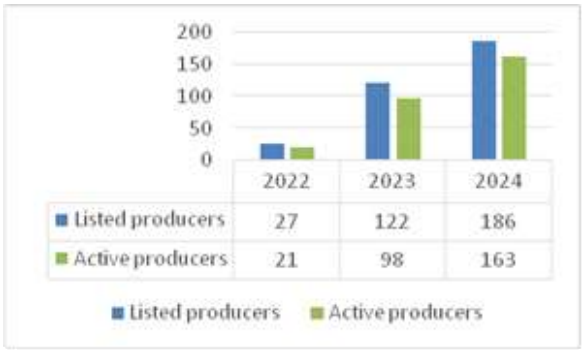

Fig. 2. Listed producers and active producers in stores
Source: Authors' Research based on the data from the retailer analyzed.

Fig. 3. Local producers' listed products in stores
Source: Authors' Research based on the data from the retailer analyzed.

Of course, each producer present in stores offers a wider range of products. Thus, by the end of 2024, the total number of listed products was approximately 1.400 items (Figure 3).

According to the provided data, approximately 95% of total spending on purchased products in 2023 was allocated to local suppliers (Profi.ro, 2023) [14].

The analyzed retailer has actively supported small local producers through two key projects – „*Via Profi*" and „*The Shelf of Delicacies*".

While the „*Via Profi*" campaign aimed to identify and register small local producers on a digital platform, the „*The Shelf of Delicacies*" initiative gained greater in-store visibility.

As an innovative initiative, „*The Shelf of Delicacies*" or „*The Shelf of Local Delicacies*" focused on traditional local producers, bringing time-honored recipes and the authentic taste of the past to consumers.

Launched in 2022, the „*The Shelf of Delicacies*" project has continued to expand, both in terms of geographical reach and the number of participating stores (Figure 4).

Fig. 4. Stores, cities, and counties involved in „*The Shelf of Delicacies*" campaign

Source: Authors' Research based on the data from the retailer analyzed.

Map. 1. The coverage of *„The Shelf of Delicacies"* campaign across Romania

Source: Authors' work based on the data from the retailer analyzed.

Regarding geographical distribution, the local producers involved in *„The Shelf of Delicacies"* campaign come from various regions of the country. The retailer aims for wide coverage, with a stronger presence in counties with larger populations and major cities (Map 1).

The success of *„The Shelf of Delicacies"* campaign was reflected in the sales growth recorded by local producers. According to their reported data, sales increased by approximately 30% in 2023 compared to the previous year.

The range of marketed products is diverse, including bakery products, sweets, and alcoholic beverages (Table 1).

Table 1. Product categories in *„The Shelf of Delicacies"* campaign

Product Categories Sold	
Meat Products	Eggs
Dairy Products	Bakery Products
Canned Goods	Fish
Vegetables	Honey Products
Fruits	Alcoholic Beverages

Source: Authors' Research based on the data from the retailer analyzed.

Based on the information collected from the selected retailer, the goal for 2025 is to increase both the number of local producers present in stores and geographical expansion. The data provided by the retailer forecasts that by 2025, local producers will be present in at least 65 stores. Regarding geographical expansion, five additional counties from the Northeast and South regions of the country have been considered.

These upward-trending forecasts align with tendencies observed at both the European Union and global levels. Research indicates a growing consumer preference for products offered by local producers.

At the European Union level, consumers are placing increasing importance on local products. For example, a study conducted in Germany found that 84% of respondents stated that the regional origin of eggs was important or very important to them. For bakery products, especially bread, the percentage was approximately 80% (Statista Research Department, 2024) [16].

Similarly, a study conducted in the United Kingdom showed that 80% of respondents believe that domestically produced goods are safer compared to those imported from EU countries (Bedford, 2023) [1]. Another key reason for choosing British-made products is the desire to support local farmers. About 68.6% of respondents believe that local producers place greater emphasis on product freshness and quality (Bedford, 2024a; Bedford, 2024b) [2, 3]. Therefore, consumer loyalty toward local producers continues to remain strong.

CONCLUSIONS

In recent years, the presence of local producers in the Romanian market has become increasingly visible. The main beneficiaries of this trend are customers, who have access to fresh products that adhere to traditional recipes.

Major retailers in the fast-moving consumer goods sector have also contributed to promoting small producers. For example, the retailer with the largest number of employees has taken action in two key areas. First, it has allocated in-store space for small producers through *„The Shelf of Delicacies"* campaign. Second, it has developed the digital platform *„Via Profi",* which brings together local producers from across Romania in an online environment.

As a result of their participation in *„The Shelf of Delicacies"* campaign, local producers have reported sales increases of up to 30%. The success of the campaign is reflected in its widespread presence across key regions of the country and the diverse range of products it offers.

Some studies (Statista Research Development, 2015) [17] indicate that the main reason consumers do not choose local products is their perception of higher prices. By emphasizing the origin and provenance of products, some consumers believe that local producers charge relatively high prices.

„The Shelf of Delicacies" campaign challenges this misconception by demonstrating to customers that they can purchase products from local producers at affordable prices while maintaining high quality and authenticity.

Based on the campaign's evolution over the three years since its launch, the retailer is considering expanding both the number of participating stores and the geographical regions where the initiative will be implemented.

REFERENCES

[1]Bedford, E., 2023, Opinion on the Safety, traceability, and quality of food produced in the UK in 2022. https://www.statista.com/statistics/1365813/trust-in-food-produced-in-the-uk/, Accessed on 17 February 2025.

[2]Bedford, E., 2024a, Reasons for choosing British produce among consumers in the UK in 2024. https://www.statista.com/statistics/1498857/reasons-for-choosing-british-produce-among-consumers-in-the-uk/, Accessed on 17 February 2025.

[3]Bedford, E., 2024b, Attributes strongly associated with British produce among consumers in the UK in 2024. https://www.statista.com/statistics/1498832/attributes-associated-with-british-produce-among-consumers-in-the-uk/, Accessed on 17 February 2025.

[4]Bejan, B., Pop, C., Sirbu, G., 2025, Why are Local and Traditional Food Producers Necessary in Romanian Retail? Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", 25(1), 73-78.

[5]Caratus Stanciu, M., 2018, Analysis of the Behavior and Motivation of Consumers Towards Short Food Supply Chains. Scientific Papers. Series „Management, Economic Engineering in Agriculture and Rural Development", 18(4), 73-78.

[6]Cetina, I., Radulescu, V., Goldbach, D., 2020, From Farm to Table. Management and Marketing for Small Farmers. Scientific Papers. Series „Management, Economic Engineering in Agriculture and Rural Development", 20(2), 111-116.

[7]Davis, K., Downs, S., Gephart, J., 2021, Towards Food Supply Chain Resilience to Environmental Shocks. Nature Food, 2(1), 54-65.

[8]Enthoven, L., Van den Broeck, G., 2021, Local food systems: Reviewing two decades of research. Agricultural systems, 193, 103226.

[9]Giller, E. K., Delaune, T., Silva, J.V., , Descheemaeker, K., van de Ven, G., Schut, G.T. A., van Wijk, M., Hammond, J., Hochman, Z., Taulya, G., Chikowo, R., Narayanan, S., Kishore, A., Bresciani, F., Teixeira, H.M., Andersson, A.J., van Ittersum, K. M., 2021, The Future of Farming: Who Will Produce Our Food? Food Security, 13(5), 1073-1099.

[10]Illeris, S., 1989, Producer Services: The Key Sector for Future Economic Development? Entrepreneurship % Regional Development, 1(3), 267-274.

[11]Malizia, E., Feher, E., Renski, H., Drucker, J., 2021, Understanding local economic development. London: Taylor & Francis.
[12]Petre, I.D., Draghici, M., 2021, Dynamics of Food Consumption in Romania in the Period 2008-2019. Scientific Papers. Series „Management, Economic Engineering in Agriculture and Rural Development", 21(2), 437-450.
[13]Preda, A., Cretu, R., 2024, From Chalets to Commerce: Exploring How the Strasbourg Christmas Market is Amplifying Local Producers' Presence in Alsace, France. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", 24(1), 811-818.
[14]Profi.ro., 2023, Raport de sustenabilitate 2023 (Sustainability Report 2023) https://www.profi.ro/raport-de-sustenabilitate-2023, Accessed on 15 Febryary 2025.
[15]Profi.ro., 2025, Company. https://www.profi.ro/companie/, Accessed on 10 February 2025.
[16]Statista Research Department, 2024, Importance of local produce for consumers in Germany in 2024. https://www.statista.com/statistics/1290787/local-produce-importance-for-consumers-germany/, Accessed on 17 February 2025.
[17]Statista Research Development, 2015, Reasons preventing consumers from buying local produce in Great Britain in 2015. https://www.statista.com/statistics/650428/reasons-for-not-buying-local-produce-great-britain/, Accessed on 17 February 2025.
[18]Stein, A., Santini, F., 2022, The Sustainability of „Local" Food: A review for policy-makers. Review of Agricultural, Food and Environmental Studies, 103(1), 77-89.
[19]Timofti, E., Timofti, G., 2015, Trends to Promote Export of Local Agricultural and Food Products Under the Conditions of European Economic Integration. Scientific Papers. Series „Management, Economic Engineering in Agriculture and Rural Development", 15(2), 405-410.
[20]Wu, W., Zhang, A., van Klinken, R., Schrobback, P., Muller, J., 2021, Consumer trust in food and the food system: a critical review. Foods, 10(10), 2490.

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DIVERSITY OF TRADITIONAL ROMANIAN PRODUCTS: CULTURAL AND ECONOMIC IMPACT IN RURAL REGIONS

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Abstract

The article explores the diversity of traditional products in Romania and their impact on rural areas from a cultural and economic point of view. The characteristics and specificity of traditional products are analyzed, highlighting their essential role in preserving the country's different regions' cultural identity and gastronomic heritage. Then, the influence of these products on the local economy is investigated, with a particular emphasis on the development of small agricultural businesses, supporting traditional farmers and stimulating rural tourism. The article presents the importance of diversifying traditional products to increase their competitiveness in the national market, highlighting successful examples from the South Muntenia Region in their valorization. Last, a series of challenges encountered in promoting and protecting traditional products are presented, including legal regulations, market access and risks related to the loss of authenticity. The article's conclusions propose a series of solutions for supporting traditional Romanian products, considering both economic and cultural aspects.

Key words**:** *traditional Romanian products**,** influence, valorization, promotion, support, authenticity, diversification*

INTRODUCTION

Diversifying traditional products is an effective strategy for attracting a larger number of customers. It not only improves a business's offering but also responds to the diverse needs of consumers. Somehow, Diversification can attract more customers by offering unique and authentic products, noting that traditional products are often handmade and reflect the cultural specificities of a region. This uniqueness gives them a competitive advantage as consumers increasingly seek authenticity in their choices. Diversifying the product range allows businesses to offer items that are not commonly available on the market, thus attracting customers who appreciate originality [20].

By diversifying the offer, businesses can improve brand visibility. A diverse range of products can attract consumer attention and generate positive discussions in the community.

Participating in local fairs and events to present directly to the customers and create an emotional connection.

Diversification allows businesses to better serve the needs of different customer segments. For example, introducing gluten-free or vegan products can appeal to consumers with specific diets, thereby expanding their customer base. By offering a variety of options, businesses can cater to the diverse preferences of the market.

Each traditional product has a unique story related to local crafts and traditions. This story can be used in marketing to create an emotional connection with customers. Consumers are often drawn to products that have cultural or historical significance, which can build customer loyalty and lead them to return for repeat purchases [5].

Product diversification can facilitate collaborations with other local producers or influencers in the field, thus expanding the distribution and promotion network. These partnerships can bring in new customers by accessing different audiences, thus increasing brand exposure.

Diversification gives businesses the flexibility to adapt quickly to changes in consumer preferences or emerging trends. This allows companies to remain relevant and competitive in a constantly changing market, which is essential for attracting a diverse clientele.

In conclusion, diversifying traditional products not only improves a business's offer but also significantly contributes to attracting a larger number of customers through uniqueness, adaptability and captivating stories. This strategy is essential for the long-term success of local businesses in the context of a competitive market. In this context, the paper aimed to explore how the diversification of traditional products can enhance the competitiveness of local businesses and strengthen their relationship with consumers.

MATERIALS AND METHODS

The paper uses data collected from the EU Eurostat Database [12] and Ministry of Agriculture and Rural Development [17, 18, 19] Aspects such as National quality schemes and European quality systems aim to raise traditional products to international standards, noting that at the European Commission, they are currently being evaluated/verified for registration for another 6 emblematic traditional products for Protected Geographical Indication. In the following period, from the list of products identified with potential for registration on a quality system, documentation will be submitted for analysis, which will determine the increase in the number of products recognised as Geographical Indications at the European Union level (practically doubling their number). Research methods used in this paper include both qualitative and quantitative approaches. The quantitative analysis is based on data collected from official sources such as the EU Eurostat Database and the Ministry of Agriculture and Rural Development, while the qualitative approach involves the review of policy documents related to the registration and promotion of traditional products within national and European quality schemes.

RESULTS AND DISCUSSIONS

The European Union aims to become a reference model in the field of food production, promoting both modern and traditional methods. The goal is to provide high-quality, healthy and nutritious products. [9], [11].

To protect certain products that fall within the quality schemes imposed by the EU, support and media coverage related to the uniqueness of the origin and the method of preparation of each product is sought. Such products benefit from a certain regime and protection to combat counterfeiting and illicit marketing.

This category of products also includes wines with a Protected Designation of Origin (PDO), Protected Geographical Indication (PGI), and spirits recognised as Geographical Indications (GI). Another group of products protected by the European Union consists of those labelled as 'Traditional Speciality Guaranteed' (TSG) [17].

In 2017, products covered by quality schemes accounted for approximately 7% of the total sales value in the European food and drink sector. Among these, wines represented more than half of that value, followed by agricultural and food products at 35%, and spirits at 13%. Out of the 3,207 product names registered in 2017, wines made up 49%, agri-food products 43%, and spirits 8%. [10].

The marketing of these products in Romania is usually done in fairs and markets, although very few are displayed on the shelves of large stores. However, the products accumulate annual sales of over 100 million euros, according to statistics from the Ministry of Agriculture and Rural Development (MADR). Since 2013, the European Union has introduced improved regulations to support both producers and consumers, enabling agri-food products to be recognized under quality schemes such as Traditional Speciality Guaranteed (TSG), Protected Geographical Indication (PGI), and Protected Designation of Origin (PDO). That same year, the label 'Mountain Product' was introduced, and starting in 2014, the designation 'Produced on my farm' also gained official recognition [23], [8].

According to data from the Ministry of Agriculture and Rural Development (MADR), more than 4,000 traditional products have been registered in Romania, with the majority coming from the dairy, meat, milling, and beverage sectors [18].

Following the increasing demand for traditional products, companies decided to

conduct studies to understand consumer requirements regarding these products better. The results obtained referred to the main criteria that a food product must meet to be considered traditional Romanian: not to contain preservatives and E-numbers (29%), the recipe must be traditional (27%), to be natural, obtained with natural ingredients (23%), mentioning the area where it was originally produced (17%).

The identification and promotion of registration of products with the potential for protection and registration will encourage the production of high-quality agri-food products, which will have a positive impact on the Romanian agri-food sector as a whole.

Recognizing and registering products will make markets more competitive in the domestic and international markets, attracting the attention of consumers and opening up new business opportunities.

Participation in international fairs, exhibitions and events will contribute to increasing the exposure of Romanian agri-food products on foreign markets, thus attracting the attention of new trading partners and consumers from other countries.

Traditional products from the EU

Product names originating from specific regions possess distinct qualities and reputations that are closely tied to their geographical area of production. These products are protected under the European Union's geographical indications system. The main distinction between PDO and PGI lies in the proportion of raw materials that must originate from the designated region or in the specific stage of the production process that must occur there. The Geographical Indication (GI) label is used exclusively for spirits. The European Union safeguards a wide range of traditional products from its member states, including Romania. These products are granted designations such as Protected Designation of Origin (PDO), Protected Geographical Indication (PGI), and Traditional Speciality Guaranteed (TSG) [23], [8].

Romania has 14 food products registered on European quality systems [4], [12], [13]:

Protected Geographical Indication:

1. "Magiun de prune Topoloveni" – registered in 2011; [16]
2. "Salam de Sibiu" – registered in 2016;
3. "Novac afumat din Țara Bârsei" – registered in 2017;
4. "Smoke Danube Smurf" – registered in 2018; [7]
5. "Cârnaţi de Pleşcoi" – registered in 2019;
6. "Telemea de Sibiu" - registered in 2019;
7. "Caşcaval de Săveni" - registered in 2021;
8. "Tulcea pike caviar salad" - registered in 2021;
9. "Plăcintă Dobrogeană" - registered in 2023;
10. "Pită de Pecica" - registered in 2023;
11. "Salinate de Turda" – registered in 2023.

Protected Designation of Origin:

12. "Telemea de Ibăneşti" – registered in 2016 [6]

Traditional Speciality Guaranteed:

13. "Traditional salad with carp roe" – registered in 2021
14. "Marinated sardine made according to Romanian tradition" – registered in 2024.

The following products are auto-register entries under evaluation/verification at the European Commission to register them as Protected Geographical Indications [23],[8]:

1. "Deltaic sturgeon blog"
2. "Babic de Buzău"
3. "Vâlcea axe sausages"
4. "Teaca kneaded cheese"
5. "Poiana Mărului salami"
6. "Bere Sadu"

These products not only illustrate the gastronomic wealth of Romania but also contribute to promoting the cultural identity of the respective regions.

The protection offered by the EU helps to preserve trade options and support local producers.

In Italy, the country with the largest number of registered products at the European level, the food industry is spread everywhere; it can be said that it is the most evenly distributed industrial branch in the territory.

Italy stands out for its pastry products, olive oil, sugar, canned fish and wine (Table 1). Compared to Italy, Romania is in a lower place for specialities in this ranking at the European level, but this does not mean that Romanian traditional guaranteed specialities are not recognized and appreciated both internally and

externally. Although Romania has a long agricultural tradition and Romanian agri-food products have long been known and appreciated abroad, at the national level, there has been a lack of effective and adequate legislation that would capitalize on the elements of traditional and popular culture reflected in these products.

Table 1. Situation of the products registered at the European level

Country	Quality system (No. products)			Total General
	I.G.P.	D.O.P.	S.T.G.	
Italy	114	183	2	299
France	127	125	1	253
Spain	91	112	4	207
Germany	86	34	-	120
EU + other countries	703	690	59	1,452
Romania	11	1	2	14

Source: MADR

Old traditional food products in Europe

1. Feta (Greece)

• Origin: Antiquity

• Description: Feta cheese is one of the oldest cheeses in the world, mentioned as early as ancient Greek writings, such as Homer's "Odyssey". It is produced from sheep's milk or a combination with goat's milk [13].

2. Parmesan (Parmigiano-Reggiano) - Italy

• Origin: Middle Ages

• Description: This hard cheese has been documented since the 12th century, being produced in the Emilia-Romagna and Lombardy regions. It is known for its long maturation process and intense flavour [21].

3. Whiskey (Ireland)

• Origin: 6th century

• Description: One of the oldest spirits in the world, Irish whiskey has been distilled since the 6th century and was originally used for medicinal purposes [14].

4. Bordeaux Wines (France)

• Origin: Roman period

• Description: Wines produced in the Bordeaux region have a tradition dating back over 2,000 years and are some of the most famous wines in the world [2].

5. Cassoulet (France)

• Origin: Middle Ages

• Description: This dish based on beans, sausages, and meat (duck or pork) comes from the south of France and has its origins in medieval recipes [4].

Old traditional drinks

1. Pálinka (Hungary)

• Origin: 14th century

• Description: A spirit distilled from fruit, originating in Hungary, with a long tradition [3].

2. Grappa (Italy)

• Origin: Middle Ages

• Description: A spirit obtained by distilling the remains left after wine production, originally consumed by peasants [15].

These products reflect the cultural diversity of Europe and the importance of preserving culinary traditions passed down through the centuries. Many of them are now protected by European schemes such as PDO or PGI to preserve their authenticity.

National quality schemes

There are 3 quality schemes regulated at the national level, namely [22]:

1) ***traditional product*** ("Order No. 724/2013 on the certification of traditional products, as subsequently amended and supplemented") [19].

Romania has 792 products certified as traditional [1].

The counties with the most certified traditional products are Brașov – 170, Maramureș – 50, Argeș and Alba – 45.

2) ***product registered according to a well-established recipe*** ("Order no. 151/1460/213/2021 on the registration of well-established recipes, as well as the certification of food products obtained according to well-established recipes") [19].

At the national level, some 29 recipes are approved, and 73 products obtained according to well-established recipes are certified and registered [1].

The small number of products obtained according to established recipes is explained by the fact that the regulatory act regulating the obtaining/registration of these products was repealed, and the implementation of the new order began in the fall of 2022.

3) ***mountain product*** ("Order no. 174/2021 approves the Procedure for verifying the

conformity of data included in the product specification required to grant the right to use the optional quality term "mountain product", as well as for conducting controls to ensure that economic operators who have obtained this right comply with both European and national legislation, including any subsequent amendments and additions") [19].

Currently, over 4,300 mountain products (4,320) are registered in Romania [1].

European certification increases quality, but costs more

Products registered under national quality schemes and European quality systems have specific quality characteristics, which define and represent the gastronomic, cultural and traditional particularities of certain geographical areas. The raw materials used, the production methods, the intrinsic link with the geographical area and the human factor give added value to this category of products, a fact confirmed by the growing consumer demand for these products, which have applied on the labels/packaging logos/symbols provided for by European or national legislation.

Advantages of registering agricultural products on European quality systems:

-opportunities to access global markets;

-increased export potential;

-provides producers with the tools to identify and promote those products that have specific characteristics and can be certified through quality systems;

-raising awareness among European consumers about the quality of traditional Romanian products that are part of the national culture;

-participation in the European Commission's promotion policy, 'Enjoy, it's from Europe', supports professionals in the sector by helping them access international markets or strengthen their presence within them. This new policy is designed to enhance the visibility and competitiveness of European products globally.

CONCLUSIONS

Consumers are eager to consume traditional products because they bring a series of health benefits, as they are less processed, contain natural ingredients and can also be recommended in certain diets.

The main goal of marketing traditional products is to support small producers and the local economy.

By consuming traditional products, one helps to promote and preserve the cultural heritage that has been passed down from generation to generation.

A traditional product is a product made with local raw materials, of very good quality, without using additives or preservatives, made in an artisanal way, over a stove flame, in a pot or over a wood fire, in a cauldron, in small quantities, with manual packaging and labelling. These products should be niche products, not in industrial quantities, with a presence in all supermarket-type stores. The raw material should be cleaned by hand, produced seasonally, when the raw material is harvested in the respective area.

REFERENCES

[1]Agency for Financing Rural Investments, AFIR, Investing Certified Romanian Products and Activities Catalogue, 2024, https://cpac.afir.info/Producers-Map?culture=en, Accessed on 23.02.2025.

[2]Alcooldiscount.ro, Everything about the wines from the Bordeaux region, https://alcooldiscount.ro/blog/vin/totul-despre-vinurile-din-regiunea-bordeaux-franta/ Accessed on 19.02.2025.

[3]Allthingsbudapest.com, 2025, Hungarian Palinka, Everything you need to know, https://allthingsbudapest.com/what-is-palinka, Accessed on 17.02.2025

[4]Blablafrancais.com, This French Dish is Older Than France Itself! Here's Where to Try It, https://blablafrancais.com/this-french-dish-is-older-than-france-itself-heres-where-to-try-it/, Accessed on 17.02.2025.

[5]Cetina, M. I., Goldbach, D., N., Popescu, L., 2018, Marketing strategies for Romanian traditional products. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 18(2), 93-100.

[6]Cheeseorigin.com, Telemea de Ibanesti, https://cheeseorigin.com/telemea-de-ibanesti, Accessed on 19.02.2025.

[7]Deltaica.ro, Welcome on the land of deltaic legends, https://deltaica.ro, accessed on 17.02.2025.

[8]European Commission, Geographic Indications and Quality Systems, https://agriculture.ec.europa.eu/farming/geographical-indications-and-quality-schemes_ro, Accessed on 23.02.2025.

[9]European Union, Regulation (EU) No 1169/2011 of the European Parliament and of the Council of 25 October 2011 on the provision of food information to consumers, https://eur-lex.europa.eu/eli/reg/2011/1169/oj/eng, Accessed on 23.02.2025.
[10]European Union, eAmbrosia, Union Register of Geographic Indications, https://ec.europa.eu/agriculture/eambrosia/geographical-indications-register/ Accessed on 19.02.2025
[11]European Union, https://eur-lex.europa.eu/, Accessed on 16.02.2025
[12]Eurostat Data base, 2025, https://ec.europa.eu/eurostat/web/main/data/database, Accessed on 17.02.2025
[13]Greekgastronomyguide.gr., History of Feta, https://www.greekgastronomyguide.gr/en/feta-ethniko-proion/#istoria-tis-fetas, Accessed on 17.02.2025
[14]Ireland.com, Irish Whiskey, https://www.ireland.com/en-us/things-to-do/themes/food-and-drink/irish-whiskey/, Accessed on 15.02.2025
[15]ItalyWeloveyou.com, Grappa brands, https://www.italyweloveyou.com/italian-grappa-brands/, Accessed on 18.02.2025.
[16]Magiun-sonimpex.ro, https://www.magiun-sonimpex.ro/company-history-new/Accessed on 13.02.2025
[17]Ministry of Agriculture and Rural Development, MARD, 2024, Register of systems in the field of national protected quality, RSCPN, December 2024. https://www.madr.ro/industrie-alimentara/sisteme-de-calitate-europene-si-indicatii-geografice/produse-agricole-si-alimentare.html, Accessed on 23.02.2025.
[18]Ministry of Agriculture and Rural Development, MARD, 2024 Register of certification of traditional products, 01.12.2024. Implementation of ORDER no. 724/1.082/360/2013 regarding the certification of traditional products. Published in M.O. no. 688 of 11 November 2013. https://www.madr.ro/industrie-alimentara/produse-traditionale-romanesti/implementarea-ordinului-nr-724-2013-privind-atestarea-produselor-traditionale-cu-modificarile-si-completarile-ulterioare.html, Accessed on 23.02.2025.
[19]Ministry of Agriculture and Rural Development, MARD, 2025, Food industry, https://www.madr.ro/industrie-alimentara.html, Accessed on 19.02.2025
[20]Neculcea, E., Dona, I., 2023, The development of traditional Romanian food products. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 23(1), 447-452.
[21]Parmigianoreggiano.com, The only Parmesan, The History, A Journey of a thousand years, https://www.parmigianoreggiano.com/product-history, Accessed on 14.02.2025
[22]Somicu, A.G., Vladu, M., 2023, Study regarding the implementation of national quality schemes for agri-food products - traditional Romanian products. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 23(1), 783-792.
[23]TMDN.org. Search for Geographical Indications across the European Union and beyond https://www.tmdn.org/giview, Accessed on 22.02.2025.

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ANALYSIS OF THE STRUCTURAL EVOLUTION OF THE DOMESTIC DAIRY PRODUCTS SUPPLY IN ROMANIA

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Abstract

The paper aimed to analyse the structural evolution of various dairy products in Romania, during the period 2014-2023, based on statistical data from the National Institute of Statistics. To study their trends, various statistical indicators were calculated, as well as characteristic regression equations. Thus, in the analysed interval, the highest growth was found for cow's milk cheeses, with +46.5%, followed by drinking milk, with +42.3%. Overall, the cheese category had a market supply of 102,078 tons in 2023, which means an increase of 37.1%, compared to the year 2014. The lowest increase was in butter, where the supply was 10,593 tons in 2014 and increased by 3.5% to 10,963 tons in 2023. The calculated statistical indicators highlighted the fact that, in all product categories, both in drinking milk and in dairy products, the dynamics were positive, with different growth rates.

Key words**:** *evolution, dairy products, milk, Romania, trends*

INTRODUCTION

Milk and dairy products have an important role in the people diets and the nutritional characteristics have determined an increase in production and consumption over the past years [6, 7].
Milk and dairy products have an importance place in food consumption per inhabitant [9].
Evaluating the supply of dairy products is part of the concerns regarding food safety aspects in the dairy supply chain.
The analysis of the near-term trends revealed that the increase in milk production is considered the most relevant in terms of the food safety.
Other factors which influence the food safety include the climate change and adapting of the farms, that consider animal welfare and environmental sustainability [10].
The safety characteristics of the dairy products affect the consumers health and the sustainability of the dairy supply chain. Sometimes, along the food supply chain could appear risks such as competition, quality of raw materials etc which have to be mitigated [12].
The increased consumers awareness regarding the food safety has determined the dairy industry to improve it, including the image of the dairy products [2].
Previous studies have shown a trend in demand for dairy products in developed and developing countries, stemming from the positive evaluation of milk fat, as well as the increasing globalization of diets, which has influenced consumer decisions. Increased milk production, population growth and changing consumption habits are resulting in an increase in the volume of the dairy product market.
Also, producing companies are now more focused on the sustainability and environmental performance of the food supply chain [3].
The supply chain of dairy products, especially milk, alongside with farmers, includes intermediates like milk traders, processors, retailers, and consumers. The milk production should be increased to meet the consumer’s demand and promoting milk production can be an important instrument for increasing farmers' income and meeting consumers' demand [4].
Research on the determinants shaping the supply and demand for milk and dairy products indicated that the demand may be influenced by the level of consumer education, or by product prices and consumer income, as well as the family spending etc. [1].

The most of economic agents rely on stable supply chain management, to support the flow from the raw material procurement, to the products delivery to consumers [11].
The sustainability of the milk and dairy production can be improved by optimizing the activities in the supply chain, taking into consideration not only the environment and the economic aspects, but also the social ones. More severe environmental constraints can result in higher economic costs and lower profit [5].
In this context, the paper aimed to study the structural dynamics of various dairy products supply in Romania based on official statistical data during the period 2014-2023.

MATERIALS AND METHODS

To analyse the structural evolution of various dairy products in Romania, the following statistic indicators were used: minimum, maximum, average, annual average rate, standard deviation, coefficient of variation, as well as regression equations.
The period analysed in this study was 2014-2023.
The data, collected from National Institute of Statistics (NIS), have been processed, and interpreted, resulting the trend lines for each dairy product analysed.

RESULTS AND DISCUSSIONS

Table 1 presents the statistical indicators calculated for cow's milk collected by processing units, raw milk imported, drinking milk, drinking cream, acidified milk, butter, total cheeses, and cow's milk cheeses. The data calculated show that the highest annual growth rate was for raw milk imported, by 4.52%, and the lowest one was for butter, by 0.39%.

Table 1. Statistic indicators for dairy products

Specification	Minimum (tons)	Maximum (tons)	Average (tons)	Annual average rate %	Standard deviation (tons)	Coefficient of variation %
Cow's milk collected by processing units	915,952.00	1,204,546.00	1,072,484.30	2.13	88,444.54	0.08
Raw milk imported	77,396.00	146,572.00	121,509.50	4.52	20,684.05	0.17
Drinking milk	250,463.00	387,208.00	318,780.70	4.07	46,379.96	0.15
Drinking cream	58,646.00	69,833.00	66,466.70	1.36	2,892.93	0.04
Acidified milk	165,997.00	225,710.00	206,833.00	2.25	17,447.95	0.08
Butter	10,483.00	12,163.00	11,213.00	0.39	601.60	0.05
Total cheeses	74,654.00	102,078.00	92,543.90	3.54	8,553.55	0.09
Cow's milk cheeses	64,382.00	94,968.00	81,275.80	4.29	9,936.19	0.12

Source: Own calculations based on the data from NIS [8].

Cow's milk collected by processing units, following a generally upward trend, increased at an average annual rate of 2.13% (by 27.8 thousand tons/year), from 996.7 thousand tons in 2014 to 1204.5 thousand tons in 2023 (Figure 1).

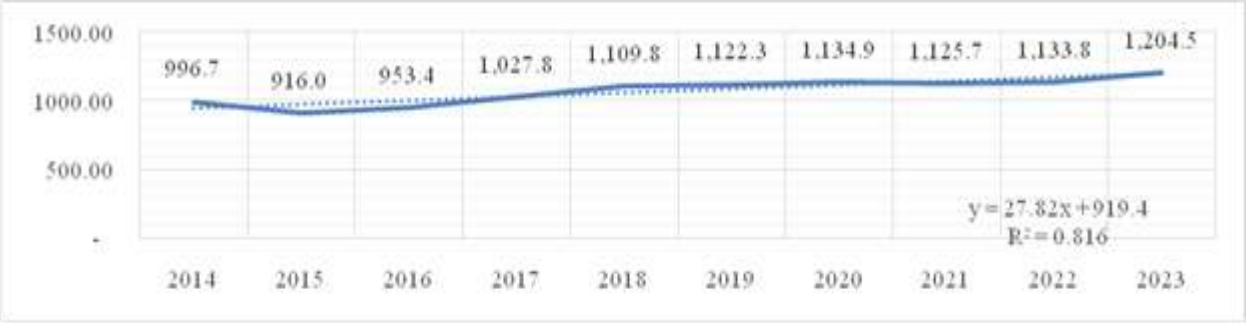

Fig. 1. Evolution of the quantities of cow's milk collected by processing units (thousand tons)
Source: Own design based on the data from NIS [8].

The quantity of the imported raw milk had a variable trend, increasing by 49.3%, the average annual rate being 4.52%, up to 115 thousand tons. Regression equation shows that imported raw milk increased every year by 4.49 thousand tons (Figure 2).

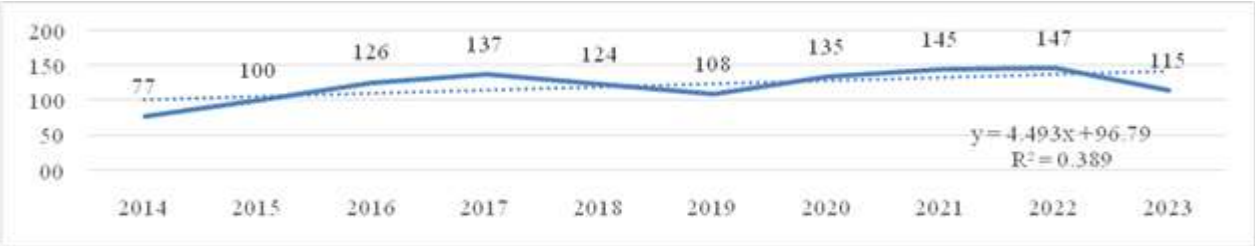

Fig. 2. The evolution of the quantities of imported raw milk (thousand tons)
Source: Own design based on the data from NIS [8].

The quantity of drinking milk produced increased continuously until 2021 (with an average of 15.3 thousand tons/year), after which it began to decrease slightly, but overall, it had a growth rate of 4.07% per year, reaching 359 thousand tons in 2023 (meaning +43.6% compared to the year 2014) (Figure 3).

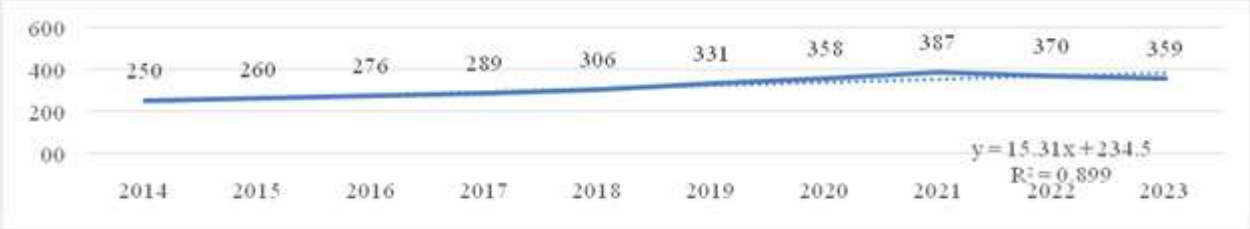

Fig.3. The evolution of drinking milk quantities (thousand tons)
Source: Own design, based on data from NIS [8].

Supply of drinking cream had increased by 12.9%, with a growth rate of 1.36% per year, from 58.6 thousand tons, to 66.2 thousand tons, on variable trajectory (Figure 4).

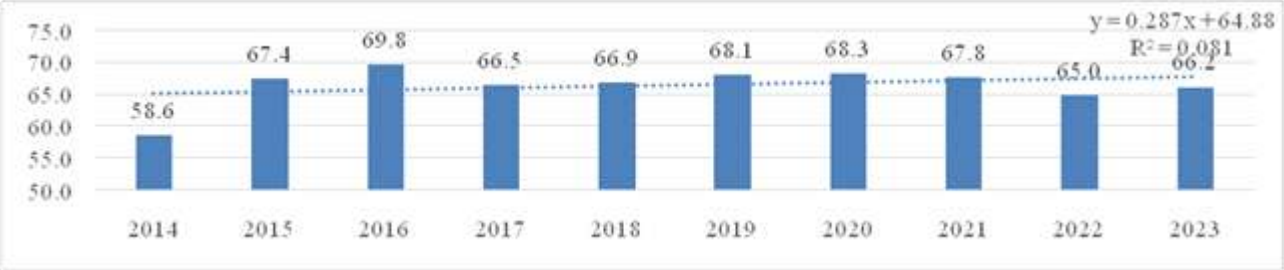

Fig. 4. Evolution of the quantities of drinking cream (thousand tons)
Source: Own design based on the data from NIS [8].

Quantities of acidified milk have also increased by 22.2%, with a growth rate of 2.25% (an average of 3.93 thousand tons/year), from 166 thousand tons in 2014, to 202.8 thousand tons in 2023. This category includes the different assortments of yogurts, kefir, whipped milk (Figure 5). The quantity of butter had a very fluctuating course during the period 2014-2023, reaching maximum values of over 12 thousand tons in 2017 and 2020, and reaching 11 thousand tons at the end of the analysed period (Figure 6). The supply of total cheeses increased by 36.7% during the analysed period, with an average annual rate of 3.54% per year (2.8 thousand tons per year), reaching 102.1 thousand tons in 2023 (Figure 7). The quantity of cottage cheese increased by 46% during the analysed period, with an average annual rate of 4.29% (3.4 thousand tons per year), reaching 94 thousand tons in 2023 (Figure 8).

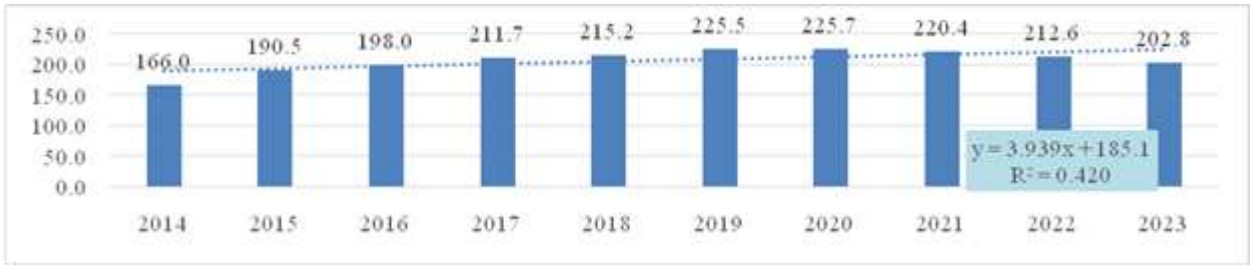

Fig. 5. Evolution of the quantities of acidified milk(thousand tons)
Source: Own design based on the data from NIS [8].

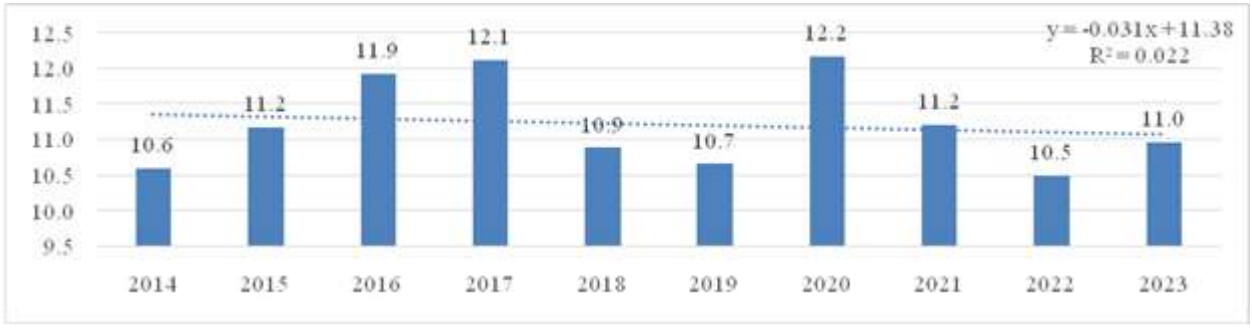

Fig. 6. Evolution of the quantities of butter(thousand tons)
Source: Own design based on the data from NIS [8].

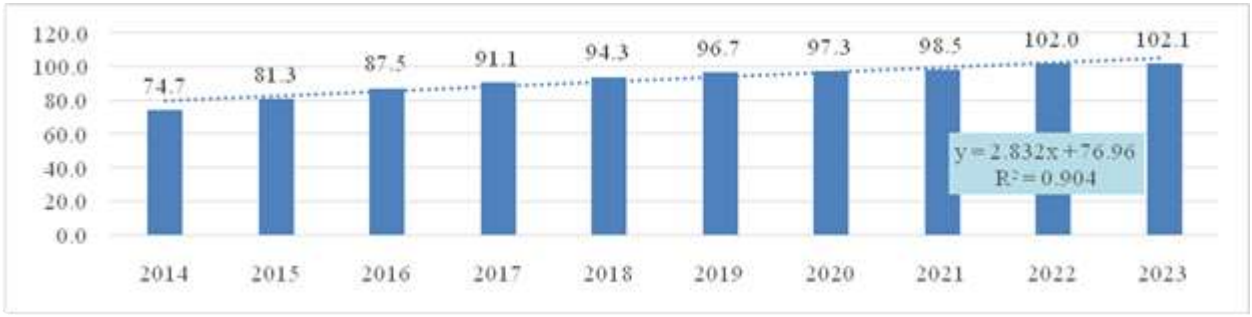

Fig. 7. Evolution of the quantities of total cheeses(thousand tons)
Source: Own design based on the data from NIS [8].

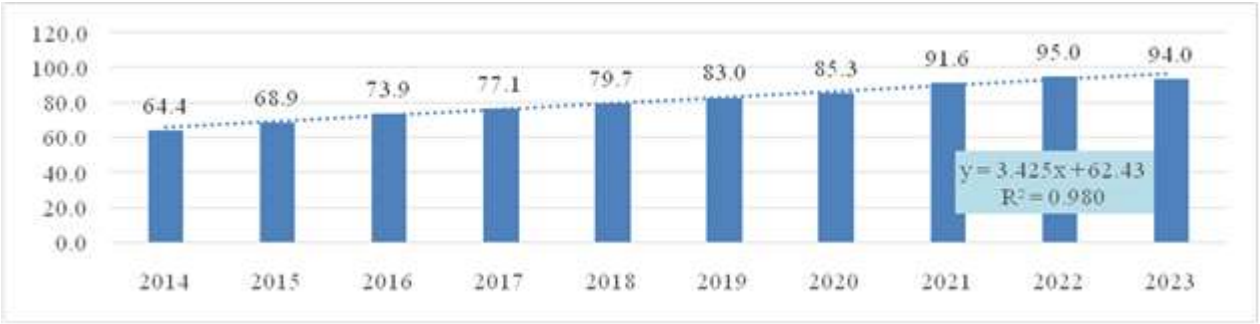

Fig. 8. Evolution of the quantities of cow's milk cheeses(thousand tons)
Source: Own design based on the data from NIS [8].

Comparing the trends of milk and dairy product supply on the market with that of the resident population in Romania between 2014-2023, it is observed that they are different, with that of the population being in decline, decreasing by over 106 thousand people per year, according to the regression equation (Figure 9).

This situation is also reflected by the annual increase in the consumption of milk products by 1.66 kg/capita/year, over the last decade, according to data in Figure 10.

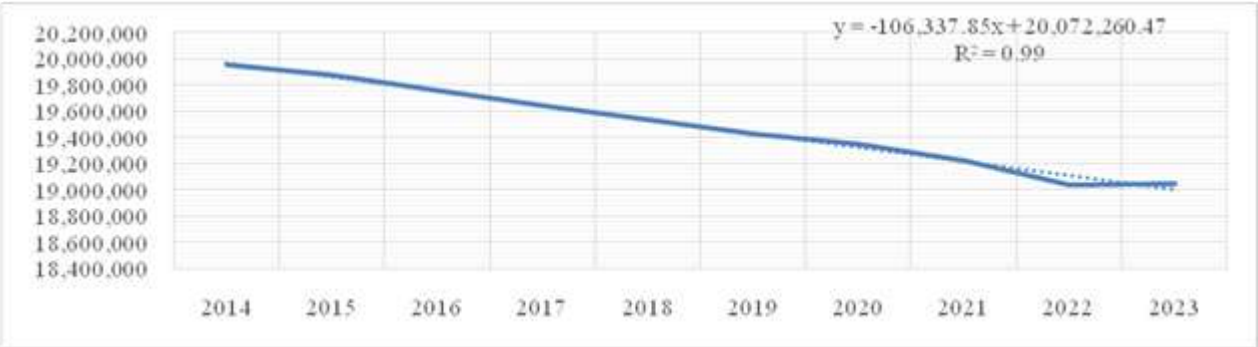

Fig. 9. The evolution of the resident population in Romania, number of persons
Source: Own design, based on data from NIS [8].

Fig. 10. The evolution of the milk products consumption in milk equivalent 3.5% fat (excluding butter)
Source: Own design, based on data from NIS [8].

CONCLUSIONS

The analyses in the paper indicated that, in the last decade, the supply of dairy products on the market in Romania followed positive trends, with the highest annual growth rate being for imported raw milk, followed by cow's milk cheeses and drinking milk. The lowest growth rate was for butter supply. In contradiction with these developments, that of
the resident population was negative, the population decreasing by over 106 thousand persons per year. This comparative situation is also reflected by the growth curve of milk and equivalent milk product consumption in the last 10 years. The laws of demand and supply are those that govern market economies and determine the functional characteristics of the markets for different products.

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REFERENCES

[1]Aslam M., LI Z., Naeem S., Nasir S., 2024, Navigating digital frontier: Factors influencing supply and demand of fresh milk in Pakistan. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 24(1), 75-86. Accessed on February 3, 2025.
[2]Ding, H., Fu, Y., Zheng, L., Yan, Z., 2019, Determinants of the competitive advantage of dairy supply chains: Evidence from the Chinese dairy industry. International Journal of Production Economics, 209, 360-373. Accessed on February 4, 2025.
[3]Ferreira, F. U., Robra, S., Ribeiro, P. C. C., Gomes, C. F. S., Almeida Neto, J. A. D., Rodrigues, L. B., 2020, Towards a contribution to sustainable management of a dairy supply chain. Production, 30, e20190019.Accessed on February 4, 2025.
[4]Hossain, S., Jahan, M., Khatun, F., 2022, Current status of dairy products in Bangladesh: A review on supply and utilization. International Journal of Business and Management Social Researches, 11, 609-18. Accessed on February 4, 2025.
[5]Kirilova, E., Vaklieva-Bancheva, N., Vladova, R., Petrova, T., Ivanov, B., Nikolova, D., Dzhelil, Y., 2022, An approach for a sustainable decision-making in product portfolio design of dairy supply chain in terms of environmental, economic and social criteria. Clean Technologies and Environmental Policy, 24(1), 213-227. Accessed on February 4, 2025.
[6]Medelete, D.M., Panzaru, R.L., Grecu, M.C., 2024, Consumption of milk and dairy products in Romania

(2017-2019) . Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 24(1) 599-606.
[7]Montgomery, H., Haughey, S. A., Elliott, C. T., 2020, Recent food safety and fraud issues within the dairy supply chain (2015–2019). Global Food Security, 26, 100447. Accessed on February 4, 2025.
[8] National Institute of Statistics NIS, Tempo online, http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table, Accessed on February 2, 2025.
[9]Popescu, A., Chirciu, I., Soare, E., Stoicea, P., Iorga, A. 2022, Trends in average annual food consumption per inhabitant in Romania. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 22(3), 561-580.
[10]Research Institute for Agriculture Economy and Rural Development, 2025, ADER 22.1.2. Project - Technical-economic models for reducing the vulnerability of livestock farm income to climate change. Accessed on February 4, 2025.
[11]van Asselt, E. D., Van der Fels-Klerx, H. J., Marvin, H. J. P., Van Bokhorst-van de Veen, H., Groot, M. N., 2017, Overview of food safety hazards in the European dairy supply chain. Comprehensive Reviews in Food Science and Food Safety, 16(1), 59-75. Accessed on February 4, 2025.
[12]Zubair, M., Mufti, N. A., 2015, Identification and assessment of supply chain risks associated with dairy products sector. Journal of Basic & Applied Sciences, 11, 167-175. Accessed on February 4, 2025.

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EXPLORING THE SPATIAL, TECHNICAL AND ECONOMICAL FEATURES OF AGRICULTURAL LAND MARKET IN ROMANIA IN THE YEAR 2024

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Abstract

This paper examines Romania`s agricultural land market by creating a comprehensive database of land sale offers. The database aggregates essential information, including location, pricing, and land characteristics, collected from Ministry of Agriculture and Rural Development for diverse regions of the country, providing a foundation to analyze land market in the year 2024. The study applies statistical methods such as: descriptive statistics, including histogram and scatterplot representation, as well as correlation exploration, to uncover the main aspects in pricing, regional disparities, and market behaviors. These insights illuminate both the challenges and opportunities within Romania`s agricultural land sector. To complement the statistical analysis, Geographic Information System (GIS) tools are employed to provide a spatial perspective on land sale distributions. GIS mapping visually represents geographic trends, identifying regions of high and low activity and enhancing the understanding of spatial patterns in land transactions. By integrating statistical and GIS analyses, the paper offers a comprehensive view of the market, delivering valuable insights for policymakers, investors, and stakeholders interested in navigating and optimizing the agricultural land market in Romania. The analysis of Romania's agricultural land market reveals notable regional disparities in both parcel sizes and offer prices. While there is a moderately strong positive correlation between parcel size and total offer price, the results indicate that other factors—such as location, accessibility, and land use—have a greater influence on land value. Spatial and statistical findings emphasize the importance of these factors in shaping market dynamics and highlight the need for region-specific investment strategies and land management policies to support sustainable market development.

Key words**:** *land market, territorial distribution, surfaces, prices, statistical analysis, GIS, Romania*

INTRODUCTION

In recent decades, rapid and widespread urbanization has transformed many regions across the globe. (Kwartnik-Pruc & Droj, 2023)[11]. Land, as a finite and valuable resource, requires strategic and sustainable management, particularly in the context of accelerated global population growth. Within this framework, it becomes essential to address the legal evaluation, clear definition, and systematic registration of real estate assets. (Kayalik and Polat, 2023) [10]. The inherent nature of agricultural activities means that risks and uncertainties are a constant presence in agricultural value chains. Therefore, it is crucial for decision support models in farming to incorporate risk management metrics and strategies. (Chiorean et al,. 2024) [5].

Furthermore, the immediate and readily apparent benefits of implementing these solutions in real estate property evaluation include the automation of the evaluation process and the availability of control methods for the obtained results. Discovering methods to seamlessly incorporate data from reliable

sources into contemporary Geographic Information Systems (GIS) would enhance the efficiency of various real estate professionals, including appraisers, brokers, developers and bank analysts (Brożek & Frosik, 2023) [4].

The real estate market encompasses the collective activities related to real estate, comprising investments, transactions, and ancillary services such as brokerage, valuation, consulting and management. This market involves interactions among various stakeholders, including property developers, sales representatives, prospective users, as well as intermediaries like brokers and appraisers. (Pawel et al., 2022) [8].

As specified by G. Liu, in the last few years, real estate prices have risen rapidly and this fact attracted many specialists from various fields (Liu, 2022) [12]. Examining and analyzing the real estate market through forecasting allows for an assessment of its stability. This evaluation serves a dual purpose: firstly, it aids the government in implementing macroeconomic controls on house prices, contributing to overall economic health. Secondly, the prediction of house prices serves as a foundation for real estate investors to develop investment strategies, helping them steer clear of potential losses (Liu, 2022) [12].

Furthermore, urban residents are increasingly prioritizing the quality of their living environments. In cities marked by pollution, environmental quality has emerged as a significant factor influencing residential and location preferences. Consequently, this dynamic plays a pivotal role in shaping land-use patterns, mobility trends, and the economic landscape of the affected areas. This concern is particularly noteworthy in industrial cities where residents confront daily health risks arising from adverse environmental conditions, notably high pollution levels. In an effort to mitigate these risks, individuals often relocate to residential areas with better environmental conditions, even if they may be less accessible in terms of transportation systems and/or urban services (Chiarazzo et al., 2014) [6].

Although there are substantial distinctions between urban and rural spaces, and there are valid methodological reasons to concentrate case studies in either setting, there is considerable value in establishing connections between the countryside and the city. Analyzing the diverse forms that property ownership assumes across these spaces can offer valuable insights (Van Sant et al., 2023) [17]. Extensive metropolitan areas encompass not only urban centers but also rural outskirts. The connections between these regions are so pronounced that they cannot be studied in isolation. In the rural outskirts, there is a modern coexistence of residential functions, work activities, and traditional agricultural sectors. Consequently, the production of goods and services for the city necessitates a comprehensive analysis, considering the vast territory that comes into play. (Bencardino & Nesticò, 2017) [3]. To delve into the dynamics of rural-urban relations and interactions, it is essential to start with the foundational assumption that certain spaces can be categorized as either "urban" or "rural." While this categorization holds true, it's important to note that urban and rural areas don't exist as isolated and distinct territories. On the contrary, they are intricately interconnected in numerous ways, necessitating a thorough exploration of their associations in terms of identity, causality, and effects, both theoretically and empirically. (Delgado-Viñas & Gómez-Moreno, 2022) [7].

According to some studies, the cities contain 54% of the world's population and this number is expected to increase to 66% by 2050, (Kaluarachchi, 2022) [9] while other studies shows that by 2030, even faster, megacities or dense metropolitan regions will house almost 60% of the world's population (Vardopoulos et al., 2023) [18]. The distinctive characteristics of urban centers, such as elevated population density, traffic congestion, and intense land development, stem from their high density and central role in hosting urban functions, setting them apart from other regions within cities (Wang & Li, 2019) [19].

The process of managing data related to the market, real estate, and transactions, which is integral to the appraisal procedure, encompasses three key phases: data collection, organization of the collected data, and subsequent analysis. For appraisers, a profound understanding of statistics has become crucial,

particularly with the integration of the valuation methodologies of individual real estate properties into overarching appraisal techniques. In this evolving environment, traditional real estate appraisers play a pivotal role, acting as a bridge between the purely mathematical models employed in valuation, local market conditions, and the analyzed physical attributes of real estate. The incorporation of statistical models and specialized applications of statistical processes offers additional support in formulating an opinion on value or conducting analysis (Zeicu et al., 2017) [20].

The primary approach to forecasting and analyzing the real estate market involves the utilization of the multiple linear regression model, followed by drawing conclusions based on the analysis of real estate data. The multiple linear regression model is a prevalent multivariate statistical method, valued for its convenience and simplicity in application (Liu, 2022) [12]. Using statistical data from the real estate market, this study examines the factors influencing real estate prices. It establishes a multiple linear regression model, employs the least square method to determine the unknown parameters in the model, and ultimately constructs a house price prediction model for forecasting and analyzing the real estate market (Liu, 2022) [12]. Multiple Linear Regression is a statistical method designed to investigate the relationship between two or more variables. The variable to be predicted is known as the dependent variable (or response variable, outcome, or target), while the variables used to predict its value are referred to as independent variables (or predictors, explanatory variables, or regressors). The overarching goal of multiple regression is to gain a deeper understanding of the relationship between multiple independent or predictor variables and a dependent or outcome variable (Abdulhafedh, 2022) [1].

Most input data contain geospatial references, involving geographical location. Managing these geospatial data is becoming increasingly crucial for public institutions such as public administration, environmental organizations, healthcare units, various financial services, etc. GIS applications utilized by these institutions provide the capability to collect, store, organize, manage, and utilize geospatial information in a graphical form, enabling efficient visualization, searching, planning, and analysis. Through these GIS applications, complex queries and advanced analyses can be performed, leveraging not only geospatial data and information but also technical and economic data and information by integrating with various other information platforms (Badea and Badea, 2013) [2]. In their 2016 study, Sălăgean et al. discuss the development of a Geographic Information System (GIS) tailored for the real estate sector, emphasizing its potential to enhance property evaluation and management through spatial data integration [16]. This approach aligns with contemporary trends in utilizing GIS technologies to improve the accuracy and efficiency of real estate assessments. (Sălăgean et al, 2016) [16].

Currently, the activity of real estate property valuation is regulated by the National Association of Appraisers in Romania, abbreviated as ANEVAR. The association was established in 1992 as a non-governmental professional association, independent, in accordance with the legal provisions in force at that time. In 2011, the regulated profession of authorized appraiser was established through the Government Ordinance of Romania No. 24/2011 regarding certain measures in the field of asset valuation, approved with modifications by Law No. 99/2013. ANEVAR was constituted as a professional public utility organization without patrimonial purposes, and it includes authorized appraisers who acquire this status under the conditions provided by the afore mentioned legal act. (National Association of Appraisers from Romania ANEVAR, ANEVAR.Html) [15]. The purpose of the National Association of Authorized Appraisers in Romania is to organize, coordinate, and authorize the practice of the authorized appraiser profession in the country. It is committed to representing and safeguarding the professional interests of its members, ensuring the independent exercise of the authorized appraiser profession in accordance with the principles of professional ethics and a high level of qualification. Additionally, the association aims to promote

standards, methods, and techniques of appraisal in the activities of authorized appraisers. (National Association of Appraisers from Romania ANEVAR, *ANEVAR.Html*) [15]. As presented in the Property Valuation Standards, 2022 edition, currently in force, more specifically in GEV 630 - Real Estate Valuation, if there are few recently completed sales or when appraisers' access to recent completed sales is restricted by various specific legal provisions or when there is limited information available to the general public, the appraiser may consider prices of identical or similar assets that are published or offered for sale (active listings), provided that the relevance of this information is clearly established, critically analyzed, and substantiated. (National Association of Appraisers from Romania ANEVAR, 2022) [14]. The aim of this study is to conduct a comprehensive analysis of the agricultural land market in Romania by exploring spatial and statistical variations in land offer prices and parcel sizes. Drawing on a robust database of approximately 2,800 land listings aggregated from the Ministry of Agriculture and Rural Development (MADR) [13], the research investigates key indicators such as average offer price per hectare, total parcel area, and regional disparities. By integrating statistical analysis with geospatial visualization, the study seeks to identify emerging trends, highlight regional imbalances, and provide data-driven insights into the dynamics of agricultural land across Romania.

MATERIALS AND METHODS

To conduct this study, a comprehensive database of agricultural lands available for sale from various counties in Romania was compiled. Approximately 3,300 data points were collected from the official website of the Ministry of Agriculture and Rural Development (MADR) [13], based on the listings available and valid as of December 2024. The database includes several variables, which are detailed in Table 1. This table presents the structure of a geospatial database used for analyzing agricultural land listings in Romania. It comprises eight fields, each with a specific role in identifying and describing land parcels. The first field, "ID-GIS," serves as a unique identifier for representing each land listing within platforms such as ArcGIS Online. This ensures the seamless integration of spatial data with mapping technologies for visual analysis and geolocation purposes.

Table 1. Data base description of study variables

Crt. no.	Fild name	The field category	Description of field	Field type
1	ID-GIS	ID	Unique identifier used for representation in **ArcGIS online**	Integer
2	Location / County	Spatial features	Name of the county (e.g., Arad) where the land is located	String
3	Name of the Administrative-Territorial Unit (ATU)		Name of the ATU (e.g., municipality or commune)	String
4	Latitude		Geographic coordinates taken from google maps	Double
5	Longitude		Geographic coordinates taken from google maps	Double
6	Area	Technical features	Total surface area of the property in hectares	Double
7	Offer price	Economical features	Total price listed for the land offer on the platform	Integer
8	Unit offer price		The offer price taken from the platform in EURO/hectares	Integer

Source: created by the authors.

The database categorizes the fields into three major types: spatial, technical, and economical.

Spatial features include the name of the county and the Administrative-Territorial Unit (ATU), along with geographic coordinates (latitude and longitude) derived from Google Maps.

These variables enable the spatial localization of each land parcel, allowing researchers to track regional disparities and distribution patterns across Romania.

Technical features are represented by the "Area" field, which indicates the total surface area of the land in hectares—a critical metric for valuation and comparative analysis. *Economical features* are captured through the "Offer price" and "Unit offer price" fields. The total offer price denotes the overall listing value of the land, while the unit price provides a standardized metric (EUR/hectare), enabling accurate comparison across properties of varying sizes. This structured database not only facilitates descriptive statistical analysis but also serves as a foundation for geospatial and econometric modeling in the context of land market assessments and rural development planning.

The diagram presented in Figure 1 outlines a structured methodology for analyzing agricultural land values at a national level, with a focus on spatial and statistical modeling.

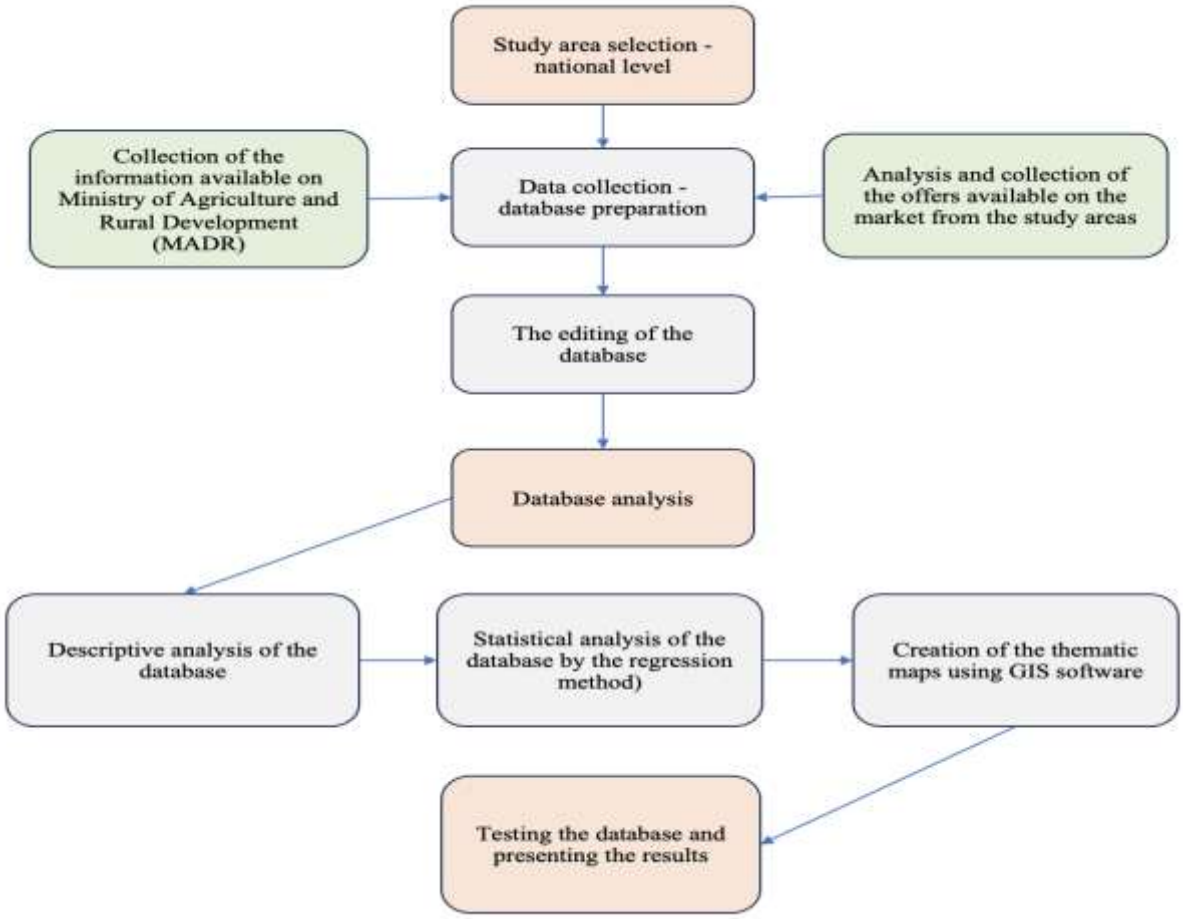

Fig. 1. The stages of running this the case study
Source: created by the authors.

The process begins with the selection of the study area across Romania, followed by the systematic collection of data from two primary sources: the Ministry of Agriculture and Rural Development (MADR) [13] and public land market listings [21].

These sources provide both official records and real-time market data, which are essential for ensuring that the database reflects current land values and territorial distribution patterns.

Once data is collected, the next step involves database preparation and editing, which includes verifying, cleaning, and standardizing variables such as geographic coordinates, land surface, and offer prices. Following this step, a comprehensive analysis is conducted through

both descriptive and inferential statistical methods.

Descriptive analysis highlights the key characteristics and trends within the dataset, while regression analysis explores relationships between variables, such as land size and unit price, to identify influential factors affecting land valuation.

The final phase emphasizes spatial representation and validation of the results. Using Geographic Information Systems (GIS), thematic maps are generated to visualize spatial disparities and regional patterns in land pricing.

These maps, along with statistical outputs, are subjected to testing and interpretation, culminating in the presentation of research findings. This integrative workflow ensures a scientifically robust approach to agricultural land market assessment, offering valuable insights.

In the initial phase of the database analysis, a descriptive examination was conducted for both dependent and independent variables. The statistical analysis was performed using the Jamovi software, version 2.6. Subsequently, the authors employed multiple regression to automate the determination of the value of property offers within the examined area. To enhance the visual representation of the analyzed region, GIS software was additionally utilized.

The data input process stands as a crucial step in developing a GIS application. The outcome relies on the existence, accuracy, and uniformity of the data.

Various methods of data input into GIS include the use of maps or plans, aerial photographs, sensors, field measurements, and various other databases, among others. Acquiring these data poses a challenging process, given that information is often not readily available in the market.

RESULTS AND DISCUSSIONS

After the data collection phase, the preparation and editing of the database were carried out, specifically focusing on the removal of extreme values (outliers).

We've analyzed the uploaded database and identified statistical outliers using the Interquartile Range (IQR) method. Outlier Variables Analyzed: Surface (ha), Offer Price (EUR), Offer Price per Hectare (EUR/ha), Offer Value (RON).

These entries have unusually high or low values, compared to the rest of the dataset. Some plots in Arad county show exceptionally high price per hectare, exceeding 10,000 EUR/ha, indicating potential urban or special-use land.

Thus, the outlier values were removed, resulting in a total of 2,799 records in the database, covering 25 counties and 638 localities analyzed in the year 2024.

Removing outliers: reduces skewness and dispersion, gives more realistic and stable averages and helps avoid misleading interpretations in market analysis, forecasting, or pricing strategy.

The mean value dropped by over 10,000 RON, and the standard deviation almost halved, confirming that outliers had a large effect on the market perception, as shown in Figure 2.

Outliers caused a heavy right-skew; without them, the distribution is more bell-shaped. This helps in building more reliable pricing models and avoiding overestimation.

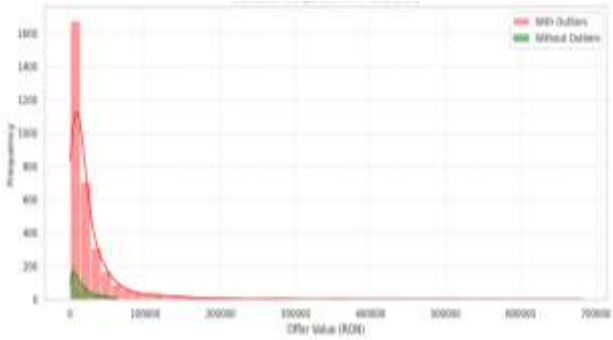

Fig. 2. Distribution comparison: Offer Value in the year 2024 (RON)
Source: created by the authors.

The drop is moderate, suggesting that most EUR/ha values are relatively consistent, but with some extreme peaks, as shown in Figure 3. The shape remains similar, but extreme spikes over 20,000 EUR/ha are removed. The

cleaned data provides a smoother and more interpretable curve.

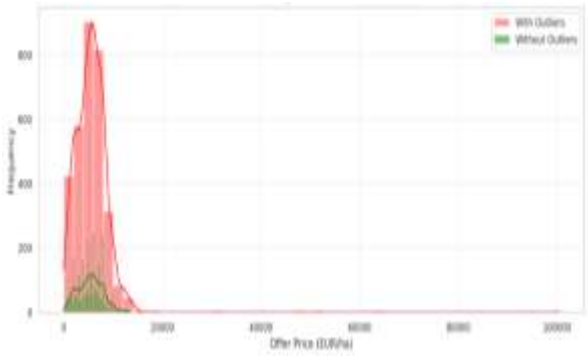

Fig. 3. Distribution comparison: Offer Price in the year 2024 (EUR/Ha)
Source: created by the authors.

Figure 4 present a surface distribution comparison in terms of standard deviation, which decreased from 1.29 to 0.44, indicating a more compact distribution.

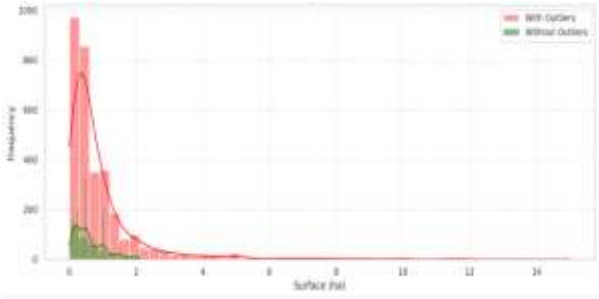

Fig. 4. Distribution comparison: Surface in the year 2024 (ha)
Source: created by the authors.

Smaller plots dominate after removing outlier records with extremely large surface areas. The red distribution (with outliers) has a long right tail → a few extremely large parcels. The red distribution (with outliers) has a long right tail → a few extremely large parcels.
Figure 5 is presenting the standard deviation that dropped from 8,818 EUR to 2,743 EUR. This shows that extreme values were inflating the perceived average significantly. Original data includes listings over 50,000 EUR, which are rare. Cleaned data focuses on offers under 20,000 EUR, better representing the market norm.
Table 2 presents a descriptive statistical summary of four key variables from a dataset comprising 2,799 agricultural land listings in Romania.
These variables include surface area (in hectares), offer price per hectare (EUR/ha), total offer price (EUR), and offer value in national currency (RON).

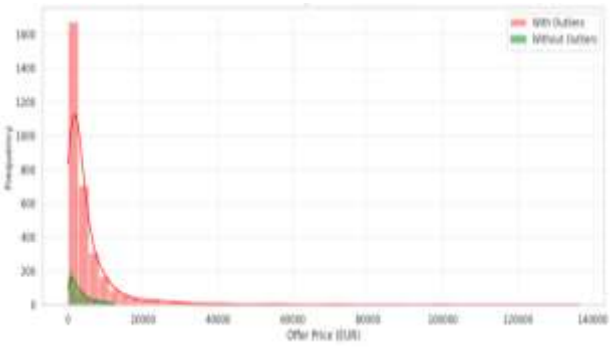

Fig. 5. Distribution comparison: Offer Price in the year 2024 (EUR)
Source: created by the authors.

For each variable, the table provides the number of valid observations, missing values (none in this case), mean, median, standard deviation, and minimum and maximum values. The average land parcel size is approximately 0.58 hectares, with a median of 0.50 ha, indicating a slightly right-skewed distribution. The size ranges from as small as 0.003 ha to 2.13 ha, with a standard deviation of 0.449 ha, showing moderate variability in land size.
The average offer price per hectare is EUR 5,382, while the median is slightly higher at EUR 5,483, suggesting a fairly symmetrical distribution, although the wide range from EUR 5.41 to EUR 13,393 and a standard deviation of EUR 2,532 indicate notable dispersion.
Similarly, the total offer price per listing varies significantly, with a mean of EUR 3,032 and a maximum of EUR 12,356, while the offer value in RON has an average of 15,162 and a maximum of 61,780 RON.
These statistics reflect the diversity of land characteristics and market conditions across regions.The absence of missing data further supports the reliability of the dataset for statistical analysis and modeling.
Figure 6 presents a comparative bar chart displaying the top 10 and bottom 10 Romanian counties based on the average offer price for agricultural land, measured in EUR per hectare (EUR/ha). The counties are categorized into two groups: "Top 10" and "Bottom 10," each represented with distinct colors for clarity. The

chart reveals that counties such as Prahova, Călărași, and Suceava lead the national ranking, with average offer prices exceeding EUR 6,500/ha.

Table 2. Data base description of study variables in the year 2024

	Surface (ha)	Offer Price (EUR/ha)	Offer Price (EUR)	Offer Value (RON)
N	2,799	2,799	2,799	2,799
Missing	0	0	0	0
Mean	0.58	5,382	3,032	15,162
Median	0.5	5,483	2,089	10,450
Standard deviation	0.449	2,532	2,744	13,719
Minimum	0.003	5.41	10	50
Maximum	2.13	13,393	12,356	61,780

Source: created by the authors.

These regions may reflect higher land productivity, better infrastructure, or stronger market demand, contributing to elevated land valuations. Other top-performing counties include Brăila, Constanța, Timiș, and Arad—well-known for fertile soil and commercial agricultural activity.

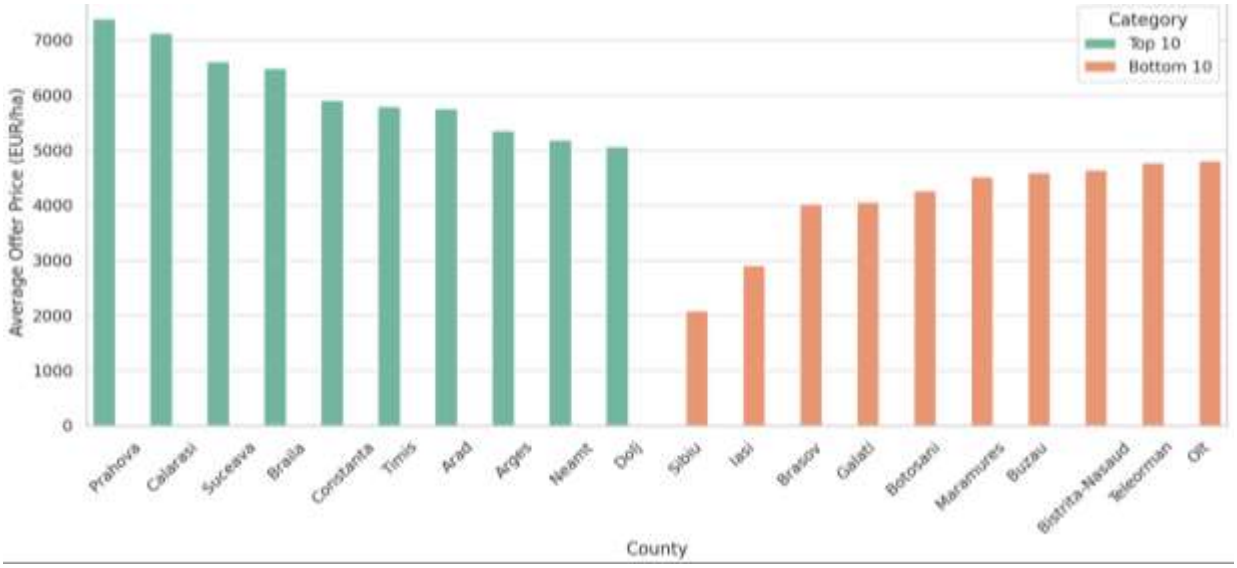

Fig. 6. Top 10 & Bottom 10 Counties in Romania, by average offer price in the year 2024 (EUR/ha)
Source: created by the authors.

Conversely, counties such as Sibiu and Iași exhibit the lowest average offer prices, with values below EUR 3,000/ha, potentially reflecting lower agricultural potential, less accessible locations, or limited market interest. The inclusion of counties like Botoșani, Maramureș, and Bistrița-Năsăud in the bottom tier further suggests regional disparities in land market dynamics.

This visual comparison underscores significant geographic variability in agricultural land values across Romania, offering useful insights for policy-makers, investors, and researchers interested in land use planning and market assessment.

Furthermore, the statistical analysis reveals reveal meaningful regional differences in both land size and pricing, offering insights into local agricultural land markets in Romania.

The plot presented in Figure 7, shows the distribution of land surface areas for each county.

The boxplot presented above illustrates the distribution of land surface areas (in hectares) across various Romanian counties.

Each box represents the interquartile range (IQR), where the middle 50% of values lie, with the median marked as a horizontal line within the box.

Counties such as Brăila and Dâmbovița exhibit relatively lower median land surface areas, indicating a tendency toward smaller land plots being offered in those regions.

On the other hand, counties like Tulcea and Timiș display higher median values and wider interquartile ranges, suggesting greater variability in land plot sizes and the availability of larger parcels.

Additionally, the presence of multiple outliers in counties like Arad, Călărași, and Olt highlights the existence of particularly large land plots that exceed the upper quartile range. These outliers may indicate strategic agricultural investments or less fragmented land ownership in certain areas.

Overall, the data suggests that while most counties maintain median land sizes below 1 hectare, regional variation is significant, reflecting differing patterns of land use, agricultural practices and market structures.

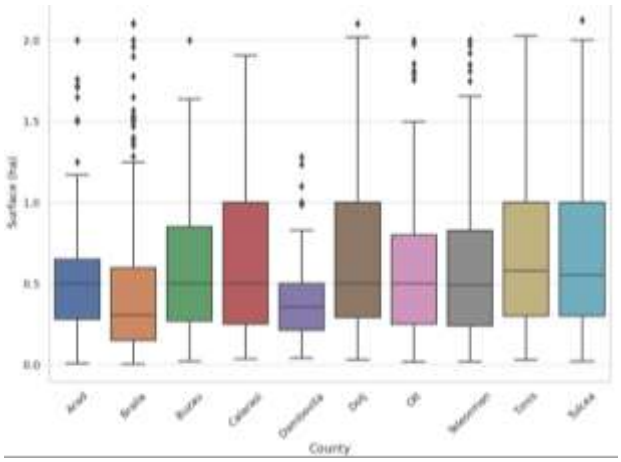

Fig. 7. Surface (ha) by county in the year 2024
Source: created by the authors.

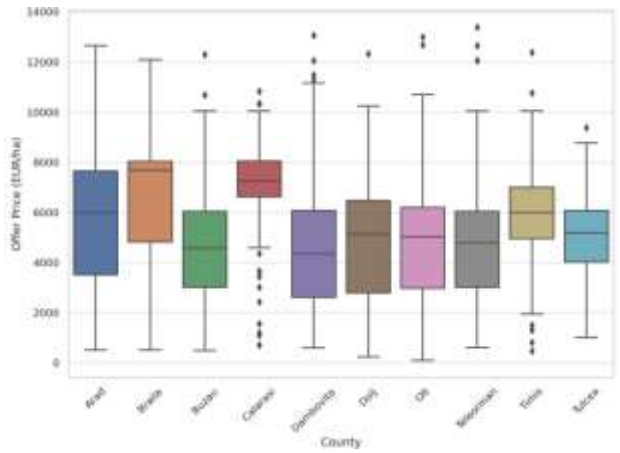

Fig. 8. Offer price by county in the year 2024 (EUR/ha)
Source: created by the authors.

The plot presented in Figure 8, compares the unit offer price (in EUR/ha) across counties. Notably, Brăila, Călărași, and Arad have higher median prices, with Brăila standing out with both high prices and low variability, indicating a more consistent land market.

In contrast, other counties like Dâmbovița and Buzău show a wider price distribution and the presence of significant outliers.

Furthermore, each important variable in the database was individually analyzed.

As illustrated in Figure 9, the distribution is right-skewed, meaning most plots have smaller areas (predominantly between 0.2 and 0.7 hectares).The majority of land parcels in the dataset are small to mid-sized, which is common in peri-urban and rural real estate markets.

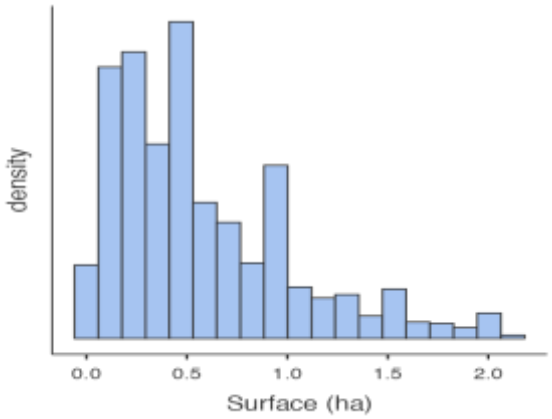

Fig. 9. Histogram for Variable Surface in the year 2024 (ha)
Source: created by the authors.

This skewness should be considered when applying statistical models that assume normality.

As evidenced in Figure 10, while most land parcels are small, the presence of outliers suggests the existence of significantly larger plots. These outliers may distort mean-based analyses and require careful treatment in statistical modeling.

According to Figure 11, the distribution is slightly right-skewed, indicating a concentration of prices around the 4,000–7,000 EUR/ha range.

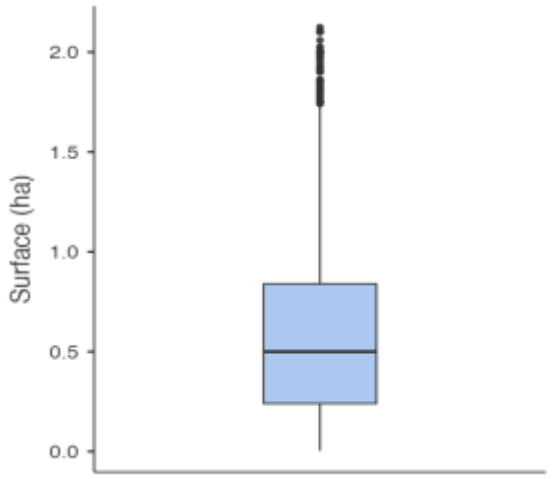

Fig. 10. Boxplot for Variable Surface in the year 2024 (ha)
Source: created by the authors.

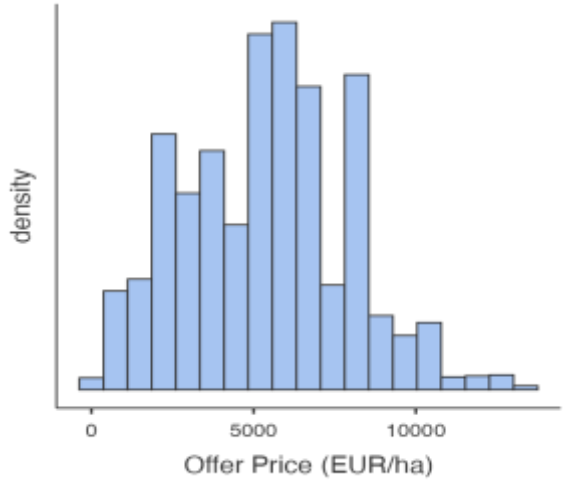

Fig. 11. Histogram for Offer Price in the year 2024 (EUR/ha)
Source: created by the authors.

Most land listings cluster within a mid-range price bracket, although a number of high-priced listings are still visible. This mix implies market heterogeneity possibly due to differences in location, land quality, or infrastructure.
As evidenced in Figure 12, the real estate offer prices exhibit moderate spread with a concentration in mid-range values and a few extreme values that may warrant exclusion or separate analysis, depending on the study's goal.

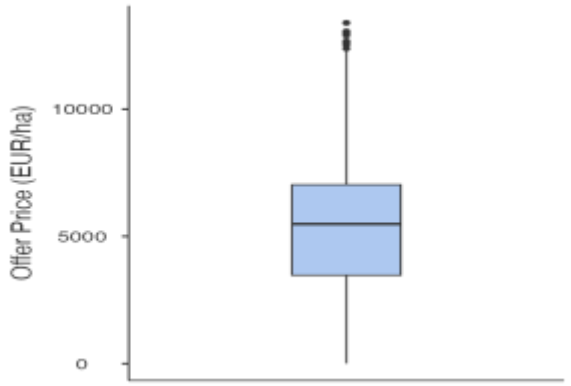

Fig. 12. Boxplot for Offer Price in the year 2024 (EUR/ha)
Source: created by the authors.

Histograms are commonly used in statistics to visualize the shape, center, and spread of a dataset. They provide a quick and effective way to understand the underlying distribution and identify patterns, such as the presence of peaks, gaps, or outliers in the data. Histograms are particularly useful for exploring the characteristics of numerical data and making informed decisions based on data patterns.
This histogram, presented in Figure 13 helps us understand how price per hectare affects the type and size of land on the market.
Most properties fall into the 1k–3k and 3k–5k EUR/ha categories, especially for small plots (under 1 ha).
Plots with prices below 1,000 EUR/ha are fewer and generally smaller. Higher-priced categories (5k–10k and 10k+) appear much less frequently, and typically involve small-sized land parcels — often peri-urban or special-use land.

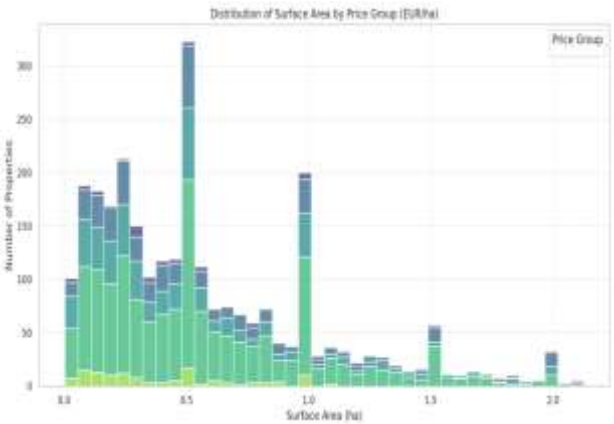

Fig. 13. Distribution of Surface Area by Price Grup in the year 2024 (Eur/ha)
Source: created by the authors.

The Figure 14 displays a correlation matrix examining the relationships between key variables associated with agricultural land offers: surface area (ha), offer price (EUR), unit offer price (EUR/ha), and offer value (RON). Correlation coefficients range from -1 to 1, with values closer to 1 indicating strong positive associations and values near -1 indicating strong negative associations. The matrix reveals a strong positive correlation (0.76) between surface area and total offer price (EUR), as well as between surface area and offer value (RON), suggesting that larger plots of land are generally associated with higher overall offer prices.

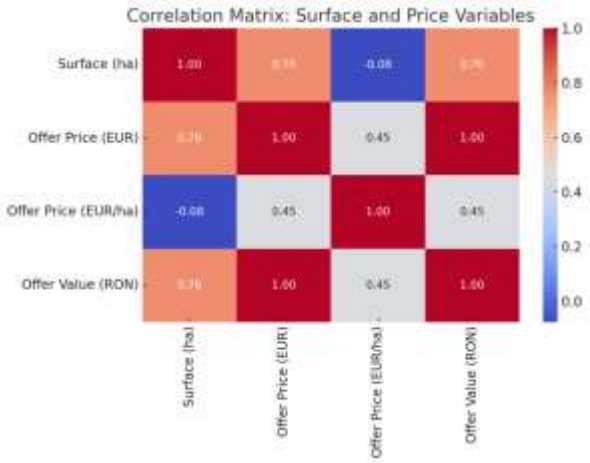

Fig. 14. Correlation matrix: surface and price variables in the year 2024
Source: created by the authors.

Interestingly, the correlation between surface area and unit offer price (EUR/ha) is slightly negative (-0.08), indicating that as the surface area increases, the price per hectare may slightly decrease. This inverse relationship suggests a potential volume discount effect or a market preference for smaller, more accessible plots at a higher rate per unit area. The unit offer price shows a moderate positive correlation (0.45) with both total offer price (EUR) and offer value (RON), indicating that it plays a notable, albeit less dominant, role in determining the total value compared to surface size. These findings provide valuable insight into how land size and pricing components interact in the agricultural land market.

The size of a land parcel significantly affects the total offer price, but not the unit price per hectare. This suggests that economies of scale or location differences may be affecting unit pricing.

The scatterplot matrix, shown in Figure 15, provides a comprehensive visual overview of the relationships between key variables in the agricultural land offer dataset: surface area (ha), offer price (EUR), unit offer price (EUR/ha), and offer value (RON).

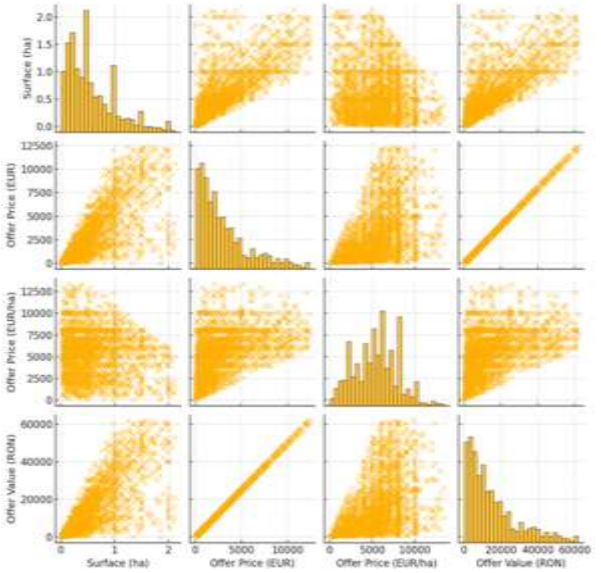

Fig. 15. Scatterplot Matrix. Surface and Price variables in the year 2024
Source: created by the authors.

Each diagonal panel presents the distribution of individual variables through histograms, revealing a right-skewed distribution for surface area and total offer price, indicating a higher frequency of small to mid-sized land parcels and lower total prices. In contrast, the unit offer price (EUR/ha) appears more evenly distributed but still displays variation across a wide range. A strong linear relationship exists between Surface (ha) and Offer Price (EUR). Offer Price (EUR/ha) shows no strong linear relationship with surface size, which is expected since it represents a normalized price. Offer Value (RON) is almost perfectly correlated with Offer Price (EUR) (due to currency conversion).

The plot shown in Figure 16 shows a positive linear relationship between the size of land (in hectares) and the total offer price. As the surface increases, the offer price tends to increase as well, which is expected.

The distribution of variables like Surface and Offer Price shows positive skewness (long tail to the right), indicating the presence of a few very large values.

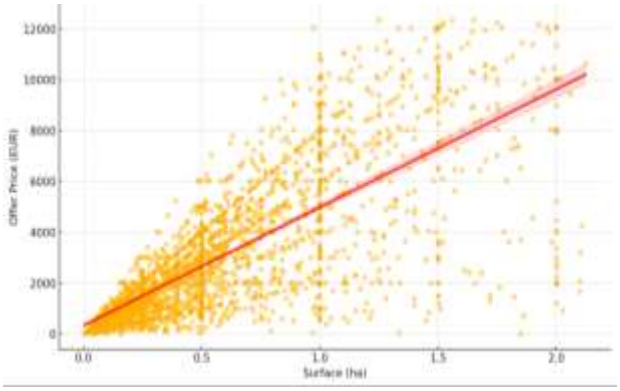

Fig. 16. Regression Plot: Surface (ha) vs. Offer Price (EUR) in the year 2024
Source: created by the authors.

The map (Figure 17) illustrates the average offer prices for agricultural land across various counties in Romania, measured in EUR per hectare. The data is visualized using proportional circles, where the size of each circle corresponds to the average offer price in that region—larger circles indicate higher land prices. Counties such as Brăila, Buzău, and Mureș display notably larger circles, suggesting elevated market values for farmland.

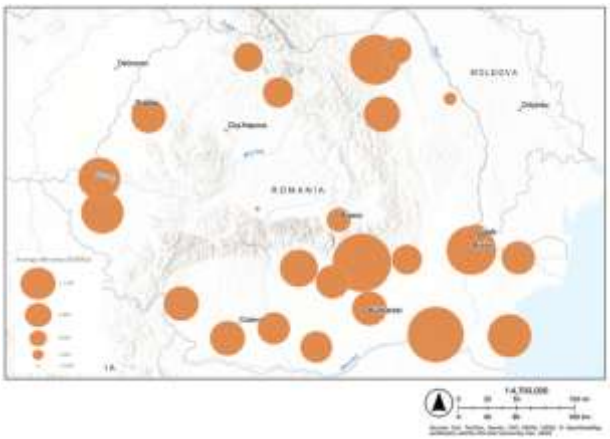

Fig. 17. Average offer price for agriculture land in Romania in the year 2024 (EUR/ha)
Source: created by the authors.

This spatial distribution highlights regional disparities in land value, influenced by factors such as land quality, accessibility, and proximity to urban centers. The map provides a clear overview of the geographical trends in Romania's agricultural land market.

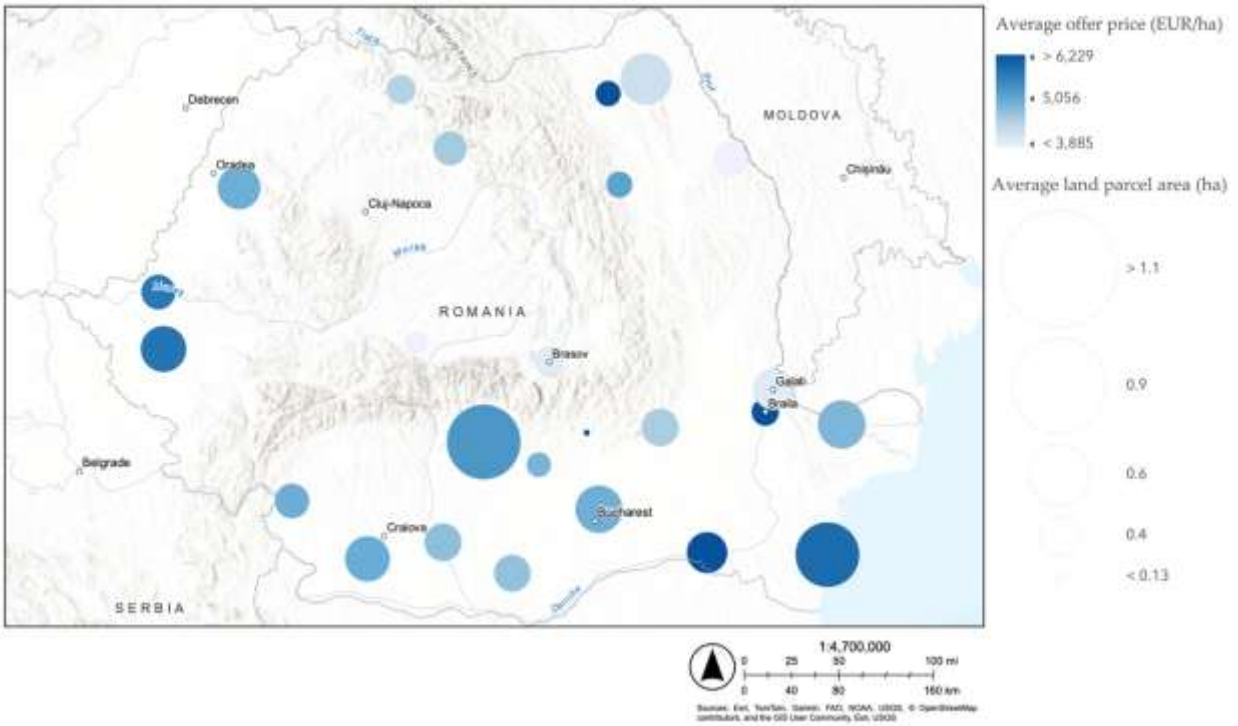

Fig. 18. Average offer price (EUR/ha) and average area for agriculture land (ha) in Romania in the year 2024
Source: created by the authors.

The map (Figure 18) shown above offers a bivariate representation of the average offer price per hectare (EUR/ha) and the average land surface area (ha) across Romanian counties. The intensity of the blue color represents the average offer price: darker shades indicate higher prices, while lighter tones correspond to lower values. Concurrently, the size of the circles reflects the average land surface area within each county — larger circles denote counties with more extensive average plot sizes, while smaller ones suggest smaller average parcels.

This visual approach enables a simultaneous examination of two critical agricultural land market dimensions: price and size. For instance, certain counties in southern and South-Eastern Romania (e.g., near Brăila and along the Danube) exhibit both high offer prices and large average surface areas, indicating regions with strong agricultural value and demand. In contrast, central or North-Eastern counties may display smaller circle sizes with varying price levels, suggesting either fragmented land ownership or less economic activity in agricultural land transactions. This map supports spatial decision-making by highlighting geographic disparities and market potential across the country.

CONCLUSIONS

There is a moderately strong and statistically significant positive correlation between the surface area and total offer price. However, additional factors (e.g., location, accessibility, land use) would likely improve model accuracy. The analysis supports the use of regression modeling for estimating land value based on parcel size.

This visualization (Figure 17 and Figure 18) reinforces the spatial disparities observed in the first map, where counties in central, southern, and eastern Romania exhibit significantly higher offer prices. The visual contrast between the maps provides valuable insights into the spatial dynamics of the Romanian agricultural land market, where high land value does not always correlate with larger surface areas. These findings can inform policymakers and investors regarding land-use strategies and investment decisions tailored to regional characteristics.

This study has provided a comprehensive exploration of Romania's agricultural land market, highlighting notable disparities in both offer prices and land parcel sizes across counties. Through statistical and spatial analyses, significant regional differences emerged—counties such as Prahova, Călărași, and Brăila consistently displayed higher average offer prices per hectare, suggesting strong market demand and perceived land value. Conversely, counties like Sibiu and Iași recorded lower price levels, which may reflect reduced market pressure or lower land productivity. The correlation analysis further emphasized a positive relationship between surface area and total offer price (EUR), while revealing a weak correlation between unit price (EUR/ha) and land size, suggesting other factors—such as location, accessibility, or land quality—may play a more decisive role in value determination.

The spatial visualizations reinforced the statistical findings, providing an intuitive understanding of market dynamics at the regional level. Maps illustrating mean prices and parcel sizes revealed clusters of high-value zones concentrated in the southern and southeastern parts of the country, aligning with areas of economic activity and infrastructure accessibility. These insights underline the complexity of Romania's agricultural land market and point to the need for regionally tailored land management and investment strategies.

Future research should delve deeper into socioeconomic and environmental factors that shape these patterns, with the goal of supporting sustainable land-use policies and informed investment decisions.

ACKNOWLEDGEMENTS

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REFERENCES

[1]Abdulhafedh, A., 2022, Incorporating Multiple Linear Regression in Predicting the House Prices Using a Big Real Estate Dataset with 80 Independent Variables. OALib, 09(01), 1–21. https://doi.org/10.4236/oalib.1108346

[2]Badea, A.C., Badea, G., 2013, Cadastru, Bănci de date și aplicații GIS în zone urbane (Cadastre, data banks and Gis applications in urban areas) In Romanian. Conspress U.T.C.B., pp.10-12.

[3]Bencardino, M., Nesticò, A., 2017, Demographic Changes and Real Estate Values. A Quantitative Model for Analyzing the Urban-Rural Linkages. Sustainability, 9(4), 536. https://doi.org/10.3390/su9040536

[4]Brożek, P., Frosik, M., 2023, New technologies in real estate market analysis. Geomatics, Landmanagement and Landscape, 1, 65–74. https://doi.org/10.15576/GLL/2023.1.65

[5]Chiorean, S., Coroian, I., Sălăgean, T., Nap, M.E., Deak J., Lupuț, I., 2024, Global Trends on research towards the valuation process of an agriculture land, Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development, 24(2), 281-286.

[6]Chiarazzo, V., Caggiani, L., Marinelli, M., Ottomanelli, M., 2014, A Neural Network based Model for Real Estate Price Estimation Considering Environmental Quality of Property Location. Transportation Research Procedia, 3, 810–817. https://doi.org/10.1016/j.trpro.2014.10.067

[7]Delgado-Viñas, C., Gómez-Moreno, M.-L., 2022, The Interaction between Urban and Rural Areas: An Updated Paradigmatic, Methodological and Bibliographic Review. Land, 11(8), 1298. https://doi.org/10.3390/land11081298

[8]Gepner, P., Tien, N.H., Dao, M.T.H., Minh, D.T., 2022, Analysis of business strategy of leading Vietnamese real estate developers using SWOT matrix. International Journal of Multidisciplinary Research and Growth Evaluation. 3(1), 181-187.

[9]Kaluarachchi, Y., 2022, Implementing Data-Driven Smart City Applications for Future Cities. Smart Cities, 5(2), 455–474. https://doi.org/10.3390/smartcities5020025

[10]Kayalik, M., Polat, Z.A., 2023, GIS-based real estate legislation information system design: The case of İzmir, 6th Advanced Engineering Days, Vol.6, 77-79.

[11]Kwartnik-Pruc, A., Droj, G., 2023, The Role of Allotments and Community Gardens and the Challenges Facing Their Development in Urban Environments—A Literature Review. Land, 12(2), 325. https://doi.org/10.3390/land12020325

[12]Liu, G., 2022, Research on Prediction and Analysis of Real Estate Market Based on the Multiple Linear Regression Model. Scientific Programming, 2022, 1–8. https://doi.org/10.1155/2022/5750354

[13]Ministry of Agriculture and Rural Development (MADR), 2025, National Unique Register regarding circulation and destination of agricultural land situated in land outside built-up areas, https://vanzareterenuri.madr.ro/, Accessed on 30.01.2025.

[14]National Association of Appraisers from Romania ANEVAR, 2022, Property Valuation Standards, https://www.anevar.ro/images/_upload/sev-2022-15-decembrie.pdf, Accessed on 01.02.2025.

[15]National Associations of Authorized Appraisers in Romania), (n.d.)., ANEVAR.html. Accessed on 01.02.2025.

[16]Sălăgean, T., Rusu, T., Porutiu, A., Deak, J., Manea, R., Vîrsta, A., Călin, M., 2016, Aspects Regarding the Achieving of a Geographic Information System Specific for Real Estate Domain. Agrolife Scientific Journal, Vol. 5(2), 137-142.

[17]Van Sant, L., Shelton, T., Kay, K., 2023, Connecting country and city: The multiple geographies of real property ownership in the US. Geography Compass, 17(2), e12677. https://doi.org/10.1111/gec3.12677

[18]Vardopoulos, I., Papoui-Evangelou, M., Nosova, B., Salvati, L., 2023, Smart 'Tourist Cities' Revisited: Culture-Led Urban Sustainability and the Global Real Estate Market. Sustainability, 15(5), 4313. https://doi.org/10.3390/su15054313

[19]Wang, D., Li, V. J., 2019, Mass Appraisal Models of Real Estate in the 21st Century: A Systematic Literature Review. Sustainability, 11(24), 7006. https://doi.org/10.3390/su11247006

[20]Zeicu (Chiorean), S., Onose, D., Ortelecan, M., Palamariu, M., 2017, Statistical modeling applied in Real Estate Valuation. "1 Decembrie 1918" University of Alba Iulia RevCAD, 22, 243-252.

[21]***Public land market listings, various sites.

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POTATO MARKET IN ROMANIA: LOCAL PRODUCTION VS IMPORTS

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Abstract

The paper analyses the Romanian potato market, focusing on cultivated areas, domestic production, consumption, and international trade. The study is based on open-access articles from international databases, reports from regional and national public institutions, and specialized articles from online media. Statistical analysis based on national and European data highlights market trends. Findings indicate a significant decline in cultivated areas and a lack of competitiveness in the domestic sector, primarily due to low productivity and high production costs. The lack of governmental support and economic inefficiency have significantly increased Romania's reliance on imports, contributing to a persistent trade deficit. In 2023, Romania imported over 800,000 tons of potatoes, covering a significant portion of domestic consumption. Additionally, a growing demand for frozen potatoes has been observed in recent years, yet Romania lacks processing facilities, making it entirely dependent on imports. In response, a Romanian company has announced a major investment in a potato processing plant, demonstrating market flexibility and business adaptability. This initiative could serve as a model for similar investments in other agricultural sectors. To counteract these challenges, a strategic approach is needed, including coherent agricultural policies, investments in technology, and financial support for local farmers to enhance self-sufficiency and food security.

Key words:*Romania, potato market, international trade, processing industry*

INTRODUCTION

The potato (*Solanum tuberosum*) is a plant belonging to the Solanaceae family, originating from South America, where it was a staple food for the Incas as early as 500 BC. The potato was introduced to Europe in the 16th century by the conquistadors, around 1530. From Spain, the plant spread to other European countries, and through colonial expansion, it eventually became cultivated on all continents.

In Europe, the lack of knowledge regarding the edible parts of the plant initially led to reluctance in its use for human consumption, as the leaves, fruits, and stems are toxic. In the Romanian territories, the potato was introduced through the Habsburg Empire, initially in Transylvania (around 1869), later being mentioned in Moldova (1812) and likely cultivated in Walachia around 1900.

The acceptance and widespread consumption of potatoes were driven by poverty and periods of famine (1815). Today, potatoes are a common staple food, widely available in markets and grocery stores, with an affordable price for the general population, often referred to as the "poor man's food." The Romanian word "cartof" is believed to derive from the German "Kartoffel," which itself originates from the Italian "tarantoffli" or "tartouffli" [1]. The cultivation of potatoes is a widespread activity across Romania, being carried out both in open fields and gardens, depending on favourable soil and climatic conditions. The main production areas, where the soil properties and climatic conditions allow for consistent yields, are primarily located in the central and northern counties of the country, including Covasna, Harghita, Brașov, Sibiu, Suceava, and Neamț.

Potato cultivation is mainly intended for direct human consumption, but it is also used for industrial processing in the food industry and as animal feed. While the tubers are consumed, the aerial parts of the plant contain solanine, a toxic compound for animals.

In Romania, different varieties of potatoes are cultivated, generally classified into early potatoes (harvested between May and July) and autumn potatoes (harvested between August and September) [11].

Characterized by significant genetic diversity, the potato plant has over 4,000 known varieties. Globally, Solanum tuberosum is the predominant cultivated species, but there are also 10 other species commonly found in agriculture. Additionally, approximately 200 wild species exist in nature. The widespread adoption of modern agricultural techniques and the impact of climate change are accelerating the loss of potato biodiversity, affecting certain genes essential for nutrient biosynthesis. Research into the nutritional composition variations of potatoes based on their genetic characteristics could support the development of effective strategies for conserving natural biodiversity, with implications for global food security. It is estimated that potatoes contribute around 2% to global human nutrition in terms of energy intake, despite being a staple food in many countries. The average caloric intake from potatoes, primarily due to their carbohydrate content, ranges from 540 kJ (130 kcal) per person per day in developed countries to just 170 kJ (42 kcal) per person per day in developing nations [4].

The high content of dietary fiber, resistant starch, elevated water percentage, and the specific composition of dry matter contribute to the low caloric density of potatoes compared to other carbohydrate-rich foods [8].

In addition to their energy supply, many potato varieties provide significant amounts of dietary fiber (up to 3.3%), ascorbic acid (up to 42 mg/100 g), potassium (up to 693.8 mg/100 g), total carotenoids (up to 2,700 mcg/100 g), and antioxidant compounds such as chlorogenic acid (up to 1,570 mcg/100 g) and its polymers. Potatoes also contain anti-nutrients like α-solanine (0.001–47.2 mg/100 g) (Table 1) [13]. Furthermore, they contain small amounts of proteins (0.85–4.2%), various amino acids, minerals, vitamins, and other bioactive compounds, some of which can have both beneficial and harmful effects.

The high content of dietary fiber, resistant starch, elevated water percentage, and the specific composition of dry matter contribute to the low caloric density of potatoes compared to other carbohydrate-rich foods [8].

Beyond their energy contribution, many potato varieties provide significant amounts of dietary fiber (up to 3.3%), ascorbic acid (up to 42 mg/100 g), potassium (up to 693.8 mg/100 g), total carotenoids (up to 2,700 mcg/100 g), and antioxidant compounds such as chlorogenic acid (up to 1,570 mcg/100 g) and its polymers. Additionally, potatoes contain anti-nutrients like α-solanine (0.001–47.2 mg/100 g) [13].

Their composition also includes small amounts of proteins (0.85–4.2%), various amino acids, minerals, vitamins, and other bioactive compounds, which may have both beneficial and potentially harmful effects.

The nutritional composition of potatoes is influenced by various factors, with genotype being one of the most significant. Cultivation conditions - including soil characteristics, nutrient availability, altitude, and weather conditions - along with storage methods, cooking techniques, and final processing, impact the bioavailability of nutrients in the final product.

The high satiety level provided by dietary fiber and resistant starch makes potatoes suitable for inclusion in diets and weight-loss programs. Additionally, cooling cooked potatoes before consumption further enhances their satiating properties.

Thermal processing during cooking can affect vitamin C content, as it is water-soluble; therefore, boiling potatoes with their skin on is recommended to preserve it.

Specialists also suggest consuming potato skin due to its high potassium content, which is primarily concentrated in or near the peel [8].

The preparation method significantly influences the energy value of potatoes.

A comparative analysis of the caloric values of potatoes prepared in different ways, as well as rice, pasta, and bread, is presented in Figure 1.

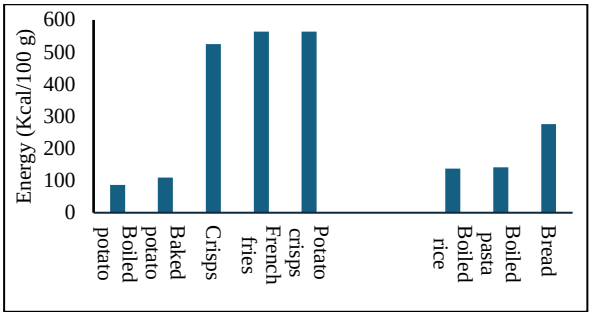

Fig. 1. Energy Content of Potatoes and Common Side Dishes (Kcal/100g).
Source: Authors, by using [8], [20], [9].

Boiled potatoes have the lowest energy value, followed by baked potatoes, making them the most recommended consumption options among the presented variants. From a nutritional perspective, baked potatoes retain the highest levels of potassium, vitamin C, and dietary fiber, with iron values relatively comparable to those found in boiled potatoes [9].

Potato chips and French fries have the highest caloric values, exceeding 500 kcal/100 g, primarily due to oil absorption during frying. Intermediate energy values are observed in boiled rice and pasta, which serve as better alternatives than fried products. Bread, with an energy level of approximately 276 kcal/100 g, falls into the category of high-energy-density foods.

When properly cooked, potatoes can provide around 30% of the daily vitamin C requirement, 7% of dietary fiber needs, a higher potassium intake than bananas, and a significant contribution of dietary antioxidants, which play a role in disease prevention. However, the presence of toxic compounds (glycoalkaloids) can cause gastrointestinal disorders [18].

From the perspective of the average annual potato consumption per capita, two regions in Europe stand out where quantities are significantly higher than in other parts of the continent: the eastern zone and the British Isles region, including the Netherlands and Belgium. The highest potato consumption levels are recorded in Belarus (182 kg) and Ukraine (139 kg), while the lowest are found in Cyprus (21 kg), Bulgaria, and Montenegro (27 kg).

Romania has a notable average consumption of 98 kg per capita, placing it above the European average (almost 90 kg).

Poland (116 kg) and Ireland (85 kg) are among the countries with high consumption, in contrast to southern European states such as Italy (38 kg) and Spain (37 kg), where potatoes play a less prominent role in daily diets [12].

Belarus also holds the highest per capita annual potato consumption worldwide, according to a 2022 World Population Review analysis. The global statistics differ from the European or national figures, with Romania reported to have an average annual consumption of 61.5 kg per capita—approximately 50% lower [23].

According to Eurostat statistics, approximately 48.3 million tonnes of potatoes were harvested in Europe from around 1.3 million hectares of cultivated land in 2023. Out of a total of 9.1 million farms registered at the European level, around 1 million farms cultivated potatoes. More than 60% of these farms had an annual average production value of less than €8,000 per year.

Nearly 66% of these agricultural holdings were concentrated in three European Union (EU) member states: Romania (32.4% of the EU total), Poland (25.1%), and Lithuania (7.0%). Although Romania accounted for almost one-third of all potato-growing farms in 2020, these farms represented only 5.8% of the EU's total cultivated potato area in 2023, as the vast majority were small or very small farms.

A similar situation was observed in Lithuania, which accounted for 7% of the total EU potato farms, yet only 1.2% of the total cultivated potato area at the European level.

The largest potato-growing areas in Europe are found in Germany (19.9%), France (15.4%), Poland (approximately 14.2%), the Netherlands (11.7%), and Belgium (7.1%).

In 2023, Germany was the EU's largest potato producer, with 11.6 million tonnes harvested, representing 24% of the total EU production, followed by France (17.9%) and the Netherlands (13.4%). These three EU countries collectively accounted for 55.4% of the total potato production harvested in the EU in 2023 [10].

The cultivation of potatoes is a significant component of Romanian agriculture and the national economy, with a recorded production of 2.4 million tonnes in 2012.

Approximately 98% of the production is sold as fresh potatoes, while only 2% is processed. In recent years, notable progress has been made in utilizing potatoes as a source of

ethanol for fuel. Potatoes grown in southern Romania under irrigated conditions have a high starch content, enabling the production of approximately 4,000 Liters of ethanol per hectare [6].

An analysis of Romania's potato production between 2005 and 2010, conducted by Bularca et al. (2013), examines the sector through statistical indicators, providing valuable insights into the cultivation, trade, and consumption of this crop at the national level [3].

Another study by Soare (2016) assessed Romania's position in the European Union potato trade between 2011 and 2016. Although Romania contributed 5.53% of the EU's total potato production, its exports accounted for only 0.07% of the total EU export value, highlighting a trade imbalance. The research suggests that Romania could enhance its potato production and international trade performance through the implementation of targeted support measures for the sector [19].

In this context, the purpose of the paper is to analyse the evolution of the Romanian potato market, focusing on cultivated areas, domestic production, international trade, and consumption trends, in order to identify the key challenges and possible solutions for improving the sector's competitiveness and sustainability.

MATERIALS AND METHODS

For the preparation of the bibliographic documentation, open-access publications available on platforms such as Clarivate, Google Scholar, and ResearchGate were consulted, along with reports issued by international organizations (such as the Food and Agriculture Organization – FAO and World Population Review)[23], regional institutions (the European Commission, the U.S. Department of Agriculture), and national institutions.

The bibliographic research also included articles from scientific journals available online. The conducted research was primarily based on public information provided by Eurostat, the National Institute of Statistics, and the Ministry of Agriculture and Rural Development.

Part of the process of data identification, linguistic verification of the English translation, and assistance in organizing the information was supported by an artificial intelligence model (ChatGPT), used for the efficient structuring of content and the synthesis of bibliographic resources.

The data were systematized, statistically processed, graphically represented, and analysed.The analysis and critical interpretation of the obtained results were strictly carried out by the authors to ensure their scientific accuracy and relevance.

The results were validated through comparisons with other specialized studies relevant to the research topic.

RESULTS AND DISCUSSIONS

Areas Cultivated and Potato Production in Romania

The evolution of the total areas allocated for potato cultivation in Romania during the period 1990-2023 is presented in Figure 2.

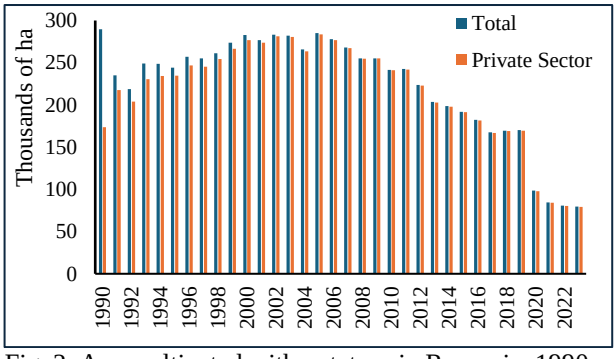

Fig. 2. Area cultivated with potatoes in Romania, 1990–2023

Source: Authors' design using the data from [15].

Except for the year 1990, when private agricultural ownership accounted for approximately 35% of the total, the restitution of agricultural land to owners led to the predominance of potato production in the private sector (over 99%) starting in 2000.

The existence of around 30% of potato crops under private ownership can be explained by household-level subsistence production and, more importantly, by the fact that potato cultivation was traditionally practiced in the

Subcarpathian hill regions, where agricultural collectivization was less extensive.Between 1990 and 2000, the total potato cultivation area remained relatively stable, with minor fluctuations. However, from 2000 onward, a sharp decline in the cultivated area was observed, likely due to the fragmentation of agricultural land and the transition to smaller cultivated plots, influenced by cheap imports and declining farmer profits.

This downward trend continued in the following years, reaching a minimum value of 79,396 hectares. The difference between total and private cultivation areas, about 173 hectares, corresponds to land cultivated within research institutes/stations or leased by the State Property Administration to private producers.

Compared to 1990, the total potato cultivation area has drastically decreased, reaching only 27% of its initial value. Several factors may be responsible for this reduction, including the decline in the number of small producers, increasing pressure from growing imports within the European single market—dominated by major producers such as Germany, France, Poland, and the Benelux countries with advanced technologies and lower production costs—rising agricultural input costs for Romanian farmers, a shift towards more profitable crops, and, more recently, the impact of climate change on a production system with limited and inefficient irrigation infrastructure.

The evolution of areas cultivated with maincrop potatoes and those allocated to extra-early, early, and summer potatoes is presented in Figure 3.

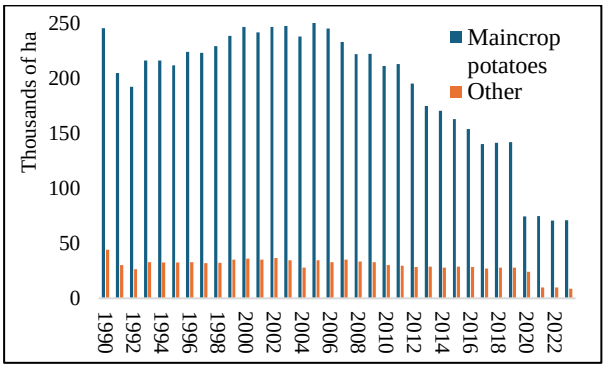

Fig. 3. Area allocated to maincrop potatoes and other potatoes in Romania (1990–2023)
Source: Authors' design using the data from [15].

The share of areas cultivated with extra-early, early, and summer potatoes represents approximately 14-15% of those allocated to main crop potatoes.

The much steeper decline in the cultivated areas of maincrop potatoes, compared to other potato varieties, can be attributed to the high perishability of early, extra-early, and summer potatoes. Importing these varieties from external markets requires specialized transport and storage facilities to minimize losses. Due to their limited shelf life, these potato varieties have a restricted market, while imports from countries with favourable climates may be more competitive.

It is likely that the cultivated potato areas will continue to decrease, with imports covering an increasing share of domestic demand. The low production levels and the ongoing decline in potato cultivation have prompted the Ministry of Agriculture and Rural Development (MADR) to introduce a support measure for local producers in 2024.

This measure takes the form of a de minimis aid program, with a total budget of approximately 2.3 million euros. The maximum support is set at 200 euros per hectare, granted proportionally to the cultivated area. To be eligible, applicants must cultivate at least 0.3 hectares of potatoes, achieve a yield of 15 tons per hectare, and sell at least 6 tons per hectare by November 18. The program targets both individual farmers and legally registered producers, including agricultural companies.

The quantitative variation of Romania's potato production between 1990 and 2023 is illustrated in Figure 4.

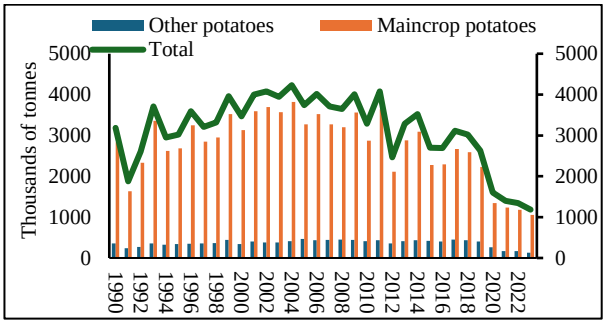

Fig. 4. Potatoes production in Romania (total, maincrop, other) 1990–2023
Source: Authors' design using data from [15].

The data presented in Figure 4 indicate that between 1990 and 2010, Romania's total potato production experienced relative fluctuations but remained at a relatively high level. However, following Romania's integration into the EU, the decline intensified, especially after 2016. This trend is closely linked to the reduction in cultivated areas mentioned earlier. The decrease in areas allocated to maincrop potatoes was significantly steeper compared to extra-early, early, and summer potatoes.

A key factor influencing this decline was the lower agricultural productivity in Romania compared to Western European countries, combined with a lack of effective policies to support domestic potato production. This resulted in an increase in imports and a decline in the competitiveness of local production.

The impact of climate change is evident when comparing 2022 and 2023, two consecutive years with different levels of precipitation. In 2022, Romania harvested approximately 1.3 million tonnes of potatoes from 81,000 hectares, with an average yield of 16.6 tonnes per hectare. However, in the extremely dry year of 2023, the harvest dropped to about 1 million tonnes from 77,000 hectares, with an average yield of 14 tonnes per hectare.

Experts' forecasts for 2024 are not optimistic. According to a study published by Economica.net in September 2024, at the end of the potato harvesting period, Romanian producers recorded the lowest average potato yield per hectare in the European Union [16]. Estimates suggest that Romania's 2024 potato production will total 1.58 million tonnes, which is 262,200 tonnes less than in 2022. The projected average yield is 14.8 tonnes per hectare, 4% lower than the initial estimates from July. Although there is a slight increase of approximately 5% compared to 2023, the productivity remains over 10% lower than in 2022. Compared to other European countries experiencing productivity declines in 2024, Romania recorded the third-largest drop after Greece (-10%), Belgium (-6%), and the Netherlands (-6%).

In contrast, potato producers in Denmark achieved an average yield of 44 tons per hectare in 2024—three times higher than Romanian farmers. The extremely low productivity of Romanian potato farms compared to Western European states can be attributed to the lack of irrigation systems and the excessive fragmentation of agricultural land. Unlike Western European farms, which average 18-20 hectares with compact and fertile land, Romania's farms are often small and inefficient. To be profitable under Romania's cost structure, farmers would need to achieve a minimum yield of 50 tons per hectare; anything below this threshold results in financial losses [14].

The area cultivated with potatoes has drastically decreased in recent years, from over 198,500 hectares in 2014 to just 77,000 hectares in 2023. This sharp decline in both cultivated area and yield, driven by a lack of profitability, has led to an increased reliance on imports to meet domestic demand. Estimates for 2024 indicate that Romania has harvested only 10% of the potatoes needed for national consumption, with a significant portion of the harvest reserved for seed potatoes for the next planting season.

Romania's international trade in potatoes is illustrated in Figure 5.

In 2023, Romania exported potatoes worth approximately 4 million euros while importing over 80 million euros' worth of potatoes.

Potato imports have increased significantly since the 2000s, reaching peak levels after 2010. Romanian exports were almost non-existent until the 2000s and have remained modest throughout the analysed period. The trade balance has consistently shown a deficit, as Romania has continuously imported more potatoes than it has exported.

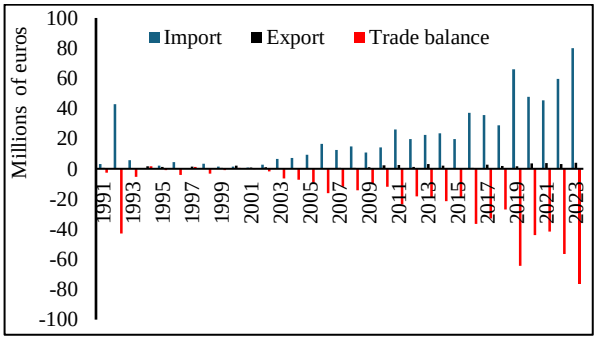

Fig. 5. Romania's Potato Trade Balance (1990-2023)
Source: Authors' design using the data from [15].

This deficit became more pronounced after 2010 due to the sharp decline in domestic potato production. In 2023, Romania's trade deficit in the international potato market exceeded 76 million euros, with more than 800,000 tonnes of potatoes imported[2].

In 2022, Romania's potato exports were primarily directed toward Italy, with a total value of $4.23 million, followed by Ukraine ($1.23 million), Moldova ($934,000), Greece ($519,000), and Poland ($373,000). This distribution reflects a strong demand from neighbouring countries and southern European nations, where domestic production does not meet consumption needs. On the other hand, imports were significantly higher, with the largest quantities of potatoes sourced from France ($17.3 million), the Netherlands ($12.3 million), Germany ($12.3 million), Greece ($4.79 million), and Poland ($3.9 million).

These figures highlight Romania's high dependency on potato imports from Western Europe, particularly from countries with advanced agricultural production and high yields. The country's negative trade balance in this sector underscores the need for measures to enhance domestic production competitiveness and reduce import dependency.

Despite declining production, domestic demand for potatoes continues to rise. In 2023, total consumption reached 2.461 million tonnes, an increase of 57,000 tonnes compared to the previous year. Of this total, 1.953 million tonnes were used for human consumption, representing 79.4% of the overall consumption volume. This combination of declining production and rising internal demand, which reached 2.461 million tonnes in 2023, has resulted in a significant reliance on imports to cover a deficit of approximately 880,000 tonnes [17].The average annual per capita potato consumption in Romania saw a notable increase between 1990 and 2010, surpassing 104 kg/year in 2008 (Figure 6).

The period coincided with a relatively stable market supply and consistent access to essential consumer products.

Potatoes have remained a staple food for the population.

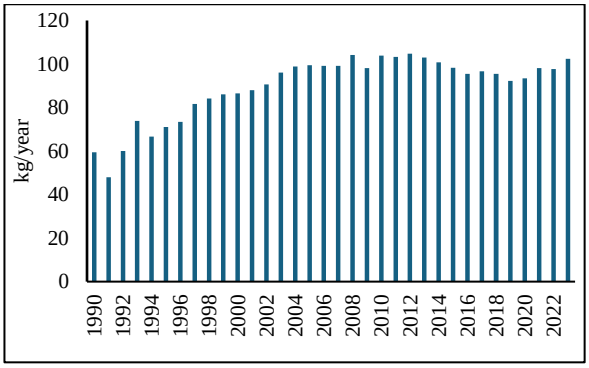

Fig. 6. Annual Average Potato Consumption in Romania (1990-2023)
Source: Authors' design using the data from [15].

After 2010, the average annual potato consumption experienced a slight decline, a phenomenon that can be attributed to changing dietary preferences, a more diversified food supply, and increased access to alternative carbohydrate sources such as pasta, rice, and whole grain bread.

Additionally, the reduction in domestic potato production led to a growing dependence on imports, impacting product availability in the market. In recent years, a slight increase in consumption has been observed, which may be linked to economic changes and a renewed interest in traditional foods.

The rising demand for frozen potatoes, a trend seen across Europe, could also explain this evolution. As with other agri-food products, Romania exports raw agricultural materials with relatively low added value while importing processed goods with higher value. The evolution of Romania's frozen potato imports is illustrated in Figure 7.

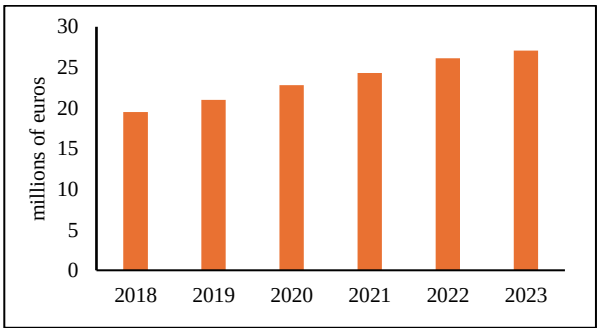

Fig. 7. Romania's Imports of Frozen Potatoes
Source: Authors'design usingthe data from [22].

In recent years, Romania has imported increasing quantities of frozen potatoes due to the absence of domestic producers for this

product. In 2023, the retail market for frozen potatoes in Romania reached 124.5 million lei, marking a 4% increase compared to the previous year [24].

Although Romania ranks among the significant producers of fresh potatoes in Europe, the lack of processing and freezing facilities results in a high dependency on imports, exceeding 80 million lei annually.

Frozen potatoes are typically sold in 1 kg and 2.5 kg packages, with prices ranging from 28 to 40 lei per sack, corresponding to approximately 3-4 million units sold in 2023.Regarding their origin, the primary supplier of frozen potatoes to Romania in 2023 was Poland, followed by France and Belgium (Table 1).

Table 1. Romania's Imports of Frozen Potatoes (2023)

Country	Trade Value (1,000USD)	Quantity (kg)
Total	27,083.08	60,164.9
Poland	6,201.53	21,136,200
France	6,118.10	13,935,500
Belgium	4,616.67	3,814,960
Netherlands	3,573.42	6,625,550
Greece	3,209.60	7,453,560
Germany	1,599.38	3,958,370
Denmark	677.71	2,006,640
Czech Republic	355.86	255,533
Bulgaria	296.44	171,610
Hungary	138.44	124,368
Austria	137.99	427,321
Italy	87.32	66,885
Lithuania	51.85	159,410
Spain	15.08	24,944
Portugal	2.56	2,762
Serbia, FR(Serbia/Montenegro)	1.12	1,280

Source [22].

The frozen potato market in Romania has significant growth potential and is currently expanding. The average annual per capita consumption of frozen potatoes is estimated at 3–3.5 kg, which is approximately one-third of the level recorded in Western European countries, where consumption reaches up to 15 kg per capita [5].

In the context of increasing demand for these products and market forecasts, correlated with the continuous decline in domestic potato production and the growing dependence on imports, Grup Șerban Holding announced in October 2024 an investment of 62.5 million euros for the construction of a potato processing factory in Sascut, Bacău County. The proposed unit will have a production capacity of 6 tons of French fries per hour and 1.2 tons of potato flakes per hour. The processed products will be marketed both on the domestic market and for export, depending on demand.

The initiative of Grup Șerban Holding could have a significant impact on reducing Romania's trade deficit in the international potato market, providing new opportunities for processing locally grown potatoes, and encouraging local farmers to increase both productivity and crop quality [21].

CONCLUSIONS

Romania's domestic potato production has experienced a significant decline following the country's political transition, leading to increased dependence on imports. The country has maintained a consistent trade deficit in the international potato market, with imports rising steadily while exports remain modest. This situation can be attributed to the reduction in cultivated areas, excessive land fragmentation, and lower yields compared to other European countries.

Several factors have contributed to this sector's decline, including the lack of substantial investments in modernizing agricultural technologies, the absence of effective support policies for farmers, rising production costs, and strong competition from imports originating in highly industrialized agricultural sectors in Western Europe. Additionally, the impact of climate change—manifested through prolonged droughts and the absence of efficient irrigation systems—has significantly affected Romania's potato productivity.

Despite these unfavourable conditions, potatoes remain a staple food for Romanian consumers, and domestic demand has continued to grow. Moreover, recent trends indicate an increasing preference for processed potato products, such as frozen potatoes, which presents an opportunity for developing Romania's food processing industry. However, the lack of adequate processing and storage facilities has heightened the country's dependence on imports, particularly from Poland, France, and Belgium.

To prevent a crisis in Romania's potato market, it is imperative that authorities and farmers

collaborate to identify viable and sustainable solutions.

Key measures that need to be implemented include:

Modernizing agricultural technologies – Investments in mechanization, irrigation, and sustainable farming practices are essential for improving yields and reducing production losses. Examples from countries such as Belgium and the Netherlands demonstrate that productivity can be tripled through efficient technologies.

Financial support through subsidies and favourable policies – The government should assist farmers by offering more effective subsidies, implementing production stimulation programs, and facilitating access to EU funds dedicated to the agricultural sector.

Investments in processing and storage facilities – Developing Romania's agri-food infrastructure would allow local producers to maximize the value of their harvest and reduce reliance on imported processed potato products.

Enhancing the competitiveness of domestic production – Strengthening farm structures and reducing land fragmentation would enable Romania to achieve an optimal level of economic efficiency and higher productivity.

Diversifying production and promoting sustainable agriculture – Encouraging farmers to adopt ecological practices and cultivate climate-resistant potato varieties could contribute to long-term food security.

In conclusion, the future of Romania's potato sector depends on the implementation of coherent policies and integrated strategies aimed at supporting local producers and reducing import dependence.

Without urgent measures, the national potato production risks becoming insignificant within the European market, while Romanian consumers will face increasing price fluctuations and vulnerabilities in the global supply chain.

The response of the domestic market to the increasing demand, through the establishment of a processing unit tailored to market needs, demonstrates flexibility and maturity, as well as an increased attention from Romanian entrepreneurs to industry trends. The fact that this investment is made by a Romanian company is even more significant, serving as a potential model for other agricultural production sectors aiming to enhance local value-added processing.

REFERENCES

[1]Adevărul, 2016 (Octomber02), Istoria cartofului. Românii din sudulțării l-au considerathranăpentruporci, (Potato history. The Romanians from the south of the country considered it a feed for pigs) https://adevarul.ro/stiri-locale/buzau/istoria-cartofului-romanii-din-sudul-tarii-1738816.html,Accessed on 18.11.2024.

[2]ARICE, 2024 (June), Comerțulinternațional al României (Romania'a International Trade) – Martie 2024, https://arice.gov.ro/1/wp-content/uploads/2024/06/RO-Comert-international-03-2024.pdf,Accessed on 08.02.2025.

[3]Bularca, E., Nicolae, C.D., Drăghici, M., 2013, The Statistical Indicators of Potato Produced in Romania, Scientific Papers Series "Management, Economic Engineering in Agriculture and Rural Development", 13(4), 69-72, https://managementjournal.usamv.ro/pdf/vol3_4/Art12.pdf, Accessed on 11.12.2024.

[4]Burlingame, B., Mouillé, B., Charrondière, R., 2009, Nutrients, bioactive non-nutrients and anti-nutrients in potatoes, Nutrition Bulletin, 34(4), 310-318, DOI: 10.1111/j.1467-3010.2009.01757.x, https://www.sciencedirect.com/science/article/abs/pii/S0889157509001756,Accessed on 12.12.2024.

[5]B1TV, 2023 (February 13). Româniaexportăcartofișiimportăalțiicongelațiînvaloare de 16 milioane de euro. Problemele pe care le întâmpinăproducătorii (Romania exports potatoes and imports frozen potatoes of Euro 16 Million. The problems that the producers are facing), https://www.b1tv.ro/eveniment/romania-exporta-cartofi-si-importa-altii-congelati-in-valoare-de-16-milioane-de-euro-problemele-pe-care-le-intampina-producatorii-1265516.html,Accessed on 08.02.2025.

[6]Dumitru, M., Matei, G., 2015, The Economic Importance of Potato Production in Romania, Proceedings of the 26th International Conference of Agricultural Economists (ICEADR), pp. 200-206, https://www.econstor.eu/bitstream/10419/163301/1/ICEADR-2015_p200.pdf, Accessed on 02.11.2024.

[7]Economica.net, 2024 (September 3), Avemcelemaimicirandamente la producția de cartofidintretoatestatele UE. ComisiaEuropeană a revizuitîn minus prognozapentru 2024 (We have the lowest potato production among the EU countries. The EU Commision revised the forecast with minus for 2024, https://www.economica.net/avem-cele-mai-mici-randamente-la-productia-de-cartofi-dintre-toate-statele-ue-comisia-europeana-a-revizuit-in-minus-prognoza-pentru-2024_770778.html,Accessed on 19.12.2024.

[8]Europatat, 2024, Potato Nutrition: Literature Review, https://europatat.eu/wp-content/uploads/2024/04/Literature-review-Potato-nutrition_final-publication.pdf, Accessed on 02.12.2024.
[9]European Food Information Council (EUFIC), 2024, The goodness in potatoes, https://www.eufic.org/en/healthy-living/article/the-goodness-in-potatoes, Accessed on 22.12.2024.
[10]Eurostat, 2024, The EU potato sector - statistics on production, prices and trade. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=The_EU_potato_sector_-_statistics_on_production,_prices_and_trade, Accessed on 08.02.2025.
[11]Horticultorul, 2024 (February 8), Cartoful (*Solanum tuberosum)*, https://www.horticultorul.ro/legume/cartoful-solanum-tuberosum, Accessed on 08.12.2024.
[12]Landgeist, 2021, Potato consumption in Europe, https://landgeist.com/2021/12/21/potato-consumption-in-europe,Accessed on 10.12.2024.
[13]Leszczynski, W., 1989, Potato Science and Technology, In: Lisinska, G. and Leszczynski, W. (Eds.), Elsevier Science Publishing Co., Inc., New York, pp. 11–128.
[14]Ministry of Agriculture and Rural Development (MADR), 2024, S-a aprobat o nouăschemă de ajutor de stat pentrususținereaproducției de cartofi, (It was approved a new schema of state aid for sustaining potato production, https://www.madr.ro/comunicare/8821-s-a-aprobat-o-noua-schema-de-ajutor-de-stat-pentru-sustinerea-productiei-de-cartofi.html,Accessed on 08.02.2025.
[15]National Institute of Statistics (INS), 2024, TEMPO-Online Database, http://statistici.insse.ro:8077/tempo-online,Accessed on 30.12.2024.
[16]Observatory of Economic Complexity (OEC), 2024 (February). Romania's Bilateral Trade Profile for Potatoes. https://oec.world/en/profile/bilateral-product/potatoes/reporter/rou, Accessed on 08.02.2025.
[17]Revista Ferma, 2025 (January 13), Cea maimicăproducție de cartofi din ultimii 10 ani: Româniadepinde de importuripentru a-șiacopericonsumul intern, (The lowest potato production in the last 10 years: Romania depends on import to cover domestic consumption), https://revista-ferma.ro/cea-mai-mica-productie-de-cartofi-din-ultimii-10-ani-romania-depinde-de-importuri-pentru-a-si-acoperi-consumul-intern, Accessed on 08.02.2025.
[18]Singh, J., Kaur, L., 2018, Potato: Chemistry, Nutritional Value and Processing, in: Siddiqui, M.W. (Ed.), Nutritional Composition and Antioxidant Properties of Fruits and Vegetables, Elsevier, pp. 441-474,https://www.sciencedirect.com/science/article/abs/pii/B9780128127803000210, Accessed on 30.12.2024.
[19]Soare, B.E., 2018, Romanian Trade with Potatoes in the European Union Context, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 18(1), pp. 459-464, https://managementjournal.usamv.ro/pdf/vol.18_1/Art57.pdf, Accessed on 18.12.2024.
[20]Souci, S.W., Fachmann, W., Kraut, H., 2008, Food Composition and Nutrition Tables, 8th ed., MedPharm Scientific Publishers, Stuttgart.
[21] Șerban Holding, 2024 (October 10). A new factory will be built in Romania: six tons of French fries per hour, with an investment of 62.5 million euros. Adevărul. https://adevarul.ro/economie/o-noua-fabrica-se-va-construi-in-romania-sase-2391886.html, Accessed on 08.02.2025.
[22]World Bank, 2024 (February 08). Romania's Imports of Frozen Potatoes (HS Code: 071010) in 2023. https://wits.worldbank.org/trade/comtrade/en/country/ROM/year/2023/tradeflow/Imports/partner/ALL/product/071010, Accessed on 08.02.2025.
[23]World Population Review, 2024, Potato Consumption by Country, https://worldpopulationreview.com/country-rankings/potato-consumption-by-country, Accessed on 08.12.2024.
[24]Ziarul Financiar, 2024 (June 20). Cartofiicongelați, vânzări de 125 mil. lei în 2023 înretailul din România, darimporturilerămânridicate. (Frozen popatoes, sales of Lei 125 Million in 2023 in the reatail of Romania, but the import still remains high), https://www.zf.ro/companii/cartofii-congelati-vanzari-125-mil-lei-2023-retail-romania-importuri-22437965,Accessed on 08.02.2025.

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IMPLEMENTING PRECISION AGRICULTURE TECHNOLOGIES IN SOUTH-MUNTENIA REGION: ECONOMIC BENEFITS AND OPERATIONAL CHALLENGES

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Abstract

Precision agriculture can be considered a revolution in modern farming, relying on data and advanced technologies aimed at optimizing production and efficiently utilizing resources. This approach enhances yields and reduces losses, thereby ensuring the sustainability and competitiveness of the agricultural sector. In a global context profoundly impacted by climate change, population growth, and increasing economic demands, precision agriculture plays a critical role in adapting farms to these new challenges while ensuring their profitability. This paper aims to asses the level of technical equipment, the degree of use and perceptions of precision agriculture technologies in eight farms with various surfaces in South-Muntenia region. The research is based on a questionnaire applied on these farms. The collected data were analyzed descriptively, with graphical representations. The results highlight the widespread adoption of self-guidance systems, the variable rate applications, digital platforms and soil sensors. The identified benefits include reduced production costs, increased efficiency and improved production quality while the main barriers are high costs, lack of training and technological complexity. The overall conclusion highlights the potential of precision agriculture to support farm performance and competitiveness, with support policies and professional training needed for widespread adoption.

Key words**:** *precision agriculture, sustainability, economic growth, agriculture profitability*

INTRODUCTION

For the global economy, agriculture is an essential sector, being responsible for producing raw materials and food necessary to feed the ever-growing population [4, 9, 22]. Currently, agriculture is facing notable challenges such as the need to increase food production to meet global demand [7], while reducing the impact on the environment [11] and conserving natural resources for future generations [21], but also with inflation and high production prices [14]. In order to meet the increasing demand, it is necessary to intensify agricultural production [15, 25], which can have negative consequences on the environment, contributing to soil degradation, water pollution and loss of biodiversity, and through various agricultural practices that have negative long-term impacts [2]. Conventional agriculture, dominant for the last hundred years, is an intensive system that uses modern technologies such as mechanized irrigation, agricultural machinery, and chemical inputs which, lead to high production costs [26] to ensure the productivity needed for global demand [19, 20], but unfortunately, this system contributes to the depletion of natural resources and implicitly to climate change.

In this context, precision agriculture emerges as an innovative solution [12,16], based on advanced technologies, which allows the optimization of agricultural production [8] through efficient resource management, reducing the impact on the environment [5] and of course increasing productivity and profitability. It is distinguished by the fact that, unlike conventional techniques, it adapts interventions to the specifics of each land, by applying and precisely executing the works

according to its potential [18]. Like many tech-driven sectors, precision agriculture has rapidly evolved and continues to develop through ongoing research and innovation [17]. Precision agriculture, with the help of technologies, offers farmers the chance to have better control over the production process to increase their profitability and reduce production risks, by enabling data-driven decision making. [3]. And some of these technologies have been adopted as standard practices in certain agricultural communities [13]. And globally, the adoption of precision agriculture is growing, as it plays an important role in addressing several challenges such as climate change, food security, and resource scarcity. Developed countries are investing heavily in research and infrastructure to support its implementation [6, 24]. Most farmers know the advantages and disadvantages that these technologies bring. Many farmers admit that it is not easy to implement and use these technologies due to the high investment costs and the lack of the necessary skills of operators to use and understand how they work [23].

Therefore, to be successful in implementing these solutions, active participation and a positive attitude of both the farmer and the entire staff are needed [10].

In this context, the purpose of this research is to assess the current state of adoption, usage, and perceptions of precision agriculture technologies among farms in the South-Muntenia region, with a focus on identifying the key benefits and barriers to their implementation.

MATERIALS AND METHODS

To analyze the degree of use and perceptions of precision agriculture technologies, a structured questionnaire, consisting of 14 questions, was developed and applied to a sample of 8 agricultural holdings in the South-Muntenia region. The selected farms are specialized in cereal cultivation and use, in one form or another, precision agriculture systems. The size of the holdings varies between 64 ha and 1,600 ha, which provides a diversified overview of the implementation of these technologies depending on the production capacity. The inclusion of a smaller farm was justified by the interest in capturing various perspectives on the access and applicability of the technologies, depending on the available resources.

The questionnaire was administered digitally through the Microsoft Forms platform, between March 28 and April 4, 2025. This interval was chosen to coincide with the period preceding spring agricultural works, when farmers' willingness to respond is increased, and the information provided is consistent with current field activities.

Data analysis was performed using descriptive methods, using frequencies and percentages to interpret the responses. The results were graphically represented to facilitate understanding and highlight trends in the use of precision agriculture.

RESULTS AND DISCUSSIONS

In this paper, we analyzed the level of farm equipment in the South Muntenia Region, both in terms of overall agricultural machinery stock and the integration of precision agriculture systems.

In the South-Muntenia region, the evolution of the agricultural machinery fleet from 2015 to 2023 indicates not only a general modernization trend, but also the beginnings of the transition to precision agriculture. The constant increase in the number of physical agricultural tractors, from 34,123 in 2015 to 38,013 in 2023, reflects a renewal of equipment on farms, in the context where modern tractors are often equipped with GPS systems, automated control and integrated sensors, essential for precision agriculture practices. The financing of these investments was supported by Measure 4.1 of the PNRD 2014–2020 and, more recently, by intervention DR-13 of the CAP Strategic Plan 2023–2027.

According to the available information, the intensity of the non-reimbursable support granted under Sub-measure 4.1 varied between 30% and 90%, depending on the economic size of the holding and the type of beneficiary. For vegetable farms with an economic size between 8,000 and 250,000 euro SO, the

support was up to 50% of the total eligible expenditure, without exceeding 350,000 euro for simple purchases (AFIR).

Another relevant indicator is the evolution of spraying and dusting machines, which recorded a decrease in 2020 followed by a recovery. This equipment is critical for variable pesticide application, based on crop health mapping — a central practice in precision agriculture. Also, seeding and cultivator equipment can be equipped with technologies that allow variable seeding based on soil analysis, which provides the premises for a more efficient use of inputs. Although the data in the table does not directly reflect the level of digitalization of equipment, the stability or growth of some key categories can be correlated with accessing European funds dedicated to innovative technologies, including additional points awarded to precision agriculture-compatible equipment in the applicant's guides. Thus, the evolution of agricultural equipment in South Muntenia over the last decade highlights a gradual process of transition towards more efficient agriculture, supported by technology and public policies oriented towards sustainability and innovation (Table 1).

Table 1. Evolution of Agricultural Machinery and Equipment in the South-Muntenia Region (2015–2023)

Category of Tractors and Agricultural Machinery	2015	2020	2021	2022	2023	Growth Rate 2015/2023 %
Physical agricultural tractors	34,123	36,336	37,292	37,802	38,013	89.77
Tractor plows	29,426	23,088	23,311	23,398	23,435	125.56
Mechanical cultivators	7,903	5,503	5,789	5,796	5,789	136.52
Mechanical seeders	17,958	13,684	13,575	13,657	13,732	130.77
Spraying and dusting machines with mechanical traction	1,751	1,423	1,527	1,746	1,774	98.70
Self-propelled combine harvesters for cereal crops	5,593	5,454	5,215	5,269	5,451	102.61
Self-propelled forage harvesters	95	142	129	140	149	63.76
Combines and machines for potato harvesting	842	976	977	984	1,012	83.20
Balers for straw and hay	2,849	2,348	2,383	2,410	2,406	118.41
Forage windrowers	254	203	199	191	191	132.98

Source: Calculation based on the number of physically registered units per category provided by National Institute of Statistics - Tempo Online, 2025 [27].

Between 2015 and 2023, the total number of farmers decreased from 882,351 to 734,653, representing a reduction of approximately 16.7%. The largest absolute decrease was recorded in the category of farmers with areas up to 10 ha, from 798,085 to 632,608 farmers, i.e. a decrease of over 165,000 people. The only category that increased in absolute terms is that of farms between 10 - 50 ha, with an increase from 64,045 to 78,540 farmers (+22.7%). The categories 50 - 150 ha and 150 - 1,000 ha also recorded increases, but more modest, of approximately 18% and 15.5%, respectively. The >1,000 ha category remained relatively constant, with a slight increase from 845 to 882 farmers (Table 2).

Between 2015 and 2023, the total utilized agricultural area increased slightly, from 9,171,661 ha to 9,868,326 ha, representing an increase of approximately 7.6%. However, the analysis by area category shows a significant redistribution between types of holdings.

The area exploited by small farms (≤10 ha) decreased significantly, from 2,342,058 ha in 2015 to 1,959,408 ha in 2023, a reduction of approximately 16.3%.

In contrast, the 10–50 ha category increased by over 430,000 ha, representing an increase of 32.6%, the highest percentage increase of all categories.

Table 2. Evolution of the number of farmers by agricultural area categories (2015–2023)

Farm surface category	Number of farmers					Growth Rate %
	2015	2020	2021	2022	2023	2015/2023
<=10 ha	798,085	685,180	677,389	653,588	632,608	126.16
10 - 50 ha	64,045	77,440	77,189	78,652	78,540	81.54
50 - 150 ha	11,485	13,171	13,583	13,906	13,509	85.02
150 - 1,000 ha	7,891	8,681	8,833	9,031	9,114	86.58
> 1,000 ha	845	892	875	879	882	95.80
Total	**882,351**	**785,364**	**777,869**	**756,056**	**734,653**	**120.10**

Source: Calculation based on the number reported by APIA, 2025 [1].

Farms of 50–150 ha and 150–1,000 ha also had moderate increases in the area exploited — approximately 19.3% and 12.1%, respectively. The area worked by large farms (>1,000 ha) remained relatively stable, with a slight increase of 6.9% (Table 3).

Table 3. Evolution of utilized agricultural area by farm size categories (2015–2023)

Farm surface category	Surface					Growth Rate %
	2015	2020	2021	2022	2023	2015/2023
<=10 ha	2,342,058	2,103,592	2,054,451	2,019,664	1,959,408	119.53
10 - 50 ha	1,320,209	1,657,503	1,668,717	1,713,129	1,751,655	75.37
50 - 150 ha	996,053	1,147,735	1,177,992	1,206,185	1,188,448	83.81
150 - 1,000 ha	2,805,553	3,026,985	3,081,643	3,131,973	3,143,930	89.24
> 1,000 ha	1,707,788	1,818,035	1,778,443	1,771,096	1,824,885	93.58
Total	**9,171,661**	**9,753,849**	**9,761,247**	**9,842,047**	**9,868,326**	**92.94**

Source: Calculation based on the number reported by APIA, 2025 [1].

In the southern area of the country, agricultural farms focus mainly on cultivating cereals, benefiting from a predominantly plain relief and fertile soil, favorable to this type of crop. This region stands out as one of the most important from an agricultural point of view at the national level, both in terms of cultivated areas and in terms of productivity obtained.

The distribution of agricultural areas by legal form highlights a clear link between the type of legal organization and the size of the holding. The four Limited Liability Companies included in the sample manage significant areas, ranging from 400 ha to 1,477 ha, which indicates an increased investment capacity, an advanced level of technology and a commercial operational structure. In contrast, the other legal forms are represented by a single holding each: the Sole Proprietorship manages 750 ha, the Self-Employed Individual operates on 500 ha, and the Family Enterprise works an area of 64.01 ha. This dispersion highlights the fact that small and medium-sized farms choose simpler legal forms, characterized by flexibility, but with limited resources, while large farms prefer legal structures that allow better mobilization of capital and wider access to high-performance technologies (Figure 1).

Fig. 1. Size of agricultural holdings analyzed according to legal status

Source: Own representation based on data collected, 2025.

The structure of farms in this area varies depending on the size of the exploited areas, directly influencing the degree of mechanization and technical equipment. Thus, the machinery park of the analyzed farms

includes between 3 and 10 agricultural equipment, reflecting a moderate diversity in operational capacity.

Regarding the adoption of modern technologies, the implementation of precision agriculture systems presents a variable chronology. The period of use of these technologies among the surveyed farms varies between 2 and 17 years, which suggests a different degree of digital maturity and integration of innovations into agricultural processes. This temporal differentiation indicates both a growing interest in optimizing agricultural activities and an evolutionary dynamic in terms of access to technologies and specialized know-how.

In the context of the intensification of extreme climatic phenomena in recent years, farmers are facing a significant reduction in optimal working windows. This situation requires rigorous optimization of agricultural activities to respond efficiently to favorable moments from an agrotechnical point of view. The implementation of precision agriculture systems directly contributes to increasing farm productivity, with percentages ranging from 10% to 40%, facilitating the rapid completion of essential agricultural work.

Empirical data indicate that the adoption of these technologies allows for the reduction of production costs by percentages ranging from 10% to 40%, depending on the degree of implementation of digital technologies and the level of mechanization of each agricultural holding. Investments in precision agriculture are in a significant range, with values ranging from 6,000 to 100,000 euros, depending on the size of the farm (number of hectares worked) and the complexity of the implemented systems.

In addition to the economic benefits, the use of precision agriculture technologies has a positive impact on the quality of agricultural production, especially on cereals, which can thus reach higher quality standards and can be more efficiently exploited on the market. These technologies also contribute to environmental protection, providing farmers with a better understanding of land variability, including in terms of productive potential and the presence of diseases or pests.

Advanced technologies also allow for the precise and efficient application of phytosanitary treatments and other inputs at the optimal times, leading to the rational use of resources and reducing the impact on the environment.

In the South-Muntenia region, the most frequently used precision agriculture system is the self-guidance system, considered the basic technology in most farms. It allows for saving input and fuel, while also contributing to increasing productivity. Around 50% of farmers use crop monitoring systems based on satellite imagery, which provide a comprehensive view of crops and allow for early identification of large-scale problems. In addition, 37.5% of respondents use soil sensors and weather stations to monitor soil and climate conditions, indicating a growing interest in sustainable natural resource management. Drones are used by around 25% of farmers, a low percentage probably due to the high costs and complex technical requirements associated with their operation.

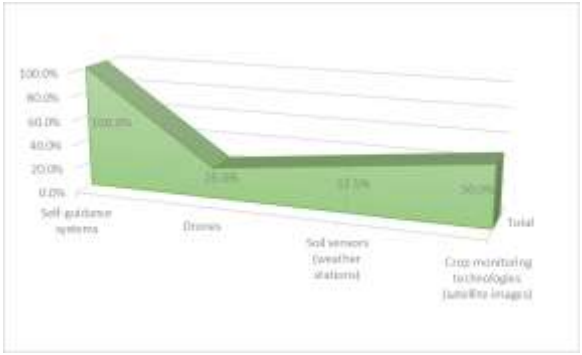

Fig. 2. Types of precision farming systems used in South-Muntenia region

Source: Own representation based on data collected, 2025.

Self-guidance technology is widely adopted by all farmers interviewed, due to its versatility and applicability in all stages of agricultural work carried out in the field. It is an essential component of modern precision farming systems, facilitating significant resource savings and increasing operational efficiency.

Section control technology is used by approximately 62.5% of farmers. It allows for cost reduction by avoiding overlaps in the application of inputs and seeds, thus

contributing to a more rational use of resources.

Variable rate application, used by 50% of farmers, gives them the opportunity to adjust the dosage of inputs according to soil heterogeneity and the productive potential of different areas within the soils, thus optimizing the yield and sustainability of the farm.

Other 50% of farmers use farm management platforms, digital tools that allow them to systematically document and analyze agricultural activities. These platforms facilitate data-driven decision-making, contributing to improved decision-making and planning of activities.

Regarding the use of prescription maps, only 37.5% of respondents use these advanced tools, which are based on data combining productivity maps, satellite images or agrochemical soil analyses. This relatively low rate of use can be explained by the complexity of the process of developing and integrating these maps into agricultural management systems.

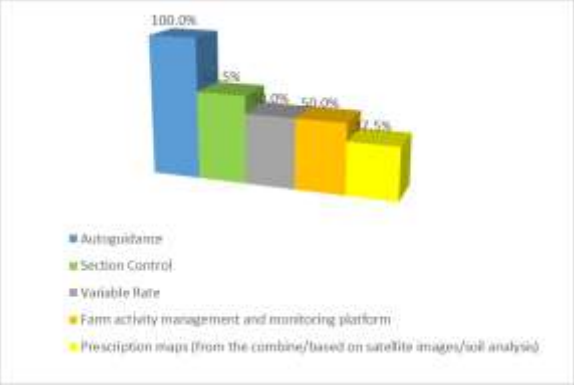

Fig. 3. Types of technologies used in the South-Muntenia selected farms

Source: Own representation based on the data collected, 2025.

The self-guidance system is one of the most widespread and fundamental technologies used in precision agriculture, due to its versatility and wide applicability to most mechanized agricultural works. This technology is compatible with tractors, combines and treatment equipment (sprayers), bringing significant benefits in terms of operational efficiency, cost reduction and optimization of input use.

Within the farms analyzed, a 100% adoption rate of self-guidance systems on tractors is noted. This underlines the importance of technology in performing basic agricultural works, such as soil preparation, sowing or fertilizer application. Self-guidance contributes to increasing the precision of the works, eliminating overlaps, reducing fuel consumption and idle times, which directly leads to increased productivity.

In contrast, the extension of these systems to other machines is lower. Only 62.5% of the farms use self-guidance on combines and sprayers as well. On combines, this technology helps maintain an optimal harvesting trajectory, which minimizes losses and allows operators to focus on harvesting quality parameters and efficient operation of the machine. In the case of sprayers, self-guidance is essential for the uniform application of plant protection products, avoiding overdoses and omissions, and thus contributing to reducing the impact on the environment and protecting crops.

The comparative benefits of using the self-guidance system are thus differentiated, depending on the type of machine: for tractors, the emphasis is on overall efficiency and reducing resource consumption; for combines, on optimizing the harvesting process; and for sprayers, on treatment precision and environmental protection. These advantages justify the growing interest of farmers in extending the use of this technology to all farm equipment.

The implementation of precision agriculture systems generates a series of significant benefits for farmers, reflected in the improvement of the economic and productive performance of agricultural holdings.

According to the data collected, 87.5% of farmers believe that these technologies contribute directly to reducing production costs, by optimizing the consumption of inputs and the efficient management of available resources.

Fig. 4. Distribution of guidance system usage by agricultural machinery type
Source: Own representation based on data collected, 2025**.**

This is possible thanks to the precise application of fertilizers, pesticides and other treatments according to the specific needs of each cultivated area, avoiding waste and overdoses.
Also, 62.5% of farmers state that the use of precision agriculture systems has led to an improvement in the quality of agricultural production and to obtaining higher yields. This increase in productivity is attributed to the ability of these systems to provide precise and real-time information, which allows for informed agronomic decisions to be made and adapted to the pedoclimatic and biological conditions of each soil.
Therefore, precision agriculture not only supports better resource management, but also plays an essential role in increasing the competitiveness and sustainability of agricultural activities.

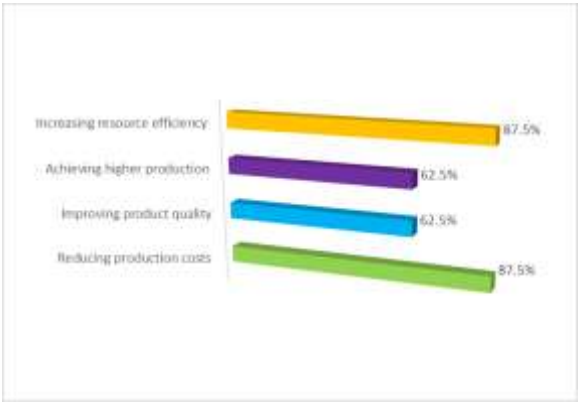

Fig. 5. Farmer-reported advantages of precision agriculture implementation
Source: Own representation based on data collected, 2025.

Although precision agriculture systems bring numerous benefits in terms of economic efficiency and sustainability of agricultural activities, farmers face several significant challenges in the process of adopting and implementing these technologies.
The main obstacle identified by 63% of farmers is the high initial cost of investments required for the acquisition and installation of specific equipment and software. This financial barrier is particularly restrictive for small and medium-sized farms, which have limited resources for such capital investments.
At the same time, half of farmers (50%) emphasize the need to participate in specialized training programs to be able to use these systems effectively. The lack of adequate training can lead to underutilization of available functionalities or inefficient implementations that do not bring the expected results.
The technical complexity of these systems is another impediment noted by 38% of respondents, who consider that the interfaces and operations involved are not intuitive and may require a high level of digital knowledge. This may discourage wider adoption, especially among farmers who are inexperienced in using information technologies.

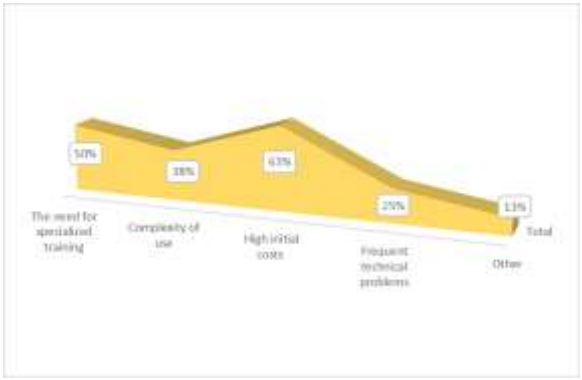

Fig. 6. Main challenges faced in the adoption of precision agriculture systems
Source: Own representation based on data collected, 2025

Also, 25% of farmers reported frequent technical malfunctions in the operation of equipment, which affects the reliability of the systems and generates downtime or additional costs for maintenance and repairs.

These constraints highlight the need for financial support policies, the development of professional training infrastructure and a simplification of technological interfaces, to facilitate the widespread and efficient integration of precision agriculture within farms.

CONCLUSIONS

The study conducted in the eight agricultural holdings in the South-Muntenia region highlights a consolidated trend of adopting precision agriculture technologies, with a full implementation of self-guidance systems on tractors. This technology is perceived by farmers as indispensable, due to its versatility and applicability in all types of mechanized farm work. In contrast, the extension of self-guidance to combines and herbicide machines is limited, which indicates significant potential for development in this direction.

Between 2013 and 2023, the South-Muntenia region recorded different growth rates for agricultural machinery categories, reflecting modernization trends and priorities in the agricultural sector. The highest growth was recorded for mechanical cultivators (131.47%), followed by forage harvesters (129.32%) and mechanical seeders (127.86%), reflecting an increased interest in streamlining soil preparation and sowing.

Among the major benefits reported by farmers are the reduction of production costs, increased efficiency in resource use, improved quality of agricultural production and higher yields. These aspects underline the essential role of precision agriculture in streamlining agricultural processes and ensuring the long-term sustainability of farms.

However, the implementation process is accompanied by several significant challenges. These include high initial investment costs, the need for specialized staff training, the complexity of using the systems and the frequency of technical malfunctions. These difficulties highlight the need for tailored support measures, both financially and in terms of farmer training, to facilitate a wider and more efficient adoption of digital technologies in agriculture. In conclusion, precision agriculture is emerging as a transformative factor in the modernization of the agricultural sector, contributing to increased competitiveness and the transition towards a sustainable agricultural model adapted to current challenges.

REFERENCES

[1]Agency for the Financing of Rural Investments. (n.d.). Investments in agricultural holdings – Sub-measure 4.1. AFIR Portal. https://portal.afir.info/informatii_generale_pndr_investitii_prin_pndr_sm_4_1_exploatatii_agricole, Accessed on 15 March 2025.

[2]Bai, Z., Caspari, T., Gonzalez, M. R., Batjes, N. H., Mäder, P., Bünemann, E. K., Tóth, Z., 2018, Effects of agricultural management practices on soil quality: A review of long-term experiments for Europe and China. Agriculture, ecosystems & environment, 265, 1-7.

[3]Bakhtiari, A. A., Hematian, A., 2013, Precision farming technology, opportunities and difficulty. International Journal for Science and Emerging Technologies with Latest Trends, 5(1), 1–14.

[4]Balan, I. M., Trasca, T. I., Iancu, T., Belc, N., Radulov, I., Tulcan, C., 2024, Food safety in the Sustainable Food Industry. In Smart Food Industry: The Blockchain for Sustainable Engineering, pp. 218-239. CRC Press.

[5]Bongiovanni, R., Lowenberg-DeBoer, J., 2004, Precision agriculture and sustainability. Precision agriculture, 5, 359-387.

[6]Getahun, S., Kefale, H., Gelaye, Y., 2024, Application of Precision Agriculture Technologies for Sustainable Crop Production and Environmental Sustainability: A Systematic Review. The Scientific World Journal, 2024(1), 2126734.

[7]Hertel, T. W., 2015, The challenges of sustainably feeding a growing planet. Food Security, 7(2), 185-198.

[8]Iagaru, P., Pavel, P., Iagaru, R., 2019, Implementation Of The Concept Agriculture Of Precision A Way To Improve The Management Of Agricultural Enterprises. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 19(1), 229-234.

[9]Jerca, I. O., Smedescu, C., 2023, a decade of change in Europe's tomato greenhouses: insights and trends. Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development, 23(4).

[10]Lencsés, E., Takács, I., Takács-György, K., 2014, Farmers' perception of precision farming technology among Hungarian farmers. Sustainability, 6(12), 8452-8465.

[11]Marcuță, A., Tindeche, C., Tudor, V., Carbarau, C., Smedescu, D., Marcuță, L., 2021, Application of the principles of the circular economy in conventional agriculture. Case study-pesticide waste recycling, Scientific Papers. Series "Management, Economic

Engineering in Agriculture and Rural Development", Vol. 21(2), 375-382.
[12]Mgendi, G., 2024, Unlocking the potential of precision agriculture for sustainable farming. Discover Agriculture, 2(1), 87.
[13]Pathak, H. S., Brown, P., Best, T., 2019, A systematic literature review of the factors affecting the precision agriculture adoption process. Precision Agriculture, 20, 1292-1316.
[14]Njegovan, N., Simin, M. T., 2020, Inflation and prices of agricultural products. Economic Themes, 58(2), 203-217.
[15]Pretty, J., Bharucha, Z. P., 2014, Sustainable intensification in agricultural systems. Annals of Botany, 114(8), 1571-1596.
[16]Șerban, D. G., Lungu, E., Șerban, F. L., Turek Rahoveanu, M. M., 2024, Digital Transformation In Romania's Agriculture In The Period 2023-2027. Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development, 24(4), 745-752.
[17]Shaheb, M. R., Sarker, A., Shearer, S. A., 2022, Precision agriculture for sustainable soil and crop management. In Soil Science-Emerging Technologies, Global Perspectives and Applications. IntechOpen.
[18]Schimmelpfennig, D., 2018, Crop production costs, profits, and ecosystem stewardship with precision agriculture. Journal of Agricultural and Applied Economics, 50(1), 81-103.
[19]Smedescu, C., Micu, M. M., Tudor, V. C., 2023, Farm size and specialization structure in the European countries in the year 2020, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Vol. 23(2), 599-604.
[20]Smedescu, C., Smedescu, D., Mărcuta, A., Mărcuta, L., Tudor, V. C. A., 2023, From soil to table: evaluating conventional and ecological cultivation systems in South-West Oltenia, Romania, Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 23(3), 821-830.
[21]Steinbuks, J., Hertel, T. W., 2016, Confronting the food–energy–environment trilemma: global land use in the long run. Environmental and Resource Economics, 63, 545-570.
[22]Sunderland, T. C., 2011, Food security: why is biodiversity important?. International Forestry Review, 13(3), 265-274.
[23]Takács-György, K., Takács, I., 2009, Economic analysis of precision weed management. Cereal Res. Commun. 37, 597–605.
[24]Tey, Y. S., Brindal, M., 2012, Factors influencing the adoption of precision agricultural technologies: a review for policy implications. Precision agriculture, 13, 713-730.
[25]Tilman, D., Balzer, C., Hill, J., Befort, B. L., 2011, Global food demand and the sustainable intensification of agriculture. Proceedings of the National Academy of sciences, 108(50), 20260-20264.
[26]Tudor, V. C., Gimbăşanu, G. F., Fîntîneru, A., Mărcuță, A. G., Coada, C. S., Teodorescu, R. F., 2022, Comparative study on the level of production costs in organic and conventional agriculture in Romania, Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 22(2), 761-766.
[27]***National Institute of Statistics, Tempo online, http://statistici.insse.ro:8077/tempo-online/ Accessed on 5 March 2025.

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ADAPTING THE U.S. UNIVERSITY-BASED EXTENSION MODEL TO THE AKIS FRAMEWORK OF ROMANIA AND THE EUROPEAN UNION

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Abstract

This paper explores the feasibility of implementing a university-led agricultural extension system in Romania, aligned with the European Union's Agricultural Knowledge and Innovation System (AKIS). Drawing on comparative insights from the U.S. Cooperative Extension model, the study examines how agronomic universities can play a central role in bridging the gap between research, policy, and rural practice. Using a mixed methodological approach that includes PESTEL and SWOT analyses, a stakeholder matrix, and a GAP analysis, the paper identifies key systemic challenges: fragmented advisory structures, limited legal mandates, and underutilized academic capacity. Results suggest that while Romania has significant institutional and human potential, it lacks the structural coordination needed to meet EU expectations and fully access CAP and Horizon Europe funds. The proposed model emphasizes local engagement, digital knowledge sharing, and student involvement. If adopted, this approach could enhance Romania's alignment with EU policy goals, strengthen rural advisory services, and position universities as key actors in agricultural innovation and sustainability.

Key words**:** *advisory, AKIS, CAP, cooperative extension, knowledge transfer*

INTRODUCTION

Romania's agriculture is marked by strong cereal production but structural imbalances. While the country is a major EU exporter of wheat and maize, over 90% of its farms are small or subsistence-level, limiting efficiency and modernization. Despite high crop yields, Romania faces a significant meat trade deficit, relying heavily on imports to meet domestic demand. This reflects underdeveloped livestock sectors and weak processing capacity. Addressing these gaps requires not only investment and farm consolidation but also improved agricultural advisory services that can support informed, sustainable development across all farm sizes (Popescu et al., 2023; 2024).

Agricultural knowledge and advisory systems have long played a critical role in shaping the productivity, sustainability, and resilience of rural economies. Historically, the development of formal agricultural extension services emerged as a response to the need for structured dissemination of research-based practices to farmers, enabling them to improve yields, manage risks, and adapt to changing socio-economic and environmental conditions (Kania et al., 2014).

In the United States, the establishment of the Cooperative Extension System in 1914 through the Smith-Lever Act institutionalized a model of university-based outreach, grounded in collaboration between land-grant universities, local governments, and rural communities. This system has since become a global

benchmark for effective agricultural innovation transfer, combining research, education, and public service in a unified framework(Borron et al,. 2019).

Within the European Union, efforts to modernize advisory services gained momentum with the reform of the Common Agricultural Policy (CAP) and the emergence of the Agricultural Knowledge and Innovation System (AKIS) concept in the early 2000s. AKIS promotes a decentralized yet interconnected approach, encouraging the integration of diverse actors—researchers, educators, advisors, farmers, and agri-food businesses—into a cohesive network that supports innovation and sustainability (Knierim et al., 2015; 2017). In recent CAP cycles (especially 2023–2027), AKIS has become a strategic priority, with member states required to coordinate national-level systems that support knowledge transfer, digitalization, and green transition in agriculture (Micu et al., 2022).

In Romania, the evolution of agricultural consultancy has been more fragmented. The socialist period institutionalized state-driven advisory mechanisms, but these were largely dismantled during the transition to a market economy. Attempts to rebuild a public extension network—such as through the former ANCA (AgențiaNațională de ConsultanțăAgricolă) and county-level CDRJ units—have been partially successful but lacked continuity, integration with universities, and sustainable funding (Stefanescu et al., 2013). As a result, many Romanian farmers rely today on informal networks, private consultants, or social media platforms for technical guidance—often with inconsistent or unreliable results(Ciocan et al., 2024a).

Although Romania currently benefits from certain EU funding streams under the CAP and Horizon Europe, its access remains partial and underutilized due to the absence of a fully functional and recognized AKIS. Without a coherent national strategy that connects universities, research institutes, advisory services, and farmers in a coordinated system, Romania is unable to capitalize on the full range of funding instruments explicitly designed to support innovation, knowledge transfer, and capacity building in agriculture (Dirimanova& Rusu, 2016).

A functioning AKIS, as defined by the European Commission, is a prerequisite for unlocking dedicated funding opportunities such as support for operational groups underEIP-AGRI, targeted training and advisory programs under CAP Strategic Plans, and multi-actor innovation projects financed through Horizon Europe. Establishing such a system would not only improve Romania's alignment with EU policy priorities, but would also significantly increase its eligibility and competitiveness in accessing structured financial support for agricultural modernization and rural development (European Commission, 2024) .

In this context, Romania faces a dual challenge: on one hand, to align with the EU's AKIS vision and strategic objectives, and on the other, to develop a model of knowledge transfer that is both cost-effective and deeply rooted in local realities(Toma et al., 2021). This article argues that a series of best practices inspired by the U.S. extension system, notably the integration of agronomic universities into community-based knowledge transfercan be successfully adapted to Romania's context and contribute meaningfully to the development of a national AKIS.These practices include the establishment of university-led extension hubs, the mobilization of students and faculty in applied research and advisory roles, and the development of digital platforms to support open-access knowledge sharing and community engagement. Such a model not only aligns with the EU's emphasis on innovation, sustainability, and youth involvement in agriculture, but also addresses specific structural gaps in the Romanian system (Ciocan et al., 2024b).

To evaluate the feasibility and implications of implementing this model within the AKIS and CAP framework, the article presents a combined PESTEL and SWOT analysis. This analytical approach highlights the political, economic, social, technological, environmental, and legal factors influencing knowledge transfer in Romanian agriculture, while identifying internal strengths and weaknesses, as well as external opportunities

and threats. The aim is to propose an actionable, scalable, and financially sustainable extension model that reinforces Romania's integration into the European knowledge economy and supports long-term rural transformation.

MATERIALS AND METHODS

This study explores the feasibility of adapting a university-led agricultural extension model to the Romanian context, in line with the European Union's Agricultural Knowledge and Innovation System (AKIS) framework. The research was conducted between January and March 2025 and is based on a conceptual, comparative, and policy-oriented methodology, with Romania as the focal case study and the European Union as the strategic reference framework.

A key asset in the research design was the direct institutional experience of the authors, acquired through participation in the Fulbright-RAF Scholar Program (2023–2024) in the United States. During this program, the authors engaged with the Cooperative Extension System at the University of Georgia, gaining practical insights into the structure, functioning, and university-community dynamics of a mature agricultural extension system. Although the American model is structurally more centralized and administratively less complex than the European AKIS framework, its operational simplicity, strong academic anchoring, and community focus provide a rich foundation of transferable practices relevant to Romania's needs (Ciocan et al., 2024b).

The methodological framework combined several strategic and institutional analysis tools, chosen for their complementarity and relevance to both the EU policy context and national implementation challenges.

First, a combined PESTEL and SWOT analysis was used to evaluate the current Romanian agricultural knowledge ecosystem. The PESTEL component assessed macro-environmental factors—Political, Economic, Social, Technological, Environmental, and Legal—while the SWOT component identified internal strengths and weaknesses, along with external opportunities and threats. Together, these tools provided a holistic diagnostic of both strategic positioning and operational readiness for systemic change.

Furthermore, a Stakeholder Matrix (Power–Interest Grid) was used to map the main actors in the Romanian AKIS ecosystem. By categorizing stakeholders according to their influence and level of engagement, the analysis supported the identification of strategic partnerships, resistance points, and potential champions for reform.

To complement this, a GAP analysis was employed to highlight the discrepancy between Romania's current, fragmented knowledge and advisory landscape and the functional AKIS model promoted by the European Commission. This approach helped identify the institutional and procedural reforms necessary to align Romania with EU expectations and to unlock targeted funding opportunities under CAP and Horizon Europe.

The study draws upon a diverse set of sources, including:

- EU policy and legal frameworks (CAP regulations, AKIS guidelines)
- Romania's CAP Strategic Plan 2023–2027 and related national legislation
- Academic literature on agricultural extension and innovation systems
- Outputs from EU platforms such as EIP-AGRI and SCAR-AKIS
- Field observations and internal reports from the Fulbright-RAF program

The research relied exclusively on document analysis, strategic modeling, and comparative institutional insights.

Study Limitations: this study is exploratory and conceptual in nature. While grounded in international field exposure and strategic analysis, it does not include empirical validation through stakeholder interviews, surveys, or pilot implementations. As such, the proposals and conclusions presented herein should be seen as a foundation for further applied research and institutional experimentation. Future studies may expand upon this work through participatory design processes, case studies, and regionally specific

pilot programs to assess the model's effectiveness under real-world conditions.

RESULTS AND DISCUSSIONS

To assess the feasibility and systemic compatibility of implementing a university-based agricultural extension system in Romania, a combined PESTEL and SWOT analysis was conducted. This dual framework offers an integrated perspective on both the external macro-environmental factors influencing implementation and the internal structural conditions of the Romanian agronomic and institutional landscape. The analysis reflects the strategic alignment of such a model with the AKIS (Agricultural Knowledge and InnovationSystem) principles promoted by the European Union.

1. Political Dimension

The EU's Common Agricultural Policy (CAP 2023–2027) mandates the development of national AKIS frameworks. This provides both pressure and opportunity for reform. However, Romania suffers from administrative fragmentation and lacks a unified political commitment to agricultural innovation and knowledge transfer (MADR, 2022).

SWOT Analysis:

- Strengths: Alignment with EU directives provides a legitimate framework for reform; academic institutions have policy credibility.
- Weaknesses: Romanian universities currently have no formal political mandate in national advisory structures.
- Opportunities: Political momentum for AKIS offers universities a chance to claim institutional roles in policy.
- Threats: Policy inconsistency, centralization, and institutional inertia may delay or undermine integration efforts.

2. Economic Dimension

There is substantial EU funding available for AKIS-compatible systems through Horizon Europe, EIP-AGRI, and national CAP StrategicPlans. Yet, Romania may miss out due to the absence of an operational, recognized AKIS (Kountios et al., 2024).

SWOT Analysis:

•Strengths: Universities have the capacity to write, manage, and implement EU projects; academic networks increase competitiveness.

•Weaknesses: Lack of a consolidated extension infrastructure limits absorption capacity.

•Opportunities: Universities can become eligible beneficiaries of dedicated EU AKIS funding once integrated into national strategy.•Threats: Continued underfunding and overreliance on short-term projects could undermine sustainability.

3. Social Dimension

Romania's rural population is aging, and smallholder farmers often lack access to modern advisory services (Smedescu et al., 2024). At the same time, universities remain largely disconnected from thesecommunities, despite their educational mission and regional presence.

SWOT Analysis:

•Strengths: Universities possess credibility and have the tools for outreach (student projects, community programs).

•Weaknesses: Weak social ties with local farming communities; limited tradition of grassroots engagement.

•Opportunities: Extension programs can strengthen community trust and promote youth engagement in agriculture.

•Threats: Social mistrust of institutional actors and reliance on informal sources (e.g., social media) could hinder adoption.

4. Technological Dimension

Digital platforms for knowledge sharing and remote advisory services are increasingly important, but Romania's rural digital literacy remains uneven. Universities, as knowledge hubs, are well-positioned to drive digital integration (Pascal & Turek-Rahoveanu,2023).

SWOT Analysis:

•Strengths: Access to IT infrastructure and expertise within universities; capacity to develop and manage digital tools.

•Weaknesses: Lack of institutional coordination for outreach and support in rural digital engagement.

•Opportunities: Universities can lead digitalization through smart agriculture initiatives, apps, e-learning, and virtual advisory.

•Threats: Digital divide in rural areas may exclude the very beneficiaries the system aims to support.

5. Environmental Dimension

The European Green Deal and Farm to Fork Strategy emphasize the urgent need for environmentally sustainable agriculture (Smedescu et al., 2023).Extension systems must play a central role in disseminating green practices.

SWOT Analysis:

•Strengths: Universities are leaders in agronomic research on sustainability, climate adaptation, and biodiversity.

•Weaknesses: Environmental research is often disconnected from practice; limited translational mechanisms exist.

•Opportunities: Extension hubs can become catalysts for the practical adoption of green technologies and regenerative agriculture.

•Threats: Delays in knowledge transfer may prevent farmers from complying with upcoming sustainability regulations.

6. Legal Dimension

While EU legislation encourages the integration of education and research institutions in AKIS. (Kountios et al., 2024). Romania lacks a legal framework that formallyassigns roles to universities in the advisory ecosystem.

SWOT Analysis:

•Strengths: Universities can align rapidly with EU-compliant roles once recognized.

•Weaknesses: Absence of legal status as advisory actors prevents funding access and coordination.

•Opportunities: New legal provisions could redefine AKIS structure and empower academic institutions.

•Threats: Legislative delays or political resistance could limit universities' involvement and block structural funding access.

The combined PESTEL and SWOT analysis suggests that Romania holds strong foundational potential for developing a university-based extension model that aligns with AKIS principles. Political and economic conditions are broadly favorable, due to EU strategic orientation and funding mechanisms, while social and technological dimensions point to real opportunities for universities to assume an active extension role. However, internal institutional barriers, including funding constraints, legal ambiguity, and weak inter-actor coordination, must be addressed.

This analysis supports the notion that an academically anchored extension system, if properly designed and integrated into Romania's national AKIS, could enhance knowledge transfer, increase farmer resilience, and unlock underexploited EU funding opportunities.

To ensure the successful implementation of a university-based agricultural extension model aligned with the European Union's AKIS framework, it is essential to understand the roles, interests, and levels of influence of key institutional actors.

The Stakeholder matrix presented in Figure 1 offers a strategic overview of the main entities involved or affected by the development of an integrated knowledge and advisory system in Romania.

By mapping stakeholders along two axes—Power/Influence and Interest—this matrix identifies the potential allies, decision-makers, and beneficiaries whose engagement is crucial for system-wide reform and sustainability.

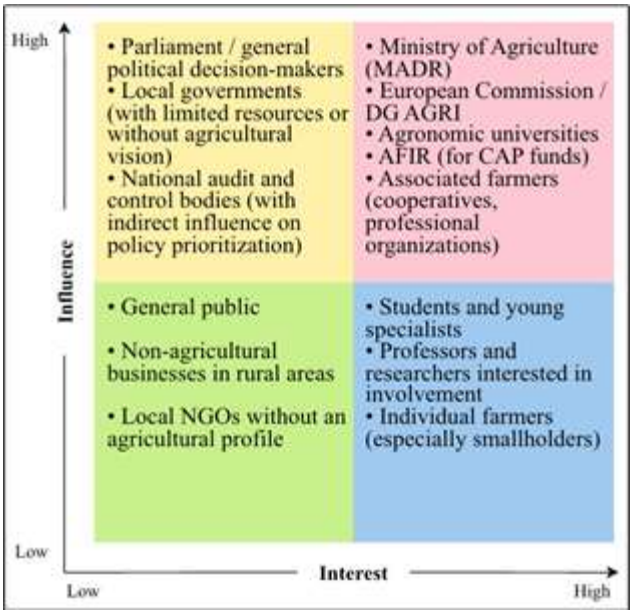

Fig. 1. Stakeholder matrix

Source: Adapted from Mendelow's Matrix and institutional mapping frameworks used in AKIS policy evaluations (Knierim et al., 2017; European Commission, 2024) [7, 4].

To understand the structural and functional challenges that hinder Romania's integration into the European Union's Agricultural Knowledge and Innovation System (AKIS), a GAP analysis was conducted.

This method allows for the identification of key discrepancies between the current national advisory and educational landscape and the desired state envisioned by EU policy frameworks, particularly under the Common Agricultural Policy (CAP 2023–2027).

The analysis focuses on seven critical dimensions—institutional integration, legal framework, funding access, knowledge transfer mechanisms, digital infrastructure, stakeholder participation, and human capacity. For each of these areas, the current situation in Romania is compared against EU expectations, revealing institutional gaps that must be addressed in order to unlock funding, improve performance, and formalize the role of agronomic universities in the national extension system.

Table 1 summarizes the findings and outlines strategic recommendations that can support the development of a functioning, EU-recognized AKIS in Romania.

The GAP analysis presented in Table 1 highlights the critical misalignments between Romania's current advisory and institutional landscape and the integrated, collaborative structure required by the EU-AKIS framework.

Table 1. GAP analysis of Romania's AKIS (compared to EU expectations)

Dimension	Current State in Romania	AKIS-Required State (Target)	Identified Gaps	Recommended Actions
Institutional integration	Fragmented responsibilities among DAJ, MADR, private consultants; universities are marginal actors	Coherent network of research, education, advisory, and farming sectors	Lack of national coordination and formal university involvement	Create a centralized coordination body and legally define the role of universities in AKIS
Legal framework	No legal status for universities as extension providers	Legal recognition of all AKIS actors, including higher education	Universities excluded from funding and policy design	Introduce amendments to national legislation to include academic institutions in the advisory system
Funding access	Limited project-based funding; universities depend on research grants	Access to CAP, Horizon Europe, and EIP-AGRI through AKIS integration	Ineligibility due to lack of official role in advisory services	Establish eligibility through legal integration and AKIS recognition
Knowledge transfer mechanisms	Academic research rarely reaches farmers; limited extension infrastructure	Multi-directional knowledge flow between farmers, researchers, advisors	Missing interface between university output and farmer needs	Develop university extension offices and digital knowledge platforms
Digitalization & tools	Uneven digital adoption in rural areas; no unified extension platform	Digital knowledge sharing, e-advisory services	Lack of infrastructure and rural connectivity gaps	Invest in university-driven digital platforms and rural digital inclusion
Stakeholder participation	Weak farmer–university engagement; lack of incentives for collaboration	Co-creation with farmers, advisors, researchers in innovation networks	Low trust, limited feedback from farmers, missing multi-actor formats	Pilot participatory models (e.g., operational groups, student–farmer teams)
Human capacity	Isolated academic staff; few extension-trained professionals	Skilled human resources trained in facilitation, innovation, outreach	No institutional training or incentives for academic outreach	Provide training and incentives for university staff and students in extension roles

Source: Adapted from EU AKIS diagnostic tools (European Commission, 2024), and institutional analysis frameworks applied in Ciocan et al. (2024b) and Rusu et al. (2015) [4, 3, 13].

While significant academic and structural potential exists, systemic barriers such as legal exclusion, weak coordination, and limited funding access continue to hinder meaningful progress. Addressing these gaps through targeted reforms and strategic investments will be essential for building a functional, EU-recognized AKIS that empowers universities as key drivers of agricultural innovation and rural development.

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CONCLUSIONS

This article has argued that a university-led agricultural extension system represents a viable and strategic pathway for Romania to modernize its knowledge transfer infrastructure and align itself with the broader ambitions of the European Union under the Agricultural Knowledge and Innovation System (AKIS) framework. The comparative perspective offered by the U.S. Cooperative Extension System, while rooted in a different socio-political context, provides compelling examples of how academic institutions can become not only sources of research and education but also active participants in rural transformation. What emerges from the analysis is a complex but actionable picture. Romania is not lacking in human capital or institutional expertise—on the contrary, its agronomic universities are home to experienced researchers, motivated students, and a growing interest in applied, field-based education. However, these resources remain underutilized due to systemic issues such as unclear legal status, fragmented governance, and the absence of a coordinated national strategy for advisory services.

The results of the combined PESTEL, SWOT, stakeholder, and GAP analyses highlight how deeply interwoven these structural limitations are. For example, without a legal mandate, universities cannot access certain funding streams. Without funding, they cannot institutionalize extension offices or train dedicated personnel. And without people and structure, meaningful engagement with rural communities remains sporadic and unsystematic. In short, without a coordinated framework—both conceptual and practical—the existing academic potential is unable to translate into real-world impact.

Yet, this diagnosis is not cause for resignation. On the contrary, it reveals a map of strategic intervention points. By addressing legal ambiguities, enhancing inter-institutional cooperation, and piloting practical outreach programs, Romania could build a cost-effective, participatory, and scalable extension model. Such a system would not only provide farmers with access to timely and relevant information but would also offer universities a new sense of relevance and public mission. Moreover, by involving students directly in community engagement and knowledge transfer, the model would enhance experiential learning and help prepare a new generation of professionals who understand the complexities of modern agriculture beyond the classroom or laboratory.

This approach also aligns with emerging trends in European policy, where funding is increasingly tied to impact, inclusiveness, and innovation. A Romanian AKIS that successfully integrates academic, advisory, and practical agricultural sectors would be far more competitive in securing long-term support through Horizon Europe, EIP-AGRI, and CAP Strategic Plans. It would also resonate with the goals of the European Green Deal, Farm to Fork Strategy, and broader sustainability objectives. Finally, and perhaps most importantly, the development of such a model represents an opportunity to restore trust and coherence within the rural knowledge ecosystem. In a time when farmers often turn to informal or unreliable sources for information, the presence of a respected, accessible, and responsive university-based extension system could help re-establish a foundation for evidence-based agricultural practice. This is not merely a technical upgrade, but a cultural and institutional shift toward long-term resilience. In conclusion, the path forward is clear, if not necessarily easy. Romania has the ingredients necessary to build an AKIS that is not only functional but exemplary within the EU. What is needed now

is a coordinated push—anchored in policy, backed by funding, and driven by institutions willing to engage with the complexity of rural realities. If this momentum can be sustained, agronomic universities can become more than academic centers; they can become catalysts for regional development, social innovation, and the revitalization of the Romanian countryside.

REFERENCES

[1]Borron, A., Lamm, K., Darbisi, C., Randall, N., 2019, Social impact assessment in the cooperative extension system: Revitalizing the community capitals framework in measurement and approach. Journal of International Agricultural and Extension Education, 26(2), 75-88.

[2]Ciocan, H. N., Batrina, S. L., Balta, I., Moraru, P. I., Săcăleanu, D. I., Borron, A., 2024a, A proposed agricultural extension model for Romania: Leveraging universities' resources to create a cost-efficient and impactful knowledge transfer system inspired by the U.S. model. Scientific Papers. Series Management, Economic Engineering in Agriculture and Rural Development, 24(4), 191–204.

[3]Ciocan, H. N., Popescu, A., Dinu, T. A., Stoian, E., Moldoveanu, I. D., 2024b, Filling the knowledge gap: How the absence of an agricultural extension system drives Romanian farmers to seek advice and informal consultancy on social media, increasing the misinformation risk. Scientific Papers. Series Management, Economic Engineering in Agriculture and Rural Development, 24(3), 213–228.

[4]European Commission, 2024, Fostering an effective and integrated AKIS in Member States: Seminar report. EU CAP Network. https://eu-cap-network.ec.europa.eu, Accessed on January 5, 2025.

[5]Kania, J., Vinohradnik, K., Knierim, A., 2014, WP3–AKIS in the EU: The inventory final report volume I–Summary findings. AKIS: Krakow, Poland.

[6]Knierim, A., Boenning, K., Caggiano, M., Cristóvão, A., Dirimanova, V., Koehnen, T., … & Prager, K., 2015, The AKIS concept and its relevance in selected EU member states. Outlook on Agriculture, 44(1), 29–36. https://doi.org/10.5367/oa.2015.0194

[7]Knierim, A., Labarthe, P., Laurent, C., Prager, K., Kania, J., Madureira, L., Ndah, T. H., 2017, Pluralism of agricultural advisory service providers–Facts and insights from Europe. Journal of Rural Studies, 55, 45–58. https://doi.org/10.1016/j.jrurstud.2017.07.018

[8]Kountios, G., Kanakaris, S., Moulogianni, C., Bournaris, T., 2024, Strengthening AKIS for Sustainable Agricultural Features: Insights and Innovations from the European Union: A Literature Review. Sustainability, 16(16), 7068.

[9]Micu, M. M., Dinu, T. A., Fintineru, G., Tudor, V. C., Stoian, E., Dumitru, E. A., ... & Iorga, A., 2022, Climate change—between "myth and truth" in Romanian Farmers' perception. Sustainability, 14(14), 8689.

[10]Ministry of Agriculture and Rural Development, MADR, 2022, National Strategic Plan 2023–2027, version 1.2. https://www.madr.ro/docs/dezvoltare-rurala/2022/PNS_2023-2027-versiunea_1.2-21.11.2022.pdf, Accessed on January 5, 2025.

[11]Pascal, M. L., Turek-Rahoveanu, A., 2023, Strategic tools in assessing the business environment of a pan-European distributed research infrastructure. Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development, 23(3), 667-673.

[11]Popescu, A., Stanciu, M., Drăghici, O., Ciocan, H. N., Serban, V., 2024, Meat production, trade, consumption and self-sufficiency rate in Romania in the period 2014–2022. Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development, 24(3). 677-694.

[12]Popescu, A., Tindeche, C., Marcuta, A., Marcuta, L., Hontus, A., 2023, Concentration of standard output and number of farms in the European Union based on the economic dimension. Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development, 23(1).

[13]Rusu, M., Dirimanova, V., Simionescu, V.M., 2015, Agricultural knowledge and information system: Lessons lerand in the postsocialist period in Romania and Bulgaria. In: Agrarian Economy and Rural Development - Realities and Perspectives for Romania. 6th Edition of the International Symposium, November 2015, Bucharest. Publisher: The Research Institute for Agricultural Economy and Rural Development (ICEADR), Bucharest, 2015, pp. 263-268.

[14]Smedescu, D., Tudor, V., Micu, M. M., Mărcuță, L., Mărcuță, A., Smedescu, C., 2024, Comparative insights into labour productivity trends in the European Union's agri-food sector. Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development, 24(1), 899-909.

[15]Smedescu, C., Smedescu, D., Mărcuță, L., Mărcuță, A., Tudor, V. C., 2023, Exploring the rise of organic agriculture in Europe: Comparative analysis and the Romanian perspective. Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development, 23(2), 591-597..

[16]Stefanescu, S. L., Steriu, S., Dumitrașcu, M., 2013, Public and Private Players on the Market of Agricultural Advice and Extension in Romania. Extension Education Worldwide, Vol. 239.

[17]Toma, I., Redman, M., Czekaj, M., Tyran, E., Grivins, M., Sumane, S., 2021, Small-scale farming and food security–policy perspectives from Central and Eastern Europe. Global Food Security, 29, 100504.

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PESTICIDES AND SUSTAINABILITY: A ROMANIAN FARMERS' PERSPECTIVE

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Abstract

The purpose of this study is to explore the perceptions and knowledge on sustainable use of pesticides of young farmers from Transylvania. The authors of the study have opted for a qualitative approach, and to this end, seven focus groups were conducted. The findings show that farmers understand the importance of adhering to recommended dosage and avoiding unnecessary treatments as part of a sustainable pesticide use practice. However, they identified several barriers to adopting these practices, including cost, access to information, and concerns about efficacy. When asked how authorities could support sustainable practices, the participants suggested increasing subsidies, offering training sessions, launching awareness campaigns, and developing supportive public policies. Considering the impact of this topic at the EU level and the lack of detailed research, this study opens the door for future quantitative research regarding the transition to sustainable agriculture.

Key words**:** *agricultural practices, EU policies, farmers` behaviour, perceptions, sustainable use of pesticides*

INTRODUCTION

The reduction of risks associated with pesticide use is a major concern for the European Union, supported by the 'From Farm to Fork' strategy and the Directive on the Sustainable Use of Pesticides (SUD) adopted in 2009 (European Commission, 2009) [9]. The aim of these initiatives is to improve the pesticide use in order to reduce the negative impact on the environment and human health, but maintaining crop efficiency (Lykogianni et al., 2021) [31]. The implementation of these measures varies between European Union (EU) Member States, with each adapting them to their local conditions through National Action Plans (European Commission, 2009) [9]. At the European level, the goal is the reduction of chemical pesticides and associated risks by 50% until 2030 (European Commission, 2009) [9]. This target represents a significant challenge for the agricultural sector, as both Romania and other EU member states are key players in the production and trade of cereals and oilseeds (rapeseed, sunflower, soy), where pesticide use has been demonstrated to exert a direct impact on yields (European Commission, 2024a) [12]. While pesticide utilization is imperative for food production preservation, their improper application can result in deleterious environmental and health consequences. A reduction in their utilization, coupled with the identification of suitable alternatives, stands to benefit both agricultural producers and consumers (Toader et al., 2024) [39]. According to the National Institute of Statistics (2025a) [21], between 2011, the year in which Member States were obliged to transpose the provisions of the Sustainable Use of Pesticides Directive into national legislation, and 2023, the last year for which official data are available, the amount of pesticides used in agriculture in Romania decreased by 11.06%. Conversely, the area of land where pesticides were applied exhibited an increase of 52.21% (National Institute of Statistics, 2025b) [22]. The regions of southern Muntenia, western, south-eastern, and south-western Oltenia have the most extensive areas where plant protection measures are applied (Popescu et al., 2021) [35]. The observed trend of decreasing quantities used is consistent throughout the

period under study. Consequently, fluctuations in usage were exclusivelyobserved among different types of pesticides. Specifically, during the period spanning from 2015 to 2017, there was a decline in the utilization of insecticides and herbicides. However, there was a notable increase in the consumption of fungicides when compared to the period from 2011 to 2013 (Stoicea et al., 2022) [37]. Nevertheless, data from the European Commission reveals that Romania has exceeded the target value for the utilization of the most hazardous pesticides (European Commission, 2025a) [15], underscoring the necessity for augmented efforts at the national level. The less positive results of the pesticide use reduction process are also determined by the fact that the majority of farms in Romania practice conventional agriculture, of which only 1% are organic farms, occupying an area of 3.5% of the UAA (Eurostat, 2020) [17]. In this context, integrated pest management (IPM) becomes essential for the transition to a more sustainable agricultural model, as it can support the economic competitiveness of European agriculture by reducing the dependence on pesticides (Lamichhane et al., 2016) [29]. To achieve this goal, it is essential for farmers to work together to maintain both the quantity and quality of their crops (Lamichhane et al., 2016) [29]. This approach includes the utilisation of a range of methods, including agricultural, mechanical, physical, and biological practices (Barzman et al., 2015) [2]. In addition, integrated pest management includes strategies for pest prevention and control, continuous monitoring, and decision-making guided by economic considerations, non-chemical approaches, and the targeted application of pesticides (Barzman et al., 2015) [2]. The European Union has established eight principles for sustainable pest management, with the objective of assisting farmers in adapting to local conditions (European Commission, 2025b) [16]. Projects such as the Farmer's Toolbox for Integrated Pest Management have identified barriers and determinants to IPM adoption and have contributed to significant reductions in pesticide use (Joint Research Centre, 2025) [23]. Meanwhile, Horizon projects are exploring innovative solutions, including the utilization of digital technologies and agro-ecological practices, to assist farmers in adopting more environmentally friendly and efficient methods (European Commission, 2022) [10]. Research indicates that, despite their familiarity with IPM, farmers frequently receive insufficient training, underscoring the necessity for further educational resources (Piwowar, 2021) [34]. Since the implementation of IPM depends on the local context and human resources play a central role in its management (Kvakkestad et al., 2021; Van den Berg & Jiggins, 2007) [28, 41], there are a number of factors that influence the decision to adopt sustainable and environmentally friendly practices. The level of knowledge possessed by farmers with regard to pesticides has been identified as a substantial predictor of their behaviour and choices concerning pesticide use and pest management. Despite the prevalence of farmers relying on readily available and immediate sources of information, those who opt for unbiased sources are more likely to adopt environmentally friendly practices (Creissen et al., 2021) [6]. In spite of the implementation of protective measures, the perception of risk and understanding of the health effects of pesticides remain unsatisfactory (Yang et al., 2014) [44]. It can thus be concluded that education and relevant information can play a major role in risk reduction, especially for those who have experienced adverse health effects (Hashemi et al., 2012) [20]. An examination of the correlation between knowledge levels and pesticide utilisation reveals that a lack of adequate information can result in the unsafe use of pesticides (Bondori et al., 20-21) [3]. Farmers who receive information from sources such as pesticide sales agents or dealers are more likely to utilise pesticides in a manner that poses a greater risk (Bondori et al., 2021) [3]. Furthermore, the reliance of farmers on a solitary source of information, typically the staff at pesticide stores, gives rise to concerns regarding the reliability of the information they receive (Tsakiris et al., 2023) [40]. In contrast, those who receive information from unbiased sources (independent of the interests of

manufacturers and distributors) are more likely to adopt environmentally friendly practices and innovative pest management solutions (Tsakiris et al., 2023; Goeb & Lupi, 2020) [40, 19]. In this context, it is imperative to acknowledge the level of awareness and knowledge of pesticide risks among farmers in order to correctly assess and implement the necessary safety measures (Damalas & Koutroubas, 2018) [8]. The study by Bagheri et al. (2019) [1] demonstrates that levels of knowledge have a significant impact on intentions regarding the application of pesticides. The implementation of effective educational strategies is therefore imperative in order to encourage the adoption of more sustainable practices. Research conducted by Piwowar (2021) [34]. Between 2013 and 2017 demonstrates that 35.5% of farmers are not well informed about sustainable practices, indicating the necessity for additional training programmes. This conclusion is further substantiated by the findings of Lekei et al. (2014) [30], who determined that reading product labels constitutes a primary source of information for farmers. Consequently, it can be concluded that access to suitable sources of information and knowledge about pesticides is imperative for the adoption of sustainable practices in agriculture (Damalas & Koutroubas, 2018) [8]. Nevertheless, it is essential that education assumes an active role in empowering farmers' behaviour and raising their awareness of the risks associated with pesticides if this knowledge is to be applied correctly (Calliera & L`Astorina, 2018) [4]. Thus, continuing education becomes an essential component in promoting the sustainable use of pesticides, a factor with an impact on both human health and the environment (Calliera & L`Astorina, 2018) [4]. Improving risk awareness can include the use of different training methods, media campaigns and expert advice in order to promote sustainable use of pesticides (Bagheri et al., 2019) [1]. This aspect becomes a priority in the EU policy and legislation, given the fact that life long education promotes the adoption of environmentally friendly practices and improve public health (Lykogianni et al., 2021) [31]. According to Yang et al. (2014) [44] farmer-specific education programmes would reduce pesticide use by increasing their understanding of the risks and benefits of adopting environmentally friendly practices. Moreover, in order to ensure a proper dissemination, it is important that the information comes from sources they are already familiar with, as well as through associations of which they are members (Bagheri et al., 2019) [1].

The adoption of sustainable practices by farmers is also influenced by their perceptions and attitudes. For instance, studies undertaken by Maican et al. (2021) [32] demonstrate that economic motivations exert a greater influence on performance than job satisfaction on family farms in Romania. This may serve to explain the farmers' resilience in the face of adverse perceptions of farm work. Consequently, personal motivation and attitudes towards agricultural work directly influence the decision to adopt organic techniques or to continue with conventional methods. Mellon-Bedi et al. (2020) [33] identify personal satisfaction as a key factor in this process, but also significant barriers such as uncertainty and lack of resources. The perception of pesticide use is a pivotal factor in this decision-making process. While 73% of farmers in Romania believe that organic products comply with regulations, this percentage is lower than the EU average of 83% (European Commission, 2023) [11], reflecting a general mistrust in the effectiveness of regulations on organic farming principles. Despite the EU's ongoing monitoring of pesticide residues, with 96.3% of samples analysed in 2022 falling within legal limits (Eurostat, 2024) [18], public perception continues to be a challenge. In Romania, this lack of confidence in compliance with pesticide legislation can have a negative impact on farmers' decisions. It is therefore imperative to promote changes in public perceptions and further education to encourage more sustainable behaviour among farmers. Finally, in addition to perceptions and attitudes, farmers' awareness and information play an important role in their decisions, and protecting biodiversity requires both individual actions by farmers and collective actions and

appropriate policies (Kelemen et al., 2013) [25].

It is evident that clear regulations and support from the relevant authorities are significant factors in determining farmers' willingness to adopt more sustainable solutions, and biopesticides are an example of an essential tool to address environmental pollution and support sustainable agriculture (Campos et al., 2018) [5]. A study conducted in Norway by Kvakkestad et al. (2021) [28] revealed that the majority of cereal farmers adopt integrated pest management (IPM) practices not only in response to economic reasons, but also because of intrinsic motivation. Following the implementation of SUD in 2015, 41% of farmers reported a significant increase in IPM use, suggesting that clear regulations can incentivise farmers to adopt more sustainable practices. Kaiser and Burger (2022) [24] emphasise that policies based solely on subsidies and financial incentives are not sufficient to bring about behavioural change among farmers. They contend that such policies must be complemented by farm advisory services tailored to different types of farms and stronger regulatory and control measures to ensure responsible pesticide use and more effective environmental protection.

In the context of the ongoing discourse on the factors that influence farmers' decisions, it is imperative to acknowledge the significance of economic and social factors. These elements exert a substantial influence on the utilization of pesticides and the adoption of sustainable practices. As Kelemen et al. (2013) [25] emphasise, although farmers can contribute to biodiversity conservation by reducing pesticide use and protecting soil, their decisions are influenced not only by personal intentions but also by economic and social factors. The financial implications associated with pesticide use, as well as the market dynamics influenced by such products, can, in some instances, render the adoption of eco-friendly practices less economically viable, in spite of the obvious environmental benefits (Kelemen et al., 2013) [25]. Despite a decline in pesticide sales within EU Member States (Eurostat, 2024) [18], the absence of explicit and directly applicable EU legislation on the sustainable use of pesticides risks undermining the achievement of the 2030 targets. In this context, the European Commission is seeking solutions to ensure both food security and environmental protection. One such initiative is the Strategic Dialogue on the Future of EU Agriculture, initiated in January 2024 (European Commission, 2024b) [13]. The final report of this dialogue, presented in September 2024, proposes recommendations for the reform of the Common Agricultural Policy and the creation of a temporary fund for sustainable transition – the Agrifood Just Transition Fund (European Commission, 2024c) [14].

This literature review identified a gap in the existing research, as the majority of studies focus on analysing trends and amounts of chemicals used in Romanian agriculture, risks and impacts on non-target species, modelling crop distribution to promote organic farming, or comparing how SUD is applied in EU Member States. However, there is a very limited number of studies dealing with knowledge, perceptions and determinants of sustainable use of pesticides. Consequently, the objective of this study is to explore farmers' perceptions of sustainable use of pesticides and to identify actual practices implemented on their farms. This research makes an important contribution by providing insight into the attitudes and behaviours of Romanian farmers, a topic that has been insufficiently researched. The study will provide valuable insights into the local context and identify barriers to the adoption of more sustainable practices.

The specific objectives of the study are as follows: to investigate farmers' pesticide use practices, to analyse their perceptions of risks and impacts on health, biodiversity and soil, to assess their knowledge of sustainable pesticide use, to identify barriers and types of support needed to adopt sustainable practices. The following research questions have been identified:

Q1: What are farmers' pesticide use practices?

Q2: What are farmers' perceptions of the risks and impacts of pesticides on health, biodiversity and soil?

Q3: What is the level of knowledge that farmers have regarding sustainable use of

pesticides, and what precautions do they take when handling and using pesticides?
Q4: Finally, what are the main barriers and what kind of support do farmers consider necessary to adopt sustainable pesticide use practices?

MATERIALS AND METHODS

In order to address the research questions, the qualitative research method was employed, with the focus group method being utilized. It allows in-depth exploration of participants' opinions, perceptions, and experiences, offering an effective way to understand farmers' behaviours and attitudes (Krueger & Casey, 2015) [27], while also encouraging communication and interaction (Kitzinger, 2000) [26]. The research aimed to gather relevant data and explore perceptions and understanding of the topic (Wilkinson, 1998) [43]. The research tool used was the facilitation grid. The group of participants selected for the discussions organized within the framework of the study consists of 68 students from the specialisations Agriculture (2nd and 4th year) and Agricultural Mechanisation (4th year), full-time and distance learning students at the University of Agricultural Sciences and Veterinary Medicine, Cluj-Napoca. Participants took part in the study on a voluntary basis, and the inclusion criteria were the presence of field crops (cereals, technical crops, forage crops) in the farm structure, regardless of the cultivated area, and the actual involvement of the participant in farm activities. The participants work on family farms, together with other family members. All farms are located in the region of Transylvania and in terms of typology they are either vegetable or mixed farms, but in all cases the vegetable component is present. In terms of size, most of the farms are between 76 and 150 hectares. In terms of age, the majority of students enrolled in full-time education are young, aged between 20 and 22, with one notable exception - a participant aged 74. In contrast, distance learners are on average over 40 years old. The groups are composed of both men and women, but it is noteworthy that two of the three distance learning groups are predominantly male. Practical experience in agriculture varies according to the type of education. Full-time students, because of their young age, have little experience of farming, generally coming from farms set up and run by their parents. In contrast, their distance learning peers have much more experience as they are active on their own farms. To conduct the research, 7 focus groups were organised, one for each study group. The discussions were moderated by a facilitator, took place in the library building of the University of Agricultural Sciences and Veterinary Medicine of Cluj Napoca, from November 2024 to January 2025, were audio recorded and each session lasted on average one hour. The recordings were then transcribed using the 'Dictate' function in Microsoft Word, with spot corrections to ensure the accuracy of the text. The qualitative data were analysed using Nvivo (Pro version 12.2.0.443) from QSR International. The transcripts from the focus group discussions were split into seven sets, each representing one group of participants. These sets were then uploaded to the platform. Once the responses were imported, they were organized and coded according to the themes in the facilitation grid. These themes included the current use of pesticides, knowledge of their sustainable use, perceptions of environmental risks and impacts, safety measures adopted, willingness to adopt sustainable practices, and resources needed to do so. As part of the analysis, we used visualization tools such as word clouds (generated by WordClouds from Zygomatic) and word trees (generated by SimpleMind Pro from ModelMaker Tools) to examine the frequency of words and interactions between them, and to identify correlations between terms relevant to the research. The analysis focused on both the most common words and those that, although less common, were considered significant in the context of the discussions.

RESULTS AND DISCUSSIONS

The initial segment of the discussion centred on the presentation of the practices employed by farmers on their own farms; consequently,

the responses to the first research question of the study were explored.

Some common themes can be distinguished among the motivations of young farmers, such as continuing the family tradition, a passion for agriculture, economic opportunities and capitalising on inherited land, and also the satisfaction of providing food for their families and communities. As one participant described:

- *I am motivated by the joy of providing food for others.*

The majority of participants providing details regarding the nature of their agricultural enterprise were from vegetable farms, followed by mixed farms. With regard to the geographical origins of the farms under investigation, the majority were located in the counties of Satu Mare (n=11), Alba, Bistrița-Năsăud, Mureș, Sălaj, Maramureș, Sibiu, Cluj and Covasna. In relation to the nature of the farm, the majority of participants possessed family-owned farms, with a significantly smaller number owning independent farms (n = 5). The majority of participants possessed farms ranging in size from 76 to 150 ha, followed by 0-25 ha and 26-75 ha. This suggests that the focus group participants predominantly own small and medium-sized farms, with only three participants having farms between 601 and 1,200 ha. Young farmers who have taken over the business as a family inheritance have larger landholdings, averaging 159 ha. At the same time, two thirds of those who inherited the farm are vegetable farms, while one third are mixed. The majority of farmers engage in conventional farming practices, with one organic farmer and two others who have farms in conversion. Although this study is qualitative in nature, the findings appear to be consistent with national-level data, which indicate that only 1% of farms are organic (Eurostat, 2020) [17]. The remaining farmers have only sporadic areas in conversion, primarily motivated by the payment schemes offered under the Common Agricultural Policy by the Agency for Payments and Intervention for Agriculture (APIA). This result reflects national trends and highlights the slow transition to organic farming. This transition is influenced more by external financial incentives than by the widespread adoption of sustainable principles. The predominant crops in the farms surveyed were maize (n = 54), followed by wheat (n = 44) and sunflower (n = 25). Other crops cultivated on the farms include alfalfa, barley, and two-row barley, as well as soybeans, rapeseed, triticale, oats, clover, and fodder crops, which are specifically cultivated for use as animal feed. Also in the case of inherited farms, there is a predominance of maize, potatoes, wheat and sunflowers, which may indicate either an inertia and an inability to diversify and adapt to changing market requirements, or a motivation to continue the family tradition. Figure 1 shows the most common words used by farmers when discussing farm typology.

Fig. 1. Most common words used by participants in the focus group sessions when discussing farm typology.
Source: Original/Own results.

With regard to pest control, the most frequently mentioned methods by the focus group participants were the use of chemical pesticides (regarded by respondents as the most effective and easiest to use), crop rotation, seed treatment, electric fencing and hunting. In terms of equipment and machinery used for pest control, participants mentioned herbicide equipment (n=25) and plant protection machines (n=14), drones (n=2), sprayers (n=2), spraying equipment (n=2) and self-propelled systems (n=1). Cooperation with other farmers for pest control is constrained by envy,

competition and lack of trust. A similar conclusion is reached by Stallman & Fames Jr. (2015) [36], who mention that economic and social factors such as envy and competition can be significant barriers to cooperation among farmers. While there may be sporadic dialogues initiated for the resolution of shared challenges, such as the emergence of a novel pest, the majority of farmers exercise caution in the dissemination of information regarding their treatment methodologies, driven by concerns regarding competition. In contrast, Stallman and Fames Jr. (2015) [36] suggest that factors such as perceived benefits, similarity of neighbouring farms, community involvement and shared concerns about the environmental impact of pesticides play an important role in farmers' decisions to cooperate in pest management. Cooperation with neighbours is rare and often problematic, influenced by antagonistic behaviour and lack of trust. Associations and cooperatives are perceived as being useful only in terms of obtaining European funds, but do not provide real support in dealing with day-to-day problems. Farmers' perceptions of the ineffectiveness of these organizations are commonly attributed to the perceived inadequacy of the members' agricultural knowledge, which hinders the development of cooperative relationships. These findings underscore the necessity for more accessible and trust-based cooperation initiatives between farmers that overcome economic and social barriers, thereby facilitating the exchange of knowledge and more sustainable practices in pest management. Similar conclusions are reached by Stallman and Fames Jr. (2015) [36], who demonstrate that farmers would prefer informal local initiatives, which are more accessible and trusted, to regional ones. In contrast, Wang et al. (2023) [42] underscore the pivotal role of farmer interactions, particularly within institutionalised frameworks, in the propagation of optimal environmental practices. Concurrently, Goeb and Lupi (2021) [19] demonstrate that the exchange of experiences and best practices among farmers plays a pivotal role in enhancing their knowledge of pesticide use. In addition, Lamichhane et al. (2016) [29] illustrate how collaboration contributes to the sustenance of sustainable and high-quality agricultural production.

The following interventions are proposed in response to the research question regarding farmers' level of knowledge on the sustainable use of pesticides. Regarding knowledge on sustainable use of pesticides, farmers agree that this includes applying pesticides in the right dose to minimise environmental impact. It is further emphasised by many that the correct dosage must be administered at the optimum time. They argue that excessive amounts should not be applied in ways that affect the soil and non-target wildlife and should only be used when absolutely necessary. Another significant element of the sustainable use of pesticides, according to farmers' responses, is the proper assessment of the need for treatment. They assert that there should be a definitive rationale for the utilization of pesticides, particularly in instances where a pesticide is employed to control a wide spectrum of pests. Furthermore, they emphasize the necessity to evaluate the risks posed by pests and to employ pesticides exclusively in circumstances where there is a demonstrable threat. These responses demonstrate the complexity of the farmers decisions, which are influenced by cost and technology. For more effective implementation, therefore, farmers would need more support from the authorities to give them access to accurate technologies and economically viable solutions. This understanding can serve as a foundational basis for the adoption of sustainable practices, as evidenced by the research conducted by Šūmane et al. (2017) [38]. Focus group participants have also expressed interest in alternative solutions that can reduce pesticide use. These include the genetic modification of plants to enhance their resistance to pests, a strategy that would diminish the necessity for chemical treatments. Additionally, there is a strong preference for advanced technologies that facilitate accurate pest identification, ensuring that treatments are used only when absolutely necessary, thereby conserving resources and reducing environmental impact. In this context, a legislative framework is required to facilitate the implementation of

advanced technologies for reducing pesticide use. The ideas expressed in the discussions are also reflected in the literature, which shows that effective pesticide management can support sustainability in agriculture (Lykogianni et al., 2021) [31]. Quotations from the above discussions are pertinent:

-It is also imperative to consider other agro-technical practices in order to avoid overuse of chemicals.

-The adoption of multifaceted treatment strategies, capable of combating multiple diseases, as opposed to a single one, is recommended. This approach is expected to lead to a substantial reduction in the residue.

Figure 2 shows the conclusions relating to plant treatments and issues.

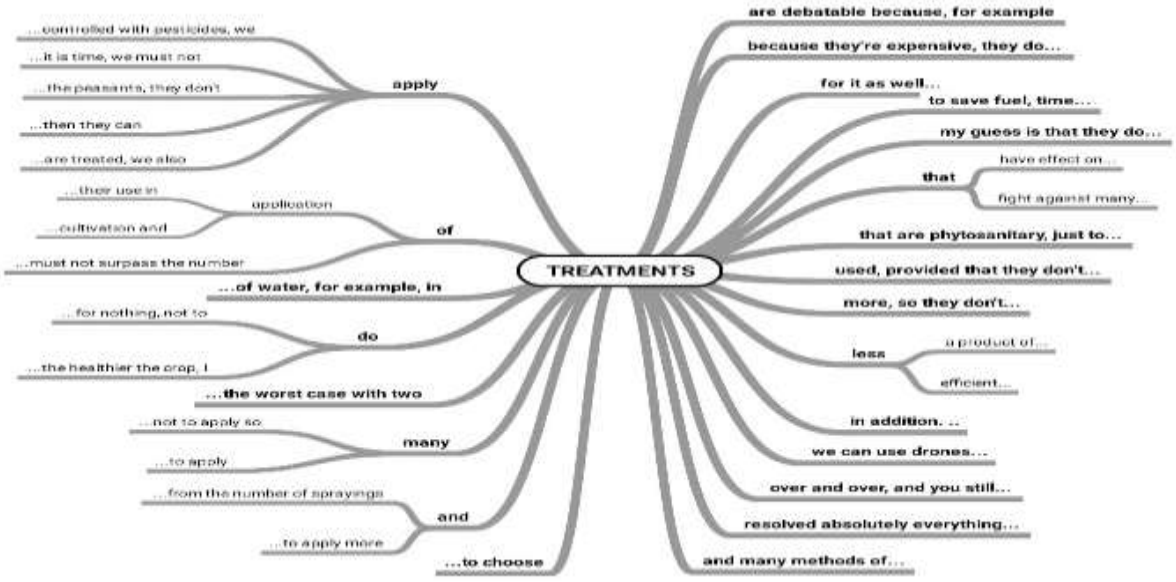

Fig. 2. Phrases most frequently associated by focus group participants with the word 'treatments'
Source: Original/Own results.

Concerning the financial implications of sustainable pesticide use, some farmers assume that accurate application and dosage can lead to cost reductions, even when using organic products. Moreover, recent technological advancements, including drones and advanced equipment, have the potential to reduce costs by ensuring precise pesticide application, thereby conserving water and other resources. Nevertheless, it is acknowledged that the initial costs associated with upgrading existing on-farm machinery to incorporate these advanced technologies can be substantial, potentially impacting short-term profitability. This perspective is further supported by Lykogianni et al. (2021) [31], who argue that adapting to new technologies and changing equipment is a prerequisite for sustainability. The concept of integrated pest management (IPM), which many farmers are moderately familiar with, was discussed, and implementation varies on farms. While many struggle with IPM for large-scale crops, crop rotation is widely adopted. Additional techniques, such as pheromonal traps and natural predators, are also employed, but chemical pesticides remain prevalent due to their effectiveness and cost-effectiveness. Despite its idealism, the integrated management concept's practical application may be constrained by additional costs and complexity, especially in contexts where limited resources are a concern. The findings of Kelemen et al. (2013) [25] further underscore the relevance of economic factors in the adoption of sustainable practices, demonstrating that economic considerations influence the decision to adopt sustainable practices. Some farmers advocate for alternative practices, such as organic fertilization and the utilization of natural predators like crows, as a more environmentally sustainable approach to pest

management. However, these farmers acknowledge that in circumstances where more sustainable methods are not available, chemicals are often the most expeditious and cost-effective solution.

In the subsequent phase of the study, the researchers explored farmers' perceptions of the risks and impacts of pesticide use in accordance with the proposed research questions. In relation to their training, farmers participated in compulsory courses administered by APIA, which focused on the appropriate utilization of pesticides, regarding regulations, the storage of substances, and waste management. Participants have expressed that the information was often theoretical and less useful in practice, perceiving the course as a formality. This observation is consistent with the findings of other studies, which have also highlighted the need for improvement in the quality and practical application of farmer training (Piwowar, 2021). Following these mandatory courses, farmers continue to seek additional information from various sources to supplement their knowledge. In this regard, most farmers turn to a wide range of sources to learn about pesticides and farming practices, including the internet, manufacturers' websites, distributors and sales agents, thus supplementing their education with practical information and constant updates. This approach is encouraging, as it suggests that ongoing information provision can contribute to safer pesticide usage (Bondori et al., 2021) [3]. It is a commonly held belief amongst farmers that the younger generation is more open to change and innovation, and more likely to experiment with new technologies and sustainable farming practices. Nevertheless, concerns regarding profitability and risk have been expressed. Figure 3 illustrates the most recurrent terms used by participants in discourse on risk perception and pesticides' impact.

The influence of necessity on the adoption of novel practices is evident, particularly in the context of the challenges posed by a changing farming environment, where traditional pesticides are observed to be less effective.

Fig. 3. Most frequent words used by participants under the heading 'Perception of risks and impacts'
Source: Original/Own results.

Notwithstanding this apparent openness to change, it has been observed by numerous participants that older generations tend to be more conservative, preferring established and safe solutions. However, they recognise that young people bring a more innovative vision and are more willing to share new ideas, especially when supported by experience gained on family farms or through academic education. The validity of this assertion is further reinforced by the findings of Kaiser and Burger (2022) [24].

In contrast, the findings of a study undertaken by Bondori et al. (2021) [3] appear to contradict this perspective, concluding that farmers with more experience are often more aware of the risks involved and may be more inclined to adopt safer practices and protective measures. It is important to note that, on the one hand, the extant academic literature supports the idea that young people bring an innovative vision, which can be beneficial in the context of changes in agriculture. On the other hand, other studies emphasize that more experienced farmers are often more aware of the risks involved and therefore may be more likely to adopt safer practices. We therefore believe that it is important for both groups to work together and learn from each other to achieve more sustainable and safer agriculture. This will require the creation of an enabling environment that encourages collaboration and knowledge exchange. In this context, it is essential to also address the ongoing debate

within the farming community regarding the impact of pesticides, a matter that remains a point of divergent opinion among farmers.

-I think pesticides are very safe, so it depends on each farmer how they work with them. We use gloves and masks when we mix them, so we don't have direct contact with them. The technology's pretty modern these days, we don't have those old tractors without cabs anymore, so when you go to spray, not all the solution comes on you, so you don't have any contact with pesticides on your skin.

-The problem is that in the soil, because of the use of pesticides, all kinds of bacteria have started to die or we're missing the ones that break down air or other plant debris, so now it takes a longer time for them to dissolve.

Whilst there is a predominant perspective that their appropriate utilization, in conjunction with suitable dosages and withdrawal periods, should not have significant negative effects, others argue that excessive use can lead to pollution of soil, groundwater and biodiversity. This highlights the need for awareness campaigns to emphasise the importance of using pesticides responsibly. These campaigns should educate farmers about the negative effects of overuse on soil, groundwater and biodiversity. In terms of health, some farmers argue that exposure to pesticides, especially through improper storage or misapplication, can lead to adverse effects, such as hospitalization of a group of people, demonstrate the risks. Concerning biodiversity, some farmers have reported a decline in insect and animal populations, particularly bees. Conversely, other farmers have considered these effects to be inconsequential, noting that changes are often more evident in specific crops. Figure 4 shows the words most commonly associated with 'affect'.

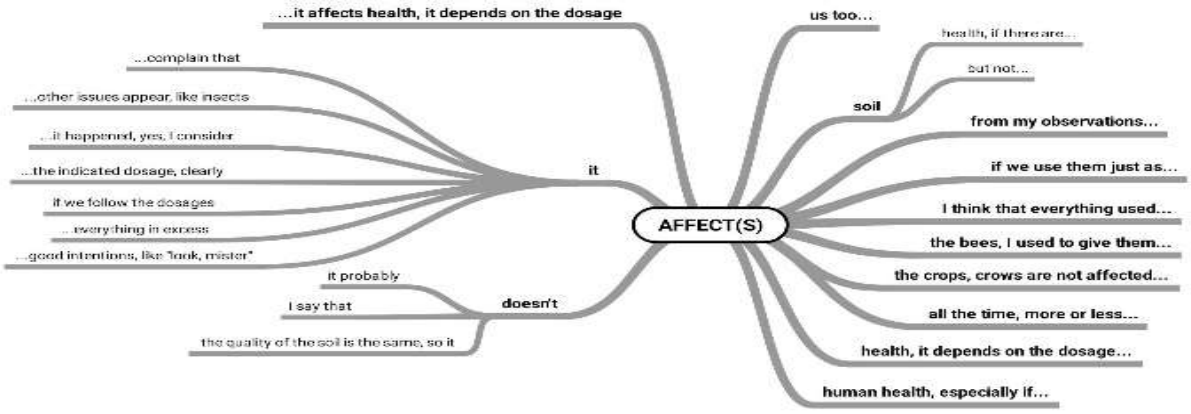

Fig. 4. Phrases most commonly associated by focus group participants with the word 'affect' in the 'Perception of risks and impacts' section
Source: Original/Own results.

A more stringent and effectively enforced legislative framework could play a crucial role in addressing the challenges related to pesticide safety and packaging management. In relation to the implementation of protection and safety measures, the most commonly utilised terms are illustrated in Figure 5.

Farmers participating in the focus group sessions claim that they apply protective measures when using pesticides, using a variety of equipment such as masks, gloves and coveralls. However, they recognise that there are situations when they do not always use these measures for reasons of comfort or because of adverse weather conditions (strong wind, rain).

Some farmers also mention that protective equipment is put aside and only used when necessary, mainly to comply with the requirements of an inspection. With regard to the management of packaging and pesticide residues, the majority of farmers return them to collection centres, with some also using recycling schemes or returning them to distributors.

Fig. 5. Most frequent words used under the heading 'Protection and safety measures'
Source: Original/Own results.

However, challenges are encountered in this process, including the absence of collection points in certain regions. Furthermore, farmers have been observed to choose to incinerate or dispose of packaging, even though this is against the regulations.

Figure 6 shows the most common phrases associated with 'collection' in the focus groups. The final research question formulated in this study is answered by the openness to adopt new practices, the main obstacles encountered or identified on the path to agricultural sustainability, and the recommendations on how the authorities can support farmers.

Willingness to adopt sustainable practices was another topic highlighted in the discussions, and Figure 7 shows the most frequently used words in this respect.

Opinions are divided on biopesticides. Some find them more expensive and less effective than conventional pesticides, while others are willing to use them in the future, especially for healthy production.

Nevertheless, it is widely acknowledged that biopesticides are particularly well-suited to organic farming and small areas, and their effectiveness depends on the quality of the product and trust in suppliers.

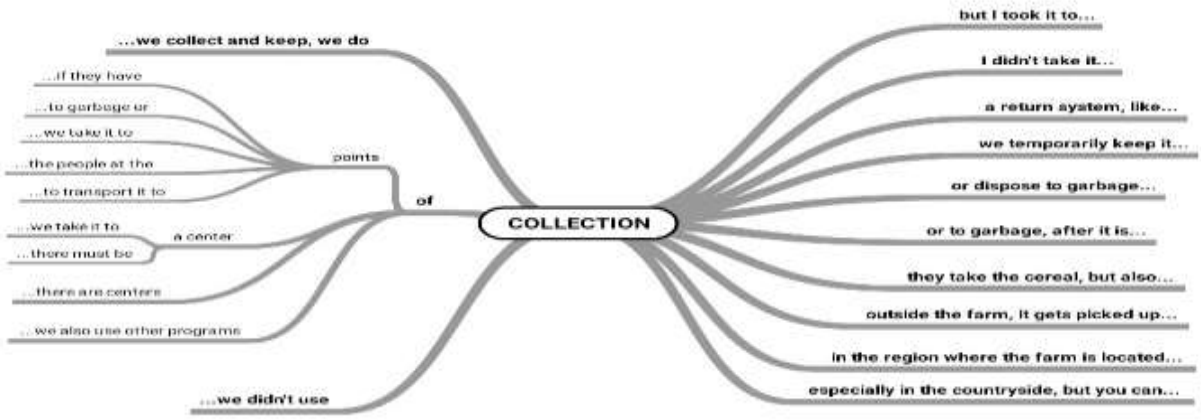

Fig. 6. Phrases most frequently associated by focus group participants with the word 'collection' under the heading 'Protection and safety measures'
Source: Original/Own results.

The primary barriers to wider adoption of biopesticides include high costs, low efficacy and a lack of clear information about products currently on the market. This finding is corroborated by other studies, which demonstrate that the majority of farmers do not intend to reduce the use of pesticide, as they fear significant economic losses (Damalas, 2021) [7]. Financial subsidies are the main driving factor that can motivate farmers to adopt sustainable practices, as they feel it would help mitigate the financial risks and promote a transition towards organic farming methods. However, many recognize that current subsidies are not sufficient to cover the additional costs and associated losses. Furthermore, farmers encounter challenges related to the equipment necessary for sustainable practices and the inability to compete with external markets, particularly in relation to more affordable products from other countries.

Fig. 7. Most frequent words under the heading 'Willingness to adopt sustainable practices'
Source: Original/Own results.

Participants also suggested that legislative amendments and knowledge could encourage sustainable farming. One intervention stressed farmer challenges and a preventative approach to sustainability, not restrictions:

-The most important thing is that public institutions work with the farmer, not against them. I mean, I go to training courses in certain fields and I only see bored people, who haven't got the latest info, and who only do it to be good, to give us a diploma. I'd like the phytosanitary office not only to send me warning notices every now and then, but to have a call centre where I can call them when I have a situation, to ask what the law says and what they recommend. So that when the controls come, it's not just fines.

With regard to the support and resources required, the term 'grants' was a recurring theme, as illustrated in Figure 8. Figure 9 demonstrates the most frequently used words in the 'recommendations' heading.

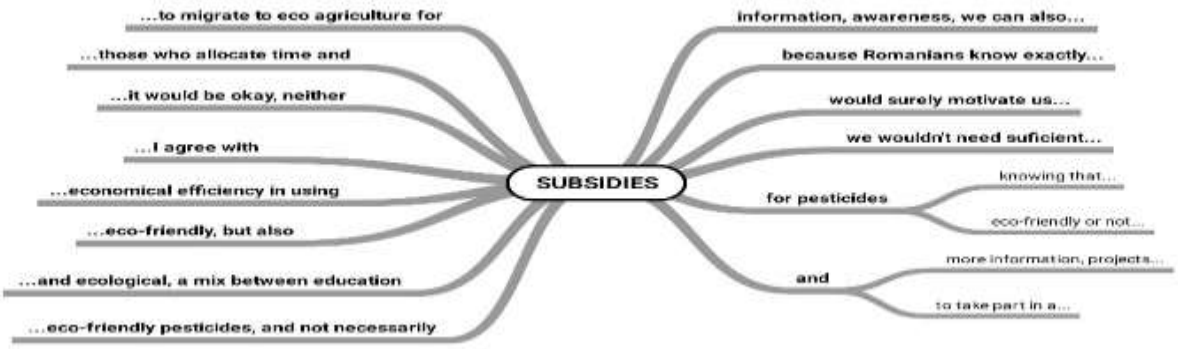

Fig. 8. Phrases most frequently associated by focus group participants with the word 'grants' under the heading 'Support and resources needed'
Source: Original/Own results

Farmers have asserted that in order to engage in sustainable farming practices, it is necessary for substantial financial support, in particular subsidies, to be allocated. This is said to be essential as farmers face significant costs and risks as a result of their commitment to sustainable farming practices.In order to implement these practices, further training is required to acquire the knowledge and skills necessary. In addition, better access to relevant and up-to-date information is required. The validity of these claims is further substantiated by the findings of the study by Kelemen et al. (2013) [24]. It is evident that a significant proportion of farmers do not receive consistent support from the relevant authorities or institutions, and that available subsidies are inadequate in terms of covering production costs and ensuring profitability. With regard to information on pesticide usage, farmers have access to relevant materials, yet these are often regarded as inadequate in terms of comprehensiveness. Many participants find this particularly problematic due to the language barrier.

They point out that most of the materials are in English, and that some Romanian-language information materials would be needed to make them accessible. The majority of farmers expressed the opinion that specialised courses or regular seminars organised by the competent authorities would be beneficial.

Fig. 9. The most frequent words used under the heading 'Conclusions and recommendations'
Source: Original/Own results.

Such seminars should include up-to-date information on new pesticides, correct application techniques and safety rules. It has been observed that a significant proportion of farmers have indicated that, while they are able to source information through distributors, this information is often incomplete or lacking in transparency regarding the potential adverse effects of pesticides. Consequently, Yang et al. (2014) [44] propose stricter pesticide registration and labelling rules, including explicit toxicity levels for humans, as a means of reducing the risks for the environment and for the human health. When it comes to improving their practices, farmers are generally in favour of stricter regulations, especially on the proper doses and equipment. They also recognize the importance of better training that helps mitigate the negative impacts of pesticides. In order to facilitate the adoption of sustainable practices, authorities and organisations should consider the provision of enhanced information to farmers through the implementation of educational campaigns and the allocation of increased financial resources. Farmers also call for simplified administrative procedures and accessible IT platforms where they can find all relevant information and receive guidance. The study of Kelemen et al. (2013) [25] has reached similar conclusions, showing that public policy have a great impact on the promotion of sustainable agricultural practices. Therefore it is important that public authorities be more involved in promoting a constructive dialogue between farmers and public institutions in order to find practicals and realistic solutions.

CONCLUSIONS

Most of the farmers who participated in the focus groups own small and medium-sized farms and practice conventional farming. Pest control is primarily carried out with chemical pesticides, although there is a growing interest in alternative solutions, such as advanced technologies and genetic modification of plants. Collaboration among farmers for pest control is often limited by jealousy and a lack of trust. While associations are seen as useful for obtaining funding, they do not provide real support for managing daily issues. Although farmers are aware of the importance of sustainable use of pesticides, emphasizing the need for correct dosing and proper treatment evaluation, pesticide use remains dominant due to its effectiveness and lower costs. To adopt more sustainable practices, farmers consider ongoing education and financial subsidies essential, requesting up-to-date information and specialized courses. Young farmers, with their academic background and hands-on experience from family farms, are more receptive to change and innovation, making them an important force in adopting new technologies and sustainable practices, but change depends on financial support, access to information, and simplification of administrative procedures.

Future research on this topic should adopt a quantitative approach to more thoroughly examine the factors that influence the adoption of sustainable pesticide use practices, with a particular focus on determining the most effective measures for encouraging behavioral change among farmers. This could include exploring the role of financial incentives, education, and technological innovations in promoting sustainable practices, as well as identifying the barriers to their implementation and the factors that drive farmers' decision-making processes.

REFERENCES

[1]Bagheri, A., Bondori, A., Allahyari, M. S., Damalas, C. A., 2019, Modeling farmers' intention to use pesticides: An expanded version of the theory of planned behavior. Journal of Environmental Management, 248, 109291.
[2]Barzman, M., Bàrberi, P., Birch, A.N.E., Boonekamp, P., Dachbrodt-Saaydeh, S., Graf, B., Hommel, B., Jensen, J.E., Kiss, J., Kudsk, P., Lamichanne, J.R., Messean, A., Moonen, A.-C., Ratnadass, A., Ricci, P., Sarah, J.-L., Satin, M., 2015, Eight principles of integrated pest management. Agron. Sustain. Dev. 35, 1199–1215 (2015).
[3]Bondori, A., Bagheri, A., Sookhtanlou, M., Damalas, C. A., 2021, Modeling farmers' intention for safe pesticide use: the role of risk perception and use of information sources. Environmental Science and Pollution Research, 28, 66677-66686.
[4]Calliera, M., L'Astorina, A., 2018, The role of research, communication, and education for a sustainable use of pesticides. In Advances in chemical pollution, environmental management and protection (Vol. 2, pp. 109-132). Elsevier.
[5]Campos, E. V. R., Proença, P. L. F., Oliveira, J. L., Bakshi, M., Abhilash, P. C., Fraceto, L. F., 2018, Use of botanical insecticides for sustainable agriculture: Future perspectives. Ecological Indicators, 93, 1133–1141.
[6]Creissen, H. E., Jones, P. J., Tranter, R. B., Girling, R. D., Jess, S., Burnett, F. J., Gaffney, M., Thorne, F. S., Kildea, S., 2021, Identifying the drivers and constraints to adoption of IPM among arable farmers in the UK and Ireland. Pest Management Science. 77(9), 4148-4158.
[7]Damalas, C. A., 2021, Farmers' intention to reduce pesticide use: The role of perceived risk of loss in the model of the planned behavior theory. Environmental Science and Pollution Research, 28(26), 35278-35285.
[8]Damalas, C. A., Koutroubas, S. D., 2018, Farmers' behaviour in pesticide use: A key concept for improving environmental safety. Current Opinion in Environmental Science & Health, 4, 27-30.
[9]European Commission, 2009, Directive 2009/128/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides. https://eur-lex.europa.eu/eli/dir/2009/128/2009-11-25, Accessed on January 28, 2025.
[10]European Commission, 2022 (September 8). EIP-AGRI activities related to sustainable use of pesticides. https://ec.europa.eu/eip/agriculture/en/news/eip-agri-activities-related-sustainable-use.html, Accessed on February 17, 2025.
[11]European Commission, 2023 (January). Agricultural Market Brief No. 20: Organic farming in the EU – A decade of organic growth. https://agriculture.ec.europa.eu/document/download/df01a3c7-c0fb-48f1-8eca-ce452ea4b8c2_en?filename=agri-market-brief-20-organic-farming-eu_en.pdf Accessed on February 17, 2025.
[12]European Commission, 2024a, Cereals, oil plants, proteic crops and rice. https://agriculture.ec.europa.eu/farming/crop-productions-and-plant-based-products/cereals_ro Accessed on February 17, 2025.
[13]European Commission, 2024b, Strategic dialogue on the future of EU agriculture. European Commission. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/agriculture-and-green-deal/strategic-dialogue-future-eu-agriculture_ro Accessed on February 17, 2025.
[14]European Commission, 2024c, Main initiatives – Strategic dialogue on the future of EU agriculture. European Commission - Agriculture and Rural Development. https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/main-initiatives-strategic-dialogue-future-eu-agriculture_en#strategic-dialogue-report Accessed on February 17, 2025.
[15]European Commission, 2025a, Member States: Trends – Sustainable use of pesticides: Farm to Fork targets progress. European Commission - Food Safety. https://food.ec.europa.eu/plants/pesticides/sustainable-use-pesticides/farm-fork-targets-progress/member-states-trends_en#Romania Accessed on February 13, 2025.
[16]European Commission, 2025b, Integrated Pest Management (IPM). February 17, 2025, https://food.ec.europa.eu/plants/pesticides/sustainable-use-pesticides/integrated-pest-management-ipm_en#principles, Accessed on February 17, 2025.
[17]Eurostat, 2020, Integrated Farm Statistics, preliminary data, specific extraction. https://ec.europa.eu/eurostat/web/products-manuals-and-guidelines/-/ks-gq-20-009 Accessed on February 17, 2025.
[18]Eurostat, 2024, Agri-environmental indicator – Consumption of pesticides. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agri-environmental_indicator_-_consumption_of_pesticides Accessed on February 17, 2025.
[19]Goeb, J., Lupi, F., 2020, Showing pesticides' true colors: The effects of a farmer-to-farmer training program on pesticide knowledge. Journal of Environmental Management, 270, 111821.
[20]Hashemi, S.M., Hosseini, S.M., Hashemi, M.K., 2012, Farmers' perceptions of safe use of pesticides: determinants and training needs. International Archives of Occupational and Environmental Health, 85(1), 57–66.
[21]Institutul Național de Statistică, National Institute of Statistics, 2025a, AGR106A - Cantitatea de pesticide aplicate în agricultură, pe forme de proprietate, macroregiuni, regiuni de dezvoltare și județe. (The amounts of pesticides applied in agriculture, by ownership form, development regions and counties), http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table Accessed on February 13, 2025.
[22]Institutul Național de Statistică, 2025b, AGR107A - Suprafața terenurilor pe care s-au aplicat pesticide, pe forme de proprietate, macroregiuni, regiuni de dezvoltare și județe. (The land surface on which

pesticides were applied by ownership form and counties) http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table Accessed on February 13, 2025.
[23]Joint Research Centre, 2025, Farmer's Toolbox for Integrated Pest Management. https://datam.jrc.ec.europa.eu/datam/mashup/IPM/index.html Accessed on February 17, 2025.
[24]Kaiser, A., Burger, P., 2022, Understanding diversity in farmers' routinized crop protection practices. Journal of Rural Studies, 89, 149-160.
[25]Kelemen, E., Nguyen, G., Gomiero, T., Kovács, E., Choisis, J.-P., Choisis, N., Paoletti, M. G., Podmaniczky, L., Ryschawy, J., Sarthou, J.-P., Herzog, F., Dennis, P., Balázs, K. , 2013, Farmers' perceptions of biodiversity: Lessons from a discourse-based deliberative valuation study. Land Use Policy, 35, 318-328.
[26]Kitzinger, J., 2006, Focus groups. Qualitative research in health care, 21-31.
[27]Krueger, R. A., Casey, M. A., 2015, Focus group interviewing. Handbook of practical program evaluation, 506-534.
[28]Kvakkestad, V., Steiro, Å. L., Vatn, A., 2021, Pesticide Policies and Farm Behavior: The Introduction of Regulations for Integrated Pest Management. Agriculture, 11(9), 828.
[29]Lamichhane, J. R., Dachbrodt-Saaydeh, S., Kudsk, P., Messéan, A., 2016, Toward a reduced reliance on conventional pesticides in European agriculture. Plant Disease, 100(1), 10–24.
[30]Lekei, E.E., Ngowi, A.V., London, L., 2014, Farmers' knowledge, practices and injuries associated with pesticide exposure in rural farming villages in Tanzania. BMC Public Health 14, 389.
[31]Lykogianni, M., Bempelou, E., Karamaouna, F., Aliferis, K. A., 2021, Do pesticides promote or hinder sustainability in agriculture? The challenge of sustainable use of pesticides in modern agriculture. Science of the Total Environment, 795, 148625.
[32]Maican, S. Ș., Muntean, A. C., Paștiu, C. A., Stępień, S., Polcyn, J., Dobra, I. B., Dârja, M., & Moisă, C. O., 2021, Motivational Factors, Job Satisfaction, and Economic Performance in Romanian Small Farms. Sustainability, 13(11), 5832.
[33]Mellon-Bedi, S., Descheemaeker, K., Hundie-Kotu, B., Frimpong, S., Groot, J. C. J., 2020, Motivational factors influencing farming practices in northern Ghana. NJAS - Wageningen Journal of Life Sciences, 92, 100326.
[34]Piwowar, A., 2021, The use of pesticides in Polish agriculture after integrated pest management (IPM) implementation. Environmental Science and Pollution Research, 28, 26628–26642.
[35]Popescu, A., Tindeche, C., Mărcuță, A., Mărcuță, L., Honțuș, A., 2021, Pesticides-a problem in Romania's agriculture? Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 21(4), 477-486.
[36]Stallman, H. R., James, H. S., Jr., 2015, Determinants affecting farmers' willingness to cooperate to control pests. Ecological Economics, 117, 182–192.
[37]Stoicea, P., Soare, E., Chiurciu, I. A., Iorga, A. M., Dinu, T. A., Micu, M. M., Firățoiu, A., 2022, Research on the sustainable use of pesticides at macro-regional level and in the development regions of Romania. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, *22*(3), 733-742.
[38]Šūmane, S., Kunda, I., Knickel, K., Strauss, A., Tisenkopfs, T., des Ios Rios, I., ...& Ashkenazy, A., 2018, Local and farmers' knowledge matters! How integrating informal and formal knowledge enhances sustainable and resilient agriculture. Journal of Rural Studies, 59, 232-241.
[39]Toader, M., Georgescu, E., Epure, L. I., Ion, V., Bășa, A. G., Dușa, E. M., Vasile, M. V., Ionescu, A. M., 2024, The evolution of pesticides use in the context of sustainability of agri-food systems. Scientific Papers. Series A. Agronomy, 67(2).
[40]Tsakiris, P., Damalas, C.A., Koutroubas, S.D., 2023, Safety behavior in pesticide use among farmers of northern Greece: the role of information sources. Pest Management Science.
[41]Van den Berg, H., Jiggins, J., 2007, Investing in farmers—The impacts of Farmer Field Schools in relation to Integrated Pest Management. World Development, 35(4), 663-686.
[42]Wang, Y., Möhring, N., Finger, R., 2023, When my neighbors matter: Spillover effects in the adoption of large-scale pesticide-free wheat production. Agricultural Economics, 54(2), 237–256.
[43]Wilkinson, S., 1998, Focus groups in health research: Exploring the meanings of health and illness. Journal of health psychology, 3(3), 329-348.
[44]Yang, X. M., Wang, F., Meng, L., Zhang, W., Fan, L., Geissen, V., Ritsema, C. J., 2014, Farmer and retailer knowledge and awareness of the risks from pesticide use: A case study in the Wei River catchment, China. Science of the Total Environment, 497, 172-179.

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SUNFLOWER PRODUCTION PERFORMANCE UNDER CLIMATE CHANGE IN DOBROGEA REGION, ROMANIA

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Abstract

The study aimed to analyze the production performance of sunflower in terms of yield in the Dobrogea Region, where climate change has a deep impact in Romania's agriculture. For this purpose, the data on sunflower yield were collected from the National Institute of Statistics and the data on air temperature and precipitation regime were provided by the National Meteorological Administration for the period 1991 – 2020. The results proved the influence of monthly average temperature and precipitations along the vegetation period which have had a deep impact on sunflower production per surface unit. The yield performance varied between 470 kg/ha in the year 2001 and 3,583 kg/ha in the year 2018. Under variability of thermal and hydric resources, it is recommended that farmers adapt sunflower technology to local climate conditions regarding: the use of the sunflower varieties resistant to drought, choosing the best moments for sowing, applying the fertilizers and treatments and also the use of the irrigations systems for meeting the water requirements of the croping order to enable it to reach the planned production whose sale to cover the production costs.

Key words**:** *air temperature, precipitation, sunflower, yields, Dobrogea Region.*

INTRODUCTION

Sunflower is the most important oleaginous plant in Romania and one of the most cultivated oil plants worldwide [13].About 90% of the world's sunflower oil production is used in human nutrition, while the rest is used in industry and in obtaining bio-diesel [11].In Europe, sunflowers were brought by Spanish explorers in the early 16th century from Central and North America. In the second half of the 18th century, sunflowers became a major global crop due to increased oil content and production of hybrids on a commercial scale [10].In Romania, the first official data regarding the sunflower cultivated area are from 1910, and after 1989 the sunflower is among the few crop plants where the cultivated area has grown significantly [10].The sunflower adapts to different environmental conditions, but similar to any cultivated plant, the whole agroclimatic conditions in an agricultural year determine the value of production [16].The variability in time and space of the main climatic factors (solar radiation, temperature and precipitation) determine the fluctuation of the yields and their deviation from the potential value of the crop [7; 16].The effects of climate change cause significant losses in agriculture, the sector being strictly dependent on weather evolution, through the intensity and frequency of extreme weather episodes (droughts, floods, frost etc.)[17].The aim of this study is to analyze the performance of sunflower production in relation to the variability of thermal and pluviometric resources in the current context of climate change, in the Dobrogea region. The

Dobrogea Region is located in southeastern Romania and overlaps the Dobrogea Plateau and Danube Delta (Fig. 1). This represents 6.5% of the Romanian surface and is characterized by a temperate continental climate with long periods of drought, which imposed the arrangement with irrigation systems, currently in conservation [14].

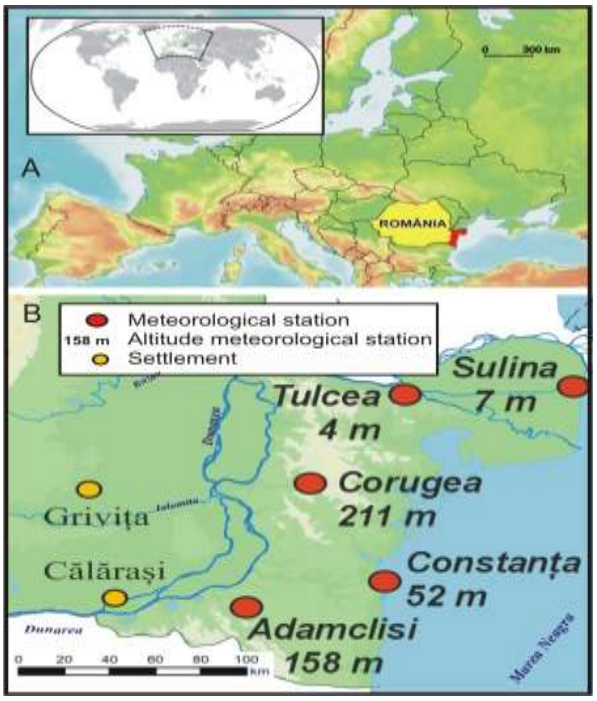

Fig. 1. The location of the study area and of the meteorological stations analyzed.
Source: own processing from GIS open sources.

The study area is part of the ecological crop areas: I (most of the Dobrogea Plateau), II (Danube Delta) and III (north Dobrogea Plateau) [9]. In the I crop area, the bioclimatic requirement for air temperature is optimal, but the requirement for humidity is ensured only under irrigation conditions. Crop zones II and III are favorable, but the increase in the frequency and intensity of drought periods, amid current climate change, is a limiting factor in production [9].

MATERIALS AND METHODS

In the analysis of the variability of the agricultural yields of sunflower were used the average production data per hectare from the National Institute of Statistics (NIS), for the period 1991 – 2020. This analysis is carried out in relation to the agro-climatic conditions in the study area. For the analysis of variability and the identification of observed changes in the air temperature and precipitation regime, depending on the bioclimatic requirements of sunflower culture, climate data were used from five meteorological stations (MS) belonging to the National Meteorological Administration (NMA).

These meteorological stations are considered representative for the study area by geographic location and by the altitude of the meteorological platforms (Fig. 1).The climate data used in the analysis are the monthly average air temperature (°C) and the monthly average precipitation amount (mm) for the period 1991 to 2020. Both agricultural data and climate data were analyzed with statistical-mathematical methods, to which computerized cartography was added.

RESULTS AND DISCUSSIONS

Sunflower, like any cultivated plant, throughout the growing season has specific requirements in relation to the environment, especially to climatic factors [6, 12]. The productivity performance of the crop depends on the complete satisfaction of the requirements for light, temperature and precipitation. Sunflower is a plant with high demands for light, which is reflected by the phenomenon of heliotropism that manifests itself from the plant's emergence to its flowering [10, 13].Temperature influences all plant physiological processes, and precipitation is the natural source of soil water supply. The fluctuation and performance of agricultural yields are determined by conditions closer or farther away from the optimum temperature and precipitation requirements for each vegetation phase and for the entire vegetation cycle of the crop.

Agricultural productions

Most of the world sunflower production is produced in Europe (74%), followed by Asia (11%) [4]. Romania is the largest producer of sunflower seeds in the European Union, providing about 27% of the total production of Europe, and the annual growth rate of sunflower seed production is 29% [5]. The average

production per hectare for the entire study area is 1,319 kg/ha for the period 1991 – 2020 (Table 1). Out of the 30 years used for analysis of the agricultural yields of sunflower crop: in 6 years were obtained productions between 501 and 1,000 kg/ha (20%); in 20 years, productions between 1,001 and 2,000 kg/ha (66.7%); in 2 years, productions between 2,001 and 3,000 kg/ha (6.7%), and higher yields of 3,001 kg/ha in one year (3.3%) (Table 1).

Table 1. The average production per hectare (kg/ha) of the sunflower in the study area (1991–2020)

Year	Average production (kg/ha)
1991	1,061
1992	965
1993	1,155
1994	928
1995	1,029
1996	937
1997	1,097
1998	1,040
1999	1,225
2000	834
2001	470
2002	1,030
2003	1,057
2004	1,428
2005	1,430
2006	1,529
2007	642
2008	1,267
2009	997
2010	1,315
2011	1,349
2012	1,010
2013	1,459
2014	1,833
2015	1,569
2016	1,656
2017	2,976
2018	3,583
2019	2,408
2020	1,144
1991-2020	1,319

Source: processed data from NIS, 2025 [15].
Note: dark green – the highest average production per hectare; light green – the lowest average production per hectare.

Also, in a single year, an average production per hectare of less than 500 kg (3.3%) was obtained (Table 1).The lowest sunflower production was 470 kg/ha in 2001. This year is part of the group of dry years 2000 – 2003, with a maximum intensity of the drought phenomenon in the second and third years [2]. In 2018, the highest average production per hectare of 3,583 kg in the study area was recorded (Table 1). In the same year, the highest production in the analyzed period of 3,041 kg/ha was recorded at national level [18]. The year 2018 was a year with a pluviometric anomaly of 10% higher than the normal climatological period 1981 – 2010, in terms of the annual precipitation amount at the level of the entire country. Also, 6 of the 12 months recorded positive pluviometric anomalies.

In the study area, annual precipitation amounts were within normal limits with isolated surpluses and deficits [1]. The fluctuation of yields reflects variability and climate change, and knowledge of the relationship between production and climatic factors is particularly important in agricultural management of cultivation.

Monthly average air temperatures

The sunflower is a mesothermal plant, generally pretentious to the temperature with a vegetation cycle, for the conditions in Romania, between 90 and 130 days. The best results are obtained in areas with an average temperature of 18 – 22°C for the period April – August [10]. The optimal values of the monthly average air temperature for sunflowers are shown in Table 2.

Table 2. Sunflower requirements for the monthly average air temperature (°C).

Months	Optimal values
Aprilie	8…12
May	15…18
June	18…20
July	20…25
August	22…25

Source: [10; 17].

In the study area, the highest thermal potential according to the annual average temperatures is realized along the seaside area, which stores heat in summer and releases it in winter, thus being higher values than in the rest of the region. The annual average temperature at Sulina MS is 12.2°C, and at Constanta MS is 12.4°C for the analyzed period. Inside the study area the annual average temperature varies between 11.0°C at Corugea MS and 11.9°C at Tulcea MS. In the annual regime of the monthly average air temperature, it is found that at all meteorological

stations analyzed the monthly average recorded values are all optimal except for June (Fig. 2).

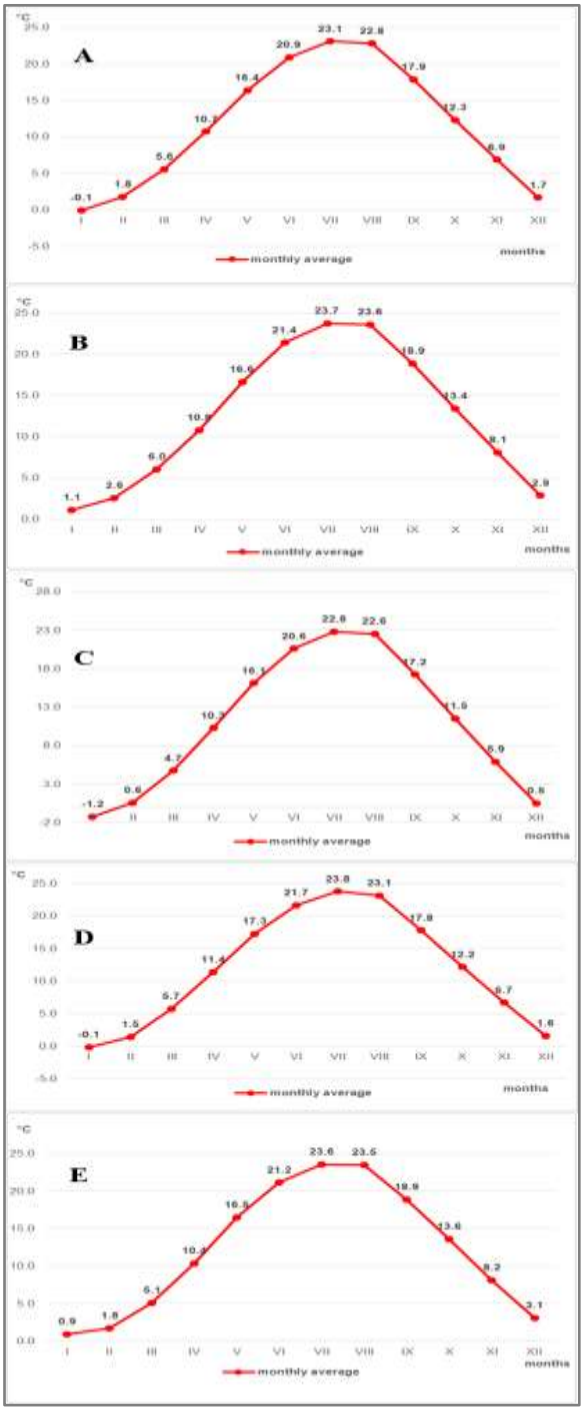

Fig. 2. The annual regime of air temperature (°C) at the meteorological stations analyzed for the period 1991–2020: Adamclisi (A), Constanța (B), Corugea (C), Tulcea (D) and Sulina (E).
Source: processed data according to NMA, 2025.

The optimal values of air temperature for June are between 18 – 20°C (Table 2). In June monthly average air temperature was 20.9°C to Adamclisi MS, 21.4°C to Constanta MS, 20.6°C to Corugea MS. More, 21.7°C to Tulcea MS and 21.2°C to Sulina MS (Fig. 2).

In June, the flowering vegetation phase takes place, and higher air temperatures together with low humidity and strong winds cause an increase in the percentage of dry grains [3; 10].

Monthly average precipitation

The sunflower has a high water consumption, but it resists drought quite well due to its well-developed root system, the water-bearing stem and the leaves that endure temporary dehydration [10]. Water consumption from precipitation in different culture conditions around the world is very variable between 290 and 765 mm/year [17].The highest sunflower yields are in areas with annual precipitation amounts of 450 to 600 mm [10; 13]. In the study area, the annual precipitation amounts, for the analyzed period, have values of: 530.4 mm at Adamclisi MS, 468.0 mm at Constanta MS, 442.2 mm at Corugea MS, 494.2 mm at Tulcea MS and 240.5 mm at Sulina MS. Dobrogea region is the territory with the smallest annual precipitation for Romania. It was found that the year-level precipitation water requirement is provided for sunflower throughout the study area, except for the seaside area.

Depending on the vegetation phase, the requirements of sunflower plants are different. The monthly optimum values for the water needs from the precipitation that ensure high yields are shown in the Table 3.

Table 3. Sunflower requirements for the monthly amount precipitation (mm).

Months	Optimal values
Aprilie	40…50
May	60…80
June	70…80
July	60…70
August	40…50

Source: [10; 17]

During the vegetation period (April – August) the amount of optimum precipitation required is 300 – 400 mm.

The annual regime of the monthly average precipitation quantities for each analyzed meteorological station is shown in Figure 3.

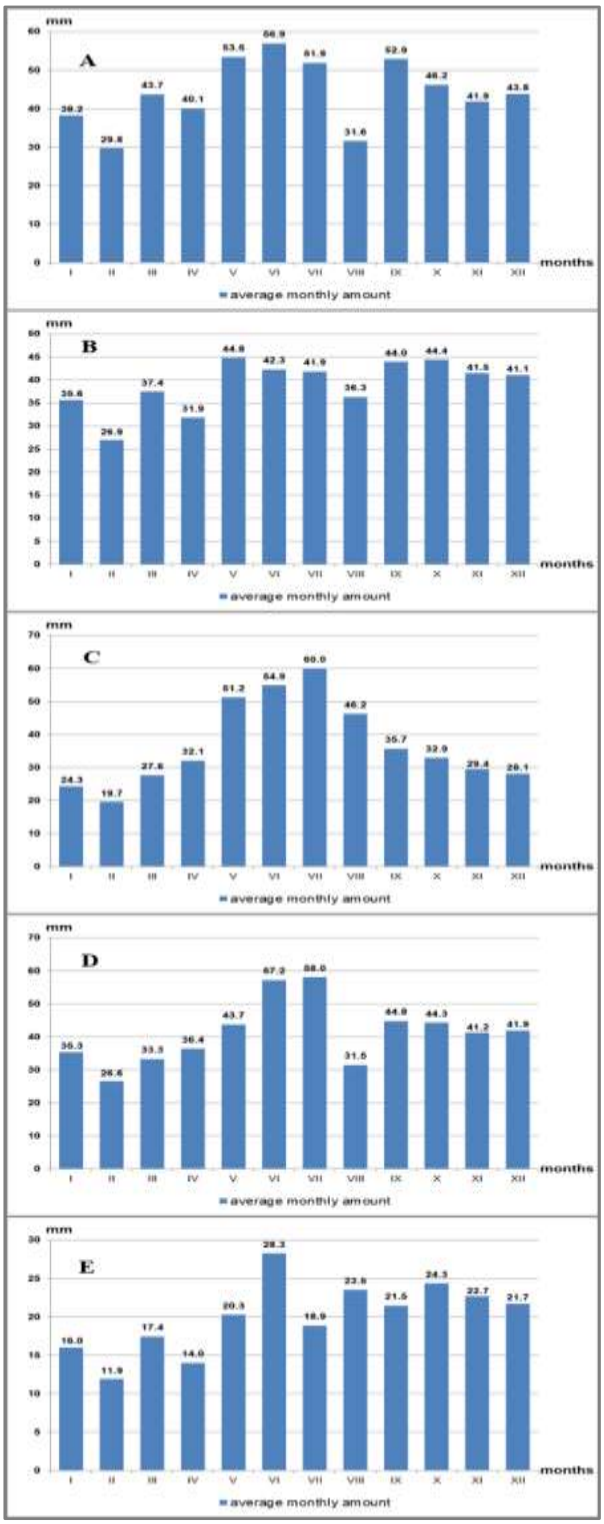

Fig. 3. The annual regime of precipitation (mm) at the meteorological stations analyzed for the period 1991–2020: Adamclisi (A), Constanța (B), Corugea (C), Tulcea (D) and Sulina (E). Source:processed data according to NMA, 2025.

The maximum water requirement is reached in June and July, when the flowering phase of the sunflower takes place[17]. In the study area, for the analyzed period, the recorded values are below the optimal water needs for the months of June and July at all meteorological stations analyzed (Fig. 3). The lowest values are recorded at Sulina MS of 28.3 mm in June and 18.9 mm in July, and the highest values are at Tulcea MS for June (57.2 mm) and Corugea MS for July (57.2 mm) (Fig. 3). The values analyzed are mediated values for the period 1991 – 2020. The great variability in space and time of each meteorological parameter, over the period analyzed, determines the fluctuations of the productions. For example, in the year when the highest sunflower production occurred (2018), at Corugea MS there were recorded monthly average precipitation amounts of 115.9 mm in June and 90.3 mm in July. For the same meteorological station in 2001 (470 kg/ha), the monthly average precipitation recorded was 108.1 mm in June and 27.3 mm in July. As a result, the annual regime of the monthly average precipitation amounts is characterized by an uneven distribution that determines the deviation of the potential production values of each agricultural crop. The optimal water requirement from precipitation can be supplemented by irrigation, so that usually a sunflower seed production of 2,500 – 3,500 kg/ha is obtained [8].

CONCLUSIONS

In the current context of variability and climate change, agriculture is the economic sector increasingly affected. Agricultural production of a region or country is influenced by social factors, scientific and technological level, investment value, soil quality, but mostly by climatic factors.

Adapting to climate change through better culture management requires knowledge and analysis of the main climatic factors at both year and extended timeframe level. Sunflower is the most important oil plant in Romania and has a high production potential in the country's pedoclimatic conditions. In Romania, the average production varies between 1,000 and 1,500 kg/ha and can be achieved over 2,500 kg/ha unirrigatedand over 3,500 kg/ha in irrigation conditions or rainy years. Dobrogea Region falls between these values of agricultural yields of sunflower, being mostly part of the ecological crop zone I, with optimal requirements of air temperature, but with

optimal humidity requirements only in irrigation conditions.As a result, this region significantly participates in the increase in the values of sunflower productions on a national scale, which allows Romania to be the largest EU producer of sunflower seeds.

REFERENCES

[1]Administrația Națională de Meteorologie (National Meteorological Administration – NMA), 2018, Annual report 2018, https://www.meteoromania.ro/despre-noi/raport-anual/raport-anual-2018/, Accessed on March 5, 2025.
[2]Alexandru, D., 2023, Drought monitoring in Romania, International Conference Drought Risk & Drought Risk Management in Romania & in Europe, Bucharest, Romania,chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.iawd.at/files/File/events/2023/Drought_Conference/DANIEL_ALEXANDRU.pdf, Accessed on March 5, 2025.
[3]Berbecel, O., Stancu, M., 1970, Agrometeorology (Agrometeorologie), Ceres Publishing House, București.
[4]Brumă, I.S., Rodino, S., Petcu, V., Micu, M.M., 2021, An overview of organic sunflower production in Romania, Romanian Agricultural Research, No. 38, https://www.incda-fundulea.ro/rar/nr38/rar38.52.pdf, Accessed on February 10, 2025.
[5]CBI Netherlands Ministry of Foreign Affairs, 2022, The European market potential for sunflower seeds, https://www.cbi.eu/market-information/grains-pulses-oilseeds/sunflower-seeds/market-potential, Accessed on March 5, 2025.
[6]Constantin (Oprea), D.M., Ionac, N., Marinică, I., Vătămanu, V.V., Marinică, A.F., Grigore, E., Bogan, E., Onțel, I., 2019, The Agro-Climatic Resources of the year 2015 and their Impact on the Agricultural Crops in the South – West of Romania, Scientific Papers Series „Management, Economic Engineering in Agriculture and Rural Development", Vol. 19(2), 81-92.
[7]Constantin (Oprea), D.M., Ionac, N., Grigore, E., Lüftner, G.D., Ilea, R.G., 2023, The variability and influence of precipitation on the winter wheat in the Extra-Carpathian area of the Meridional and Curvature Carpathians (Romania). Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 23(2), 181-186.
[8]Food and Agriculture Organization of the United Nation (FAO), 2025, Sunflower, https://www.fao.org/land-water/databases-and-software/crop-information/sunflower/en/, Accessed on March 9, 2025.
[9]Hera, C., Sin, Gh., Toncea, I., 1989, Sunflower culture (Cultura florii-soarelui), Ceres Publishing, București.
[10]Ion, V., Bășa, A. Gh., 2021, Phytotechnics of oleaginous plants (Fitotehnia plantelor oleaginoase), Ex Terra Aurum publishing House, București.
[11]Jodić, S., Miladinović, D, Kaya Y., 2015, Breeding and Genetics of Sunflower. Chapter 1, p. 1-25, in: Sunflower: Chemistry, Production, Processing, and Utilization. Editors: Martinez-Force E., Dunfort N.T., Salas J.J. AOCS Press, Urbana, Illinois, USA.
[12]Lalic, B., Eitzinger. J., Marta, A.D., Orlandini, S., Sremac, A.F., Pacher, B., 2018, Agricultural Meteorology and Climatology, Firenze University Press, Florence.
[13] Marin, Șt., Constantinescu, E., 2011, Phytotechnie III-IV, (Fitotehnie), University Publishing House, Craiova.
[14]National Institute of Geography, 2005, Geography of Romania (Geografia României), vol V., Romanian Academy Publishing House, București.
[15]National Institute of Statistics, 2025, www.insse.ro, Accessed on February 10, 2025.
[16]Povară, R., 2000, The meteorological risk in agriculture. Winter wheat. (Riscul meteorologic în agricultură. Grâul de toamnă.), Economic Publishing House, București.
[17]Sandu, I., Mateescu, E., Vătămanu, V.V., 2010, Climate change in Romania and their effects on agriculture (Schimbări climatice în România şi efectele asupra agriculturii). Sitech Publishing House, Craiova.
[18]Soare, E., Chiurciu, I.A., 2023, Study on the sunflower seeds market in Romania. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 23(1), 739-744.

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CONSUMERS' ATTITUDE TOWARDS SENSORY ATTRIBUTES AND WILLINGNESS TO PURCHASE MEAT OF MALE LAYER-TYPE OR DUAL-PURPOSE CHICKENS

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Abstract

In recent years the practice of culling the one day-old male layer-type chickens has been strongly criticized for both humane and environmental concerns. A possible solution for this problem is to rear the layer cockerels for meat or to use dual-purpose poultry lines. Hence, our survey aimed to assess the consumers' preferences forcertain sensory attributes and the willingness to purchase meat from malelayer-type and dual-purpose chickens. For the objective of the study the chicken meat was derived from two poultry lines– layer type L and dual-purpose Salmon raised in the Institute of Animal Science-Kostinbrod, Bulgaria. A total of 257 respondents were involved in the survey. The latter was designed in three panels and contained 22 questions.The results indicated that the meat from both layer-type and dual-purpose birds scored higher in texture and taste in comparison to the commonly purchased poultry meat, however, the ready-to-cook chicken carcasses were smaller. The comparison between both layer and dual-purpose lines showed similar results for the meat sensory evaluation, however, the declared annual consumption gave significant advantage to the layer-type chickens.

Key words**:** *chicken meat, dual-purpose, male layer-type chickens, consumers*

INTRODUCTION

Globally, the production and consumption of chicken meat has been steadily increasing in recent years. According to FAO [12] the consumption of chicken meat has increased from 97.58 to 126.53 million tons for the period 2013-2023. For the same period, in Europe, the consumption of the chicken meat increased from 15.86 to 20.46 million tons. The reasons for this growth are numerous, but the main factor is that chicken meat is a cheap [7], yet valuable protein source [15]. In addition, as an alternative to red meats, chicken meat consumption is associated to lower risk of obesity, type 2 and certain types of cancer [20]. In 1950s development of special chicken genotypes, selected for high performance at lower cost began. The broilers we know today are reared indoors, at high densities, their growth is fast and they can be slaughtered at 40 days of age [4, 19]. These birds have high feed efficiency, carcass and breast yields [8]. The modern poultry industry demands birds genetically selected to be highly productive in egg or meat production, but not both [2]. As a consequence, the male chickens of layer type have been culled right after hatching, since they are considered unprofitable in comparison to broilers [1]. This practice has been widely criticized across Europe, resulting in legislative changes to end it in Germany, France, Italy, Luxembourg and Austria [21]. So far three possible solutions against culling of the male layer chickens exist. First is the determination of the chicken's sex *in ovo*, which allows the male embryos to be killed prior hatching [22]. Another possible solution is the use of dual-purpose lines when females are reared for eggs and the males for meat. However, a certain disadvantage is the lower breast yield of these birds in comparison to the broilers [16, 17]. The use of dual-purpose lines was supported by consumers according to some studies [5, 14]. The higher prices are the most frequently cited negative aspect for the dual-purpose chickens. Nevertheless, their meat is considered tastier and healthier, that

can made the consumers will to pay more for such products [1, 9]. The third possible solution is to rear the layer cockerels for meat. According to some studies, their meat has an excellent quality and they can form a particular niche for manufacture of boutique products. Similar to the dual-purpose chickens, layer cockerels also have lower breast yield and are smaller in comparison to commercial broilers.
The aim of this study was to evaluate the common consumers attitude towards chicken meat consumption as well as to compare some sensory attributes and the willingness to purchase male chickens of layer type or dual purpose to those of traditionally purchased poultry products.

MATERIALS AND METHODS

Experimental birds

Male chickens from two poultry lines were used in this study, both belonging to the Bulgarian National Gene Pool. The first was layer type – line L, while the second was dual-purpose line called "Salmon". It was developed after crossing hens of line L with Bresse Gauloise cocks (♀L × ♂BB). A total of 157 L chickens and 100 Salmon chickens were involved in the study. The birds were reared in controlled microclimate in the experimental poultry farm of the Institute of Animal Science-Kostinbrod and were fed the same feed. At 9 weeks of age all the cockerels were slaughtered at live weight of 876.03 g and 988.89 g, respectively for L and Salmon chicks. After slaughter, the ready to cook carcasses weighed 571.33 g (line L) and 644.05 g (line Salmon). The carcasses were packed into plastic bags kept at 4°C and distributed among the participants in the survey within 24h after slaughter. The participants were able to choose the method and the duration of cooking. All the questionnaires were filled and returned within 1 week after slaughter.

Contents of the questionnaire

The questionnaire consisted of 22 questions, divided in three panels. The first panel (7 questions) evaluated the attitude of the consumers towards chicken meat consumption. The second panel contained 13 questions related to the cooking methods and the taste of the cockerels. The third panel had two questions to assess the willingness of the consumers to purchase the products at different frequency and price ranges. The number of possible answers varied between 3 and 7, as the questions about the sensory evaluation of the chicken meat were descriptive.

Participants in the survey

A total of 257 participants were selected among colleagues, their families and friends. The distribution of the number of respondents by gender, age, education and income is relatively even, which gives us reason to believe that the results of the survey can be considered representative.

Statistical analysis

The statistical analysis was done through JMP v.18. Descriptive statistic was applied to the variables. Significant differences between the answers as affected by the line of the chickens, carcass form, mode of cooking, time, demographics were detected by Kruskal-Wallis test, followed by post-hoc comparisons made by Dunn's test ($P<0.05$).

RESULTS AND DISCUSSIONS

It has been found that some factors related to the sex, age, place of residence (rural, urban), eating habits and social status of the consumers generally have an effect on meat preferences and consumption [13].
Other important factors are the origin of meat, price and shelf life [6].
Table 1 shows the socio-demographic characteristics of the respondents involved in this study.
The division by sex showed that the majority of respondents were female. In terms of education, the groups with higher and secondary education were almost equal (44.75% to 47.47%), whereas the groups with a lower level of education were less than 8%.
With regard to the age and income, the respondents indicated an exact number, but in order to facilitate the statistical models, they were grouped in an interval of 10 years by age and €300 by income, respectively. In the interval 30 to 70 years, the variation between the groups were insignificant (less than 2%). The majority of respondents (over 60%)

indicated an income between €300 and €600, which is slightly lower than the average for the country.

Table 1. Socio-demographic characteristics of the sample (n=257)

Item	n	% of total
Sex		
female	150	58.37
male	107	41.63
Educational level		
doctoral degree	27	10.51
master's degree	60	23.35
bachelor's degree	28	10.89
high school (12 years)	122	47.47
primary (7 years)	13	5.06
basic (4 years)	1	0.39
student	6	2.33
Age group		
to 19 years	9	3.51
20-29 years	29	11.28
30-39 years	50	19.46
40-49 years	50	19.46
50-59 years	51	19.84
60-69 years	47	18.29
over 70 years	21	8.17
Monthly average household income		
under 300 €	34	13.23
300-450 €	82	31.91
450-600 €	74	28.79
600-750 €	31	12.06
750-900 €	17	6.61
over 900 €	19	7.39

Source: Own data.

First panel

The questions in the first panel concerning the attitude of the consumers towards chicken meat consumption are presented in Table 2.

Table 2. Questions asked consumers regarding their preferences towards chicken meat

№	Question
1	What kind of chicken meat do you prefer?
2	What is the optimum weight of the chickens you prefer?
3	Which parts of the chicken do you consume?
4	What is the colour of the chicken meat you prefer?
5	What is the colour of the chicken skin you prefer?
6	How often do you buy chicken meat?
7	What is the maximum amount you would spend to buy a whole chicken?

Source: Own data.

The distribution of the possible answers of the questions is presented in Figures 1 to 7.

The majority of the respondents preferred the products derived from backyard birds (back yard chicken, broiler and to a less extent hen) (Fig.1).

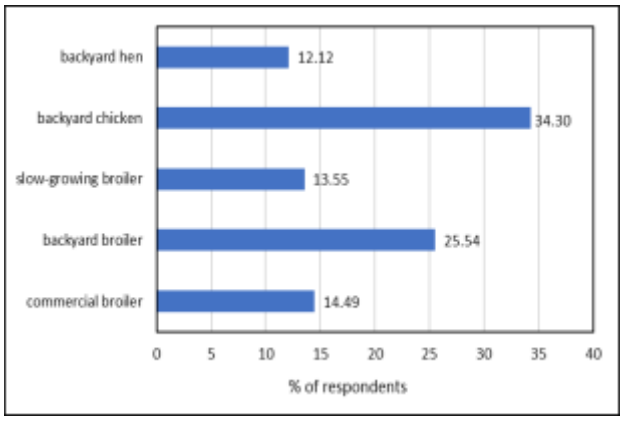

Fig.1. Preference for type of chicken product
Source: Own calculation.

The most widely available meat in the market derived from commercial broilers was preferred by less than 15% of the respondents. The preferences for slower growing broilers were similar. Hence, the products for evaluation in the second panel were selected as an alternative to the commercial broiler. The respondents that preferred these products – dual-purpose and layer-type chickens were approximately 50%, which indicates that they have promising market share.

The preferences for the weight of the chicken carcasses are presented in Figure 2. The answers of the majority of respondents were concentrated in 2 ranges: 1.5-2 kg (36.58%) and 1-1.5 kg (32.68%).

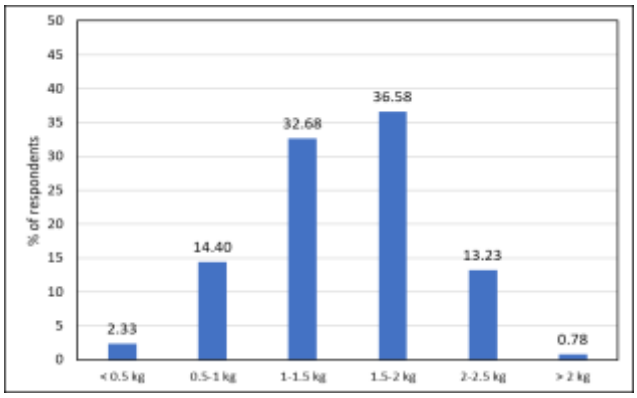

Fig. 2. Chicken weight preference
Source: Own calculation.

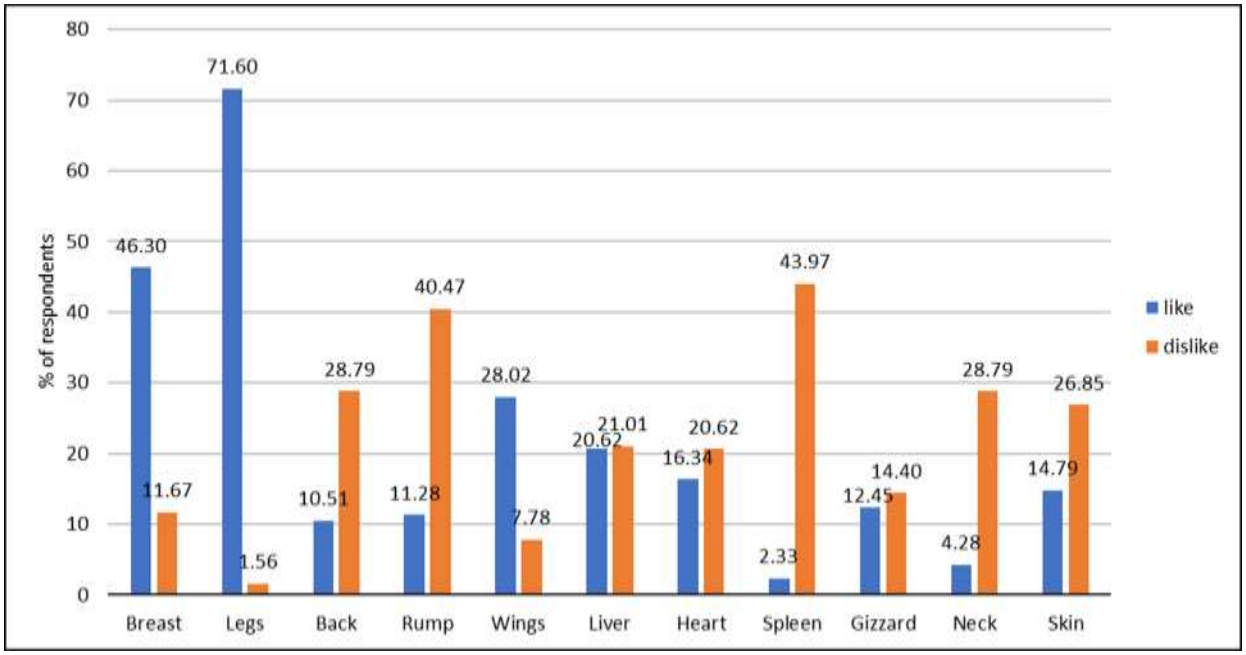

Fig. 3. Preference for chicken's carcass parts
Source: Own calculation.

Figure 3 shows both preferences and disapproval for the individual parts of the chicken carcass. The thighs were most approved (71.60%), followed by the breast (46.30%) and wings (28.02%). It could be mentioned that there was no lack of approval for almost all parts of the carcass, which is typical for the attitudes of a large part of Bulgarian consumers to utilize all parts of the carcass. The figure shows that the sum of the approval and disapproval for each part of the carcass is not 100%. The same was true for the answers regarding the preference for skin colour. It is assumed that either the consumers did not understand the question correctly or did not fully answered.

The distribution of answers to the questions regarding the preferred color of the meat and skin of chickens is shown in Fig. 4 and Fig. 5. There are clear preferences for lighter meat color and yellow skin. A small part of the respondents have expressed preferences for purple-black meat colour and blue, gray or black skin. We have included these options because the Salmon line we used for the study in the second panel, has a bluish skin tone, hence our interest in how the respondents perceived this colour.

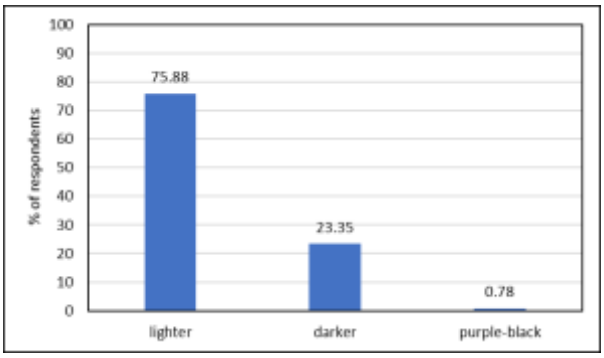

Fig. 4. Preference for chicken's meat colour
Source: Own calculation.

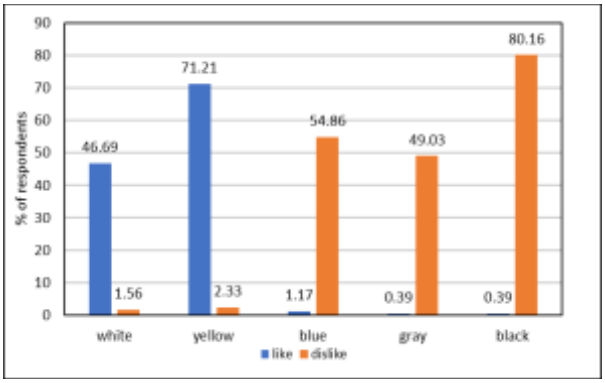

Fig. 5. Preference for chicken's skin colour
Source: Own calculation.

In the answers about the frequency of purchasing chicken products, the options once a week (49.81%) and twice a week (32.68%) prevailed (Fig. 6). This is confirmed by other studies [18]. A small part of the respondents consumed chicken meat once a month or less

often, which is probably due to more pronounced preferences for other types of meat (pork, beef, lamb).

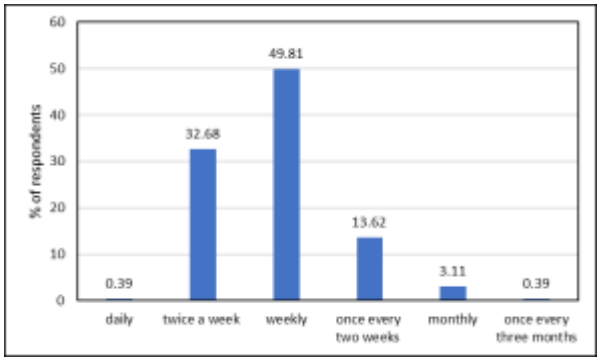

Fig. 6. Frequency of purchase a chicken
Source: Own calculation.

The maximum amount that the respondents would spend to buy a whole chicken varied widely (Fig. 7), but the majority prefer the ranges 2.50-5.00 € (50.19%) and 5.00-7.50 € (28.02%).

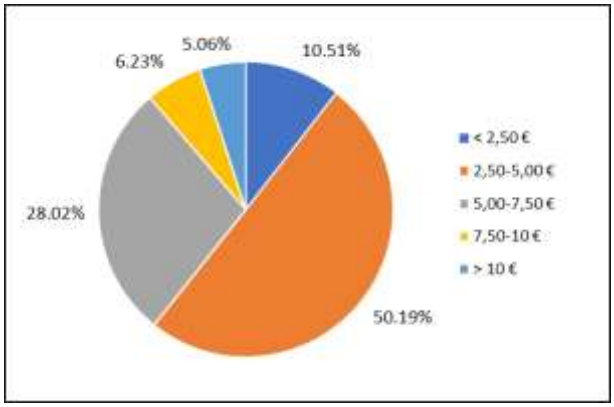

Fig. 7. Maximum price for purchase of chicken
Source: Own calculation.

Second panel

In the second panel, through 13 questions, the respondents evaluated the sensory qualities of the two lines of male chickens - layer type (L) and dual-purpose (Salmon). Three of the questions concerned the method of cooking and its duration. The first question concerned the preparation of the meat prior cooking with possible answers – cooking of whole chicken without cutting, cutting into two parts, or cutting into more than 2 parts (in portions). The second question was about the cooking method used, with possible answers being boiling, stewing, roasting and frying. The third question asked about the duration of cooking, expressed in minutes. Questions 4 to 13 concerned the sensory qualities of the cockerels. The fourth question required an assessment of the constitution of the carcass before cooking. The 9 questions remaining, treated the evaluation of three of the sensory characteristics – quantitative assessment, texture and taste of three parts of the carcass – skin, breast and thighs after cooking. The answers were descriptive, and were transformed into numerical values for the statistical processing. A detailed description of the transformation from descriptive to numerical assessment is shown in Table 3.

Table 3. Assessment of the sensory attributes of male L and Salmon chickens

Indicator	Descriptive value	Numerical value
Carcass conformation	Very muscular	2
	Muscular	1
	Normal	0
	Slim but good	-1
	Very slim	-2
Thickness – skin, breast, thighs	Thick	1
	Normal	0
	Thin	-1
	Very thin	-2
Texture of the skin	Tender	1
	Crispy	1
	Normal	0
	Firm	-1
	Very tender	-1
	Very crispy	-1
	Very firm	-2
Texture of the breast	Tender	1
	Normal	0
	Firm	-1
	Very tender	-1
	Very firm	-2
Texture of the thighs	Tender	1
	Normal	0
	Firm	-1
Taste of the skin, breast and thighs	Excellent	2
	Different and pleasant	1
	Pleasant	1
	Normal	0
	Weird, not unpleasant	-1
	Unpleasant	-2

Source: Own data.

In questions 4 to 13 concerning the sensory attributes of the male chickens, one of the possible answers was “normal”, explicitly meaning that with this answer, the assessment coincided with that of products usually purchased and consumed. The numerical value of this assessment was “0”. The remaining

possible answers, depending on the degree of approval or disapproval of the product, received a numerical assessment with the sign "+" (better than normal) or "–" (worse than normal), thus allowing to make comparisons both between the studied products and with traditionally consumed chicken products. Table 4 shows the results of the sensory evaluation of the chickens, according to the line (L and Salmon), the cut, the method and duration of cooking.

The carcass conformation of the L chickens received significantly higher score (-0.68) than the Salmon ones (-1.15) ($p<0.0001$), with both lines receiving a negative score compared to chicken products that the respondents usually purchase.

Table 4. Carcass conformation assessment according to the line

Line	Carcass conformation
L	-0.68±0.67[a]
Salmon	-1.15±0.76[b]
χ^2	27.1409
P	<0.0001

Source: Own calculation; Values with different superscripts differ significantly ($P<0.05$)

This was not surprising since it is known that dual-purpose and layer lines have slower growth and leaner bodies than the widely used commercial broilers. The sensory assessment according to the line, preparation prior cooking, cooking method and time for the skin, breast and thigh are presented in Tables 5, 6 and 7 respectively. The difference in the quantitative assessment due to the line of the birds are significant only in the breast ($p=0.0004$), showing higher score for the layer-type chicks. No significant differences were found for the texture and taste of the skin, breast and thigh meat, however the assessment was positive. This indicates that in regard to these two attributes, both layer type and dual-purpose lines are above the average level of the chicken meat purchased in the market. The preparation prior cooking did not induce significant differences in the assessment of either of the attributes.

However, a tendency towards crispier than normal skin was observed in the chickens when cut in two parts ($p=0.0546$). Cooking method was shown to affect significantly the assessment of the texture and taste of the three carcass parts.

Table 5. Skin assessment

Item	Skin		
Line	**Content**	**Texture**	**Taste**
L	-0.55±0.56	0.52±0.61	0.41±0.83
Salmon	-0.70±0.59	0.52±0.67	0.35±0.86
χ^2	3.6173	0.1438	0.0458
P	0.0572	0.7045	0.8306
Preparation			
whole	-0.63±0.59	0.47±0.62	0.43±0.87
Two parts	-0.70±0.52	0.70±0.57	0.43±0.55
portion	-0.51±0.57	0.54±0.68	0.24±0.90
χ^2	3.3210	5.8153	2.4073
P	0.1900	0.0546	0.3001
Cooking			
Boiling	-0.61±0.57	0.34±0.64[a]	0.09±0.80[a]
Stewing	-0.67±0.58	0.67±0.66[b]	0.44±1.02[ab]
Roasting	-0.58±0.61	0.54±0.60[ab]	0.43±0.70[a]
Frying	-0.65±0.65	0.71±0.59[b]	0.94±0.89[b]
χ^2	1.2017	14.9170	23.0661
P	0.7526	0.0019	<0.0001
Duration			
0-30 min	-0.59±0.50	0.50±0.67	0.95±0.95[a]
30-60 min	-0.63±0.61	0.46±0.66	0.27±0.89[b]
60-90 min	-0.59±0.52	0.59±0.60	0.47±0.69[ab]
+90 min	-0.59±0.64	0.63±0.56	0.30±0.67[b]
χ^2	0.1526	2.9369	12.3903
P	0.9849	0.4015	0.0062

Source: Own calculation; Values with different superscripts differ significantly ($P<0.05$).

Table 6. Breast assessment

Item	Breast		
Line	**Content**	**Texture**	**Taste**
L	-0.36±0.52[a]	0.30±0.52	0.60±0.78
Salmon	-0.60±0.55[b]	0.32±0.63	0.60±0.83
χ^2	12.3643	0.4083	0.2257
P	0.0004	0.5229	0.7337
Preparation			
whole	-0.45±0.55	0.34±0.54	0.57±0.83
Two parts	-0.43±0.50	0.38±0.55	0.81±0.57
portion	-0.46±0.57	0.17±0.65	0.54±0.84
χ^2	0.0234	3.3605	3.0456
P	0.9883	0.1863	0.2181
Cooking			
Boiling	-0.55±0.50	0.10±0.50[a]	0.32±0.79[a]
Stewing	-0.38±0.49	0.44±0.60[b]	0.74±0.82[ab]
Roasting	-0.42±0.58	0.35±0.57[b]	0.63±0.71[ab]
Frying	-0.42±0.56	0.48±0.57[b]	1.00±0.89[b]
χ^2	4.4749	17.2192	16.1222
P	0.2145	0.0006	0.0011
Duration			
0-30 min	-0.45±0.60	0.36±0.58	0.91±0.87
30-60 min	-0.47±0.54	0.27±0.58	0.55±0.84
60-90 min	-0.44±0.50	0.37±0.59	0.62±0.70
+90 min	-0.41±0.64	0.30±0.47	0.56±0.75
χ^2	0.7985	1.9442	3.0263
P	0.8498	0.5841	0.3876

Source: Own calculation; Values with different superscripts differ significantly ($P<0.05$).

For both indicators boiling had the lowest score, while frying gained the preferences of the consumers, especially with regard to the taste in the skin (p<0.0001), breast (p=0.006) and thighs (p=0.0004). The duration of cooking also significantly affected the taste of the skin (P=0,0062), with highest score for the interval up to 30 min. The texture of the thighs also differed according to the time of cooking (p=0.0040) with highest score for the interval 60-90 min.

Table 7. Thigh assessment

Item	Thigh		
Line	**Content**	**Texture**	**Taste**
L	-0.41±0.57	0.34±0.51	0.64±0.79
Salmon	-0.50±0.54	0.28±0.55	0.71±0.74
χ^2	2.1394	0.5398	0.6156
P	0.1436	0.4625	0.4327
Preparation			
whole	-0.49±0.58	0.34±0.54	0.61±0.82
Two parts	-0.43±0.50	0.35±0.59	0.76±0.68
portion	-0.34±0.51	0.24±0.47	0.78±0.67
χ^2	3.0377	2.1034	2.2605
P	0.2190	0.3493	0.3230
Cooking			
Boiling	-0.40±0.54	0.12±0.46^{a}	0.51±0.82^{a}
Stewing	-0.38±0.54	0.46±0.51^{b}	0.77±0.87^{ab}
Roasting	-0.49±0.57	0.35±0.53^{b}	0.65±0.67^{ab}
Frying	-0.48±0.57	0.48±0.57^{b}	1.00±0.77^{b}
χ^2	1.8632	17.9703	9.0321
P	0.6013	0.0004	0.0289
Duration			
0-30 min	-0.55±0.60	0.36±0.58^{ab}	0.95±0.79
30-60 min	-0.47±0.54	0.23±0.52^{a}	0.63±0.83
60-90 min	-0.41±0.52	0.49±0.53^{b}	0.68±0.66
+90 min	-0.37±0.69	0.22±0.42^{ab}	0.59±0.75
χ^2	2.6964	13.3257	3.3830
P	0.4408	0.0040	0.3363

Source: Own calculation; Values with different superscripts differ significantly (P<0.05).

Third panel

The third panel included two questions and the respondents had to answer how many and at what price they would purchase the studied products. The choice of the number of price ranges is influenced by two factors. On the one hand, smaller differences between the ranges can lead to a more biased assessment, which is confirmed in a number of studies [10,11]. On the other hand, it is necessary for the ranges to be numerous for a clearer differentiation between the individual groups. The use of 4 levels of assessment is quite common in the literature [3]. In our survey, due to evaluation of two products, we settled on 5 price ranges. The frequency of shopping varied between "Every day" and "Once a year", as well as a possible answer "I would not buy". Figure 8 summarizes both questions. The declared willingness to purchase the chickens in the study (kg/year) at different price ranges is presented. The results showed clear preference of the respondents towards the L line in all price ranges. The declared consumption of the Salmon cockerels varied from 43 to 7% lower values compared to the L line.

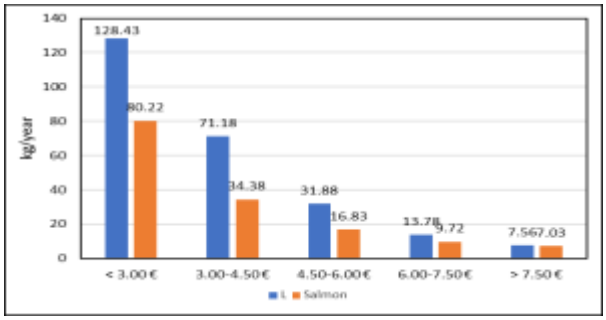

Fig. 8. Annual chicken consumption declared by respondents
Source: Own calculation.

CONCLUSIONS

Consumers' preliminary attitudes towards chicken meat showed that the most widely used product –commercial broiler– had low levels of preference as a first choice for consumption. The alternative chicken products included in our survey, namely male layer-type and dual-purpose chickens showed a higher level of approval in the sensory characteristics of skin, breast and legs compared to traditionally purchased chicken products. Respondents gave approximately the same assessments of the sensory characteristics of the chickens from both lines, but the declared consumption on an annual basis is significantly higher for the layer type L cockerels.

REFERENCES

[1]Aerts, S., Boonen, R., Bruggeman, V., De Tavernier, J.,Decuypere, E., 2009. Culling of day-old chicks: opening the debates of Moria? In: Millar, K., West, P.H., Nerlich, B. (Eds). Food Futures: Ethics, Science and Culture, Wageningen Academic, 115-122. DOI:https://doi.org/10.3920/9789086866731_019

[2]Barbato, G. F., 1999, Genetic relationships between selection for growth and reproductiveeffectiveness.Poultry Science, 78:444−452. DOI:https://doi.org/10.1093/ps/78.3.444

[3]Barreiro-Hurle,J., Gracia, A.,De-Magistris,T. 2010. The effects of multiple health and nutrition labels on consumer food choices. Journal of Agricultural Economics, 61(2): 426–443. DOI:https://doi.org/10.1111/j.1477-9552.2010.00247.x

[4]Bessei, W., 2006, Welfare of broilers: A review. World's Poultry Science Journal, 62: 455–466.

[5]Brümmer, N., Christoph-Schulz, I., Rovers, A.K., 2018, Consumers' perspective on dual-purposechickens as alternative to the killing of day-old chicks, International Journal on Food SystemDynamics, 9 (5): 390-398. DOI:https://doi.org/10.18461/ijfsd.v9i5.951

[6]Caratus Stanciu, M. 2020, Research regarding consumers attitude, in relation with poultry meat purchase and consumption. Case study Sibiu, Romania. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", 20(1):125-130. https://managementjournal.usamv.ro/pdf/vol.20_1/Art17.pdf, Accessed on 2 January, 2025.

[7]Chihaia, A., Costaichie, G.M., Arghiroiu, G.A., Beciu, S., 2017, Comparative study of inland production and consumption of poultry meat in Romania. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development",17(3): 95-100. https://managementjournal.usamv.ro/pdf/vol.17_3/Art12.pdf, Accessed on 2 January, 2025.

[8]Dalle Zotte, A., Tasoniero, G., Puolanne, E., Remignon, H., Cecchinato, M., Catelli, E., Cullere, M., 2017, Effect of "Wooden Breast" appearance on poultry meat quality, histological traits, and lesions characterization. Czech Journal of Animal Science, 62: 51–57.DOI:https://dx.doi.org/10.17221/54/2016-CJAS

[9]Damme, K., 2015, Economics of dual-purpose breeds - A comparison of meat and egg production using dual purpose breeds versus conventional broiler and layer strains. LOHMANN Information, 50 (2): 4–9. https://lohmann-breeders.com/lohmanninfo/economics-of-dual-purpose-breeds/, Accessed on 20 November, 2024.

[10]De Wilde, E., Cooke, A. D. J., Janiszewski, C., 2009, Attentional contrast during sequential judgements: A source of the number-of-levels effect. Journal of Marketing Research, 45: 437–449. DOI:https://doi.org/10.1509/jmkr.45.4.437

[11]Eggers, F., Sattler, H., 2009, Hybrid individualized two-level choice-based conjoint (HIT-CBC): A new method for measuring preference structures with many attribute levels. International Journal of Research in Marketing, 26(2): 108–118. DOI:https://doi.org/10.1016/j.ijresmar.2009.01.002

[12]Faostat, 2024, Crops and livestock products,https://www.fao.org/faostat/en/#data/QCL, Accessed on 16 November, 2024.

[13]Gossard, H.M., York, R., 2003, Social structural influences on meat consumption. Human Ecology Review,10: 1–9. DOI:https://www.jstor.org/stable/24707082

[14]Leenstra, F., Munnichs, G., Beekman, V., Van den Heuvel-Vromans, E., Aramyan, L. and Woelders, H., 2011, Killing day-old chicks? Public opinion regarding potential alternatives, Animal Welfare, 20 (1): 37-45. DOI:https://doi.org/10.1017/S0962728600002414

[15]Magdelaine, P., Spiess, M. P., Valceschini, E., 2008, Poultry meat consumption trends in Europe. World's Poultry Science Journal, 64:53–64. DOI:https://doi.org/10.1017/S0043933907001717

[16]Mueller, S., Messikommer, R. E., Kreuzer,M., Gangnat, I. D. M., 2016, Laying performance of layer vs. dual purpose genotypes under low methionine supply. 5th EAAP International Symposium on Energy and Protein Metabolism and Nutrition, Kraków, Poland, September 12-15, 2016. DOI:https://doi.org/10.3920/9789086868322_113

[17]Mueller, S., Taddei,L., Messikommer,R. E., Kreuzer,M., Gangnat,I. D. M., 2017, Carcass and meat quality of dual-purpose poultry types vs. extensive broiler and layer types fattened for 67 and 84 d. Proceedings of 62nd International Congress of Meat Science and Technology, Bangkok, Thailand. https://digicomst.ie/wp-content/uploads/2020/05/2017_06_08.pdf, Accessed on 12 December, 2024.

[18]Ozkan, G., Er S., Gurbuz, I.B., 2023, Consumer dynamics for poultry purchasing behaviour in Turkey. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", 23(1):491-502.https://managementjournal.usamv.ro/pdf/vol.23_1/Art54.pdf, Accessed on 2 January, 2025.

[19]Petracci, M., Mudalal, S., Soglia, F., Cavani, C., 2015, Meat quality in fast-growing broiler chickens. World's Poultry Science Journal, 71: 363–374. DOI:https://doi.org/10.1017/S0043933915000367

[20]Ramel, A., Nwaru, B.I., Lamberg-Allardt, C., Thorisdottir, B., Bärebring, L., Söderlund, F., Arnesen, E.K., Dierkes, J., Åkesson, A, 2023, White meat consumption and risk of cardiovascular disease and type 2 diabetes: a systematic review and meta-analysis. Food& Nutrition Research, 67. DOI:https://doi.org/10.29219/fnr.v67.9543

[21]Vinci, C., 2022, Male chick culling. European Parliamentary Research Service, PE 739.246.https://www.europarl.europa.eu/RegData/etudes/ATAG/2022/739246/EPRS_ATA(2022)739246_EN.pdf, Accessed on 21 November, 2024.

[22]Vizzier Thaxton, Y., Christensen, K.D., Mench, J.A., Rumley, E.R., Daugherty, C., Feinberg, B., Parker, M., Siegel, P., Scanes, C.G., 2016, Symposium: Animal welfare challenges for today and tomorrow. Poultry Science, 95(9):2198-2207. DOI: https://doi.org/10.3382/ps/pew099

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STUDY ON ROMANIAN RURAL TOURISM BASED ON AUTHENTICITY CRITERIA FOR VERNACULAR HERITAGE

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Abstract

The socio-cultural heritage in rural tourism highlights the unique traditional lifestyles of local communities, offering both diversity and genuinely authentic experiences. Vernacular culture, characterized by enduring traditional principles, norms, values, knowledge, habits, practices and material things, encompasses, among others, rural architecture, interior decor, customs, traditions, and local gastronomy - these compounds being facets of authenticity concept in rural tourism. This paper presents the results of a questionnaire on the specific facets mentioned above, applied to tourists from an authentic Romanian guesthouse to assess the impact of vernacular cultural elements on perceptions of authenticity in rural tourism. The results indicate that the vernacular concept is not well recognized by tourists, underscoring the need for greater emphasis on its impact and relevance to agritourism activities. Given the criteria for local authenticity, customers play a crucial role in selecting guesthouses to further support and promote vernacular tradition and local specificity in rural tourism.

Key words**:** *vernacular heritage, authenticity criteria, rural tourism, questionnaire survey*

INTRODUCTION

Perception of the cultural offerings of a tourist destination plays an essential role in its selection. Cultural heritage tourism not only conserves and valorizes the legacies of the past but also has socio-cultural and economic implications, contributing to the sustainable development of local communities.

UNESCO defines **heritage** as "our legacy from the past, what we enjoy in the present, and what we pass on to future generations"(UNESCO Convention, 1972) [13], emphasizing the importance of understanding the past within the context of the present (Poria, 2009) [11]. According to the Faro Convention, **cultural heritage** encompasses the entirety of historical, social, and natural resources that individuals identify as expressions of their values and traditions, resulting from the interaction between people and places over time (CETS 199, 2005) [2].

Cultural heritage tourism involves the exploration and interpretation of both tangible and intangible elements of the past (Kaminski, 2014) [8], characterized by the following features:

-it valorizes historical, socio-cultural, and natural resources;
-it offers significant educational experiences;
-it integrates lifestyles, arts, and contemporary cultural expressions;
-it is dynamic, adapting to changing social and cultural contexts.

An important segment of heritage tourism is **vernacular heritage**, which reflects the everyday life of ordinary people in the past. That species of rural tourism that capitalizes among the resources available in the rural space on those that are directly and necessary correlated regional/national with identity the heritage, zonal, are recognizable, coherent in the respective space and informally transmitted, which ensured the cohesion, authenticity and specificity (originality) of a community during its history (Dobre, 2024) [5]. This contributes to the strengthening of cultural identity and can become a strategic criterion for development (Timothy, 2011) [12].

In this context, **rural tourism represents an authentic form of heritage tourism**, where nature and culture are integrated into a traditional, vernacular lifestyle. It saved tourism during the Covid-19 pandemic attracting tourists to rediscover Romania's beautiful landscapes and hospitality [3, 4]. The valorization of rural heritage contributes both to the economic development of local communities and to the creation of authentic, relevant, and sustainable tourist experiences.

Consumer tourism directs tourists toward recreational, enjoyable, and easily accessible activities (Boorstin,1992) [1]. However, despite the growing interest in authentic experiences, tourists are often led toward artificial contexts that lack authenticity (MacCannell, 2013) [9].

Vernacular tourism contributes to the construction of a social reality based on meaning and significance, providing tourists with an authentic understanding of (Romanian) cultural **identity**. Heritage tourism facilitates a deep connection between tourists and a complex network of meanings, significances, and cultural values. The **authenticity** of an object is the result of a dynamic and continuous process of "negotiation" that supports and strengthens relational networks, integrating people, places, and objects within the same world (Moore, 2021) [10].

Rural tourism is seen overall as a way of preserving the natural and human qualities of a destination combined with cultural tourism, it contributes both to education and to increase the quality of life for those who practice these forms of tourism (Dobre, 2024a and 2024b) [6, 7].

Building on these considerations, this study is guided by the following research questions: Do Romanians still value their vernacular rural heritage? If so, why? To explore this broader inquiry, we examine specific aspects, such as the types of experiences tourists seek. Are they more drawn to entertainment and leisure, or do they desire authentic experiences?

Accordingly with the research interrogation, **the goal** of this study results in presenting and analysing the research data referring to the authenticity criteria from vernacular culture, and the main **objectives** are: first - identifying the importance of each criterion in respondents' perception and second - analysis and interpretation of their inner motivation which determined their responses.

MATERIALS AND METHODS

As this study analyzes tourists' perceptions of elements of vernacular cultural heritage within the context of rural tourism, the present research is focused on the **components of the vernacular concept** as shown in Table 1.

Table 1. Analysis of vernacular concept applicable to rural tourism

***Vernacular* main components**
✓ rural landscape
✓ architecture of the guesthouse
✓ room decoration
✓ gastronomy
✓ traditions and customs
✓ crafts (craft workshops)
✓ rural household activities
✓ local folk costumes
✓ significant places (circuits)

Source: own processing.

Data collection

To investigate tourists' perceptions and preferences, a mixed questionnaire was used, including both quantitative and qualitative items, each of them addressing a component of the vernacular concept (Table 1):

-the quantitative items were formulated on a five-point Likert scale, assessing the preference for authentic tourism and the importance of each component of vernacular heritage;

-the qualitative items aimed to explore the motivations underlying the tourists' perceptions for each component.

Note: within the questionnaire, we paired each quantitative item with a qualitative one for each component of *vernacular* concept.

Furthermore, the instrument utilized in this study is an original one designed specifically to assess the impact of vernacular heritage elements on tourists. It aims not only to measure tourist preferences, but also to understand how the experiences offered in a guesthouse influence perception of Romanian

cultural authenticity in rural settings. That is why this questionnaire allows to explore the relationship between exposure to vernacular heritage and the appreciation of traditional values, providing insight into how rural tourism contributes to the strengthening of cultural identity.

Sample, time interval for data collection and collecting method

Data was collected from October 1 to December 31, 2024 by applying the questionnaire to 33 tourists hosted by Satul Banului Guesthouse. The socio-demographic peculiarities of the sample are already accurately described in (Dobre, 2023, 2024). The questionnaires were distributed to the subjects in printed form and they were required for self-filling in.

Data analysis method

For data processing, SPSS software was used, applying descriptive statistics to identify trends and preferences of tourists concerning the elements of vernacular heritage. Complementary to the descriptive statistics we applied the qualitative analysis of the responses regarding the motivation in assessing the criteria.

RESULTS AND DISCUSSIONS

The results are presented accordingly to the categories of items in the questionnaire, including both quantitative and qualitative aspects that reflect tourists' preferences for authentic tourism and the valorization of Romanian cultural heritage in rural environments.

Quantitative analysis

Tourists' preference for authentic tourism

The analysis of responses indicates that 90.9% of tourists prefer the tourist experience in an authentic guesthouse compared to the offerings of classic tourism.

The choice of this type of experience is influenced by several factors, including the diversity and personalization of the tourism offer, the integration of authenticity elements, and the opportunity to learn about and explore the local cultural identity.

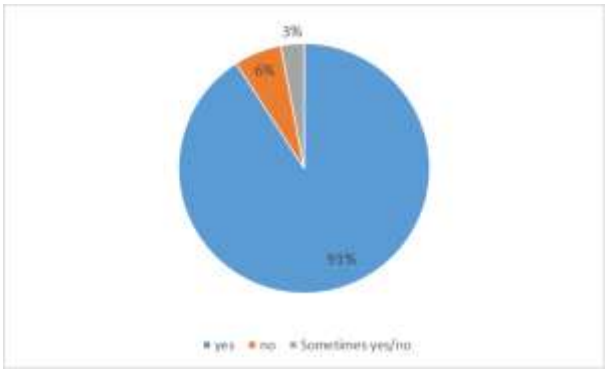

Fig. 1. Preference for authentic tourism
Source: own processing.

These aspects highlight the importance of vernacular cultural heritage in shaping a valuable and relevant tourist experience for visitors. (Figure 1)

The importance of the rural landscape

The Romanian rural landscape is distinguished by the diversity of its relief and the specific cultures of each region, significantly contributing to the authenticity of the tourist experience. In this context, 54.5% of tourists consider the rural landscape to be very important, while 33.3% regard it as important in evaluating the authenticity of the tourist guesthouse. These percentages highlight the essential role of the landscape in visitors' perceptions of the authenticity of the rural tourism offering (Figure 2).

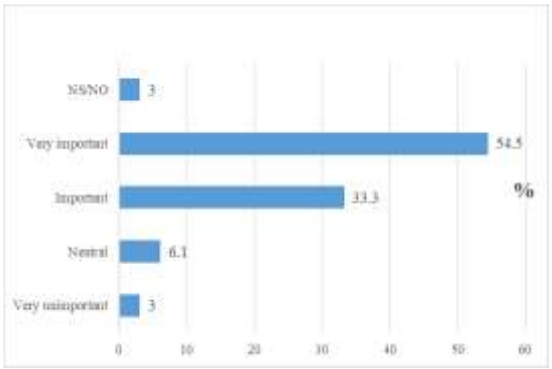

Fig. 2. The importance of rural landscape
Source: own processing.

The importance of the architecture of the tourist guesthouse

Eeach region of Romania has specific architecture characterized by traditional styles in the construction of houses and farm annexes, which significantly contribute to the authenticity of the tourist destination. In this context, a majority of respondents consider the

architecture of the guesthouse to be very important - 57.6%, while 24.2% regard it as important. These results underscore the wide appreciation among tourists for architectural authenticity within rural tourism (Figure 3).

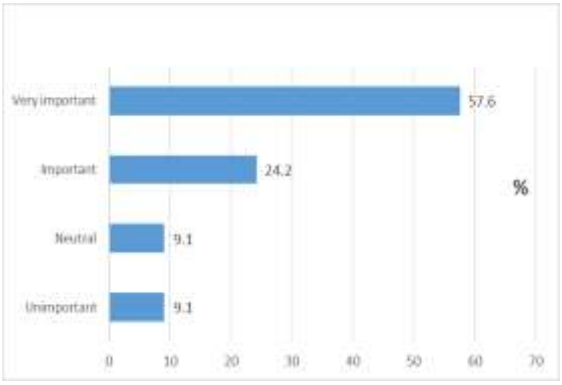

Fig. 3. The importance of architecture
Source: own processing.

The importance of room decoration

The functionality of the rural household directly impacts how the rooms are arranged and decorated, with traditional elements such as handwoven cloths and pottery being used to create an authentic and region-specific decor. These decorative components are considered important by 27.3% of respondents and very important by 39.4%, highlighting the essential role of authenticity in the decoration of the guesthouse rooms (Figure 4).

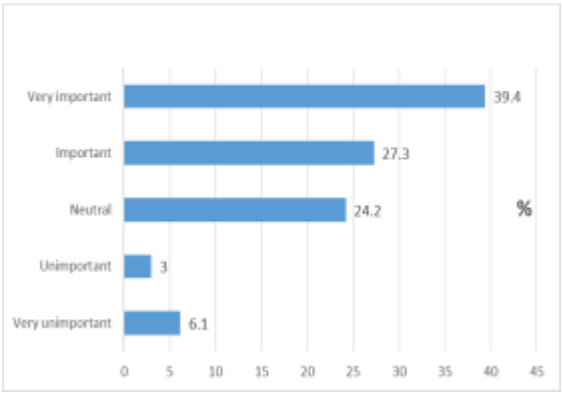

Fig. 4. The importance of room design
Source: own processing.

The importance of gastronomy

Authentic Romanian gastronomy, with its blend of spices and flavors that evoke childhood memories, family moments, and traditional celebrations, plays a central role in the tourist experience. It is considered very important by 63.6% of respondents and important by 21.2%, emphasizing the profound connection between tastes, tradition, and the sense of belonging to an authentic cultural community (Figure 5).

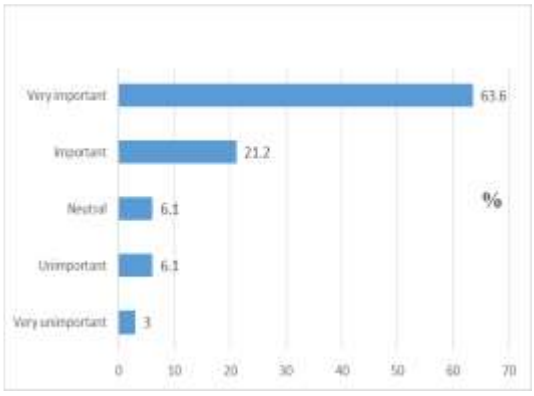

Fig. 5. The importance of gastronomy
Source: own processing.

The importance of participating in traditions and customs

The rural lifestyle, with its simplicity and authenticity, plays an essential role in the appreciation of local traditions and customs. These are considered very important by 36.4% of respondents and important by 9.1%, highlighting the relatively lesser value that tourists attribute to the preservation and transmission of the rural community's authentic traditions. Additionally, 39.4% of participants view the discovery of local traditions as a neutral objective. While not a priority for all tourists, some do not place particular emphasis on this aspect of the tourist experience.

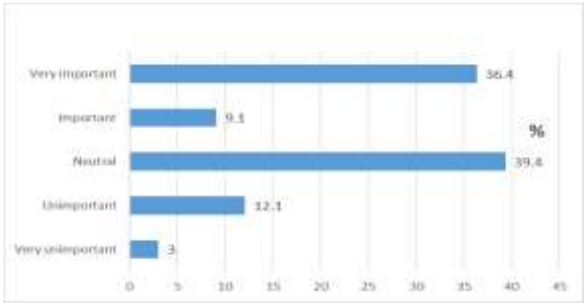

Fig. 6. The importance of participating in traditions and customs
Source: own processing

These results indicate a diversity of perceptions among visitors, reflecting both an opportunity for more active promotion of local

traditions and a greater openness to other forms of authentic tourism (Figure 6).

The importance of participating in craft workshops

The appreciation of rural intelligence and creativity manifested through traditional crafts is perceived differently by tourists. A percentage of 39.4% of respondents consider this activity neutral, suggesting a relative indifference towards direct involvement in the process of learning traditional crafts. However, 18.2% of participants value the importance of crafts, while 24.2% regard them as very important, recognizing their cultural and educational value. This diversity of responses indicates that, although some tourists do not prioritize participation in craft workshops, others acknowledge their essential role in preserving and transmitting traditional knowledge, as well as in developing an authentic learning experience and interaction with local crafts (Figure 7).

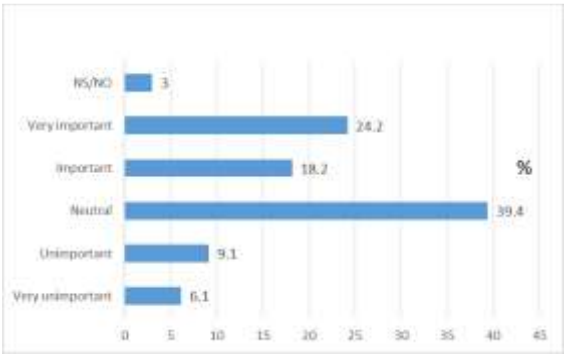

Fig. 7. The importance of crafts workshops
Source: own processing.

The importance of specific rural activities within the household

Such a participation within the guesthouse is considered very important by 36.4% of respondents, highlighting the appreciation for the direct involvement of tourists in the everyday life of the rural household. These activities allow visitors to authentically experience the rural lifestyle, bringing them closer to the realities of a simple life connected to traditional household tasks. In this context, the rural lifestyle not only enriches the tourist experience but also makes tourists aware of the profound connection between humans and nature, emphasizing the importance of direct interaction with the surrounding environment and natural resources. This active engagement helps reinforce a sense of authenticity and closeness to rural traditions, and for many tourists, participating in household activities becomes an essential element of their experience (Figure 8).

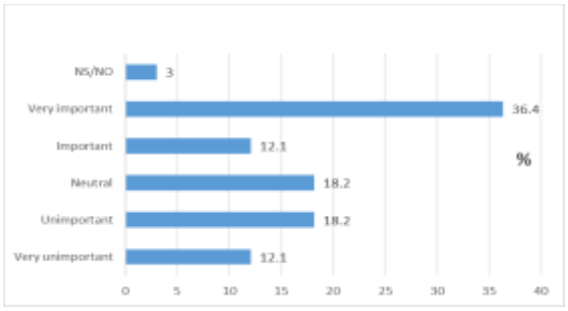

Fig. 8. The importance of rural specific activities within the household
Source: own processing.

The importance of the folk costume

Folk costume represents a fundamental element of cultural identity, serving to convey information about social status, material wealth, and the traditions of the community in which it is worn. It reflects the values, history, and customs of a region, symbolizing the close connection between the individual and their community. Within the tourist guesthouse, the folk costume is appreciated by 33.3% of respondents as important in the context of the activities carried out. This appreciation underscores its essential role in creating an authentic atmosphere where tourists can better experience and understand local traditions and culture.

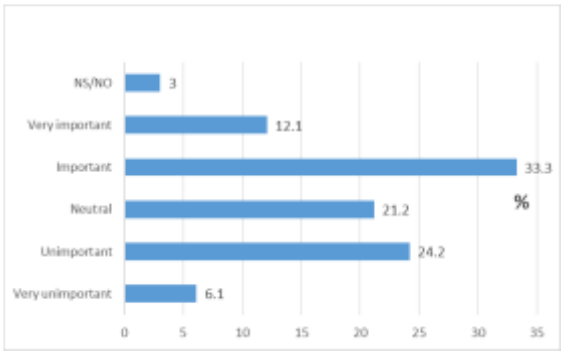

Fig. 9. The importance of the folk costumes.
Source: own processing.

The folk costume not only enriches the tourist experience but also helps strengthen the connection between visitors and the rural

community, providing a deeper perspective on regional history and identity (Figure 9).

The importance of local cultural circuit

Understanding the cultural identity of a region is essential for comprehending the values and traditions that define it. Organizing tourist circuits that include key elements of local history, tourist attractions, and specific traditions of the area deepens the tourist experience and strengthens visitors' connection to the places they explore. In this regard, 33.3% of respondents consider participation in local cultural circuits to be important, while 27.3% rate it as very important. These percentages underscore that, for tourists, a profound knowledge of the area's history and culture within a travel circuit represents a significant aspect of their experience. The local cultural circuit not only allows for a detailed understanding of the region's past but also facilitates a more personal connection with the visited places through the authentic exploration of the historical and cultural heritage of the area (Figure 10).

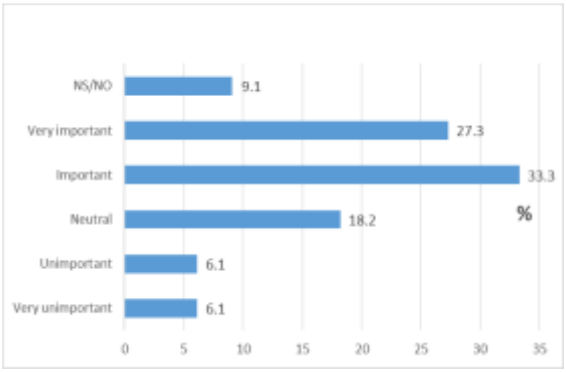

Fig. 10. The importance of local cultural circuits
Source: own processing.

The questionnaires also collected the motivations underlying the responses to highlight defining aspects of the tourist experience for each respondent. The information obtained is indicative of the authenticity of the tourist experience in alignment with the authenticity of the visited place. Statements such as “It is different from the standard, it is authentic”, “it values local resources to create a traditional environment” are accompanied by strong impressions and emotions like “It reconnects me with the roots, it reminds me of my childhood” and “It makes us feel free and peaceful to relive the most beautiful childhood memories”. These responses emphasize the profound impact of authentic local rural heritage on tourists’ experience, which goes beyond merely appreciating the place, evoking personal feelings and memories. The motivation for the importance of the vernacular cultural heritage, studied through various items, was reflected in tourists' responses as follows:

- ***Motivation for the importance of the rural landscape***

The rural landscape is perceived as an essential element for reconnecting with nature and the authenticity of a place. Experiences in this setting help tourists disconnect from often overwhelming urban lifestyles, providing them with a *"break from exhausting urban life, relaxation,"* making them feel *"free and at peace"* by offering an oasis of tranquility and reflection. Statements like *"It reconnects me with my roots""It reminds me of childhood"* demonstrate the strong emotional impact and connection to roots and childhood memories. Expressions such as *"The landscape transports you to a traditional universe," "I am a great fan of nature," "The village's authenticity must be preserved"* indicate the desire for the rural landscape to be included in a heritage that must be protected and preserved. Comments like *"It is different from the standard offerings," "To reconnect with authenticity," "To experience a complete connection with nature and authenticity,"* and *"It is important to respect traditions"* highlight the complexity of the tourist experience, fostering knowledge of the natural setting and loyalty to certain places. Thus, the profound impact of the rural landscape on visitors and its importance in preserving traditions and the connection with nature is clearly reflected.

- ***Motivation for the importance of the architecture of the tourist guesthouse***

The architecture specific to each region harnesses local natural and cultural resources, while being harmoniously integrated into the local landscape. It reflects the characteristics of the area and contributes to the authenticity of the tourist experience. Tourists appreciate the architecture of the guesthouse because it *"is authentic, valuing local resources,""for accumulating a basic understanding of the*

field," "to relive the most beautiful childhood memories," "it is important to respect traditions," "it must integrate naturally into the landscape," and "it represents the area and helps you discover it better." At the same time, some opinions highlight a more critical perspective: *"It is not that important"* or *"Authentic houses are affected by elements of modernity, which affects their authenticity"*. Such comments illustrate both the appreciation for traditional architecture and the challenges related to maintaining authenticity in the face of modern influences.

- ***Motivation for the importance of room design***

The traditional arrangement of rooms plays a crucial role in creating an authentic atmosphere that revives a deep connection with family life and the spirit of childhood. Some tourists emphasize that room design is essential for *"creating a traditional environment"* and *"experiencing a complete cultural immersion."* Additionally, many consider that interior design should form a *"harmonious whole,"* where each decorative element contributes to conveying a coherent message about the local identity and regional traditions. Comments such as *"It reminds us of childhood"* suggest the profound emotional connection that tourists have with traditional elements, which evoke personal memories related to family and cultural roots.

Furthermore, some visitors highlight the role of room design as a *"bridge of communication between guests and tradition,"* indicating that decor not only reflects local heritage but also facilitates a deeper understanding of it. In this regard, the importance of using *"traditional objects in a comfortable manner"* is frequently mentioned, as it ensures the preservation of authenticity while simultaneously addressing the modern needs of visitors.

- ***Motivation for the importance of gastronomy***

Local gastronomy plays a central role in showcasing a region's natural resources, serving as both a medium for tradition and an expression of an authentic way of life. Many tourist responses highlight their appreciation for *"local flavors and products, as well as supporting the community,"* suggesting a strong connection between culinary experiences and the reinforcement of local economies. Some respondents emphasize the importance of culinary diversity, stating that they *"prefer a combination, not 100% authentic,"* indicating a willingness to integrate modern elements into traditional cuisine to better suit contemporary tastes.

However, the majority of visitors stress the importance of preserving culinary traditions, asserting that *"it is important because it keeps local traditions alive and preserves a distinctly Romanian taste."* A strong emphasis is also placed on the quality of the food, with many tourists valuing *"high-quality dishes made with local ingredients, following authentic recipes,"* as well as *"simple, tasty, and healthy traditional recipes."* These responses reflect both a deep respect for culinary authenticity and a growing interest in healthy, locally sourced food that aligns with regional traditions.

Additionally, statements such as *"it reminds me of the flavors of my childhood"* highlight the profound emotional connection tourists have with local gastronomy, evoking memories from the past and reinforcing a sense of cultural belonging. Conversely, some tourists exhibit a more cautious approach toward unfamiliar dishes, with remarks like *"I don't like trying new things,"* illustrating a preference for familiar and comforting flavors over culinary exploration.

In this context, the importance of maintaining *"the traditional way of preparing food"* is seen as essential for safeguarding and transmitting Romania's authentic gastronomic heritage to future generations.

- ***Motivation for the importance of participating in local traditions and customs***

Tourists' motivations for engaging in local traditions and customs are diverse. Firstly, some respondents view participation as a means of *"learning about and passing down folk traditions to future generations,"* emphasizing the significance of preserving and perpetuating authentic cultural heritage. This perspective reflects a deep respect for cultural patrimony and a commitment to its conservation, particularly in the face of globalization's challenges.

Other tourists see involvement in traditions as an opportunity *"to keep them alive and be part of them,"* highlighting the need to maintain a connection with the customs that once defined community life. Some are drawn to the educational value of these experiences, stating that participation is a way *"to enrich their general knowledge"* and *"gain a deeper understanding of local folklore."*

At the same time, certain tourists perceive traditions and customs as a form of passive recreation, showing a preference for being spectators rather than active participants. They express enjoyment in *"watching someone well-prepared for such events"* or state that they *"prefer to relax and observe rather than engage."* These viewpoints suggest that, for some visitors, traditional experiences serve primarily as an opportunity for appreciation and cultural observation rather than hands-on involvement.

Another segment of respondents considers participation in traditions and customs as a way *"to escape urban stress and learn about folklore,"* viewing it as a means of relaxation and spiritual renewal.

Overall, local traditions offer tourists a unique opportunity to disconnect from urban life and immerse themselves in the cultural authenticity of the local community.

- ***Motivation for the importance of participating in craft workshops***

Active engagement in traditional crafts such as weaving, pottery, or painting enables tourists to develop a deeper appreciation for the significance of these practices and the dedication of artisans who preserve local history and cultural identity. These artisans are often regarded as *"human treasures"* who not only safeguard traditional crafts but also pass them down to future generations, ensuring their continuity.

Tourists' motivations for participating in such workshops vary. Many view craft activities as *"a way to prevent the loss of traditions,"* while for families with children, these workshops serve as *"an educational, engaging, and interactive activity"* that fosters younger generations' interest in preserving traditional craftsmanship. Additionally, taking part in craft workshops provides visitors with *"the satisfaction of actively contributing to the creative process,"* adding significant value to their tourism experience.

However, some tourists feel that the time allocated for these activities is insufficient to explore them in depth, while others express a preference for *"a more passive approach, depending on mood or time of day."* Despite these perspectives, the majority of responses emphasize the importance of such workshops both in preserving traditions and in fostering a deeper respect for craftsmanship and local culture.

- ***Motivation for responses referring to activities in the traditional peasant household***

The traditional peasant household functioned as a self-sufficient space where essential daily activities were carried out to sustain rural life. Engaging tourists in these activities provides them with a deeper understanding of not only the simplicity and modesty of rural existence but also the challenges faced by those living in such environments.

Tourist impressions reveal a diverse range of perspectives regarding these activities. While some express nostalgia recalling personal experiences, others show less enthusiasm: *"I'm not particularly interested in these activities", "I lived them in childhood. That was enough."* However, many visitors recognize the cultural and educational value of these practices. One tourist notes: *"It is pleasant to discover the activities of our ancestors,"* while another highlights the importance of *"connecting with folk traditions"*. For some, participation is driven by a desire to educate the younger generation: *"It is important for the child."* or simply for leisure: *"I participate for recreation."* Others see it as an opportunity to honor past generations *"To value the work of the ancestors."* or to revisit childhood memories *"To remember childhood."*

These reflections suggest that while not all tourists are equally engaged in traditional peasant household activities, many recognize their role in preserving and transmitting cultural heritage.

- ***Motivation for the importance of the folk costume***

The folk costume is a fundamental element in preserving cultural identity, serving as a symbol of the traditions and values unique to each region. Its promotion, particularly among younger generations, plays a crucial role in the transmission and perpetuation of vernacular culture, ensuring the continuity and recognition of authentic traditions from one generation to the next.

Tourist impressions reflect a range of perspectives on the significance of the folk costume. While some do not see it as essential, they still express admiration: *"It's not a criterion, but I admire it."* Others emphasize its role in cultural preservation: *"For the preservation of the cultural and historical identity."* and its connection to specific events: *"Wearing the folk costume related to a specific event."* However, some view it as less relevant in a contemporary context:*"It seems irrelevant to me for the moment in time we are living in."* At the same time, many appreciate the folk costume's aesthetic and symbolic value. One tourist notes that it *"gives a picturesque air to the place,"* while another highlights its function in distinguishing regional identities*" To differentiate the people from different areas."* Additionally, some see it as a marker of cultural pride: *"It shows that one proudly wears its costume and treasures local traditions."* and recognize the importance of sustaining traditional craftsmanship saying that *"It is necessary to know and stimulate the crafts related to the folk costume."*

These reflections illustrate the varying degrees of significance attributed to the folk costume, ranging from admiration and cultural pride to concerns about its contemporary relevance. Nonetheless, its role in preserving and celebrating regional heritage remains widely acknowledged.

- ***Motivation for the importance of cultural circuits***

Cultural circuits play a crucial role in helping tourists gain a deeper understanding of the ethno-cultural characteristics of each region. By engaging in these guided experiences, visitors can explore the historical, architectural, and social dimensions of a destination, enriching their overall travel experience.

Tourist impressions highlight various motivations for participating in cultural circuits. Many see them as an opportunity for learning and personal development: *"For the development and accumulation of new knowledge."* Others are drawn to the exploration aspect, appreciating the chance to *"discover the area, new information, memories."* A significant number of visitors value the architectural insights provided by such circuits: *"To get to know the architecture of the area."* or use them as a tool to *"better understand the specifics of the area."*

However, perspectives on their importance vary. Some tourists consider cultural circuits less relevant: *"Not important"*, while others acknowledge that their appeal depends on individual travel preferences *"Depends on the type of tourist: active/relaxed."*Practical considerations also emerge, with some valuing cultural circuits for their *"access to various services."* Additionally, a few travellers emphasize their role in providing enriching experiences for younger generations, *"To give your child this experience."*

These diverse viewpoints suggest that while cultural circuits are not universally prioritized, they remain a valuable means of engaging with local heritage, offering both educational and experiential benefits tailored to different types of travellers.

Finally, it is necessary to note **the limits of this study that must be taken into account**:

-***Sample size*** – The number of respondents (33 tourists) is relatively small, which may affect the representativeness of the results. A larger sample would have allowed for a more robust generalization of the conclusions.

-***Specific context of data collection*** –The questionnaires were administered exclusively to tourists accommodated at the Satul Banului Guesthouse, which may limit the diversity of perceptions. The results could be influenced by the specific characteristics of this accommodation facility and the surrounding area.

-***Subjectivity of responses*** – In the case of qualitative items, tourists' responses are shaped by their personal experiences and expectations, which may introduce a degree of subjectivity into the interpretation of the data.

-***Data collection period*** – The study was conducted between October 1 and December 31, a timeframe that could influence tourists' perceptions due to the seasonality of rural tourism and traditional activities.

-***Methodological limitations*** – The use of descriptive statistics in data analysis provides a general overview of trends but does not allow for the establishment of causal relationships between variables. A more in-depth analysis using inferential techniques could offer additional insights into the factors influencing tourists' preferences.

Still, limitations suggest directions for future research, such as expanding the sample size, diversifying data collection locations, and employing more advanced analytical methods to achieve a deeper understanding of tourists' perceptions of vernacular heritage.

CONCLUSIONS

The analysis conducted in this study has demonstrated that vernacular tourism plays a crucial role in providing an authentic and immersive experience, allowing tourists to discover and appreciate the rural lifestyle and the cultural values unique to each region.

The results indicate that the concept of vernacular tourism in rural areas is not widely recognized by tourists, emphasizing the need for greater awareness of its impact and significance within agritourism activities. Key components of this form of tourism–such as local gastronomy, traditional architecture, rural landscapes, customs and traditions, participation in craft workshops, and cultural circuits–are highly valued by visitors and considered essential for the authenticity of the tourism experience.

Respondents' answers highlight both the importance of these elements and their motivations for engaging in such experiences, reflecting a profound desire to connect with the cultural roots of the visited region. Consequently, this study not only identifies tourists' preferences and expectations but also underscores the value of vernacular tourism as a means of preserving and promoting cultural heritage, offering a sustainable development opportunity for rural destinations.

Taking into account local authenticity criteria, customer preferences play a crucial role in selecting agritourism guesthouses, thereby contributing to the support and promotion of vernacular, traditional, and locally distinctive elements in rural tourism. Vernacular tourism provides a unique and authentic experience by immersing tourists in the rural lifestyle and fostering direct interaction with local traditions and customs.

The motivations for engaging in these aspects are clearly reflected in the responses, reinforcing the authenticity of the tourism experience and its alignment with the specific character of the visited location.

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REFERENCES

[1]Boorstin, D. J., 1992, The image: A guide to pseudo-events in America. Vintage.

[2]CETS 199 - Council of Europe Framework Convention on the Value of Cultural Heritage for Society, 2005, https://rm.coe.int/1680083746, Accessed on 5 February 2024.

[3]Dobre, C.A., Iorga, A.M., Stoicea, P., 2022, Authentic Romanian and rural tourism in the Sub-Carpathian Muntenia area. Original case study "Satul Banului guesthouse" . Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 22(2), 293-300.

[4]Dobre, C.A., Stoicea, P., Iorga, A.M., 2023, The pandemic, a chance for an authentic Romanian rural tourism. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 23(2), 201-206.

[5]Dobre, C. A., Zaharia, I., Iorga, A. M., 2023, Authenticity in Romanian Rural Tourism - Defining a Concept. Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development, 23(4), 253-260.

[6]Dobre, C. A., Iorga, A. M., Zaharia, I., 2024a, Preliminaries on the agritourism tourist's typology in Romania. Case Study Satul Banului Guesthouse, Prahova County. Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development, 24(2), 425-430.

[7]Dobre, C.A., Balan, A.V., Stoicea, P., Iorga, A.M., 2024b, Romanian rural tourism in guesthouses - evolution perspectives. Scientific Papers. Series

"Management, Economic Engineering in Agriculture and Rural Development", Vol. 24(2), 419-424.
[8]Kaminski, J., Benson, A. M., Arnold, D., 2014, Contemporary Issues in Cultural Heritage Tourism, Routledge 2 Park Square, Milton Park, Abingdon, Oxon OX14 4RN.
[9]MacCannell, D., 2013, The tourist: A new theory of the leisure class. Univ of California Press.
[10]Moore, K., Buchmann, A., Månsson, M., Fisher, D., 2021, Authenticity in tourism theory and experience. Practically indispensable and theoretically mischievous? Annals of Tourism Research, 89C, 103208.
[11]Poria, Y., Ashworth, G., 2009, Heritage Tourism - Current Resource for Conflict, Annals of Tourism Research, 36(3), 522-525.
[12]Timothy, D. J., 2011, Cultural heritage and tourism: An introduction, Bristol: Channel.
[13]United Nations Educational, Scientific and Cultural Organization. "Convention for the Protection of the World Cultural and Natural Heritage." UNESCO Digital Library,
1972, https://unesdoc.unesco.org/ark:/48223/pf0000133369. Accessed on February 5, 2025.

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INFORMATION ECONOMY AND THE NEXUS OF ICT AND GROWTH

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Abstract

In recent years, the development of the information economy, as part of the knowledge economy, is seen as closely related to the aspects of digital and telecommunication impact and efficiency. Modern theories of economic growth focus on the contribution of ICT, research and development (R&D) and innovation to stimulate growth, while digital technologies are considered to increase inclusion in the knowledge economy. The article aims to identify and analyze key indicators that define the information economy's progress and its relationship with GDP growth. It investigates both widely used and less explored ICT-related metrics, resulting in a systematic classification of existing indicators used to assess the information economy's impact on economic expansion. Findings highlight the e-government index, the online services index and telecommunications infrastructure as the reliable measures. In contrast, the productive capacities index, although indicative, is less suitable for practical application due to its complexity and focusing on narrower aspects of information economy such as ICT accessibility.

Key words**:** *knowledge-based economy, GPD growth, ICT index, information economy*

INTRODUCTION

The information economy represents the next phase in economic evolution following industrialization. It integrates the key elements from digital, Internet and knowledge economies; emphasizes the similar importance of technological, human capital and innovation; applies information and communication technologies (ICT); and focuses on the effective creation, storage and utilization of information [40]. It added a new meaning to these concepts by positioning the information as the most valuable resource and prioritizing seamless, continuous interaction between economic agents within socio-economic systems.

In the development of modern society, the change in the laws of micro- and macroeconomic development of the territory through the dominance of the information effect allows us to conclude about the leading role of information [37]. Information was integrated into theoretical laws and concepts in post-industrial society and applied as quantitative indicators of economic growth (which includes Gross domestic product (GDP)).

The contribution of information to overall economic performance is related to the amount of resources devoted to ICT, human resource development, and the creation of an enabling environment, among other factors. In particular, the information revolution is a major driver of economic change, restructuring businesses, affecting skills and employment, contributing to growth and facilitating the opening of markets through the broader and faster flow of information and knowledge.

The study of the factors driving economic growth has been a key area of research in macroeconomics, leading to the development of various growth theories. In classical and neoclassical growth models, the main factors are labor, land, and physical capital while in modern ones they emphasize the role of technology, R&D, and knowledge, arguing that economic growth is largely dependent on investment in ICT. ICT plays a crucial role in facilitating trade, regional integration, knowledge sharing, cross-border communication, financial transactions, and improving living standards.

The present study attempts to contribute to the existing scientific literature by exploring and examining the impact of additional measures of ICT on GDP growth. The results of the study

can be used for future scientific research in examining the development and role of the information economy.

L**iterature review**

Although the idea of the information economy emerged at the end of the 18th century, it gained momentum and was developed at the end of the 20th century, following the rise of the Internet and related technologies. Seen as the subsequent stage of economic progression after industrialization, it plays a central part of evolution of the modern information society. The information economy is deeply connected to the new forms of socio-economic interactions that have developed through both electronic and real-world information exchange and ongoing generation of new information. Considering the various definitions [3, 32, 42], it can be concluded that the information economy is an economic system in which the main part of the GDP is formed by intellectual and innovative activities, and in which digital technologies are used for the production, processing, storage, exchange and distribution of information and information products. In turn, this allows new knowledge and innovations to be extracted, which will help solve countries' socio-economic problems effectively and create and offer higher value to consumers to expand connectivity. Information is becoming a key competitive advantage and plays a vital role in globalization in the information society.

The contribution of information to overall economic performance is related to the amount of resources devoted to ICT, human resource development, and the creation of an enabling environment, among other factors. In particular, the information revolution is a major driver of economic change, restructuring businesses, affecting skills and employment, contributing to growth and facilitating the opening of markets through the broader and faster flow of information and knowledge. The modern global information economy is fundamentally driven by intangible assets, information, innovation and creativity, which together widen economic potential [44]. Key components of this economy include digitalization, the intensive utilization of information, the codification of knowledge, the commercialization of information, and the emergence of new models for organizing work and production.

The evolution of the information economy, as a subdivision of the broader knowledge economy, is closely tied to advancements in digital technologies and telecommunications, as well as the pursuit of greater efficiency. In the 21st century, the information economy focuses on monetization of information, recognizing it as a key driver for creating both public and national wealth, which emphasizes its central role in economic development.

The evolution of post-industrial society has laid foundation for conditions for the rise of the information economy. In [40] a conceptual model is presented that outlines the formation and development of the information economy, incorporating the noosphere approach to investigate its components and mirroring the depth of transformation in the economic system (noosphere) at each development stage. The first of the three stages in this process is linked to the integration of the sphere of ICT into economy – referred to as the technosphere. This stage provides the technological basis necessary for the information economy, through which a large volume of data can be created, processed and distributed, and socio-economic systems can be informatized. It is generally accepted that the term ICT refers to all devices, network components, and applications that, in combination, enable communication, data exchange, information, and global connectivity between people and organizations, as well as between people and machines. The definition changes as technologies, devices and even ideas related to ICT are constantly evolving [16]. The second phase in the development of the information economy involves the formation of the sociosphere, or social core, which corresponds to the emergence of the information society. The subsequent stage is the emergence of the economic sphere, representing the economic peak of the information economy, which aims to informatize all spheres of the economy, envisages their transition to electronic form and achieves efficiency and growth in production.

The investigation of the different factors influencing economic growth has been a prominent area of research in macroeconomics, leading to the creation of several economic growth theories. Classical and neoclassical economic growth theories view labor, land, and physical capital as the primary drivers of economic growth. In the Solow growth model [39], technological change is treated as an external (exogenous) factor that influence long-run economic growth. This assumes that technology is a public good, and firms have access to it without incurring costs for its acquisition and use. [34] and [21] developed endogenous growth theories, in which endogenous factors such as human capital, innovation, and knowledge contribute significantly to economic growth. In this theory, technology is perceived as an endogenous factor, i.e. technological progress is induced by firms or individuals aiming to achieve profit.

Many studies are presenting the socio-economic factors of economic growth. However, there are still few studies on the relationships of ICT indicators, reflecting the main components of the information economy, with GDP growth. Modern theories of economic growth focus mainly on the contribution of technology, R&D and knowledge innovation to stimulate growth. These new theories also suggest that economic growth depends mainly on investment in ICT. ICT is the modern symbol of the technological revolution and a key factor for economic growth, especially in industrial economies [10]. ICT can play a role in facilitating trade, regional integration, information and knowledge sharing, cross-border communication, and financial transactions. Similarly, ICT also contributes to other important sectors of the economy such as e-commerce, e-business and e-banking. Therefore, it can be concluded that digital technologies increase inclusion, efficiency and innovation in the knowledge economy and promote sustainable development.

A considerable number of studies in academic literature explore the relationship between ICT and GDP or overall economic growth. While majority of these studies confirm a positive correlation, some failed to demonstrate a significant impact, although they do not deny the potential advantages of the information economy. Most analyses focus on specific elements of ICT related to only some of the elements of the information economy, such as fixed telephone lines, broadband and mobile access subscriptions, Internet and mobile phone users, and ICT investments, and the results for them are mixed. The majority of studies validate their anticipated positive and significant effect on GDP growth [5, 6, 8, 9, 10, 14, 18, 20, 23, 24, 26, 27, 36, 38]. [18] found that the networks quality plays a substantial role in economic advancement. Similarly,[6] highlights that the use of mobile and broadband networks has a strong and positive long-term impact on economic growth and emphasizes its importance for improving economic resilience during future crises [5]. In contrast, other studies present different findings. For instance, [4, 46] analysed data from 45 developing countries in the Middle East and North Africa, as well as 31 provinces in China, and identified a negative correlation between fixed-line telephony and economic growth - likely due to increasing replacement of fixed lines by mobile technologies. [13] examined the relationship between ICT and GDP growth in Western Balkan countries and reported a negative contribution of both fixed broadband and mobile subscriptions to GDP growth. One reason for these results could be the inefficient ICT infrastructure use, economic misallocation, or insufficient electrification. [17] analyzing 33 African countries, find that if the share of the population with access to electricity is below 60%, each 1% increase in fixed broadband subscriptions causes a decline in economic growth of about 2.58%.

Internet and mobile phone users are essential for economic growth and significantly impact GDP growth and GDP per capita. [14] find that the tipping point for Internet and mobile phone use is 30% — before reaching this value, ICTs increase economic growth, but their insignificant impact decreases after this level.ICT investment plays a key role in economic growth. The scientific literature findings highlight its significant and positive impact on GDP growth, especially for

developed economies [1, 28, 33]. [35] discover a strong bidirectional causal relationship between ICT investment and GDP growth over the long term, indicating that ICT investment not only drives economic growth but is a consequence of it. However, in the short term, the relationship appears to be unidirectional. [29] studied 59 countries – covering developing, emerging and developed economies - from 1995 to 2010, and found that ICT investment earns excess returns, likely due to positive spillovers and complementarities. Moreover, their analysis does not support the assumption that developing and emerging countries could gain more from ICT investments due to potential network effects and lower transaction costs, contrary to other studies. [36] studying EU countries and Turkey, and [24], studying SAARC and BRICS countries, found that investing in digital infrastructure is essential for sustainable economic progress, especially for developing countries. These findings support the "leapfrogging" hypothesis and are consistent with previous research showing that digital transformation helps emerging and developing economies bypass traditional development stages and "catch up". Other relevant ICT indicators for analyzing their impact on GDP growth that are poorly addressed in the literature. Here could be mentioned the e-government index, online services index, and telecommunications infrastructure. Many studies [19, 22, 23, 24, 25, 26] examined the relationship between e-government and economic growth and found that improvements in e-government, broadband infrastructure, education system, e-commerce and internet services will contribute to future economic growth. The results further highlight that e-government and online services are particularly effective in enhancing growth through the diffusion of information and knowledge, improving the efficiency of services, business and government operations, reducing transaction costs, trade openness, and ensuring the online availability of government and web connections. [13] found that final government consumption negatively affects GDP growth, while foreign direct investment positively affects it. [24] analyzed the impact of various new ICT indicators such as telecommunications, online services and e-government index on economic growth at both global and regional levels. The study's findings indicate that investing in ICT infrastructure is vital to extract value from the 21st century knowledge economy. Concurrently, [33] stress that the quality of infrastructure is a crucial determinant of growth, especially for developed countries [24]. Other authors [23, 41] also confirm that ICT infrastructure, together with other macroeconomic factors, is an important driver of economic growth in European Union countries. They highlight its particular effectiveness in promoting economic development in these countries by enabling rapid and effortless information and knowledge exchange, lowering firms' transaction and capital costs, enhancing global connectivity, and favoring market expansion. [43] examined the influence of next-generation ICT on national economic development, utilizing data for 31 Chinese provinces for period from 2011 to 2020. They find that data traffic, computing power and total telecommunications business positively and significantly impact economic growth.

[2, 11, 23] examined the relationship between DESI and economic development, and [27] applied the Knowledge Economy Index. Both studies found a positive and significant relationship between ICT indicators and GDP growth, with the most significant being the promotion of economic development, among them ICT infrastructure, ICT connectivity and access, ICT investment, and the importance of online services and e-government. [2] concludes that in CEE countries, the role of ICT depends on human capital development and institutional reforms. [11] point out that ICT is an endogenous factor of economic growth.

We can conclude that ICTs are a crucial catalyst for modern economic growth. Their contribution is associated with increased productivity and improved connectivity, encouraging and promoting global trade and economic integration, deepening digitalization and business transformation, improving public sector efficiency, and increasing economic effectiveness.

MATERIALS AND METHODS

To achieve the aim of the paper, a detailed literature review was carried out regarding key indicators of the information economy in terms of GDP growth.

Substantive analysis was applied to qualitative research and the analysis of scientific texts.

The authors adopt a chronological (historical) approach to extracting and summarizing results from Bulgarian and other scientific literature.

The following keywords were used with a search in the international databases Web of Science and Scopus to find suitable literary sources:

("information economy" OR "digital economy" OR "knowledge economy" OR "information society") AND ("GDP" OR "gross domestic product" OR "economic growth" OR "national income") AND ("indicators" OR "metrics" OR "measures" OR "statistics") AND ("development" OR "progress" OR "advancement" OR "growth").

In order to expand the scope of the literature, a Google search is applied.

RESULTS AND DISCUSSIONS

Referring to the literature review, Table 1 provides a summary of the indicators used to assess the development of the information economy and its impact on economic growth.

We can distinguish indicators related to the study of the role of the digital economy in promoting economic growth into two groups: those that are often found in scientific research and have gained popularity as basic research indicators and indicators that are significant but, due to the specificity of their application, are still found in a limited number of studies.

The main indicators that are most often applied in the scientific literature in terms of GDP growth, related to ICT infrastructure, penetration and access to ICT are:

- *Fixed telephones, Fixed Broadband and Mobile Subscriptions* – These traditional indicators measure access to communication networks, connectivity and digital inclusion. Higher broadband penetration is often associated with increased economic activity and digital transformation. Studies show mixed results in terms of their impact on GDP growth. The predominant influence of these ICT components on economic development is positive and significant, but a negative correlation is also observed [13]. The quality of ICT infrastructure is assumed to be crucial, as is its efficient distribution.
- *Internet and Mobile users/ ICT usage* – Indicators related to ICT usage. Their effect on GDP growth is positive, with ICT increasing economic growth significantly up to 30% of usage [41]. Better quality ICT infrastructure enhances ICT usage and stimulates economic growth.
- *ICT Investments*—Capital expenditure on ICT infrastructure and services reflects an economy's level of digitalization and modernization. ICT investments positively correlate and contribute significantly to GDP, especially in developed economies [28]. Countries with higher ICT investments tend to experience faster GDP growth rates.

Less studied in the scientific literature are indicators and composite indices of the information economy in terms of economic growth:

- *E-Government Index*—The index assesses how effectively governments use ICT to deliver public services [45], aiming to improve administrative efficiency, business operations, and citizen engagement. It has been shown to correlate positively with economic growth, and countries with advanced e-government services tend to experience improved economic outcomes [23].
- *Online Services Index*—The index measures online government services' scope, availability, and quality, highlighting the country's digital readiness and accessibility [46]. Implementing online services has a significant positive impact on economic growth.
- *Telecommunications Infrastructure* - based on basic infrastructure indicators, determines the capacity of a country's ICT infrastructure [45]. The expansion of telecommunications networks and the deployment of 5G and data centers facilitate business operations and innovation and are crucial for economic development, enabling seamless communication and digital transactions.

- *Computing Power Development Index*—The index is related to the ability of individual ICT devices to aggregate, process, and transact massive data and shows the scale and potential for the development of the digital market. Growing computing power correlates positively with economic growth [43].
- *Total Telecommunication Business* measures the added value of the telecommunications business and reflects the use and development of telecommunications services and the activity of digital businesses. The index correlates positively with GDP growth [43].
- *Data Traffic*—This indicator is related to the transmission and use of ICT for real-time data production [43]. It has a positive impact on economic growth.
- *Digital Economy and Society Index* – A composite index that includes the sub-indices Connectivity, Human Capital, and Integration of Digital Technology, including e-Business and Digital Public Service (e-Government). Studies show a strong positive correlation between DESI results and GDP growth [23].
- *Knowledge Economy Indicators*—The index shows a country's strengths and weaknesses in creating a favorable environment for the effective use of knowledge for economic development. KEI includes indicators based on the four pillars of the knowledge economy: economic incentives and institutional regime, education and human resources, research and development, and ICT. Studies show that knowledge indicators significantly impact economic growth, especially in developing countries [27].
- *ICT production* – shows the value of output produced in the ICT sector. Research indicates that it has a positive impact on GDP growth [7].
- *ICT Development Index* - it serves as a key measure of progress in both the ICT sector and the information economy. It is a composite index and includes ICT Readiness; ICT use; ICT access and ICT impact. It is positively related to GDP growth [15, 40, 41].
- *ICT penetration* – a composite index that includes mobile, fix, internet, Wi-Fi penetration, etc., which is related to the adoption, integration, and utilization of ICT. The studies have shown that the index positively influences GDP growth [31].
- *ICT access index* – a composite measure that considers the availability and accessibility of ICT. Increased access and widespread utilization of ICT are shown to have a notably positive impact on economic growth [9].
- *UNCTAD Productive Capacities Index* – a composite index of eight categories that allow developing countries to understand the state of their productive capacity and how it can be improved. The ICT sub-component assesses the accessibility and integration of communication systems among the population. A positive correlation with economic development and sustainability is reported [5].

Other indicators of the information and knowledge economy, in relation to their influence on economic development, include:

- *Human capital and innovation*:
  - *Education and Digital Skills* – enhancing both quantity and quality of the workforce through education and ICT-related skills development is critical for fully deriving the benefits of the information economy. Countries that invest in developing a skilled ICT workforce experience higher economic growth [23, 28].
  - *Innovation and research and development*—Spending on ICT-related research and development stimulates innovation, increasing productivity and economic growth. This is particularly important for maintaining the competitive advantage of high-income countries [7, 23, 28].
- *Macroeconomic factors:*
  - *Trade Openness and foreign direct investment* positively impact GDP growth when combined with investment in ICT. Trade openness and FDI facilitate the flow of technology and capital, further enhancing ICT's impact on economic growth [26, 41].
  - *Inflation and political stability*—To maximize the benefits of ICT investments, a stable macroeconomic environment, including political stability and low inflation, is necessary [30, 41].

Table 1. Key indicators and the impact on GDP growth

Indicators	**Impact on GDP growth**
Most frequently studied indicators	
Fixed telephones	A positive correlation is predominantly proven [9, 13, 23, 24, 26, 27, 36].
	A few studies do not confirm this correlation [4, 46]
Fixed Broadband Subscriptions	A significant positive correlation is predominantly proven [4, 5, 6, 8, 10,18, 23, 24, 38]. The quality and context are crucial. A few studies do not confirm this correlation [13, 17]
Mobile subscriptions	A significant positive correlation is predominantly proven [4, 6, 8, 9, 10, 24, 26,46]. A few studies do not confirm this correlation [13].
Internet users	Positive correlation [4, 10, 13, 14, 24, 26, 27, 36].
Mobile phone users	Positive correlation [14, 20, 27].
ICT Usage	Positive correlation [1, 11, 28, 33].
ICT Investments	Strong positive correlation; Significant contribution to GDP, especially in developed economies [1, 23, 26, 28, 29, 30, 33, 35,40].
Less studied indicators	
E-Government index	Positive correlation, improving the efficiency and transparency of public services, leads to the increase of economic growth [19, 23, 24].
Online services index	Significant impact; highlights the importance of digital service consumption in boosting economic growth [19, 20, 23, 24].
Telecommunications infrastructure	Positive correlation; well-developed infrastructure is crucial [19, 23, 24, 33, 41, 43].
Computing Power Development Index (CPDI)	Positively correlated to GDP growth [43].
Total Telecommunications Business (TTB)	Positively correlated to GDP growth [43].
Data Traffic	Positively correlated to GDP growth [43].
Digital Economy and Society Index (DESI)	Strong positive correlation; Underlined digital competitiveness [2, 11, 23]
Knowledge Economy Indicators (KEI)	Significant contribution; crucial for the developing countries [27]
ICT Production	Positive correlation [7, 33]
ICT Development Index	The better developed ICT sector, the better outcomes [8, 40, 41]
ICT Penetration	Positive correlation [12, 14, 31, 36]
ICT Access Index	Significant positive effect on economic growth, especially for the high-income countries [9]
UNCTAD Productive Capacities Index (PCI)	Investment in ICT is crucial for improving the economic resilience for the future crisis [5]
Other indicators of the information and knowledge economy	
Human Capital and Innovation	ICT education and R & D boost the productivity and growth [23, 28]
Trade Openness and Foreign Direct Investment	Facilitating technology and capital flow, enhancing the impact of ICT [7, 26, 41]
Inflation and Political Stability	Necessary to maximize the benefits of ICT investments [30, 41].

Source: Own contribution.

CONCLUSIONS

The advancement of the information economy appears a key driver in shaping the emerging information society. While numerous studies examine the socio-economic determinants of economic growth, comparatively fewer focus on the relationships between ICT indicators - representing the core components of the information economy - and GDP growth. Modern theories of economic growth suggest that economic growth depends mainly on investments in ICT, which are considered a symbol of technological progress and are of key importance for GDP growth. Much of the research focuses on the relationship between ICT investment and GDP growth, proving a positive relationship but also finding contradictory results. It can be summarized that the studies in the literature mainly analyze

traditional aspects of ICT, related to only some of the elements of the information economy, for example, Internet users, fixed telephones and broadband subscriptions, Internet and mobile users, ICT investments, which reflect the availability and use of ICT. The majority of them establish a positive influence of the studied determinants - the use of the Internet and mobile devices, ICT investments, and research and development activities on economic growth. A small part of them point to adverse effects of ICT, potentially linked to inferior ICT infrastructure quality.

Certain suitable indicators for studying the impact of ICT on economic growth that remain under-researched are the e-government index, the online services index, telecommunications infrastructure, data traffic, general telecommunications business, the computing power development index, and composite indices such as the Digital Economy Development Index (DESI), the ICT Development Index (IDI), the ICT Access Index, ICT Production, and other related indicators and composite indices that take into account the development and use of ICT. Studies that have applied these indicators find that improvements in e-government, telecommunications networks, digital skills, e-commerce, and Internet services will contribute to future economic growth. The results also highlight that e-government and online services enhance growth by diffusing information and knowledge, improving the efficiency of services, business, and government operations, and reducing transaction costs. Understanding traditional and emerging indicators will provide a holistic approach to promoting the information economy and help formulate policies regarding the development and use of ICT to achieve sustainable economic growth.

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REFERENCES

[1]Abu Alfoul, M.N., Tajaddini, R., Gholipour, H.F., Bashar, O., Jamaani, F., 2024, The Impacts of ICT on Economic Growth in the MENA Countries: Does Institutional Matter?, Politická ekonomie, 72(3), 446-477, https://doi.org/10.18267/j.polek.1409

[2]Arendt, Ł., 2015, The Digital Economy, ICT and Economic Growth in The CEE Countries, Olsztyn Economic Journal, 10(3), 247-262.

[3]Badalzade, A., 2023, Information economy: a look at its features, Labour and Social Relations (LaSR), 20 (20), 98-104.

[4]Bahrini, R., Qaffas, A.A., 2019, Impact of Information and Communication Technology on Economic Growth: Evidence from Developing Countries, Economies, 7(1), 21.

[5]Bilal, M., Aqib, S., Raza, A., 2024, Strengthening economic resilience through ICT during the COVID-19 pandemic: evidence from 100 countries, Discover Sustainability, 5(1), December 2024, Article number 534.

[6]Birincia, T., Kirikkaleli, D., 2021, Modeling broadband, mobile telephone and economic growth on a macro level: Empirical evidence from G7 countries, Accounting, 7, 837–844.

[7]Costaiche, G., Chihaia, A., 2024, The role of Foreign Direct Investments in Romania’s economic development: analysis 2013-2023, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 24(4), 205-211.

[8]Farhadi, M., Ismail, R., 2012, Does Information and Communication Technology Development Contributes To Economic Growth?, Journal of Theoretical and Applied Information Technology, 39(1), 11-16.

[9]Farhadi, M., Ismail, R., 2014, The Impact of Information and Communication Technology Availability on Economic Growth, Research Journal of Applied Sciences, Engineering and Technology, 7(7), 1226-1231.

[10]Farhadi, M., Ismail, R., Fooladi, M., 2012, Information and Communication Technology Use and Economic Growth, PLoS ONE, 7(11), e48903.

[11]Fernandez-Portillo, A., Almodovar-Gonzalez, M., Hernandez-Mogollon, R., 2020, Impact of ICT development on economic growth. A study of OECD European union countries, Technology in Society, 63 101420.

[12]Haftu, G.G., 2019, Information communications technology and economic growth in Sub-Saharan

Africa: A panel data approach, Telecommunications Policy, 43, 88–99.
[13]Ibrahimi, A.E., Fetai, B., 2022, The Impact of ICT on the GDP Growth of Western Balkan Countries, *SEEU* Review, 17(1), 105-119.
[14]Ishnazarov, A., Kasimova, N., Tosheva, S., Isaeva, A., 2021, ICT And Economic Growth: Evidence from Cross-country Growth Modeling, In The 5th International Conference on Future Networks amp Distributed Systems (ICFNDS 2021), December 15, 2021, Dubai, United Arab Emirates. ACM, New York, NY, USA, 4 pages, Retrieved from: https://doi.org/10.1145/3508072.3508204
[15]Khan-Khoyskaya, I., 2024, Analysis of the impact of digital technologies on the level of digital skills development in rural areas of Azerbaijan, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 24(1), 521-530.
[16]Kirvan, P., Awati, R., Pratt, K.M., 2025, What is ICT (Information and Communication Technology?), https://www.techtarget.com/searchcio/definition/ICT-information-and-communications-technology-or-technologies, Accessed on 02th March 2025.
[17]Kouam, J.C., Asongu, S., 2022, The non-linear effects of fixed broadband on economic growth in Africa, AGDI Working Paper, No. WP/22/039, African Governance and Development Institute (AGDI), Yaoundé.
[18]Koutroumpis, P., 2019, The economic impact of broadband: Evidence from OECD countries, Technological Forecasting & Social Change, 148, 119719.
[19]Kuziyeva, G.R., Rakhmatullaeva, D.O., Abdukadoriva, K.A., Babajanova, M.R., Botirova, X.O., Kaxorova, A.N., 2022, Analysis of digital economy performance and economic growth nexus: case of Uzbekistan, ICFNDS '22, December 15, 2022, Tashkent, TAS, Uzbekistan, https://doi.org/10.1145/3584202.3584231
[20]Liakhovych, O., Zaluzhnyi, A., Prytula, M., Skakovska, S., Osadcha, O., 2023, Factors of the information and network economy sustainable development in Ukraine, In: IOP Conf. Ser.: Earth Environ. Sci., 1126, 012005, October/2022, Riga, Latvia, DOI 10.1088/1755-1315/1126/1/012005.
[21]Lucas, E., 1988, On the mechanics of economic development. Journal of Monetary Economics, 22, 3–42.
[22]Ma, L., Chung, J., Thorson, S., 2005, E-government in China: Bringing Economic Development through Administrative Reform, Government Information Quarterly, 22(1), 20-37.
[23]Magoutas, A.I., Chaideftou, M., Skandali, D., Chountalas, P.T., 2024, Digital Progression and Economic Growth: Analyzing the Impact of ICT Advancements on the GDP of European Union Countries, Economies,12(3), 63.
[24]Majeed, M.T., Ayub, T., 2018, Information and communication technology (ICT) and economic growth nexus: A comparative global analysis, Pakistan Journal of Commerce and Social Sciences (PJCSS), 12(2), 443-476.
[25]Majeed, M.T., Malik, A., 2016, E-government, Economic Growth and Trade: A Simultaneous Equation Approach, The Pakistan Development Review, 55(4) Part II (Winter 2016), 499–519.
[26]Makun, K., Jayaraman, T.K., 2020, , Spread of ICT and Economic Growth in Pacific Island Countries: A Panel Study, Bulletin of Monetary Economics and Banking, Special Issue 2020, 109 – 128.
[27]Mohamed, M.M.A., Liu, P., Nie, G., 2022, Do Knowledge Economy Indicators Affect Economic Growth? Evidence from Developing Countries, Sustainability,14, 4774.
[27]Nchor, D., 2024, The information and communication technology sector in Czechia and its contribution to innovation and economic growth, In Book: Stavárek, D., & Tvrdoň, M. (Ed.) Modeling Economic Growth in Contemporary Czechia (Entrepreneurship and Global Economic Growth), Emerald Publishing Limited, Leeds, pp. 265-279. https://doi.org/10.1108/978-1-83753-840-920241017
[29]Niebel, T., 2018, ICT and economic growth – Comparing developing, emerging and developed countries, World Development, 104, 197–211.
[30]Oliinyk, A., Melnyk, T., Kovtoniuk, K., Tkachenko, I., 2024, ICT Investment Impact on Economic Growth: Comparing Developing and Advanced Economies, Proceedings - 14th International Conference on Advanced Computer Information Technologies, ACIT, pp. 197 – 202, Ceske Budejovice, 19-21 September 2024, Code 203443.
[31]Pradhana, R.P., Arvin, M., Nair, M., Bennett, S., Bahmani, S., 2017, ICT-finance-growth nexus: Empirical evidence from the Next-11 countries, Cuadernos de Economía, 40, 115-134.
[32]Porat, M.U., 1977, The information economy: definition and measurement. OT Special publication 77-12(1). Washington: US Dept. of Commerce, Office of Telecommunications.
[33]Qiang, C.Z.W., Pitt, A., Ayers, S., 2003, Contribution of Information and Communication Technologies to Growth, World Bank Working Paper № 24.
[34]Romer, M., 1986, Increasing returns and long-run growth, Journal of Political Economy, 94(5), 1002–1037.
[35]Sawng, Y., Kim, P., Park, J.Y., 2021, ICT investment and GDP growth: Causality analysis for the case of Korea, Telecommunications Policy, 45, 102157.
[36]Sen, A., Saray, M.O., 2019, Information and Communication Technologies and Economic Growth: Evidence from EU and Turkey, Journal of Economic Cooperation and Development, 40(2), 169-192.
[37]Seninger, S.F., 2001, The Information Economy. Montana Business Quarterly, 39(1), 2.
[38]Shodiev, T., Turayev, B., Shodiyev, K., 2020, ICT and Economic Growth Nexus: Case of Central Asian Countries, Procedia of Social Sciences and Humanities Proceedings of the International Conference on Intellectuals' Global Responsibility 2020 (ICIGR):

Science for Handling the Effects of Covid-19, Facing the New Normal, and Improving Public Welfare, 155-167.
[39]Solow, M., 1956, A contribution to the theory of economic growth, Quarterly Journal of Economics, 70(1), 65–94.
[40]Sukhodolov, A.P., Popkova, E.G., Litvinova, T.N., (eds.). 2018, Models of Modern Information Economy: Conceptual Contradictions and Practical Examples, Publisher Emerald Publishing.
[41]Toader, E., Firtescu, B.N., Roman, A., Anton, S.G., 2018, Impact of Information and Communication Technology Infrastructure on Economic Growth: An Empirical Assessment for the EU Countries, Sustainability, 10, 3750.
[42]Trushkina, N., 2019, Development of the information economy under the conditions of global economic transformations: features, factors and prospects, Virtual Economics, 2(4), 7-25.
[43]Tu, X., Li, Z., Xie, S., Yan, R., Zuo, K., 2022, Shaping the future of application for information and communication technology in national economic analysis, Intelligent and Converged Networks, 3(3), 282−293.
[44]United Nations. Economic and Social Council; United Nations. Economic Commission for Africa (2005-04). Concept paper: information as an economic resource. UN. ECA Committee on Development Information Meeting (4th: 2005, Apr. 23-28: Addis Ababa, Ethiopia). Addis Ababa: UN. ECA, https://repository.uneca.org/bitstream/handle/10855/14299/bib.%20%2055795.pdf?sequence=1&isAllowed=y Accessed on 25th February 2025.
[45]UN E- Government Knowledgebase, Glossary, https://publicadministration.un.org/egovkb/en-us/Resources/Glossary#e, Accessed on 01st March 2025
[46]Ward, M.R., Zheng, S., 2016, Mobile telecommunications service and economic growth: Evidence from China, Telecommunications Policy, 40, 89–101.

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CONSUMER BEHAVIOR TOWARDS THE CONSUMPTION OF PROTEIN ENRICHED BAKERY PRODUCTS – A CONJOINT STUDY

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Abstract

Nowadays, consumers are informed and have an increased awareness of the importance of a healthy diet and high - quality food. Today's foods are designed not only to satisfy hunger and provide necessary nutrients to human beings, but also to prevent nutrition-related diseases and improve the physical and mental well-being of consumers. This paper studied the behaviour and price sensitivity of consumers regarding protein-enriched vegetable biscuits. Adaptive conjoint analysis was used, which is a statistical technique used in market and marketing studies and personalizes the survey experience of each respondent based on the answers to the initiated questions. Therefore, the present study started from establishing the main attributes evaluated by the consumer (sustainability claim, price, brand, origin), respectively the value levels of these attributes. The results of the conjoint study show that for plant-based biscuits rich in protein and fibres, the most important attribute in choosing the product is the origin, followed by price and brand.

Key words**:** *conjoint, vegetable biscuits, consumers, origin, price sensitivity, protein enriched food*

INTRODUCTION

Recent advances in elucidating the relationship between nutrition and health—particularly at the molecular level—have given rise to the concept of functional foods, also referred to as nutraceuticals or pharmaceutical foods. Contemporary food products are formulated not solely to address hunger and meet basic nutritional requirements, but also to aid in the prevention of nutrition-related diseases and to enhance both the physical and mental health of consumers. The term "functional food" was first introduced in Japan during the 1980s to describe food products enriched with specific components believed to confer beneficial physiological effects beyond basic nutrition. Functional foods - including prebiotics, probiotics, and postbiotics - have been shown to support overall health, contribute to the reduction of disease risk, and, in certain cases, assist in the management or treatment of specific medical conditions. It is important to note that, by definition, all foods possess a degree of functionality insofar as they provide essential nutrients; however, functional foods are distinguished by their targeted health-promoting properties.

It was observed that numerous food products contained bioactive components whose physiological efficacy was not consistently demonstrated when incorporated into a complete diet, or whose benefits were limited to specific age groups. As a result, the designation of functional food status has been restricted to products whose health-promoting effects have been substantiated through rigorous scientific evidence.

The criteria for the classification of functional foods were first proposed by the U.S. Food and Drug Administration (FDA) in 1999 and were subsequently adopted, with certain modifications, by the European Union. Within the European regulatory framework, any health claims associated with functional foods must be authorized by the European Food Safety Authority (EFSA), following a comprehensive and rigorous scientific evaluation.

In recent years, consumer interest in personal health and well-being has grown substantially, leading to heightened expectations for food products that are both nutritious and beneficial to health. Concurrently, there is a demand for the development of innovative products with novel organoleptic properties to satisfy evolving market preferences. In this context, the incorporation of potential functional ingredients offers a promising strategy to address both nutritional and sensory consumer demands.

A broad spectrum of functional ingredients may be incorporated into food products, depending on the intended health benefits or technological functions. Commonly utilized compounds include dietary fibers, flavor enhancers, vitamins, minerals, bioactive substances, as well as prebiotics, probiotics, and postbiotics, all of which contribute to enhancing the nutritional and functional value of foods. The bakery sector, in particular, comprises a diverse range of products such as bread, biscuits, muffins, bagels, pancakes, donuts, waffles, cakes, pastries, sandwiches, pizzas, and quiches, offering numerous opportunities for the integration of such value-added ingredients.

Bakery products are primarily composed of basic raw materials such as wheat flour, water, yeast, salt, and various supplementary ingredients. The continuous expansion of the bakery industry has been largely driven by evolving consumer preferences. Modern consumers increasingly seek convenient, high-quality bakery items that are not only fresh and attractively packaged but also exhibit extended shelf life. In response to these demands, the development of nutritious and functional bakery products has gained momentum. A notable example is the fortification of baked goods with functional ingredients, which not only offer health benefits to consumers but also contribute to enhanced product stability and improved organoleptic properties. [15].

Biscuits are ready-to-eat food products that are traditionally prepared with wheat flour, different kind of fats and sugar [16]. However, in recent years, biscuit manufacturing technologies have been rapidly developed to improve their nutritional properties. These innovations have included the use of healthier and sustainable ingredients, such as vegetable wastes, dried fruits, nuts and seeds, and preparation techniques that preserve nutrients and promote digestion. In addition, most biscuit manufacturers have started to offer biscuit options enriched with functional ingredients, gluten-free, lactose-free or low-sugar to meet the needs of consumers with dietary restrictions [6, 9, 16].

Even traditional recipes have been utilized for enlarging the variety of products in milling and bakery industry [17].

All of these have allowed consumers to enjoy biscuits in new ways and improve their health. The biscuit industry has set out to contribute to improving people's health by creating a wide range of biscuits that contain ingredients containing essential and/or functional nutrients.

Muffins are soft-textured, leavened bakery products that are widely consumed as breakfast items or snacks. Nutritionally, traditional muffins are rich in carbohydrates due to their high content of refined wheat flour and sugar, and they often contain moderate amounts of fat and low levels of protein and dietary fiber. However, their nutritional profile can be significantly enhanced through ingredient modifications, such as incorporating whole grains, plant-based fibers, or protein-enriching components like whey, soy, or legume flours.

All of these products have been the subject of many studies, most of which aim to increase the nutritional value and antioxidant potential by replacing some ingredients with vegetable powders obtained from waste and vegetable by-products of the food industry. The recovery of these waste and vegetable by-products could lead to the obtaining of functional ingredients - flours that have nutritional value and antioxidant potential.

Barbhai et al. (2022) [2] studied different formulations of buns and muffins using foxtail (or spear grass) and millet bran. The conclusion of the study was that buns prepared with 20% foxtail and muffins prepared with 30% millet bran showed better acceptability of consumers.

Adsare and Annapure (2024) [1] conducted a study in which partially defatted coconut flour

was obtained after processing virgin coconut oil. Incorporation of 50% partially defatted coconut flour significantly increased the overall acceptability of the muffins (with a maximum score of 8.5). Pomegranate peel is a by-product of the pomegranate processing industries and is a rich source of dietary fiber and bioactive compounds. The final product had good antioxidant activity and a better shelf-life.

In the study conducted by Giri et al. (2024) [5] it was studied the replacement of wheat flour with pomegranate peel powder (PPP) in different concentrations (2%, 4%, 6%, 8% and 10%). This lead to possitive effects on the physicochemical and sensory properties as well as the oxidative and microbial stability of the muffins. The muffin samples were organoleptically acceptable up to a level of 8% pomegranate peel and the nutritional value was improved by a significant increase in fiber content, total phenolics, antioxidant activity, etc. Srivastava et al. (2012) [24] investigated the effect of incorporating fenugreek seed hulls in muffins at different levels of 5%, 10% and 15%. The inclusion of fenugreek seed hulls in muffins was accepted by the panelists with a better rating than the control sample. The optimal level of incorporation of fenugreek seed hull flour, based on the sensory quality in muffins, was found to be 10%.

Mala et al. (2018) [7] made a study in which they determined the optimal level of substitution of carotene from pumpkin powder in the formulation of muffins and to evaluate their quality. The influence of replacing wheat flour with pumpkin powder in the formulation of muffins led to changes in the sensory quality of the muffins. Sensory evaluation indicated that the muffin with pumpkin powder incorporated at the level of 20% proved to be more acceptable. Substitution above 20% affected the color and overall acceptability of the product.

Nasar-Abbas and Jayasena (2012) [11] studied the development of rich protein muffins that were made from lupin flour. In the analysis the dietary fiber content was studied and also sensory analysis was perfomed in order to evaluate the consumers preferences towards these novel food products. The authors replaced the wheat flour in the traditional recepy with lupin flour at quantities between 10% to 50%. The results showed that a substantial improvement in the nutritional value (increased protein and dietary fiber content) of the muffins could be achieved by replacing wheat flour with lupin flour up to a level of 30%, without any significant loss in physical measurements, textural quality and sensory values.

In a study developed by Olawuyi and Lee (2019) [14] was demonstrated that muffins can become functional food products by incorporating food materials rich in bioactive components (mushroom powder and carrot pomace powder). Rice flour was progressively replaced with mushroom powder and carrot pomace powder and the effects on physical and textural properties, as well as antioxidant activity and consumer acceptability were evaluated. The sensory result showed that muffins enriched with mushroom powder and carrot pomace had comparable and better consumer acceptability than rice muffins. The improvement of antioxidant properties of functional rice muffins developed by incorporating mushroom powder and carrot pomace makes it a potential snack, suitable for consumption for its health benefits.

In the study by Tukassar et al. (2023) [27] cauliflower (*Brassica oleracea* var. *botrytis*) by-products (leaves and stems) were successfully used in muffins as a model functional ingredient and the feasibility of their incorporation was investigated. Replacing flour with cauliflower powder resulted in an increase in the crude protein, crude fiber, mineral, total phenolic and total flavonoid content, as well as the total antioxidant activity values of the muffins. In addition, the sensory evaluation confirmed the positive effects of incorporating cauliflower flour only up to 10%.

Rupasinghe et al. (2009) [28] conducted a study highlighting the improvements in nutritional properties of muffin samples by using apple peel, a rich source of dietary fiber and phenolics, that resulted from apples processing. A sensory panel of 66 participants showed that replacing wheat flour with 8, 16 or 24% apple peel flour in muffin mix did not affect the overall acceptability.

Other studies that have analysed the use of vegetable wastes as functional ingredients can be highlighted in the next section. Troilo et al. (2022) [26] analysed grape pomace powder, Sethi et al. (2022) [22] used soybean industry waste (okara) and citrus juice (citrus peel) to develop functionalized bakery products, Ramya and Anitha (2020) [19] conducted a study on coconut flour, Srinivasamurthy et al. (2017) [23] explored the potential of dried *Moringa oleifera* leaves in muffins, Nath et al. (2018)[12] used red pepper pomace obtained as a by-product, Rabail et al. (2022) [18]studied the benefits of chia seeds in bakery products, Romjaun and Prakash (2013) [21] conducted a study in which they wanted to develop muffins enriched with dietary fiber from vegetable and cereal sources.

In Romania, innovative and sustainable solutions are being sought to reduce food waste and improve the nutritional value of food products through the valorization of vegetable waste and by-products and their integration into food products, respectively in bakery products [3, 4, 8]. Also, research and development of meat alternatives is taking shape in Romania and aim to obtain sustainable products that recreate conventional meat in all its aspects, taste, appearance, and texture [13].

The purpose of this research is to investigate consumer preferences for protein-enriched bakery products using a conjoint study approach, with a specific focus on key attributes such as protein type, flavor, texture, price, and health-related claims, in order to guide the development of products that align with the expectations of health-conscious consumers and fitness-oriented individuals.

MATERIALS AND METHODS

Various investigation methods are used in marketing research based on both direct and indirect information and data, both qualitative and quantitative methods. In formulating a marketing strategy for a brand (of a product or service), several interrelated decisions are involved. These include decisions regarding not only the product's features, but also its positioning in the market, communication, distribution, and pricing to selected sets of target customers. When making a choice, consumers typically make trade-offs between the attributes of a product or service. Conjoint analysis is a set of techniques ideally suited for studying customer choice processes and determining trade-offs [20].

Five different characteristics of conjoint studies have contributed to its versatility for addressing marketing management problems [20]:

- is a measurement technique for quantifying buyer trade-offs and values;
- is an analytical technique for predicting likely buyer reactions to new products/services;
- is a segmentation technique for identifying groups of buyers who share similar trade-offs/values;
- is a simulation technique for evaluating new product/service ideas in a competitive environment;
- is an optimization technique for finding product/service profiles that maximize share/profitability.

According to Stobierski (2020) [25], conjoint analysis is a form of statistical analysis used in market research to understand how customers value different components or features of their products or services. It is based on the principle that any product can be divided into a set of attributes that ultimately influence the users' perceived value of an item, service, or product.

Types of conjoint analysis:

- ***Choice-based conjoint analysis***: This is one of the most common forms of conjoint analysis and is used to identify how a respondent valuescombinations of features.
- ***Adaptive conjoint analysis***: This form of analysis personalizes the survey experience for each respondent based on their responses to the initial questions. It is often used in studies where multiple features or attributes are assessed to streamline the process and extract the most valuable information from each respondent.
- ***Full-profile conjoint analysis***: This form of analysis presents the respondent with a series of complete product descriptions and asks them to choose the one they would be most inclined to buy.

- ***MaxDiff conjoint analysis***: This form of analysis presents the respondent with multiple options, which they are asked to organize on a scale from "best" to "worst" (or "most likely to buy" to "least likely to buy").

The type of conjoint analysis a company uses is determined by the objectives driving its analysis (i.e., what does it hope to learn?) and, potentially, the type of product or service being evaluated. It is possible to combine multiple types of conjoint analyses in "hybrid models" to take advantage of the advantages of each.

The conjoint study designed in this study also involved establishing the attributes evaluated by the model, and the value levels of these attributes, as shown in Table 1.

Table 1. Conjoint study design

Attribute	Value levels
Vegetable protein product	• Can replace a meal • Rich in protein and fibres
Sustainability mention	• Contributes to the recovery vegetable waste • Contains eggplant skins left over after using the pulp
Price	• 9 lei for 100 g • 12 lei for 100 g
Brand	• Known brand • New brand
Origin	• Produced in Romania • Produced in EU

Source: Conjoint.ly. [29].

Following the collection of information, its analysis was carried out and, based on it, the editing and interpretation of the related graphic representations.

The questionnaire was published online, in Romania, and spread to 100 consumers. An initial sample of 100 people from a homogeneous population was considered sufficient to obtain the information necessary for the conjoint analysis, the same sample size being chosen in other research in the field [10].

RESULTS AND DISCUSSIONS

The statistical analysis of the results was performed automatically by the platform on which the questionnaire was built, more precisely Conjoint.ly. According to the platform's algorithm, depending on the number of attributes in the model and the value levels of each attribute, a sample size of 100 people is recommended for conducting the proposed analysis. Figure 1 shows an example of a question evaluating attribute sets in the conjoint model.

Which of the following biscuits products would you choose?

Origin	Produced in EU	Produced in Romania	Produced in EU
Brand	New brand	Known brand	Known brand
Sustainability	Contributes to the recovery vegetable waste	Contributes to the recovery vegetable waste	Contains eggplant skins left over after using the pulp
Vegetable protein product			
	Can replace a meal	Can replace a meal	Rich in protein and fibres
Price	9 lei for 100 g	12 lei for 100 g	9 lei for 100 g
	CHOOSE	CHOOSE	CHOOSE

Fig. 1. Example of a question for evaluating attribute sets in the conjoint model
Source: Conjoint.ly, [29].

The main results obtained in this study are presented in Figure 2.

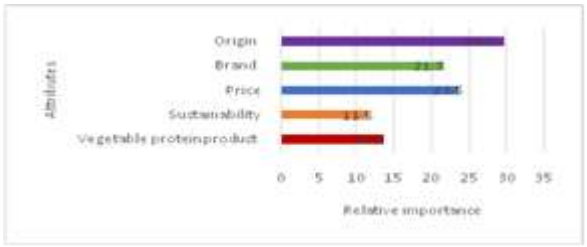

Fig. 2. Relative importance of attributes
Source: Conjoint.ly, [29].

In the case of protein and fiber-rich vegetable biscuits, the most important attribute in product choice is origin (29.6%), followed by price (23.5%) and brand (21.7%). In the last places are content mentions (13.6%) and sustainability (11.5%).

High utility valuesindicate a higher preference. As can be seen in Figure 3, in the case of price, the higher preference is for the lower price (having the highest utility value), while the higher price indicates a lower preference (the lowest utility value). Similarly, the higher preferences are for biscuits obtained in Romania, the mention "Rich in protein and fiber" and the mention "Contributes to the valorization of vegetable waste". In the case of brand, the preference is for a well-known brand.

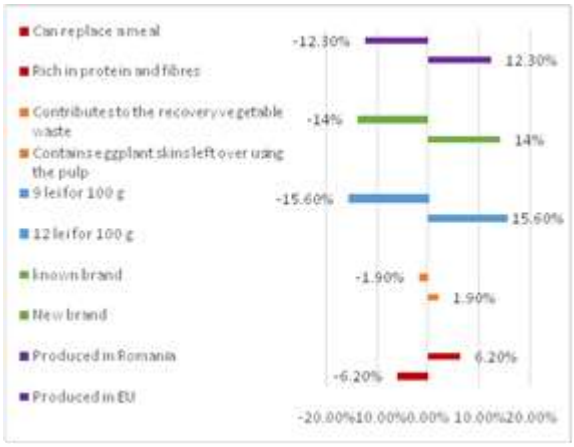

Fig. 3. Consumer preferences for each attribute level Source: Conjoint.ly, [29].

The utilities are expressed in a common unit of measurement and can therefore be added together to obtain the total utility for any of the combinations. Thus, the analysis results in a top of product concepts (total utilities) with different combinations of attributes according to consumer preferences, with the "ideal" product for the evaluated dimensions in the first position (Table 2): biscuits produced in Romania, from a well-known brand on the local market, priced at 9 lei per 100 g, with the statements "Rich in protein and fiber" and "Contributes to the valorization of vegetable waste".

Table 2. List of product concepts in order of consumer preferences. The first position is the "ideal" product resulting from the evaluated dimensions

Vegetable protein product	**Sustainability**	**Price**	**Brand**	**Origin**	**Total utility**	**Position in the preference ranking**
Rich in protein and fibres	Contributes to the recovery vegetable waste	9 lei for 100 g	Known brand	Produced in Romania	14.8	1
Rich in protein and fibres	Contains eggplant skins left over using the pulp	9 lei for 100 g	Known brand	Produced in Romania	13.6	2
Can replace a meal	Contributes to the recovery vegetable waste	9 lei for 100 g	Known brand	Produced in Romania	11.1	3
Can replace a meal	Contains eggplant skins left over using the pulp	9 lei for 100 g	Known brand	Produced in Romania	10.0	4
Rich in protein and fibres	Contributes to the recovery vegetable waste	9 lei for 100 g	Known brand	Produced in EU	7.5	5
Rich in protein and fibres	Contributes to the recovery vegetable waste	9 lei for 100 g	New brand	Produced in Romania	6.5	6
Rich in protein and fibres	Contains eggplant skins left over using the pulp	9 lei for 100 g	Known brand	Produced in EU	6.4	7
Rich in protein and fibres	Contributes to the recovery vegetable waste	12 lei for 100 g	Known brand	Produced in Romania	5.6	8
Rich in protein and fibres	Contains eggplant skins left over using the pulp	9 lei for 100 g	New brand	Produced in Romania	5.3	9
Rich in protein and fibres	Contains eggplant skins left over using the pulp	12 lei for 100 g	Known brand	Produced in Romania	4.4	10
Can replace a meal	Contributes to the recovery vegetable waste	9 lei for 100 g	Known brand	Produced in EU	3.9	11
Can replace a meal	Contributes to the recovery vegetable waste	9 lei for 100 g	New brand	Produced in Romania	2.8	12
Can replace a meal	Contains eggplant skins left over using the pulp	9 lei for 100 g	Known brand	Produced in EU	2.7	13
Can replace a meal	Contributes to the recovery vegetable waste	12 lei for 100 g	Known brand	Produced in Romania	1.9	14
Can replace a meal	Contains eggplant skins left over using the pulp	9 lei for 100 g	New brand	Produced in Romania	1.7	15
Can replace a meal	Contains eggplant skins left over using the pulp	12 lei for 100 g	Known brand	Produced in Romania	0.8	16
Rich in protein and fibres	Contributes to the recovery vegetable waste	9 lei for 100 g	New brand	Produced in EU	-0.8	17
Rich in protein and fibres	Contributes to the recovery vegetable waste	12 lei for 100 g	Known brand	Produced in EU	-1.7	18
Rich in protein and fibres	Contains eggplant skins left over using the pulp	9 lei for 100 g	New brand	Produced in EU	-1.9	19
Rich in protein and fibres	Contributes to the recovery vegetable waste	12 lei for 100 g	New brand	Produced in Romania	-2.7	20
Rich in protein and fibres	Contains eggplant skins left over using the pulp	12 lei for 100 g	Known brand	Produced in EU	-2.8	21
Rich in protein and fibres	Contains eggplant skins left over using the pulp	12 lei for 100 g	New brand	Produced in Romania	-3.9	22
Can replace a meal	Contributes to the recovery vegetable waste	9 lei for 100 g	New brand	Produced in EU	-4.4	23
Can replace a meal	Contributes to the recovery vegetable waste	12 lei for 100 g	Known brand	Produced in EU	-5.3	24
Can replace a meal	Contains eggplant skins left over using the pulp	9 lei for 100 g	New brand	Produced in EU	-5.6	25
Can replace a meal	Contributes to the recovery vegetable waste	12 lei for 100 g	New brand	Produced in Romania	-6.4	26
Can replace a meal	Contains eggplant skins left over using the pulp	12 lei for 100 g	Known brand	Produced in EU	-6.5	27
Can replace a meal	Contains eggplant skins left over using the pulp	12 lei for 100 g	New brand	Produced in Romania	-7.5	28

Rich in protein and fibres	Contributes to the recovery vegetable waste	12 lei for 100 g	New brand	Produced in EU	-10.0	29
Rich in protein and fibres	Contains eggplant skins left over using the pulp	12 lei for 100 g	New brand	Produced in EU	-11.1	30
Can replace a meal	Contributes to the recovery vegetable waste	12 lei for 100 g	New brand	Produced in EU	-13.6	31
Can replace a meal	Contains eggplant skins left over using the pulp	12 lei for 100 g	New brand	Produced in EU	-14.8	32

Source: Conjoint.ly., 2025, Survey platform with easy-to-use advanced tools and expert support [29].

CONCLUSIONS

Fruits and vegetables are a class of food products with high nutritional value, constituting essential elements of a balanced and healthy diet, and at the same time being the basic plant raw materials for the food industry. The quality of fresh fruits and vegetables consists in the association of attributes, properties or characteristics that determine the purchasing decision of consumers. Awareness of the link between diet and health has led to a higher interest from consumers, the food industry and decision-makers sides in the health properties of foods. Innovations are emerging in the food industry that improve the health attributes and sustainability of foods. Food products have diversified with the globalization of the industry. In order to market functional foods effectively, food managers must assess the cross-cultural variation in the acceptance of functional foods. Fruits and vegetables are widely processed and the residues are often discarded. However, due to their rich composition, they could be reused by the industry leading to develop new product and minimizing food waste at the same time.

The products designed in studies conducted in recent years have shown high fiber content, reasonable consumer acceptance, and were microbiologically stable.

This research promotes the reduction of food waste, as whole plant tissues were used, leading to the maximum exploitation of food raw materials, but also the integration of potentially functional ingredients in biscuits and muffins to add quality attributes that make them more appreciated and purchased by people who want to have a healthier lifestyle.

In conclusion, following the study carried out, it can be said that in the case of biscuits rich in fiber and protein, the order of importance of the evaluated attributes is: origin (29.6%), followed by price (23.5%), brand (21.7%), content (13.6%), and sustainability (11.5%).

In terms of preferences between the different levels tested, the following emerged. In the case of price, the higher preference is for the lower price (having the highest utility value), while the highest price indicates a lower preference (the utility value is the lowest). Similarly, the highest preferences are for biscuits obtained in Romania, the mention "Rich in protein and fiber" and the mention "Contributes to the recovery of vegetable waste". In the case of brand, the preference is for a well-known brand.

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REFERENCES

[1]Adsare, S. R., Annapure, U. S., 2024, Partially defatted coconut flour as a functional ingredient in replacement of refined wheat flour for development of fiber rich muffins. Journal of Food Science and Technology, 61(3), 491-502.

[2]Barbhai, M. D., Hymavathi, T. V., Kuna, A., Mulinti, S., Voliveru, S. R., 2022, Quality assessment of nutri-cereal bran rich fraction enriched buns and muffins. Journal of Food Science and Technology, 59(6), 2231-2242.

[3]Cozma, A., Mihut, C., ... & Rada, M., 2024, Determination of the nutritional composition of carrot pomace. Scientific Papers. Series B, Horticulture. 18(1), 431-437.

[4]Galit, I., Radu, N., Babeanu, N., Coman, O., 2024, Valuable compounds derived from cucurbitaceae subproducts and potential ways of its valorization. Scientific Papers. Series B, Horticulture. 18(1),766-778.

[5]Giri, N. A., Gaikwad, P., Gaikwad, N. N., Manjunatha, N., Krishnakumar, T., Kad, V., ... & Marathe, R. A., 2024, Development of fiber-enriched muffins using pomegranate peel powder and its effect on physico-chemical properties and shelf life of the muffins. Journal of the Science of Food and Agriculture, 104(4), 2346-2358.

[6]Lazova - Borisova, I., Durmishi N., 2023, Method for obtaining gluten free high protein biscuits. AgroLife Scientific Journal 12(2), 95-100.

[7]Mala, S. K., Aathira, P., Anjali, E. K., Srinivasulu, K., Sulochanamma, G., 2018, Effect of pumpkin powder incorporation on the physico-chemical, sensory and nutritional characteristics of wheat flour muffins. International Food Research Journal, 25(3), 1081-1087.

[8]Marcuta, A., Popescu, A., Tindeche, C., Angelescu, C., Marcuta, L., 2020, Measuring the satisfaction of consumers of apple juice. Case study, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Vol. 20(1), 321-326.

[9]Marcuta, L., Popescu, A., Purdoiu, I., Purdoiu, S., Stoian, M., Marcuta, A., 2020, Use of sensory analysis in assessing the quality of bakery products. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 20(4), 347-354.

[10]Mongi, R.J., Gomezulu, A.D., 2022, Descriptive sensory analysis, consumer acceptability, and conjoint analysis of beef sausages prepared from a pigeon pea protein binder, Heliyon 8 (9).

[11]Nasar-Abbas, S. M., Jayasena, V., 2012, Effect of lupin flour incorporation on the physical and sensory properties of muffins. Quality Assurance and Safety of Crops & Foods, 4(1), 41-49.

[12]Nath, P., Kale, S. J., Kaur, C., Chauhan, O. P., 2018, Phytonutrient composition, antioxidant activity and acceptability of muffins incorporated with red capsicum pomace powder. Journal of food science and technology, 55, 2208-2219.

[13]Nichita, A., Tylewicz, U., Popa, M.E., 2023, Transition to the future: meat analogues & cultured meat. AgroLife Scientific Journal 12(1), 132-142.

[14]Olawuyi, I. F., Lee, W. Y., 2019, Quality and antioxidant properties of functional rice muffins enriched with shiitake mushroom and carrot pomace. International Journal of Food Science & Technology, 54(7), 2321-2328.

[15]Pinto, D., Castro, I., Vicente, A., Bourbon, A.I., Cerqueira, M.A., 2014, Functional Bakery Products: An Overview and Future Perspectives, in Bakery Products Science and Technology, Second Edition. Edited by W. Zhou, Y. H. Hui, I. De Leyn, M. A. Pagani, C. M. Rosell, J. D. Selman, and N. Therdthai. John Wiley & Sons, Ltd., 431-452.

[16]Popa, N.C., Tamba-Berehoiu, R.M., Simion, V., Visan, l. 2017, Quality statistical evaluation of bakery functional products from different cereals flours mixtures, with a high content of β-glucans. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 1793), 313-322.

[17]Popa, C.N., Tamba Berehoiu, R.M., Visan, L., Simion, V., Muresan, C., Palcu, S.E., 2020, Romanian consacrated recipes in the milling and bakery industry. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 20(1), 417-424.

[18]Rabail, R., Sultan, M. T., Khalid, A. R., Sahar, A. T., Zia, S., Kowalczewski, P. Ł., Aadil, R. M., 2022, Clinical, nutritional, and functional evaluation of chia seed-fortified muffins. Molecules, 27(18), 5907.

[19]Ramya, H. N., Anitha, S., 2020, Development of muffins from wheat flour and coconut flour using honey as a sweetener. Int. J. Curr. Microbiol. App. Sci, 9(7), 2231-2240.

[20]Rao, V.R., 2010, Conjoint Analysis. Part 2. Marketing research. Wiley International Encyclopedia of Marketing, edited by Jagdish N. Sheth and Naresh K. Malhotra.

[21]Romjaun, Z. Z., Prakash, J., 2013, Development and assessment of fibre-enriched muffins. Advances in Food Sciences, 35(4), 159-165.

[22]Sethi, S., Joshi, A., Seth, K., Bhardwaj, R., Yadav, A., Grover, M., 2022, Phytonutrient content, antioxidant potential and acceptability of muffins functionalized with soy and citrus industry waste. Journal of Food Processing and Preservation, 46(7), e16606.

[23]Srinivasamurthy, S., Yadav, U., Sahay, S., Singh, A., 2017, Development of muffin by incorporation of dried Moringa oleifera (Drumstick) leaf powder with enhanced micronutrient content. Development, 2(4), 65-71.

[24]Srivastava, D., Rajiv, J., Naidu, M. M. M., Puranaik, J., Srinivas, P., 2012, Effect of fenugreek seed husk on the rheology and quality characteristics of muffins.Food and Nutrition Sciences, 3(11), DOI: 10.4236/fns.2012.311191

[25]Stobierski, T., 2020, What is conjoint analysis & how can you use it?, https://online.hbs.edu/blog/post/what-is-conjoint-analysis#:~:text=Conjoint%20analysis%20is%20a%20form,of%20their%20products%20or%20services. Accessed on 10 march 2025

[26]Troilo, M., Difonzo, G., Paradiso, V. M., Pasqualone, A., Caponio, F., 2022, Grape pomace as innovative flour for the formulation of functional muffins: How particle size affects the nutritional, textural and sensory properties. Foods, 11(12), 1799.

[27]Tukassar, A., Shukat, R., Butt, M. S., Nayik, G. A., Ramniwas, S., Al Obaid, S., ... & Sarwar, N., 2023, Compositional profiling and sensory analysis of cauliflower by-products-enriched muffins. Food Science & Nutrition, 11(10), 6020-6031.

[28]Vasantha Rupasinghe, H. P., Wang, L., Pitts, N. L., Astatkie, T., 2009, Baking and sensory characteristics of muffins incorporated with apple skin powder. Journal of Food Quality, 32(6), 685-694.

[29]***Conjoint.ly., 2025, Survey platform with easy-to-use advanced tools and expert support, https://conjointly.com/, Accessed on January 5, 2025.

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PRODUCTIVITY ELEMENTS AND YIELD IN GRAPEVINE IN RELATION TO THE MANAGEMENT SYSTEM – CASE STUDY IN SAUVIGNON BLANC

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Abstract

Grapevine is a plant with a long history and complex values in the history and economy of humanity. Different grapevine management systems have been promoted, in order to obtain quality wine products and by-products. This study comparatively analyzed two growing systems of the 'Sauvignon Blanc' grapevine cultivar (SB), in high form (HF), and in semi-high form (ShF). The experiments were conducted in the area of Recas locality. Productivity elements defined by current technological works, plant productivity indices, and yield per plant, respectively per unit area, were analyzed. Under the study conditions, the semi-high form (ShF) management system ensured better yield per plant (Y/plt) and per unit area (Y/ha), $p<0.001$. Regression analysis described the values of yield per plant (Y/plt) in relation to productivity elements, FL (fruit load), FS (fertile shoots), $R^2 = 0.951$, $p = 0.0098$; respectively FL and IN (inflorescence number), $R^2 = 0.958$, $p = 0.0075$. The results showed that FL and FS parameters presented convergent action and can be optimized concomitantly, while FL and FS parameters presented divergent action and require a differentiated approach.

***Key words*:** *management system, productivity elements, productivity indices, vineyard, yield*

INTRODUCTION

Grapes are a category of fruits particularly appreciated for their taste, aromas and nutritional principles (sugars, minerals, vitamins, polyphenols, etc.) they contain, for wine products and by-products [9, 13].
Grapevine yield varies in relation to plant age, cropping system and plant architecture, environmental and technological factors [10].
Morphological and physiological traits and primary productivity elements varied in the grapevine in relation to technological measures, rootstocks and environmental factors, respectively their interactions [16].
The role of nutrients, and especially nitrogen management for nutritional balance in the vine, was analyzed in relation to vegetative growth of shoots, yield and quality of grapes [15].
Morphological and physiological parameters of grapevines were analyzed in relation to rootstocks tolerant to drought conditions and climate change [16]. The authors recorded variations in primary productivity and yield in relation to rootstock tolerance.
Ensuring an adequate water regime for vines through irrigation is the subject of more and more studies under current climate change conditions to ensure grape yields and quality [8].
The behavior of grapevine genotypes under climate change conditions, and adaptations of local germplasm, are analyzed to identify adaptive traits, as well as to adjust technologies to ensure grape yields and quality [1, 3, 5].
Different pruning systems for vines (manual pruning, light mechanized pruning) have been studied in relation to their influence on viticultural performance in certain grape varieties [11]. The authors recorded the differential influence of pruning systems on plant vigour, yield, grape and wine characteristics.
Mechanical pruning of vines has been comparatively analyzed in different wine-growing areas (vineyards) in relation to the vine growing system, with advantages but also some disadvantages on plant vigour, grape

quality [12].
Grapevine pruning systems have been analyzed in relation to plant health and tolerance to certain pathogens [14].
Maintenance and fruiting pruning in grapevines is important for plant vigour and health and to ensure yields [4]. The authors tested different types of pruning, in relation to the stages of vine growth, grape production and quality.
The systems for positioning the architectural structure in the vineyard have been studied, analyzed and adapted in relation to the grape varieties, climatic conditions, and plantation work systems (manual, mechanized, or mixed) in order to ensure yields, grape quality, and optimize vineyard operations [18].
Grapevine yield estimation has been analyzed using different comparative methods based on parameters from the growing season [2]. The authors recorded variable accuracy of yield estimation models, with the possibility of adjustment by collecting more data during the growing season, at different representative stages.
The evaluation of yield in viticulture has always been adapted to the dynamic elements of wine farms and the wine market [7].
This study comparatively analyzed the influence of two management and pruning systems on morphological parameters, productivity elements and yield in the 'Sauvignon Blanc' grapevine cultivar.

MATERIALS AND METHODS

The study was conducted in the area of Recas, Romania, 2020 – 2021 period. The soil units on the territory, where the vineyard plantation was located, were represented by the luvosol class.
The multiannual average temperature was 12.3 °C, and the average temperature during the grape growing season was 18.9 °C (April 1 – September 30). The average monthly precipitation for 2021 was 52.5 mm, with the total precipitation for 2021 being 630 mm.
The biological material was represented by the 'Sauvignon Blanc' (SB) grape cultivar. It is a variety with medium growth vigor and good fertility (60 – 70% fertile shoots). The grapes are small to medium (90 – 100 g), cylindrical in shape, with the berries tightly packed on the bunch. The berries are small, spherical, greenish yellow in color when ripe, the skin is thin, covered with a layer of dew. The pulp is juicy, with a pleasant, harmonious taste, not aromatic. It is a variety with a medium-late harvest maturity, in September 15 – 25 interval. It is a cosmopolitan variety, preferring lands with a southern, southwester exposure, well-sunny, which provide conditions for over-ripening of the grapes.
During the growing season, the land in the vineyard plantation was maintained through repeated mechanical tillage.
Under the study conditions, two types of pruning and vine management were used, on the 0.70 – 0.80 m stem (semi-high form – ShF), and on the 1.00 – 1.20 m stem (high form – HF).
The two forms of grapevine cultivation (ShF, HF), the Sauvignon Blanc variety, were comparatively analyzed, based on morphological parameters, productivity and yield elements.
The following parameters were determined: fruit load (FL), number of buds started (BSN), total shoots (TS), fertile shoots (FS), number of inflorescences (IN), Relative Fertility Coefficient (Rfc), Absolute Fertility Coefficient (Afc), Relative productivity index (Rpi), Absolute productivity index (Api), yield per plant (Y/plt) and yield per hectare (Y/ha). The weight of grapes per plant was determined by weighing the grapes with a laboratory balance.
To conduct the study, the authors generated a flow chart, Figure 1, which synthetically included the stages and methods of work and data analysis.
The primary data, resulted based on observations, were analyzed first to assess statistical reliability, and the source of variance in experimental data set. According to the objectives, multivariate analysis, correlation analysis, regression analysis, and comparative analysis were applied, based on software resources [6, 17].

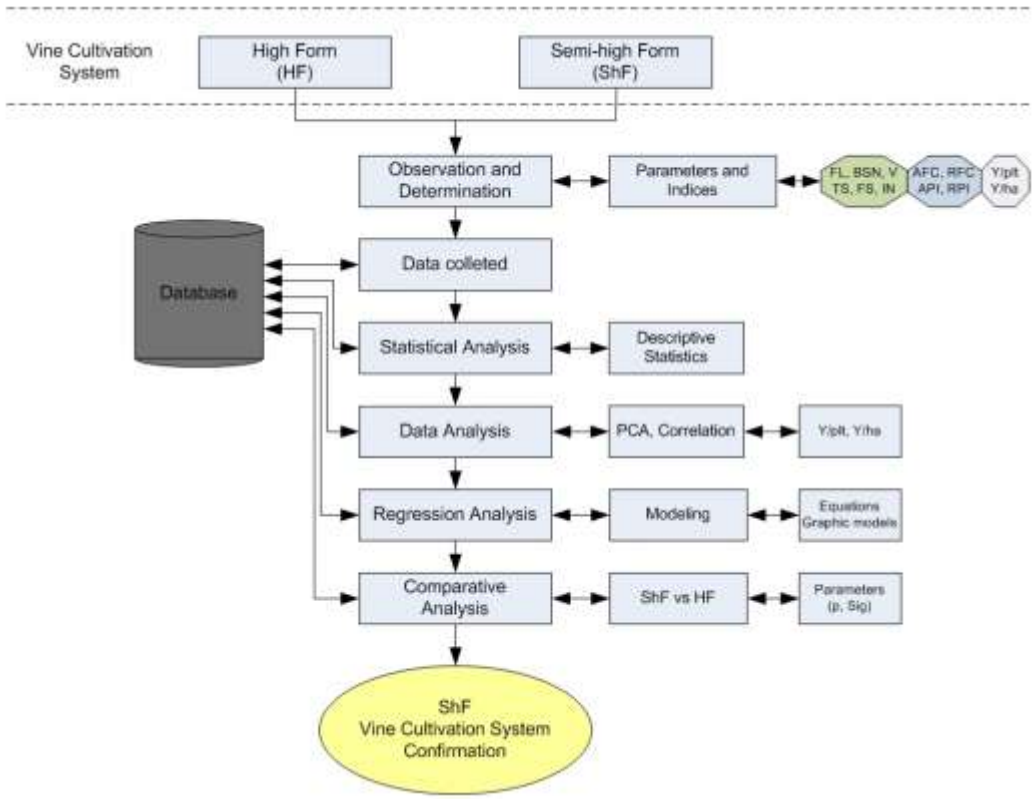

Fig. 1. Flowchart for conducting the study and data analysis
Source: Original figure.

RESULTS AND DISCUSSIONS

The two grapevine cultivation systems, 'Sauvignon Blanc' cultivar (SB), in high form (HF) and in semi-high form (ShF), were analyzed based on common morphological, productivity and yield elements. The recorded data are shown in Table 1. Statistical safety of the results, respectively the source of variance, were confirmed by Anova Test (Alpha = 0.05), Table 2.

Table 1. Values of parameters determined in the grapevine, 'Sauvignon Blanc' cultivar

Trial	FL	BSN	V	TS	FS	IN	AFC	RFC	API	RPI	Y/plt	Y/ha
	(No)	(No)	(%)	(No)			index				(kg plt^{-1})	(kg ha^{-1})
	High Form (HF)											
HF-T1	14	12	85.71	12	8	8	1.00	0.67	160.00	107.20	1.39	6,177.16
HF-T2	15	13	86.67	13	9	10	1.11	0.77	177.60	123.20	1.52	6,754.88
HF-T3	16	15	93.75	15	12	15	1.25	1.00	200.00	160.00	1.61	7,154.84
HF-T4	15	13	86.67	13	11	12	1.09	0.92	174.40	147.20	1.50	6,666.00
HF-T5	14	12	85.71	12	9	10	1.11	0.83	177.60	132.80	1.48	6,577.12
SE_{HF}	±0.37	±0.55	±1.53	±0.55	±0.73	±1.18	±0.04	±0.06	±6.41	±9.18	±0.04	±157.12
	Semi-high Form (ShF)											
ShF-T1	9	8	88.89	8	6	10	1.67	1.25	267.20	200.00	2.70	11,156.00
ShF-T2	10	9	90.00	10	7	9	1.29	0.90	206.40	144.00	2.84	11,735.00
ShF-T3	11	10	90.91	11	9	14	1.56	1.27	249.60	203.20	3.10	12,809.00
ShF-T4	10	9	90.00	8	6	10	1.67	1.25	267.20	200.00	2.72	11,239.00
ShF-T5	10	9	90.00	10	7	10	1.43	1.00	228.80	160.00	2.92	12,065.00
SE_{ShF}	±0.32	±0.32	±0.32	±0.60	±0.55	±0.87	±0.07	±0.08	±11.73	±12.30	±0.07	±301.83

Source: Original data.

Table 2. Summary of Anova Test

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	7.74E+08	11	70,375,474	111.353	1.2E-53	1.8784
Within Groups	68,256,199	108	632,001.8			
Total	8.42E+08	119				

Source: Original data.

The multivariate analysis evaluated the positioning of the two grapevine cultivation systems (HF, ShF), in comparison with the productivity and yield elements. The graphic representation in Figure 2 expresses the recorded distribution. First two principal components explained 96.022% of the total variance. Based on the results expressed in the diagram, the orientation of the RPI, AFC and Y/plt parameters with the ShF system, and of the FS, FL, TS, BSN parameters with the HF system was observed. The IN parameter presented an intermediate position.

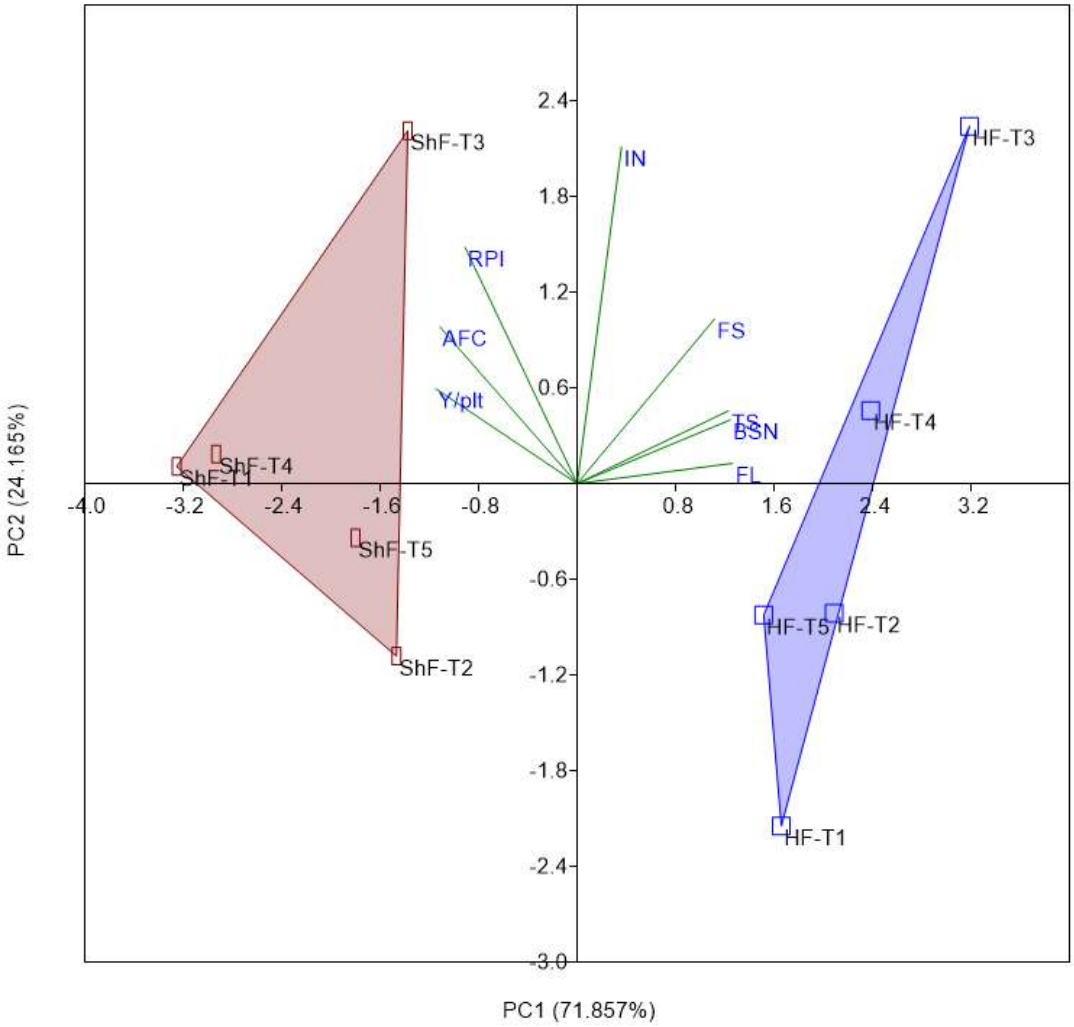

Fig. 2. PCA diagram regarding the positioning of the two systems HF, and ShF, in relation to the analyzed parameters, the 'Sauvignon Blanc' grape cultivar (HF – blue color; ShF – purple color)
Source: Original figure.

Correlation analysis was used to quantify the interdependence between the parameters considered. The recorded correlation coefficient values are presented in graphic form, in Figure 3. Positive and negative correlations were recorded, with different levels of intensity between the parameters considered.

Based on the recorded correlation, the variation of yield per plant (Y/plt) was analyzed, as the main element of grapevine productivity.

The variation of yield per plant was studied in dependence on important morphological and productivity elements, as manifestation of the

"genotype x environment" interaction, and which are largely controlled by maintenance work.

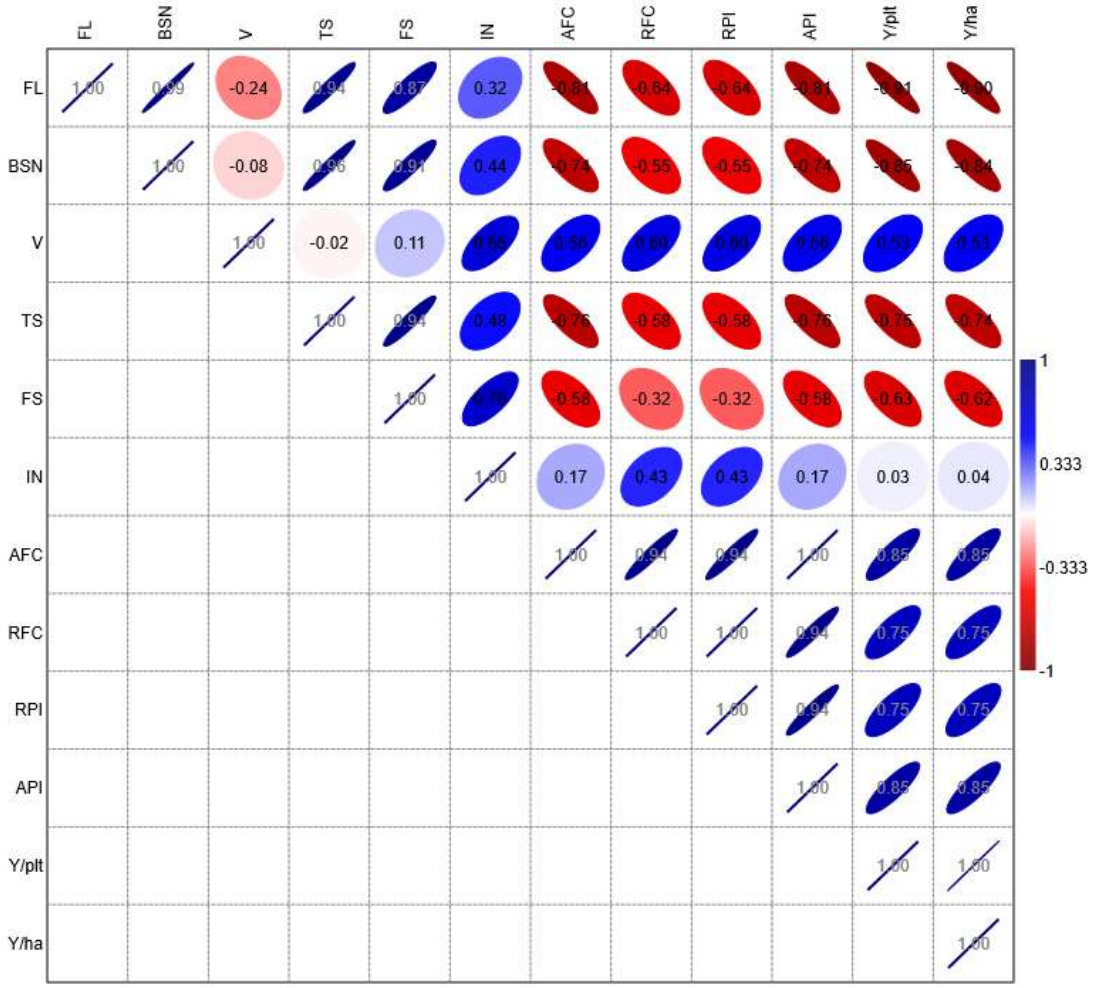

Fig. 3. Correlation diagram between parameters considered in the vineyard, 'Sauvignon Blanc' cultivar
Source: Original figure.

Yield (Y/plt) variation, according to FL (fruit load) and FS (fertile shoots) parameters, was expressed by equation (1), with safety conditions (R^2 = 0.951; p = 0.0098; F = 15.6092). Graphical expression of the yield variation based on the two parameters (FL, x-axis; FS, y-axis), is shown in Figure 4, and in Figure 5.

$$Y/plt_{(FL,FS)} = ax^2 + by^2 + cx + dy + exy + f \quad (1)$$

where: $Y/plt_{(FL,FS)}$ – grape yield (kg plt^{-1});
x – FL (fruit load);
y – FS (fertile shoots);
a, b, c, d, e, and f – the coefficients in equation (1);
a = 0.06317946; b = 0.10760554; c = -0.63827903; d = 0.42873531; e = -0.16099849; f = 5.83437467

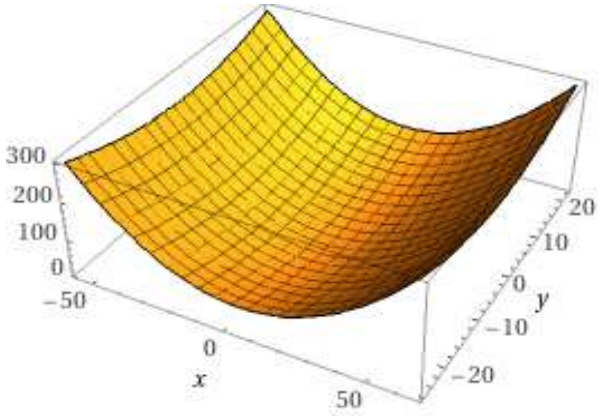

Fig. 4. Representation in 3D format for yield distribution according to FL, and FS parameters, 'Sauvignon Blanc' cultivar
Source: Original figure.

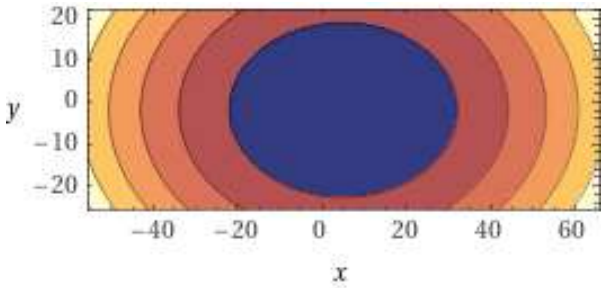

Fig. 5. Isoquant representation of the yield distribution in relation to FL, x-axis; FS, y-axis, 'Sauvignon Blanc' cultivar
Source: Original figure.

The variation of yield (Y/plt) in relation to parameters FL (fruit load) and IN (inflorescences number) was expressed described by equation (2), according to R^2 = 0.958, F = 18.0687, and p = 0.00753.
Graphical expression of yield variation, according to the two parameters, FL (x-axis), and IN (y-axis), is shown in Figure 6, and in Figure 7.
The values of the coefficients in equation (2), and the graphical representation (Figure 6, and Figure 7), showed the divergent action of the two parameters (FL and IN) in the formation of yield.

$$\text{Y/plt}_{(FL,IN)} = ax^2 + by^2 + cx + dy + exy + f \quad (2)$$

where: $\text{Y/plt}_{(FL,FS)}$ – grape yield (kg plt^{-1});
x – FL (fruit load);
y – IN (inflorescence number);
a, b, c, d, e, and f – the coefficients in equation (1);
a = -0.03466673; b = 0.00485975; c = 0.45441817; d = -0.12279220; e = 0.01092545; f = 1.34652616

Comparative study and interpretation of the values of morphological characters (FS, IN) and yield (Y/plt) was performed to evaluate which of the two grapevine cultivation systems (HF, ShF) presented advantages for the study conditions. The values presented in Table 3 resulted.
In the case of the FS parameter, the ShF system recorded the average value FS = 7.00, with a negative difference of ΔFS = - 2.80, under conditions of statistical safety ($p < 0.05$).

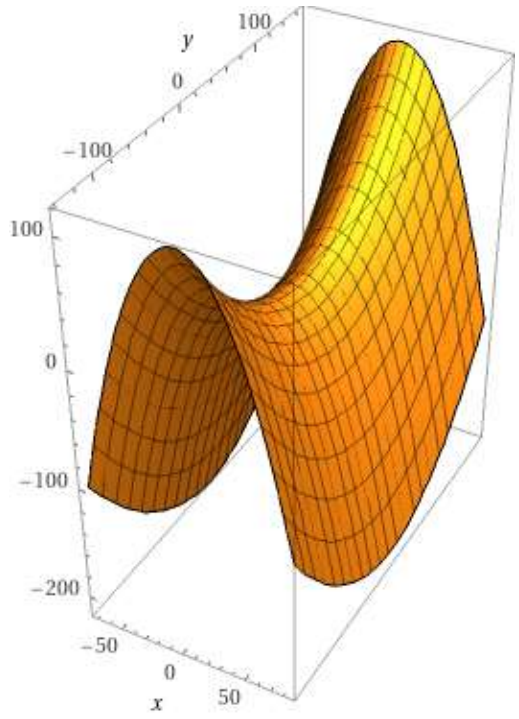

Fig. 6. 3D representation of yield distribution in relation to FL (x-axis) and IN (y-axis) 'Sauvignon Blanc' cultivar
Source: Original figure

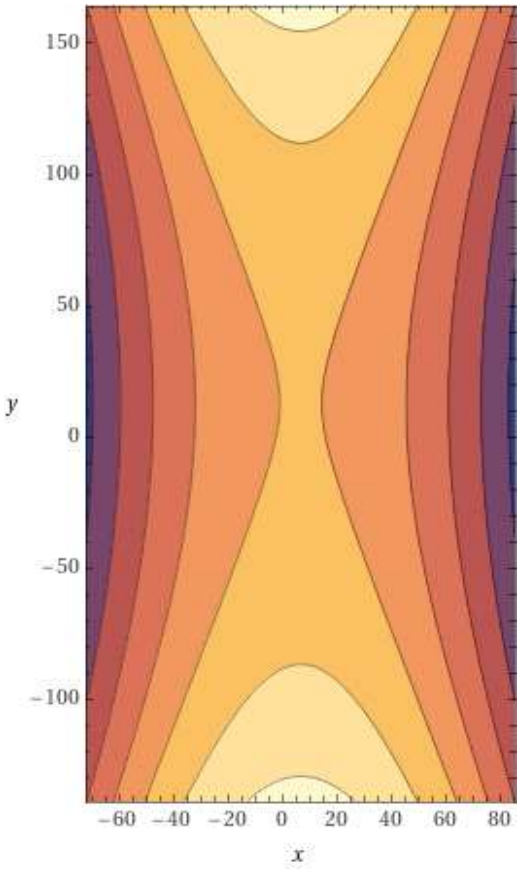

Fig. 7. Isoquant representation of the yield distribution in relation to FL (x-axis) and IN (y-axis) 'Sauvignon Blanc' cultivar
Source: Original figure.

Regarding the IN parameter in the ShF system,

the value IN = 10.60 was recorded, with a negative difference ΔIN = - 0.40, but without statistical significance in relation to the HF system.

In the case of yield (Y/plt), within the ShF system the value Y/plt = 2.86 kg plt^{-1} was recorded, with a difference ΔY = 1.36 kg plt^{-1}, compared to the HF system, under conditions of statistical safety (p<0.001).

Table 3. Results of the comparative analysis between the ShF and HF systems, 'Sauvignon Blanc' cultivar

Statistical parameters	Grapevine parameters		
	FS	IN	Y/plt
Given mean (ShF)	7.00	10.60	2.86
Sample mean (HF)	9.80	11.00	1.50
95% conf. interval	(7.7597 11.84)	(7.7149 14.285)	(1.4018 1.5982)
Difference	2.80	0.40	1.36
95% conf. interval	(0.75974 4.8403)	(-2.8851 3.6851)	(1.2578 1.4542)
T	3.8103	0.3381	-38.3530
p (same mean)	0.0189	0.7523	2.76E-06
Significance of differences	o	ns	***

Source: Original data.

The results of the study recorded specific values of parameters and yield in the Sauvignon Blanc grapevine variety, in relation to the two management and pruning systems for fruiting. Fruit load is an important factor influencing primary productivity, yield and quality of grapes [13].

Light mechanical pruning has provided certain benefits to the vine, through higher production, morphological characteristics of the grape bunches, oenological characteristics of the grapes, and cost reductions in the overall technology [11].

The balance between plant vigor and the number of clusters per plant is important for grape yield and quality and is ensured through pruning [13].

Differences in cluster parameters, along with other elements in the vine, have been recorded in relation to the pruning system, but also with plant age groups, young vineyard plantations and older plantations [10].

Cutting at different times in relation to the stages of vegetation and vegetative dormancy in the vine also influenced the yield and quality of the grapes [4].

In the study, differentiated values of vegetation parameters and indices were recorded in relation to the two cutting systems (HF, ShF), but the ShF system ensured an increase in yield, with statistical certainty, for the study conditions.

CONCLUSIONS

Morphological parameters, productivity indices and yield represented appropriate elements for the comparative analysis of the two grapevine management and pruning systems, the high form (HF) and the semi-high form (ShF).

According to the PCA and the generated diagram, RPI, AFC and Y/plt parameters showed orientation towards the ShF system, and FL, TS, BSN and FS parameters showed orientation towards the HF system. This showed which management and pruning systems favored certain parameters at the vine turn, given that the principal components (PC1, PC2) explained 96.022% of the total variance.

The research results generated various models, mathematical and graphical, which showed how the yield (Y/plt) was distributed with certain plant parameters. This provided important information for optimizing technological work for the vineyard.

The comparative analysis of the two driving and cutting systems showed that the ShF system ensured an increase in yield (ΔY) under conditions of statistical safety (p<0.001), which recommends this system for the study conditions.

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REFERENCES

[1]Bucur, G.M., Dejeu, L., 2024, Phenological and some eno-carpological traits of thirteen new Romanian grapevine varieties for white wine (*Vitis vinifera* L.) in the context of climate change, Scientific Papers. Series B, Horticulture, LXVIII(1):254-263.

[2]De la Fuente, M., Linares, R., Baeza, P., Miranda, C., Lissarrague, J.R., 2015, Comparison of different methods of grapevine yield prediction in the time window between fruitset and veraison, OENO One, 49(1):27-35.

[3]Dobrei, A., Dobrei, A.G., Nistor, E., Iordanescu, O.A., Sala, F., 2015, Local grapevine germplasm from Western of Romania - An alternative to climate change and source of typicity and authenticity, Agriculture and Agricultural Science Procedia, 6:124-131.
[4]Falginella, L., Gaiotti, F., Belfiore, N., Mian, G., Lovat, L., Tomasi, D., 2022, Effect of early cane pruning on yield components, grape composition, carbohydrates storage and phenology in Vitis vinifera L. cv. Merlot, OENO One, 56(3):19-28.
[5]Gayretli, Y., Abdulhadi, S.A.A., Demirkeser, O.K., Turkoglu, I., Aslan, B., Sabir, A., 2024, Physiological responses of different grapevine genotypes (Vitis spp.) to variable temperatures artificially established as climate change scenery, AgroLife Scientific Journal, 13(1):98-105.
[6]Hammer, Ø., Harper, D.A.T., Ryan, P.D., 2001, PAST: Paleontological Statistics software package for education and data analysis, Palaeontologia Electronica, 4(1):1-9.
[7]Laurent, C., Oger, B., Taylor, J.A., Scholasch, T., Metay, A., Tisseyre, B., 2021, A review of the issues, methods and perspectives for yield estimation, prediction and forecasting in viticulture, European Journal of Agronomy, 130:126339.
[8]Ma, X., Han, F., Wu, J., Ma, Y., Jacoby, P.W., 2023, Optimizing crop water productivity and altering root distribution of Chardonnay grapevine (*Vitis vinifera* L.) in a silt loam soil through direct root-zone deficit irrigation, Agricultural Water Management, 277:108072.
[9]Micu, D.M., Beciu, S., 2023, Study on brand strategies and brand architecture in the wine industry – Case study: Drăgășani vineyard, Valcea County, Romania, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 23(4):523-530.
[10]Nader, K.B., Stoll, M., Rauhut, D., Patz, C.-D., Jung, R., Loehnertz, O., Schultz, H.R., Hilbert, G., Renaud, C., Roby, J.-P., Delrot, S., Gomès, E., 2019, Impact of grapevine age on water status and productivity of *Vitis vinifera* L. cv. Riesling, European Journal of Agronomy, 104:1-12.
[11]Pérez-Bermúdez, P., Olmo, M., Gil, J., García-Ferriz, L., Olmo, C., Boluda, R., Gavidia, I., 2015, Effects of traditional and light pruning on viticultural and oenological performance of Bobal and Tempranillo vineyards, OENO One, 49(2):145-154.
[12]Poni, S., Tombesi, S., Palliotti, A., Ughini, V., Gatti, M., 2016, Mechanical winter pruning of grapevine: Physiological bases and applications, Scientia Horticulturae, 204:88-98.
[13]Senthilkumar, S., Vijayakumar, R.M, Soorianathasundaram, K., Devi, D.D., 2015, Effect of pruning severity on vegetative, physiological, yield and quality attributes in grape (*Vitis Vinifera* L.) - A review, Current Agriculture Research Journal, 3(1):42-54.
[14]Travadon, R., Lecomte, P., Diarra, B., Lawrence, D.P., Renault, D., Ojeda, H., Rey, P., Baumgartner, K., 2016, Grapevine pruning systems and cultivars influence the diversity of wood-colonizing fungi, Fungal Ecology, 24(Part A):82-93.
[15]Verdenal, T., Dienes-Nagy, Á., Spangenberg, J.E., Zufferey, V., Spring, J.-L., Viret, O., Marin-Carbonne J., van Leeuwen, C., 2021, Understanding and managing nitrogen nutrition in grapevine: A review, OENO One, 55(1):1-43.
[16]Villalobos-Soublett, E., Verdugo-Vásquez, N., Díaz, I., Zurita-Silva, A., 2022, Adapting grapevine productivity and fitness to water deficit by means of naturalized rootstocks, Frontiers in Plant Science, 13:870438.
[17]Wolfram, Research, Inc., 2020, Mathematica, Version 12.1, Champaign, IL (2020).
[18]Zozzo, F.D., Poni, S., 2024, Climate change affects choice and management of training systems in the grapevine, Australian Journal of Grape and Wine Research, 2024(1):7834357.

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THE ROLE OF CARBON CREDITS IN SUSTAINABLE AGRICULTURE: A REVIEW OF LITERATURE

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Abstract

Climate change constitutes a significant challenge of the modern period, profoundly affecting sustainable development and the global economy. The creation of carbon credit markets has become significant as a strategic tool for reducing greenhouse gas emissions and promoting a sustainable economic model. This study provides a thorough examination of the current literature about greenhouse gas emissions linked to agricultural practices, emphasizing the relationship between sustainable agriculture, carbon credit systems, and the economic incentives for farmers. The aim of the paper is to inform stakeholders about agricultural greenhouse gas policies and the carbon credit market in the European Union. In doing so, the authors seek to answer farmers` questions: i) What is the financial motivation for choosing agricultural technologies that reduce greenhouse gas (GHG) emissions?; ii) What are the technical and environmental motivations that lead farmers to replace conventional technologies with conservative and sustainable technologies? The results of the paper present the role of carbon credits in sustainable agriculture, both technically (sustainable farming practices, carbon sequestration) and economically (prices, revenues, carbon market).

Key words**:** *carbon credits, GHG emissions, carbon market, sustainable agriculture*

INTRODUCTION

The climate change caused by pollution from industries, agriculture and humans has determined the scientists to look for solutions to pass to a Green economy destined to assure economic growth, human health and environment protection (Blaj, 2013) [1].

Agriculture is situated among polluters and that is why its economic performance is affected by the negative impact of climate change. In this context, agriculture needs to be changed into a resilient economic sector (Rusali, 2018) [9].

The agricultural sector faces three interconnected and urgent challenges: the necessity to diminish greenhouse gas (GHG) emissions, the requirement to adapt production systems to changing climatic conditions, and the obligation to satisfy the rising global food demand resulting from population growth. (Lokuge et Anders, 2022) [7].

Shockley and Snell (2021) found that greenhouse gas (GHG) emissions, especially carbon dioxide (CO_2, from agricultural operations are lower than those produced by the industrial sector. In this context, agricultural carbon credit schemes have attracted significant attention globally as a solution to achieve climate neutrality [12].

The article by Havens et al. (2023) [5] defines a carbon credit as a certificate that indicates a specified quantity of carbon dioxide has been extracted from the atmosphere and sequestered for an extended duration. Their buyers can then claim credit for the carbon fixed on their behalf by someone else and in this way offset their own carbon emissions.

Assessing and reporting carbon emissions in agriculture is a topic of major importance in the current context of climate change and increasing pressure to implement sustainable agricultural practices.

An increasing number of researchers have quantified the carbon footprint of agricultural production, carbon emissions from agricultural activities, and greenhouse gas emissions associated with agricultural production. Lately,

the carbon sequestration function of agricultural practices has started to receive increasing attention, especially carbon accumulations due to plant photosynthesis (Li et al., 2024) [6].

Stefan (2012) [13] presented that the economy was at the beginning of a period of structural change, which is driving new economic theories.

Private enterprises may utilize carbon credits to mitigate their greenhouse gas emissions, achieve corporate social responsibility (CSR) goals, or act as trial projects in preparation for future compliance market engagement.

In recent years, the voluntary carbon market has undergone substantial growth and expansion. According to a report by the Boston Consulting Group (BCG) and oil company Shell, more than 286 million credits have been generated by 2023, up from just over 5 million credits in 2007. (Shell et BCG, 2023) [14].

In the final report by the International Institute of Finance in 2021, the voluntary market was projected to be valued at around $2 trillion in 2021 and is expected to reach between $10 and $40 billion by 2030, with forest carbon credits expected to account for the largest share of the market. However, concerns about the environmental integrity of the credits have been brought into the spotlight by numerous revelations of over-crediting and lack of impact (ITF, 2021) [14].

Innovation significantly contributes to the reduction of greenhouse gas emissions. Innovation in agriculture addresses the necessity to enhance the competitiveness of the agricultural industry against escalating social and political demands to mitigate climate change effects and guarantee food security. Innovation in agriculture aims to identify novel solutions that enhance the efficiency of economic entities within the sector while promoting sustainable development in agriculture (Coca et al., 2017) [2].

In this context, the paper aimed to inform stakeholders about agricultural greenhouse gas policies and the carbon credit market in the European Union.

MATERIALS AND METHODS

In the context of the research on carbon credits, the following methods were used: meta-analysis and bibliometric study.

Meta-analysis can be defined as a research method based on the analysis of results obtained in previous studies. In its simplest form, it involves identifying a common statistical measure across studies and averaging this measure.

The primary aim of a meta-analysis is to enhance statistical power by yielding more accurate results than those derived from an individual study. The process of conducting a meta-analysis involves a number of decisions that may influence the final results. These include how to search, select, and exclude studies how to deal with incomplete data and how to choose the most appropriate method of data analysis.

The objective of performing the bibliometric survey in carbon credit research encompasses multiple facets, offering an extensive comprehension of the existing literature landscape, as well as identifying trends, emerging patterns, and knowledge deficiencies within the domain. Through a systematic survey of scholarly publications, it aims to map the breadth and depth of carbon credit research, providing insights to inform future research directions and evidence-based decision-making.

One of the main objectives of the bibliometric study is to map the carbon credit literature, identifying the main authors, journals, and research topics. By analyzing publication trends over time, the researchers were able to distinguish patterns in terms of research focus, methodologies used, and geographical distribution of academic contributions.

In addition, the study aims to identify influential papers and research groups in the field, providing a clear picture of current knowledge on carbon credits. The results of the methodology developed are presented below. As a result, the keyword "carbon credits" was used, and the Web of Science database was searched, where 1,000 related papers were identified.

The identified papers are written by researchers from around the world and published in journals and magazines such as

Climate Policy, Carbon Management, Forest Policy and Economics, Environmental Research Letters.

RESULTS AND DISCUSSIONS

The 2023 article "Revealed: more than 90% of rainforest carbon offsets by biggest certifier are worthless, analysis shows," published by Patrick Greenfield in The Guardian [4], elucidates the manner in which corporations utilize carbon offsets to achieve their emissions objectives (Figure 1).

Fig. 1. How companies use carbon offsetting to meet their emissions targets
Source: Own design based on https://www.theguardian.com/environment/2023/jan/18/revealed-forest-carbon-offsets-biggest-provider-worthless-verra-aoe [4].

Under Step 1, an offset project is set up. This project aims to mitigate the effects of global warming by preventing greenhouse gas emissions. Projects may include initiatives that prevent the release of gases resulting from deforestation or fossil fuel use. However, projects do not remove carbon already in the atmosphere, but focus on preventing additional emissions.

In Step 2, carbon credits are calculated. Each project generates a number of credits, determined by rigorous methods. For example, in the case of avoided deforestation projects, it is estimated what would have happened if the project had not been implemented. The difference between expected and actual emissions is the amount of carbon offset, which is converted into credits.

Next, Step 3 involves businesses adopting a net-zero strategy. Companies assess emissions from their own activities and implement measures to reduce them. However, to offset unavoidable emissions, companies decide to purchase carbon credits, thus helping to support offset projects.

In Step 4, companies search for and purchase carbon credits. These can be obtained through a specialized broker or directly from the projects that generate the credits. To ensure their validity, most credits are verified and approved by organizations such as VERRA or GOLD STANDARD. The credits are then used to offset the company's remaining emissions.

At the end, Step 5 focuses on the company's official climate change declaration. After acquiring the necessary credits, companies can communicate that they have achieved carbon neutrality. This declaration can cover the entire business or just specific products and is an important step to demonstrate commitment to sustainability.

Through this five-step process, businesses can help combat climate change and respond to growing demands for greener solutions. Each step plays a key role in achieving a more sustainable future.

The term regenerative has been linked to notions like "agriculture" and "farm" since the late 1970s; nevertheless, the phrase regenerative agriculture became prominent in the early 1980s, especially through its endorsement by the Rodale Institute in the United States.

In 1983, Robert Rodale provided a fundamental definition of regenerative agriculture, describing it as a system that concurrently increases productivity and broadens the biological resource base, particularly land and soil. Rodale asserts that such a system is characterized by significant economic and ecological stability, negligible environmental impact beyond farm perimeters, food production devoid of biocides, and the promotion of greater human involvement during the shift towards diminished dependence on non-renewable resources. (Griller et al., 2021) [3].

Climate change is the biggest environmental challenge facing the world today. Agriculture is a vital sector that produces food and other products, contributing significantly to social and economic development and poverty

reduction in many countries. Despite these substantial benefits, agriculture contributes about 10-12% of global emissions. Contributors to agricultural emissions include livestock production, fertilizer use, and land-use change. The main source of CO_2 emissions in agriculture is the burning of fossil fuels and excessive use of fertilizers.

The agricultural sector is estimated to contribute 80% of nitrogen dioxide (N_2O) emissions, 70% of ammonia (NH_3) emissions, and 40% of methane (CH_4) emissions. (Nsabiyeze et al., 2024) [8].

From a climate change perspective, the agricultural sector is a major player at the regional, national, and global levels. In addition to CO_2 emissions, the agricultural sector is a source of methane and nitrous oxide, both important greenhouse gases.

A ton of CH_4 has a warming potential 20 times greater than a ton of CO_2, and a ton of N_2O has an impact 300 times greater. Agriculture generates these gases through diverse processes and practices.

Agriculture and forestry account for 18.40% of total global anthropogenic CO_2 emissions, as illustrared in Figure 2.

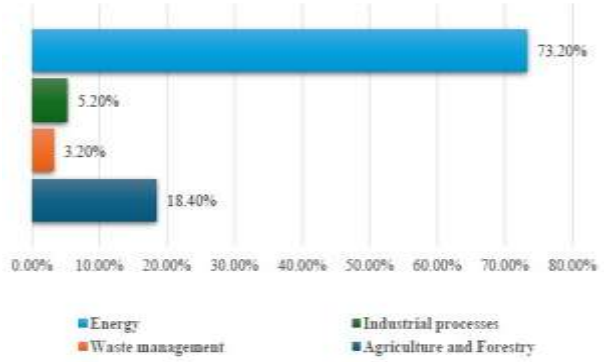

Fig. 2. Allocation of worldwide greenhouse gas emissions by sector
Source: Own design.

Figure 3 illustrates the emissions contribution from the agriculture and forestry sectors.

The largest contributions come from the livestock sector (31.50%) and agricultural soils (29.90%), indicating the major impact of livestock management and intensive farming practices on greenhouse gas emissions. Rice cultivation (19%) and deforestation (12%) are also significant sources, reflecting the role of land conversion and traditional farming methods in increasing emissions.

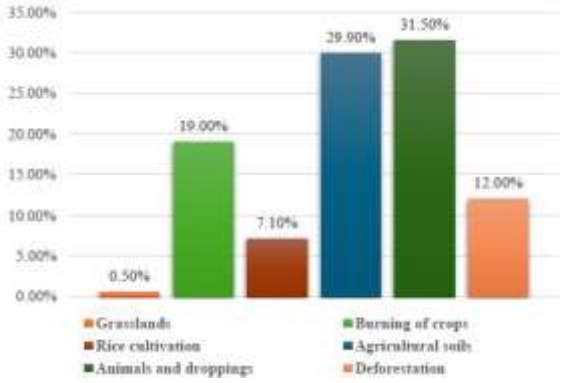

Fig. 3. Total CO_2 emissions from agricultural, forestry, and land use sectors
Source: Own source.

Crop burning contributes 7.10%, indicating an agricultural practice that can be optimized to reduce emissions.

In contrast, grasslands (0.50%) have the lowest impact, suggesting that maintaining these ecosystems may have benefits for reducing carbon footprints.

While until the 1800s these changes could be attributed exclusively to natural causes such as variations in the solar cycle, since the 1800s the main driver of climate change has become human activity characterized by the increasing use of fossil fuels, which has resulted in greenhouse gas emissions that have affected the Earth's ability to conserve solar energy (radiative forcing). This issue is of paramount importance for the present and future of mankind because its negative consequences are felt in all areas of social life: health, agriculture, food, energy, transport, and defense (Sarcinschi et al., 2022) [10].

The results obtained from the developed methodology are presented below. Following the first step, the Web of Science database was used for the keyword *carbon credits*. The cluster analysis is summarized below.

VOSviewer software [15] was used to analyze and visualize the degree of association of keywords in the dataset. This tool applies classification techniques to organize keywords into thematic clusters, highlighting the relationships between them.

Figure 4 highlights four distinct clusters, represented by the colors red, green, blue, and

yellow. These were classified and illustrated using the VOSviewer program.

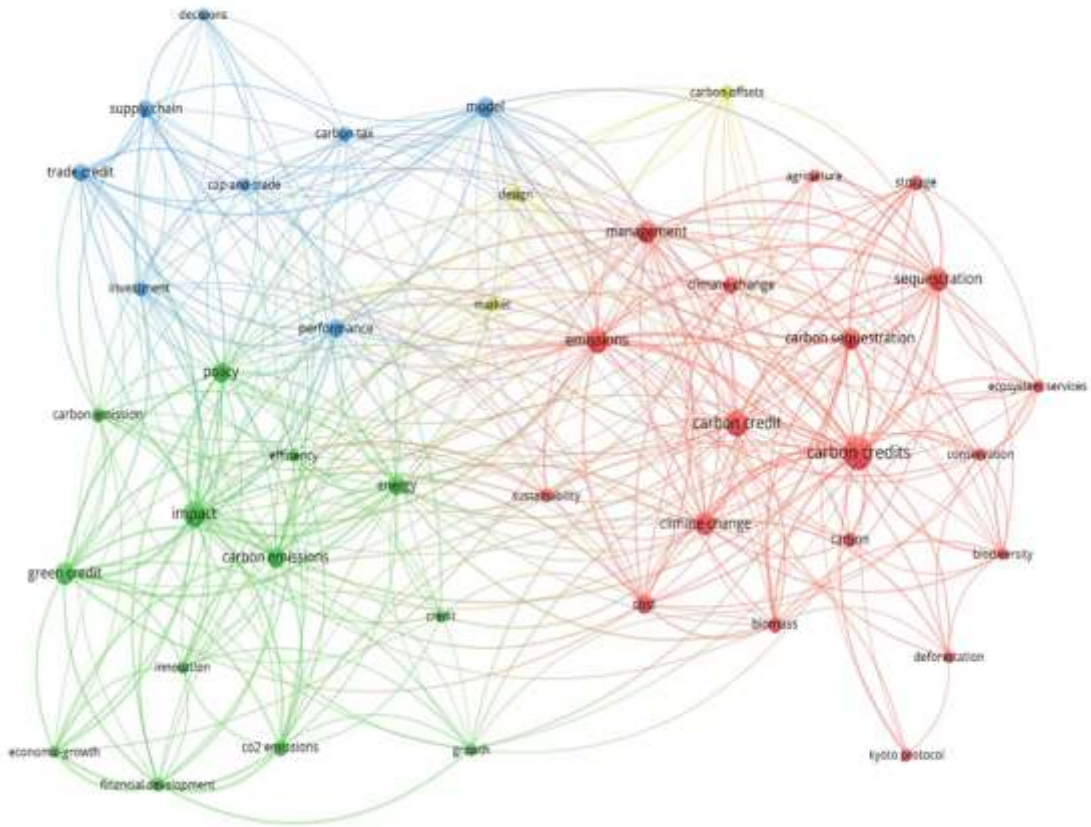

Fig. 4. VOSviewer ranking results – keywords Web of Science
Source: Web of Sciences database [15].

The clusters formed reflect the thematic connections between concepts and keywords frequent in the analyzed articles. Each cluster suggests a main theme, and the relationships between concepts are represented by the links (lines) between nodes.

The red cluster focuses on economic and environmental mechanisms related to carbon reduction, such as carbon credits, carbon sequestration, and ecosystem services. The strong link to "climate change" indicates an interest in climate mitigation and adaptation measures.

The green cluster emphasizes the link between economic policies and environmental protection, with an interest in the use of green credits and their impact on emissions and economic growth, with "financial development" and "innovation" playing an important role.

The blue cluster explores optimizing supply chains and integrating economic strategies (e.g., "trade credit" and "cap-and-trade") into business models. This suggests an interest in operationalizing sustainability in the business environment.

The yellow cluster is linked to the use of natural resources, biodiversity conservation, and the role of biomass in combating climate change.

Four major connections between keywords were identified, reflecting the main thematic interactions in the analyzed research.

The first important connection is between "carbon credits" and "emissions" both belonging to the red cluster. "Carbon credits" appears 140 times in the articles analyzed, and "emissions" 76 times. The strength of the link between these two concepts, expressed by the number of links, is 157, one of the highest in the graph. This link highlights the importance of carbon credits as an economic tool for mitigating greenhouse gas emissions, establishing them as a key element of climate

policy frameworks and market-based strategies to combat climate change.

The second significant connection associates "impact" with "carbon emissions," both situated in the green cluster. "Impact" is one of the most used terms, with 85 occurrences, and "carbon emissions" appears 54 times. The strength of the 118 connections between them highlights the crucial role of analyzing the impact of carbon emissions on the economy, the environment, and society. This link underlines the need to assess the effectiveness of measures to reduce emissions and to develop long-term sustainable strategies.

The third relevant connection is between "climate change" in the red cluster and "policies" in the green cluster. "Climate change" appears in 62 articles and "policies" in 52, and the strength of the connection between them is 121. This demonstrates the interdependence between the challenges of climate change and the development of public policies to manage them. It is clear that without a strong legislative and policy framework, climate change cannot be effectively managed.

The last significant connection links "supply chain" in the blue cluster and "carbon emissions" in the green cluster. "Supply chain" appears 36 times and "carbon emissions" 54 times, with a connection strength of 78. This relationship highlights the importance of optimizing supply chains to reduce the ecological footprint. It is a key link for implementing sustainable practices in logistics and production, showing how the industry can contribute to reduce carbon emissions and tackling climate change.

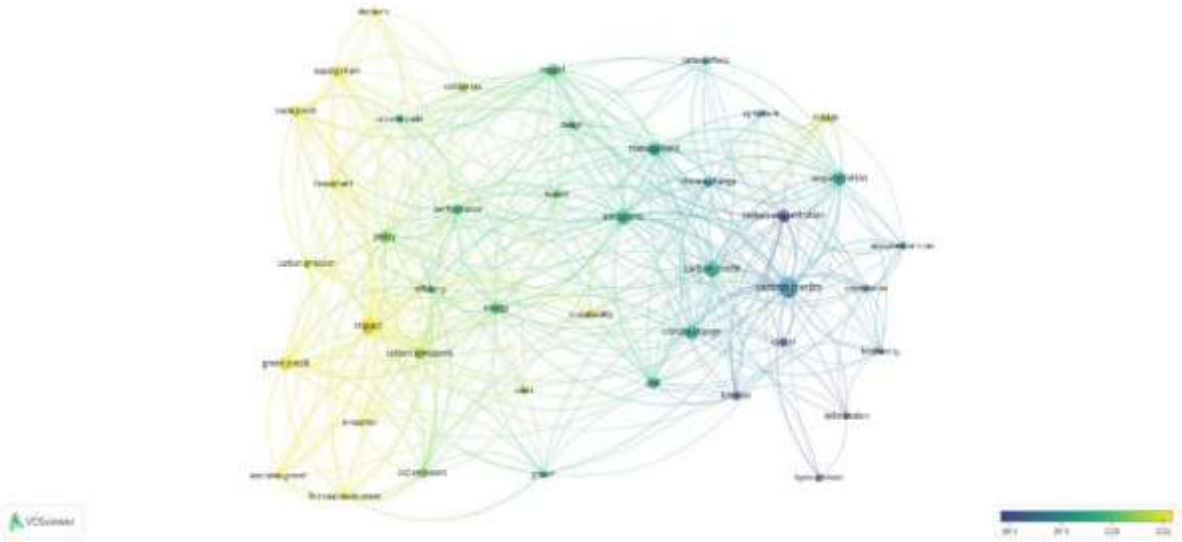

Fig. 5. VOSviewer ranking results - years publications
Source: Web of Sciences database [7].

Figure 5 shows a clear transition in the scope of research from climate change and emission reduction studies (2016-2018) to economic policy and energy efficiency (2018-2020) and finally to the development of sustainable financial instruments and the integration of green principles into supply chains (2020-2022). This development suggests that as awareness of climate change has grown, the focus has shifted from recognizing the problem, to identifying financial and economic solutions to tackle it.

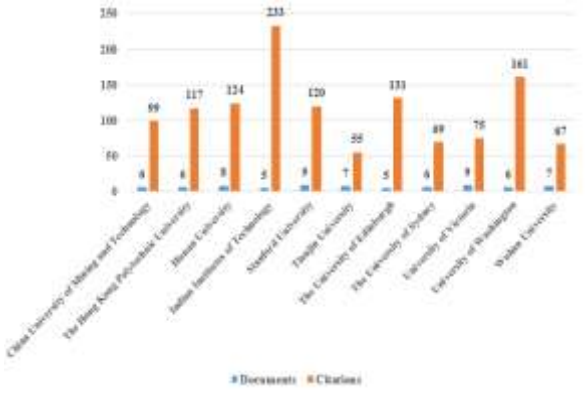

Fig. 6. Ranking results by university
Source: Own source.

In terms of universities (Figure 6), Stanford University, the University of Victoria and Hunan University are among the most active institutions in the field analyzed, each with a significant number of publications.

However, although several universities hold a substantial amount of publications, not all of them have shown a proportional influence in terms of citations.

An exemplary case is the Indian Institute of Technology, which, although publishing merely five papers, has achieved a remarkable 233 citations—underscoring the significant effect and academic importance of its contributions to the subject.

This indicates that the influence of academic work is contingent not alone upon the volume of publications but also on their pertinence and caliber.

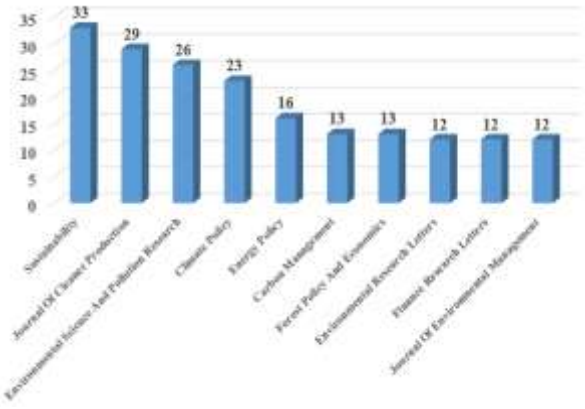

Fig. 7. Categorization of outcomes by publication
Source: Own source.

In terms of the distribution of articles in scientific journals (Figure 7), it can be noted that Sustainability is the journal with the highest volume of published articles, indicating a growing interest in research on sustainability and environmental impacts.

The Journal of Cleaner Manufacturing ranks second in terms of volume of articles published, indicating a research focus on sustainable production techniques and their environmental ramifications. In addition, journals such as Climate Policy and Energy Policy point to distinct public policies and strategies for the energy transition, while Finance Research Letters highlights an evolving aspect of sustainable finance research.

The journals disseminating these articles indicate a connection among environmental science, public policy, and economics, emphasizing the multifaceted character of modern research.

CONCLUSIONS

1.A carbon credit is a certificate stating that a certain amount of carbon dioxide has been removed from the atmosphere and fixed for a long period of time. Purchasers can then claim credit for the carbon fixed on their behalf by someone else and in this way offset their own carbon emissions.

2.According to the distribution of global greenhouse gas emissions, the largest impact of emissions in the context of economic sectors is energy with 73.20%, followed by agriculture with 18.40%.

3. For the agriculture sector, the largest contributions come from the livestock sector (31.50%) and agricultural soils (29.90%), indicating the major impact of livestock management and intensive farming practices on greenhouse gas emissions.

4. Carbon credits are gaining global prominence, as demonstrated by the growing number of publications and the multitude of universities and institutes in different corners of the world working on the topic.

5. There is currently relatively little interest in regulatory proposals that include the term "carbon offsets" in EU legislation, despite growing international market opportunities and increased focus on the credibility of offsetting.

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REFERENCES

[1]Blaj, R. 2013, Green economy - The economy of the future. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 13(4), 63-68.
[2]Coca, O., Stefan, G., Mironiuc, M., 2017, Empirical evidences regarding the relationship between innovation and performance in the agriculture of European Union, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 17(1), 99-110.
[3]Giller, K. E., Hijbeek, R., Andersson, J. A., Sumberg, J., 2021, Regenerative Agriculture: An agronomic perspective, Outlook on Agriculture, Vol. 50(1) 13–25, DOI: 10.1177/0030727021998063
[4]Greenfield, P., 2023, Revealed: more than 90% of rainforest carbon offsets by biggest certifier are worthless, analysis shows, The Guardian, https://www.theguardian.com/environment/2023/jan/18/revealed-forest-carbon-offsets-biggest-provider-worthless-verra-aoe, Accessed on 22 January 2025.
[5]Havens, D., Perrin, R., Fulginiti, L., 2023, Carbon Farming: A Preliminary Economic Analysis of Carbon Credits for No-Till and Cover Crops, Cornhusker Economics, Agricultural Economics, 1206, Univerosty of Nebraska, USA. https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=2200&context=agecon_cornhusker, Accessed on 22 January 2025.
[6]Li, J., Ning, J., Song, J., Chen, X., 2024, Analysis of the spatial mismatch pattern of net carbon in agriculture and its influencing factors, Environmental Impact Assessing Review, 106, 107522.
[7]Lokuge, N., Anders, S., 2022, Carbon-credit systems in agriculture: A review of literature, The Simpson Centre For Agricultural And Food Innovation and Public Education, Vol. 15:12
[8]Nsabiyeze, A., Ma, R., Li, J., Luo, H., Zhao, Q., Tomka, J., Zhang, M., 2024, Tackling climate change in agriculture: A global evolution of the effectiveness of carbon emission reduction policies, Journal of Cleaner Production, Volume 468, 142973.
[9]Rusali, M.A. 2018, Romania's agriculture polluter effects vs. potential contribution to a climate change resilient economy. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 18 (1), 435-440.
[10]Sarcinschi, A., Bogzeanu, C., Atanasiu, M., Băhnăreanu, C., Ioniță, C.C., Zodian, M., Lică, D., Potîrniche, M., 2022, Threats and risk regarding national security of Romania- Horizon 2040 (Amenințări și riscuri la adresa securității naționale a României – orizont 2040), University of Defence,,Carol I", Publishing House, Bucharest, pp.13-14.
[11]Shell, Boston Consulting Group, 2023, The voluntary carbon market: 2022 insights and trends, https://www.shell.co.jp/ja_jp/about-us/nature-based-solutions/_jcr_content/root/main/section/simple_843705749/promo_copy.multi.stream/1698220196565/e484b5f772a755e6cbb6585eab088d60ab2e4ff8/the-voluntary-carbon-market-2022-insights-and-trends-june.pdf, Accessed on 20 January 2025.
[12]Shockley, J., Snell, W., 2021, Carbon markets 101, Economic and Policy Update, 21 (4), April 29.
[13]Stefan, G., 2012, Considerations on the theory of economic growth and development, Proceedings of World Conference on Business, Economics and Management (BEM-2012), vol 62, pp. 280-284, DOI10.1016/j.sbspro.2012.09.045
[14]The Institute of International Finance (ITF), 2021, Taskforce on scaling voluntary carbon market – Final report, https://www.iif.com/Portals/1/Files/TSVCM_Report.pdf, Accessed on 20 January 2025.
[15]VoSViewer, Visualizing Scientific Landscapes, https://www.vosviewer.com/, Accessed on 17 January 2025.

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MANAGEMENT OF THE NON-WOOD FOREST PRODUCTS IN THE AGROFORESTRY SYSTEM ESTABLISHED IN HORTINOVA NURSERY, CÂRCEA COMMUNE, DOLJ COUNTY, ROMANIA

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Abstract

Agroforestry systems involve the integration of trees and shrubs with forestry value alongside cereals and/or other horticultural crops. In 2023, twenty 24m x 24m plots were established, with two of them planted with 800 raspberry plants (plot no. 3) and 800 blackberry plants (plot no. 8). The planting layout had a 1.2m row spacing and a 0.6m plant spacing within the same row. Another two plots were dedicated to cereals, another two to vegetables, while 14 plots featured a mix of various tree and shrub species. The purpose of this study was to emphasize the economic impact of incorporating non-wood forest products into the overall management of an agroforestry system. In the second year of the experiment (2024), the fruits were harvested and weighed. Calculations regarding the potential yields that could be obtained and comparisons with the costs needed for the maintenance works in forestry cultures were made. Preliminary results suggest that the combination of trees and shrubs is key to the sustainability of this agroforestry system. By adding additional shrub species, such as hazelnuts, the diversity of products can be expanded, providing landowners with more opportunities to commercialize a wider range of agroforestry products and additional time to manage them.

Key words**:** *agroforestry systems, Craiova, cultivated raspberry and blackberry, Dolj, non-wood forest products*

INTRODUCTION

Agroforestry is defined as the integration of trees and/or shrubs alongside crops and livestock within agricultural systems [18]. Together with protective forest shelterbelts, afforestation, and irrigation, agroforestry systems provide a complementary strategy to combat desertification, aridization and climate change [22], [23], [30], [39]. It was recently reported that climatic changes have a profound effect on forest ecosystems, directly influencing forestry and related industries [33]. Moreover, the rising frequency of extreme climate events driven by climate change is increasingly affecting crop yields [2], [32].

Agroforestry systems are increasingly recognized worldwide for their environmental and economic advantages, contributing significantly to the development of rural communities [14]. By enhancing crop protection, diversifying production, and offering shelter for both humans and animals [26], agroforestry practices, in some cases incorporating agro-forestry-pastoral methods [9], have become widely embraced as effective solutions for sustainable land management.

Given these benefits, agroforestry systems have attracted growing interest from landowners and foresters in various regions of Romania, including Bihor County [4], Călărași County [37], and the Oltenia Region [8].

Field protective shelterbelts, key elements for agroforestry systems, consist of rows, usually between five and twenty, of trees and shrubs planted to serve as barriers against winds. These areas delimited and protected by the shelterbelts are vital for preserving biodiversity, supporting a balance between pests and beneficial species, and enhancing the biological control of crop pests [27]. The Romanian Academy has also been involved in planting shelterbelts as part of its efforts [12].

Particularly, in Romania, the creation of field protective shelterbelts is essential for advancing agroforestry systems in agricultural landscapes [15].

Additionally, it serves to expand forested areas into vulnerable environments, such as the sandy soils located in the southern part of Dolj County [13].

To diversify the products in agroforestry systems, special attention should be given to non-wood forest products which could be obtained/harvested from different shrub species.

In Romania, the most common non-wood forest products (NWFPs) include forest fruits, edible mushrooms, medicinal plants, forest seeds, and fauna of hunting interest [3], [7] [16], [17]. These products have a wide array of uses, particularly in culinary applications [6]. Dolj County holds significant potential for the production, harvesting, and marketing of NWFPs [5].

The aim of this study was to highlight the economic contribution of integrating non-wood forest products into the overall management of the agroforestry system established in 2023 at HortiNova Nursery.

MATERIALS AND METHODS

In 2023, an experiment was conducted at the HortiNova Nursery in Cârcea Commune, near Craiova, Romania (Dolj County; 44°16'53.6"N 23°55'37.7"E), where 20 square plots, each covering 576 m², were created.

Each plot featured a unique combination of trees (14 plots), cereals (2 plots),vegetables (2 plots) and shrubs (2 plots).

Two of the 20 plots (plots no. 3 and no. 6, respectively) were planted only with red raspberry (*Rubus idaeus* L.) 'Tulameen' cultivar and blackberry (*Rubus fruticosus* L.) 'Thornfree' cultivar (Photo 1).

These shrubs are two of the most representative species of the genus *Rubus*, which has a complex taxonomy, with estimates ranging from 400 [29] to 700 [25] species.

The plants were propagated from cuttings and planted on March 15, 2023 (in the case of raspberry), and April 14, 2023 (in the case of blackberry), respectively.

Photo 1. The two plots planted with raspberry and blackberry
Source: Original photo from 6th of July 2024.

In both cases, the plants were spaced 1.2 meters apart between rows and 60 cm apart within each row (800 plants per plot). At the start of 2024, the rows were thinned, leaving 400 plants in each plot.

An irrigation system was installed in the raspberry-planted plot in April 2024 (Photo 2), whereas no such system was implemented in the blackberry-planted plot.

Photo 2. Irrigation system installed in the raspberry-planted plot
Source: Original photo.

In both plots, no fertilizers or insecticides were applied, and two maintenance operations were carried out to trim the grass between the rows during 2024 (Photo 3).

Photo 3. The raspberry (a) and blackberry (b) plots after the first maintenance operation
Source: Original photo from 21st of May 2024.

Climatic data were collected using a HoBo sensor and an iMETOS 3.3 data logger. In this survey, temperature (^{0}C) and relative humidity (%) data recorded every 30 minutes by the HoBo sensor were compiled for the period from April 1st to September 15th, 2024, using Microsoft Office Excel. The HoBo sensor (model U23-001A Data Logger U23 Pro v2) was positioned 1.5 meters above the soil surface (Photo 4).

Photo 4. HoBo sensor
Source: Original photo.

The iMETOS 3.3 data logger was installed near the experimental plots, 10 meters from plot no. 3. Soil analyses were performed by the Dolj Office of Pedological and Agrochemical Studies, measuring pH (soil reaction), total nitrogen (%), humus content (%), as well as potassium (K) and phosphorus (P) levels (ppm).

To determine the yield in each plot, 30 plants per plot were randomly selected. All berries were collected from the raspberry plot between mid-June 2024 and mid-July 2024, while all berries from the blackberry plot were collected in August 2024.

The berries were weighed after each collection phase, and the total quantities for each of the 60 plants were calculated.

RESULTS AND DISCUSSIONS

Soil analysis

The results of the soil analysis are shown in Table 1.

Table 1. Results of soil analysis

Plot	pH	Humus (%)	N (%)	P (ppm)	K (ppm)
2	5.83	3.16	0.16	66	242
5	5.75	2.76	0.14	20.8	246

Source: Own results.

These results suggest poor soil quality, as the optimal pH range is between 6.0 and 7.5. The humus content is low, nitrogen (N) levels are moderate, and phosphorus (P) and potassium (K) levels are moderate to high.

Relative humidity

As for relative humidity (RH), it varied between 17.95% and 88.53%, with an average of 54.50 ± 17.47%.

Precipitations

In 2024, the total recorded precipitation was only 238.8 mm (Figure 1).

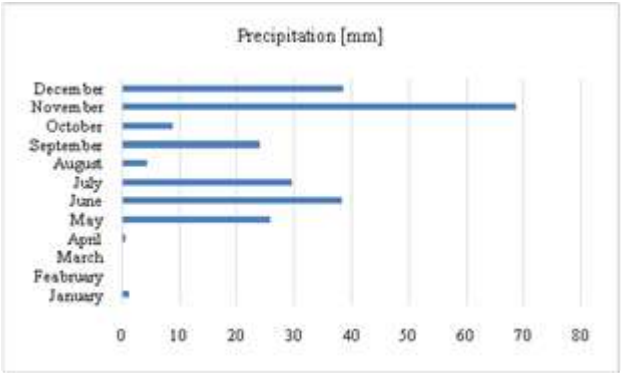

Fig. 1. Monthly precipitation recorded in 2024
Source: Data recorded with iMETOS 3.3 data logger.

Almost half of the total rainfall occurred in the last three months of the year, and only 97.6 mm were recorded in the growing season, from May to August.

Temperatures

During this period, temperatures ranged from 1.65^0C to 39.13^0C, with an average of 21.89^0C $\pm$ 7.23^0C.

Irrigation water

In the raspberry-planted plot, a total of 72,000 liters of water were used for irrigation from May to July 2024, averaging 2 liters of water per plant every day.

Raspberry and blackberry yields

In the experiment from HortiNova Nursery, in 2024, the average yield per raspberry plant was 0.96 kg, ranging from a minimum of 0.84 kg to a maximum of 1.17 kg. Similarly, for blackberry plants, the average yield was 1.41 kg per plant, with a minimum of 1.29 kg and a maximum of 1.51 kg.

Multiplying the average yield by 400 results in a total of 380 kg of raspberries and 565 kg of blackberries for each 576 m² plot, which means up to 6.59 $t \cdot ha^{-1}$ in the case of raspberry and up to 9.81 $t \cdot ha^{-1}$ in the case of blackberry (Table 2).

Table 2. Raspberry and blackberry yields per plant, plot and hectare in the year 2024

Fruit	Average yield per plant Kg/plant	Minimum yield Kg/plant	Maximum yield Kg/plant	Production per plot of 576 m² kg/plot	Production per ha tons/ha
Raspberry	0.96	0.84	1.17	380	6.59
Black berry	1.41	1.29	1.51	565	9.81

Source: Own results.

These results are consistent with those found in other studies. For instance, the average raspberry fruit yield typically ranged from 4.5 $t \cdot ha^{-1}$ to 6 $t \cdot ha^{-1}$ [20], but it reached up to 8.44 $t \cdot ha^{-1}$, as observed in a Polish experiment where the plants were grown under balanced fertilization conditions [31].

Regarding the yield per cane, it was reported that different cultivars are growing worldwide, with yields typically ranging from about 150 g to 600 g, as observed in the 'Tulameen' cultivar [10], [35]. In certain cases, such as with pot-grown long canes with high yield potential, the yield can even reach up to 3 kilograms per cane [34].

Income, maintenance costs and profit

Income per hectare

In the year 2024, the average selling price at the farm gate was Lei 35/kg raspberries and Lei 20 per kg blackberries.

Taking into account, the average production per ha of 6,590 kg raspberries and, respectively, 9,810 kg blackberries, it results an income of Lei 230,650 per ha from sold raspberries and Lei 196,200 per ha from sold blackberries (Table 3).

Table 3. Average raspberry and blackberry sale price at farm gate and income per ha in the year 2024

Fruits	Production kg/ha	Average sale price at farm gate Lei/kg	Income Per ha Lei/ha
Raspberry	6,590	35	230,650
Blackberry	9,810	20	196,200

Source: Own calculations.

Note: Average exchange rate: 1 Euro=Lei 4.9753, according to National Bank of Romania, in 2024.

Maintenance costs and profit per ha

Based on the results mentioned above and considering the maintenance costs for a black locust (*Robinia pseudoacacia* L.) monoculture as outlined in the afforestation guide adopted through the National Resilience and Recovery Plan, implemented by the Romanian Ministry of Environment, Waters, and Forests [28], which amount to up to 2,749 Euros per hectare, the profit from 1 hectare of raspberry, with only 1 Euro profit per plant, could cover the maintenance costs for 2.4 hectares. In other words, the profit generated in the second year from 1 hectare of raspberry cultivation could fully cover the maintenance costs of a black locust monoculture and provide the farmer with an additional income of over 3,800 Euros.

For an oak-based (*Quercus* spp.) mixed culture, the maintenance costs for the second year, according to the same guide [28], are up to 4,866 Euros per hectare. In this case, the farmer will have sufficient funds to cover the maintenance costs for the oak-based mixed culture while also generating additional income.

These two shrubs were selected due to their high yield and strong market demand both at national level, but also worldwide. The leading raspberry-producing countries worldwide are Russia, Serbia, Montenegro, Poland, and the United States [19], [29], [38]. For example, in 2022, the combined production share of the top three countries accounted for approximately 46% of the global produced quantity [29].

It can be observed that the top rankings are dominated by two large countries, the United States and Russia, as well as by countries with site conditions and land infrastructure like those of Romania.

Additional benefits for farmers growing raspberry and blackberry

It was also reported that the raspberry could provide additional benefits for the farmers. For example, at the end of the growing season, one-year-old raspberry shoots, considered crop residues, could serve as a valuable biofuel. Recent studies have shown that their calorific value ranges from 16.07 to 16.39 MJ·kg−1, highlighting their potential like that of typical plant-based biomass [21].

Blackberries are rich in antioxidants, offering numerous health benefits [1]. Consequently, their cultivation has garnered considerable interest in Romania in recent years. The fruit is consumed fresh or used in a variety of processed forms, including syrups, juices, jams, and desserts [11]. Additionally, the oil is extracted from the seeds using ultrasound-assisted extraction [24]. These are only a few examples from the multiple benefits that the two shrub species could provide to farmers and/or landowners.

CONCLUSIONS

The yield data, combined with environmental conditions, suggests that both raspberry and blackberry cultivation can be productive. However, optimizing factors such as irrigation, temperature control, and soil fertility could enhance yields, especially for raspberries, which showed potential for improvement compared to the results of other studies done across Europe.

Additionally, the profitability of raspberry cultivation is underscored by its ability to cover the maintenance costs of both black locust monoculture and oak-based mixed culture, two of the most common forestry systems in the region. This highlights raspberry cultivation as an economically viable option for farmers, enabling them to diversify their income streams while promoting the sustainability of other forestry and/or agro-forestry systems.

In conclusion, integrating raspberry and blackberry cultivation into agroforestry systems offers farmers significant economic benefits, making them a practical and profitable choice for sustainable land management.

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REFERENCES

[1]Albert, C., Codină, G.G., Hejja, M., Andras, C.D., Chetrariu, A., Dabija, A., 2022, Study of Antioxidant Activity of Garden Blackberries (*Rubus fruticosus* L.) Extracts Obtained with Different Extraction Solvents. Applied Sciences, 12, 4004, https://doi.org/10.3390/app12084004.

[2]Bâră, A., Văduva, A.G., Oprea, S.V., 2024, Anomaly Detection in Weather Phenomena: News and Numerical Data-Driven Insights into the Climate Change in Romania's Historical Regions. International Journal of Computational Intelligence Systems, 17, 134, https://doi.org/10.1007/s44196-024-00536-2.

[3]Budău, R., 2022, The market of edible mushrooms from the spontaneous flora of Romania. Annals of the University of Oradea, Fascicle: Environmental Protection, 1, 57-62.

[4]Budău, R., Apăfăian, A., Caradaică, M., Bratu, I.A., Timofte, C.S.C., Enescu, C.M., 2023, Expert-Based Assessment of the Potential of Agroforestry Systems in Plain Regions across Bihor County, Western Romania. Sustainability, 15, 15724, https://doi.org/10.3390/su152215724.

[5]Cântar, I.C., Enescu, C.M., Dincă, L., 2018, Application of the Analytic Hierarchy Process in selection of the most important non-wood forest products for Dolj County. Annals of the University of Craiova - Agriculture, Montanology, Cadastre Series, XLVIII, 50-57.
[6]Chivu, M., Stanciu, S., 2024, Promoting Romania's culinary heritage. Case study: local gastronomic points. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 24(1), 203-212.
[7]Cioacă, L., Enescu, C.M., 2018, Trends in the evolution of harvesting non-wood forest products in Romania. Research Journal of Agricultural Science, 50(4), 82-86.
[8]Ciuvăț, A.L., Abrudan, I.V., Ciuvăț, C.G., Marcu, C., Lorenț, A., Dincă, L., Szilard, B., 2022, Black locust (*Robinia pseudoacacia* L.) in Romanian Forestry. Diversity, 14, 780, https://doi.org/10.3390/d14100780.
[9]Copăcean, L., Cojocariu, L., Simon, M., 2021, Remote sensing and GIS for change detection in the agro-forestry-pastoral space. Research Journal of Agricultural Science, 53(1), 18-26.
[10]Darnell, R.L., Brunner, B., Alvarado, H.E., Williamson, J.G., Plaza, M., Negron, E., 2006, Annual, Off-season Raspberry Production in Warm Season Climates. HortTecnology, 16(1), 92-97.
[11]Dogaru, M., Mihalache, M., Popa, G., Dragomir, D., Ion, A., Gheorghe, C., 2024, The effect of the culture substrate on the content of bioactive compounds in some blackberry genotypes. Scientific Papers. Series A. Agronomy, LXVII(1), 66-79.
[12]Dolocan, C., Mușat, M., Ciceoi, R., Argatu, G., Mușat, I.B., Petcu, M., 2022, Aspects regarding the shelterbelts establishment in Bărăgan Plain. Scientific Papers. Series A. Agronomy, LXV, 2, 54-60.
[13]Enescu, C.M., 2019, Sandy soils from Oltenia and Carei Plains: a problem or an opportunity to increase the forest fund in Romania? Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 19(3), 203-206.
[14]Enescu, C.M., Caradaică, M., 2023, Which woody species are preferred in the composition of agroforestry systems in sandy soils of Dolj County? Annals of the University of Craiova - Agriculture, Montanology, Cadastre Series, 53(2), 78-83.
[15]Enescu, C.M., 2024, Perspectives on field protective shelterbelts: an essential component for agroforestry system expansion across Romania. Scientific Papers. Series A. Agronomy, LXVII(1), 809-814.
[16]Enescu, C.M., Belciug, M.C., 2018, Diversity and marketing potential of non-wood forest products in Bertea locality (Prahova county). Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 18(4), 105-18.
[17]Enescu, C.M., 2020, Economic input of non-wood forest products of animal origin to the turnover of forest districts in Romania. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 20(2), 223-226.
[18]Gheorghe-Irimia, R.A., Șonea, C., Tăpăloagă, P.R., Tăpăloagă, D., Șonea, G.C., 2024, Climate-smart livestock: integrating agroforestry practices in pasture management for enhanced environmental benefits. Annals of University of Oradea, Fascicle: Ecotoxicology, Animal Science and Food Science and Technology, 294-300.
[19]Hărțăgan, R.M., Maxim, A., Odagiu, A., Balint, C., Buzan, R.L., 2018, The Dynamic, Characteristics and Challenges of Organic Raspberry Cultivation Worldwide and in Romania. ProEnvironment, 11, 162-169.
[20]Kljaic, N., Vukovic, P., Arsic, S., 2022, Raspberry production, trade and market in the Republic of Serbia. Ekonomika, 68(3), 91-102.
[21]Maj, G., Buczynski, K., Klimek, K.E., Kalpan, M., 2024, Evaluation of Growth and Energy Parameters of One-Year-Old Raspberry Shoots, Depending on the Variety. 17, 3153, https://doi.org/10.3390/en17133153.
[22]Marușca, T., 2012, Sustainable agroforestry system, in the context of global climate warming. Revista de Silvicultură și Cinegetică, 17(3), 67-77.
[23]Marușca, T., Taulescu, E., Memedemin, D., 2020, Preliminary study of agrosilvopastoral systems from Romania. Romanian Journal of Grassland and Forage Crops, 22, 25-32.
[24]Matei, P.L., Deleanu, I., Brezoiu, A.M., Chira, N.A., Busuioc, C., Isopencu, G., Cîlțea-Udrescu, M., Alexandrescu, E., Stoica-Guzun, A., 2023, Ultrasound-Assisted Extraction of Blackberry Seed Oil: Optimization and Oil Characterization. Molecules, 28, 2486, https://doi.org/10.3390/molecules28062486.
[25]Memete, A.R., Sărac, I., Teusdea, A.C., Budău, R., Bei, M., Vicas, S.I., 2023, Bioactive Compounds and Antioxidant Capacity of Several Blackberry (*Rubus* spp.) Fruits Cultivars Grown in Romania. Horticulturae, 9, 556, https://doi.org/10.3390/horticulturae9050556.
[26]Mihăilă, E., Tudora, A., Bîtcă, M., Popovici, L., 2021, Alley cropping versus taungya system, two distinct types of agroforestry systems. Revista de Silvicultură și Cinegetică, 26(49), 72-80.
[27]Mușat, M., Ciceoi, R., Dolocan, C., Argatu, G., Cioroianu, I., 2021, Increasing the productive potential of agroecosystems affected by climate change using shelterbelts in southeastern part Romania. Romanian Agricultural Research, 38, 505-515.
[28]National Program for Recovery and Resilience. Component 2. Forests and biodiversity protection. Investment 1. National campaign of afforestation and reforestation, including urban forests (Planul Național de Redresare și Reziliență. Componenta 2: Păduri și protecția biodiversității. Investiția 1. Campania națională de împădurire și reîmpădurire, inclusiv păduri urbane). https://pnrr.mmap.ro/wp-content/uploads/2024/01/GHID_PNRR_C2_I1_IMPADURIRI.pdf, Accessed on 9th of February 2025.
[29]Popa, R.G., Șchiopu, E.C., Pătrașcu, A., Bălăcescu, A., Toader, F.A., 2024, Raspberry Production Opportunity to Develop an Agricultural Business in the Context of the Circular Economy: Case Study in South-

West Romania. Agriculture, 14, 1822, https://doi.org/10.3390/agriculture14101822.
[30]Popovici, L., Mihăilă, E., Costăchescu, C., Constandache, C., 2018, Can agroforestry systems be ordinary practices in Romania? Lucrări științifice seria Horticultură, 61(1), 263-268.
[31]Sawicka, B., Barbas, P., Skiba, D., Krochmal-Marczak, B., Pszczolkowski, P., 2023, Evaluation of the Quality of Raspberries (*Rubus idaeus* L.) Grown in Balanced Fertilization Conditions. Commodities, 2, 220-245.
[32]Schmidt, M., Felsche, E., 2024, The effect of climate change on crop yield anomaly in Europe. Climate Resilience and Sustainability, 3, e61, https://doi.org/10.1002/cli2.61.
[33]Szmyt, J., Dering, M., 2024, Adaptive Silviculture and Climate Change – A Forced Marriage of the 21st Century? Sustainability, 16, 2703, https://doi.org/10.3390/su16072703.
[34]Sonsteby, A., Stavang, J.A., Heide, O.M., 2013, Production of high-yielding raspberry long canes: The way to 3 kg of fruit per cane. The Journal of Horticultural Science and Biotechnology, 88(5), 591-599.
[35]Titirică, I., Roman, I.A., Nicola, C., Sturzeanu, M., Iurea, E., Botu, M., Sestraș, R.E., Pop, R., Militaru, M., Ercisli, S., Sestraș, A.F., 2023, The Main Morphological Characteristics and Chemical Components of Fruits and the Possibilities of Their Improvement in Raspberry Breeding. Horticulture, 9, 50, https://doi.org/10.3390/horticulturae9010050.
[36]Tomorrow's Forests Foundation, We plant forests for a real impact in the climatic fight, padureademaine.ro, Accessed on 9th of February 2025.
[37]Tudora, A., Bîtcă, M., Mihăilă, E., 2022, Evolution of the agroforestry system of the alley cropping type in the first years after plantation. Revista de Silvicultură și Cinegetică, 27(51), 74-81.
[38]Vanghele, N.A., Botoran, O.R., Pruteanu, A., Marin, E., Vlăduț, V., 2024, Research on the development of raspberry cultivation in conditions of organic agriculture. Scientific Papers. Series B, Horticulture, LXVIII, 2, 219-223.
[39]Vălean, A.M., Crișan, I., Șopterean, L., Tărău, A., Suciu, L., Chețan, F., Filip, E., Negrea, A., 2023, Benefits of Agroforestry Shelterbelts on Useful Athropod Fauna from Wheat Culture in the Climate Change Context. ProEnvironment, 16/55, 118-125.

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CLUSTERING AND RANKING OF CORN HYBRIDS BASED ON YIELD AND SEED QUALITY INDICES

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Abstract

The research evaluated the yield and seed quality indices of 15 corn hybrids created within NIARD Fundulea. The comparative corps was organized under the specific climate and soil conditions of ARDS Lovrin. Yield (Y) recorded values between Y = 4,126.00–6,786.00±186.46 kg ha^{-1}. Physical indices of seeds recorded values TKW = 204.41–316.45±7.93 g (TKW – weight of 1000 seeds), HW = 73.50–79.90±0.42 kg hl^{-1} (hectoliter weight). Cluster analysis (CA) generated the grouping of corn hybrids, according to similarity, based on the studied parameters (Y, TKW and HW). Hybrid 8029 was associated with hybrid 8025 with high yield values (Y = 6,786.00 kg ha^{-1}, Y = 6741.00 kg ha^{-1}) and TKW (TKW = 316.45 g, TKW = 315.54 g). In the case of the HW index, hybrid 8027 (HW = 79.90 kg hl^{-1}) was positioned with the highest values, followed by hybrid 8021 (HW = 78.20 kg hl^{-1}). Multivariate analysis generated the differentiated distribution of corn hybrids according to the principal components, in which PC1 explained 49.303%, and PC2 explained 40.077% of total variance. Based on the three parameters considered (Y, TKW, and HW) a ranking of the corn hybrids was done.

Key words**:** *cluster, maize, quality indices, ranking, yield*

INTRODUCTION

Corn is an important crop plant, which provides food, feed and industrialization resources, and participates with a high share in the agri-food products market [1, 6, 15, 20].
Genotype, environmental factors, their interactions, crop technologies and management decisions, contribute to the formation of corn yield, and corn kernels quality indices [3].
Corn production has increased considerably in recent decades, but some kernel quality indices have remained elusive, and require improvement for crop value [23]. Corn kernel filling was analyzed in relation to different factors, e.g. genotypes, plant density, and mineral fertilization [23]. The variation of grain weight with plant density and nitrogen application rate were recorded.
Corn yield variation was analyzed in relation to different genotypes, environmental factors, agricultural systems, and management practices [4, 10, 22]. In relation to plant density, the authors of the study recorded variations in yield and physical seed quality parameters [22]. They also found quadratic models that described the variation of quality parameters in relation to plant density.
Seed quality parameters (e.g. HW, TKW) in maize were studied comparatively in relation to hybrids from different FAO groups and water supply conditions [12]. The authors identified hybrids with high potential for the parameters considered under the study conditions, and recorded significant TKW values in relation to water supply conditions.
Studies on grain weight and grain number in corn were analyzed in relation to mineral nitrogen fertilization, to understand physio-logical aspects and yield formation [17].
Different maize genotypes (e.g. inbred lines)

were analyzed in comparative crops in terms of morphological characters and grain quality parameters [19].

"Multi-location" studies on maize are important to observe the behaviour of biological material under varying climate and soil conditions, and to develop high-yielding, high-performing genotypes [2]. Corn seed quality parameters were studied under cultivation conditions of a collection of 45 corn hybrids in different locations, in order to identify valuable genotypes [2]. Based on the obtained results, have been identified corn genotypes with variable potential, for the considered quality parameters. In this way, it was possible to select corn hybrids with high potential in a certain geographical region, with specific climate and soil conditions. Quality parameters have specific importance for each agricultural crop, and have been studied under farm-specific conditions, in relation to certain technological practices [13]. Based on the results recorded, it was possible to classify production into quality classes for each crop, with formulations that can be found in management practices.

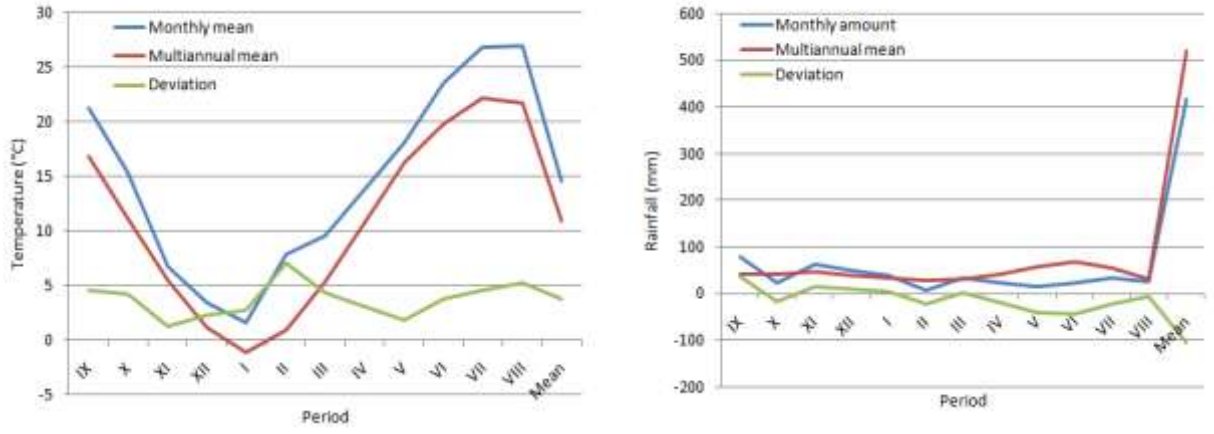
Multivariate analysis methods (cluster analysis, principal component analysis) were used to evaluate the degree of homogeneity and physiological and agronomic variability in maize genotypes [24]. The author recorded a significant contribution of the genotype ($p<0.01$) to the variation of the analyzed traits. Based on the cluster analysis, the author obtained distinctly differentiated groups between the analyzed genotypes.

Physical quality parameters of corn seeds (e.g. TW) determine the classification of production quality groups and influence the market price of corn production [22].

The study analyzed the behaviour of fifteen corn hybrids, created within NIARD Fundulea, under cultivation conditions specific to the Western Plain of Romania, with the experimental location within ARDS Lovrin.

MATERIALS AND METHODS

Fifteen corn hybrids, created within NIARD Fundulea, were tested in the context of pedoclimatic conditions in the Western Plain of Romania. The study and field research was conducted within ARDS Lovrin, agricultural year 2023 - 2024, with the climatic conditions presented in Figure 1.



(a) (b)

Fig. 1. Climatic conditions during the study period; (a) – temperature, (b) - rainfall
Source: Original figure, based on climate data recorded within ARDS Lovrin.

The corn hybrids were grown in a non-irrigated system, on a chernozem soil. Conventional technology (plowing + disc tillage + combiner) was used for land preparation. Mineral fertilization was applied during land preparation (300 kg ha^{-1}, complex 1:1:1) and during vegetation (200 kg ha^{-1}, ammonium nitrate). Weed control was done through pre-emergence herbicides and vegetation work (mechanical weeding supplemented with manual work, as appropriate).

The corn hybrids were numbered 8021 to 8035.

Sowing was done in April (first decade), with a distance of 0.7 m between rows. Each hybrid was cultivated in replicates.

According to study purpose, the weight of 1,000 kernels (TKW, g), the yield (Y, kg ha^{-1}), hectolitre weight (HW, kg hl^{-1}) was determined. Harvesting was done at physiological maturity [11].

The corn hybrids were analyzed comparatively based on the considered parameters values. Multivariate analysis (PCA), cluster analysis (CA), ranking analysis (RA) was applied to understand, explain and rank the corn hybrids in relation to each parameter. The PAST software [9] and the calculation module in EXCEL were used.

RESULTS AND DISCUSSIONS

Corn hybrids, tested in comparative cultivation, expressed the genetic potential for yield and seed quality parameters (physical properties of seeds) under uniform cultivation conditions, specific to the Western Plain of Romania, within the ARDS Lovrin.

Within the tested corn hybrids, TKW values were recorded as TKW = 204.41±7.93 g (hybrid 8023) and TKW = 316.45±7.93 g (hybrid 8025).

For the HW parameter, values between HW = 73.50±0.42 kg hl^{-1} (corn hybrid 8035) and HW = 79.90±0.42 kg hl^{-1} (corn hybrid 8027) were recorded.

For yield (Y), values of Y = 4,126.00±186.46 kg ha^{-1} (corn hybrid 8035) and Y = 6,786.00±186.46 kg ha^{-1} (corn hybrid 8029) were recorded. The statistical values of seed quality parameters and yield for corn hybrids are shown in Table 1.

To quantify the position of corn hybrids studied in relation to the three elements considered in their evaluation (TKW, HW, Y) multivariate analysis was used.

The PCA diagram (Figure 2) presented the corn hybrids distribution according to considered elements. The two main components (PC1, PC2) explained 89.38% of the total variance.

Table 1. Descriptive statistical values for parameters studied in corn hybrids

Statistical parameter	TKW	HW	Y
N	15	15	15
Min	204.41	73.50	4,126.00
Max	316.45	79.90	6,786.00
Sum	4,168.77	1,156.20	87,986.00
Mean	277.92	77.08	5,865.73
Std. error	7.93	0.42	186.46
Variance	943.2118	2.6146	521,505.2
Stand. dev	30.712	1.617	722.153
Median	276.39	77.60	6,010.00
25 prcntil	262.38	75.70	5,509.00
75 prcntil	300.83	78.00	6,540.00
Skewness	-0.959	-0.567	-0.945
Kurtosis	0.895	0.429	1.146
Geom. mean	276.207	77.064	5,820.386
Coeff. var	11.0507	2.0978	12.3114

Source: Original data.

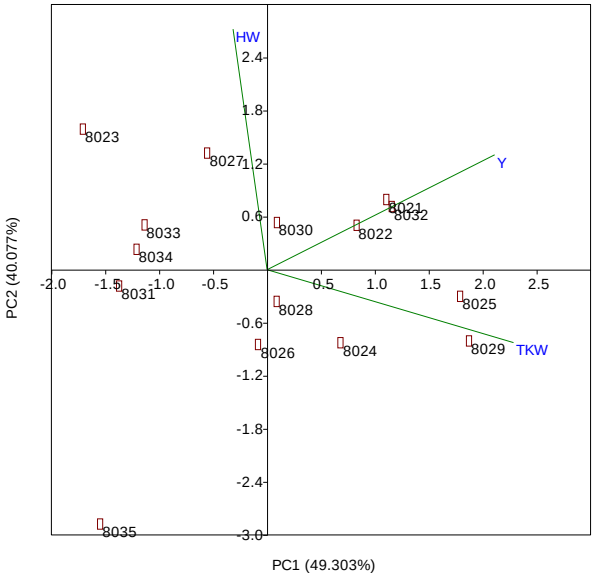


Fig. 2. PCA diagram for the distribution of corn hybrids
Source: Original figure.

Hybrids 8029 and 8025 were closely correlated with TKW. Hybrid 8027 was associated with the HW parameter, and hybrids 8021, 8022 and 8032 were associated with yield (Y).

Within the PCA loadings, the correlation level was studied according to each component considered, with the results in table 2. According to the first component (C1), r = 0.889 for TKW, r = -0.123 for HW, respectively r = 0.821 in the case of Y were recorded.

Table 2. PCA loadings correlation values

Component	Correlation coefficient values

	TKW	HW	Y
C1	0.889	-0.123	0.821
C2	-0.289	0.954	0.456
C3	0.355	0.272	-0.344

Source: Original data.

According to the second component (C2), r = -0.289 for TKW, r = 0.954 for HW, respectively r = 0.456 in the case of Y were recorded (Table 2). According to the third component (C3), r = 0.355 for TKW, r = 0.272 for HW, respectively r = -0.344 in the case of Y were recorded (Table 2).

Cluster analysis (CA) was applied in order to obtain the grouping of the studied corn hybrids, according to each parameter. Cluster dendrograms were generated in relation to each parameter, as well as an overall analysis, which presented the grouping of the studied corn hybrids, based on similarity. In each dendrogram, the first two hybrids (thick red line) were marked, as well as the hybrids in the upper quartiles (thin red line).

According to the TKW parameter, resulted the dendrogram presented in figure 3 (Coph. corr. =0.835). Corn hybrid 8025 (TKW = 316.45) was associated with corn hybrid 8029 (TKW = 315.54), with the SDI = 0.91.

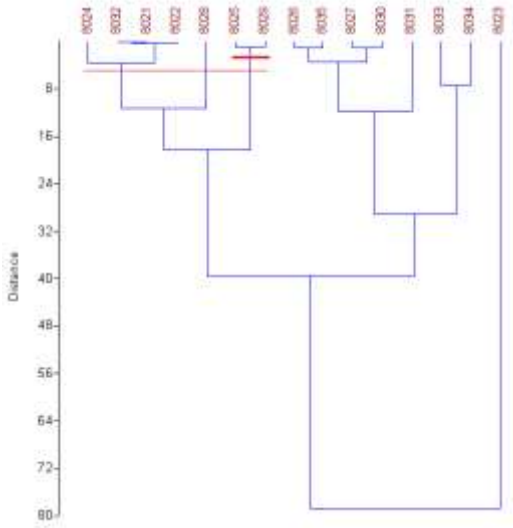


Fig. 3. Cluster dendrogram for corn hybrids according to TKW parameter
Source: Original figure.

According to HW parameter, the dendrogram in Figure 4 was generated (Coph. corr. = 0.765). Hybrid 8027 was positioned separately within cluster C1, with the value HW = 79.90 kg hl^{-1}. Along with hybrid 8027, in the upper quartile and in cluster C1, hybrids 8023 (HW = 78.70 kg hl^{-1}) and 8021 (HW = 78.20 kg hl^{-1}) were associated, with the SDI value = 0.50. Hybrids 8022 and 8032 followed in the upper quartiles with the same value of the HW parameter (HW = 78.00 kg hl^{-1}).

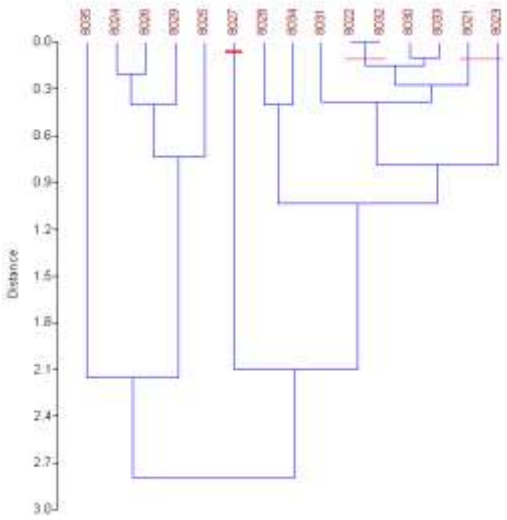


Fig. 4. Clustering dendrogram of corn hybrids based on HW parameter
Source: Original figure.

In relation to yield (Y) the dendrogram in Figure 5 was generated (Coph. corr. = 0.843). Hybrid 8029 (Y = 6,786.00 kg ha^{-1}) was associated with hybrid 8025 (Y = 6,741.00 kg ha^{-1}) within cluster C1, subcluster C1-1 (SDI = 45.00). In cluster C1, subcluster C1-1, hybrid 8032 (Y = 6,586.00 kg ha^{-1}) was also associated with hybrid 8021 (Y = 6,540.0kg ha^{-1}), with a similarity level SDI = 46.00. The four hybrids were positioned in the upper quartiles, based on the recorded Y values.

Cluster analysis was performed considering all three elements together (TKW, HW and Y), Figure 6 (Coph. corr. = 0.842), and the resulting dendrogram was similar to that in Figure 5, based on yield. A similar grouping of hybrids resulted, which showed the high importance of yield in the similarity-based association of the studied hybrids. The series of SDI values, obtained according to the three parameters considered together, is presented in Table 3.

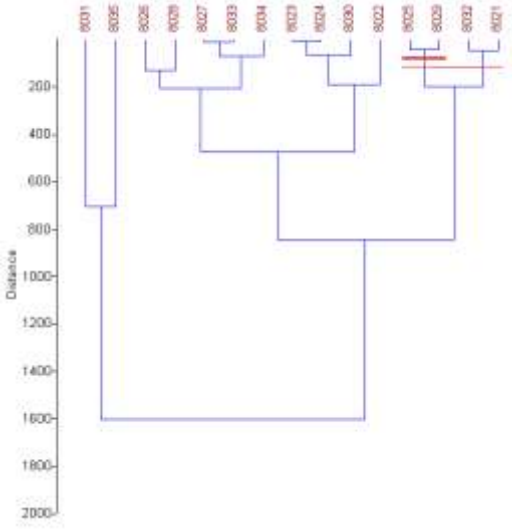


Fig. 5. Cluster dendrogram for corn hybrids according to Y parameter
Source: Original figure.

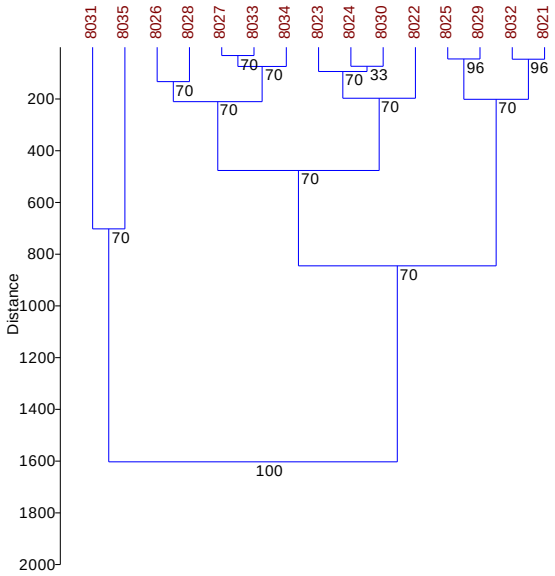


Fig. 6. Cluster dendrogram for corn hybrids according to the three parameters (TKW, HW, Y)
Source: Original figure.

Table 3. SDI values among corn hybrids, general analysis (TKW, HW, Y)

	8021	8022	8023	8024	8025	8026	8027	8028	8029	8030	8031	8032	8033	8034	8035
8021		315.0	530.8	530.0	201.6	741.5	1,042.3	873.1	246.5	460.7	1,712.4	46.0	1,032.4	969.0	2,414.2
8022	315.0		228.5	215.1	516.2	426.9	727.4	558.1	561.2	147.3	1,397.5	361.0	718.1	655.0	2,099.2
8023	530.8	228.5		93.2	731.6	229.5	525.0	361.0	776.0	94.1	1,191.4	576.1	510.7	446.3	1,893.2
8024	530.0	215.1	93.2		731.3	212.4	512.4	343.1	776.2	73.4	1,182.5	576.0	503.6	440.9	1,884.2
8025	201.6	516.2	731.6	731.3		943.0	1,243.7	1,074.4	45.0	662.3	1,913.8	155.8	1,234.0	1,170.6	2,615.4
8026	741.5	426.9	229.5	212.4	943.0		301.1	133.0	987.9	281.0	971.1	787.5	291.2	228.6	1,673.0
8027	1,042.3	727.4	525.0	512.4	1,243.7	301.1		169.5	1,288.6	582.0	670.2	1,088.3	32.1	83.9	1,372.0
8028	873.1	558.1	361.0	343.1	1,074.4	133.0	169.5		1,119.3	413.2	839.4	919.1	163.6	106.4	1,541.1
8029	246.5	561.2	776.0	776.2	45.0	987.9	1,288.6	1,119.3		707.2	1,958.7	200.6	1,278.9	1,215.4	2,660.4
8030	460.7	147.3	94.1	73.4	662.3	281.0	582.0	413.2	707.2		1,252.1	506.6	571.7	508.3	1,954.0
8031	1,712.4	1,397.5	1,191.4	1,182.5	1,913.8	971.1	670.2	839.4	1,958.7	1,252.1		1,758.4	681.2	745.4	702.1
8032	46.0	361.0	576.1	576.0	155.8	787.5	1,088.3	919.1	200.6	506.6	1,758.4		1,078.4	1,014.9	2,460.2
8033	1,032.4	718.1	510.7	503.6	1,234.0	291.2	32.1	163.6	1,278.9	571.7	681.2	1,078.4		64.4	1,383.2
8034	969.0	655.0	446.3	440.9	1,170.6	228.6	83.9	106.4	1,215.4	508.3	745.4	1,014.9	64.4		1,447.4
8035	2,414.2	2,099.2	1,893.2	1,884.2	2,615.4	1,673.0	1,372.0	1,541.1	2,660.4	1,954.0	702.1	2,460.2	1,383.2	1,447.4	

Source: Original data.

In comparative studies, the ranking of subjects is important to highlight the positioning in the upper, lower and middle areas of the ranking. The studied hybrids were classified and ranked based on the ranking analysis, which led to the diagram in figure 7, with the representation of the hybrids in the confidence interval (95%) in Figure 8.

The TKW parameter is an index that expresses the physical properties of seeds, and determines the size of the grains and their density [21]. Larger seeds have a higher content of nutrients, which is important both for sowing (seed material, for the establishment of new crops), but also for consumption (seeds intended for consumption and industrialization; higher content of nutritional principles) [16, 21].

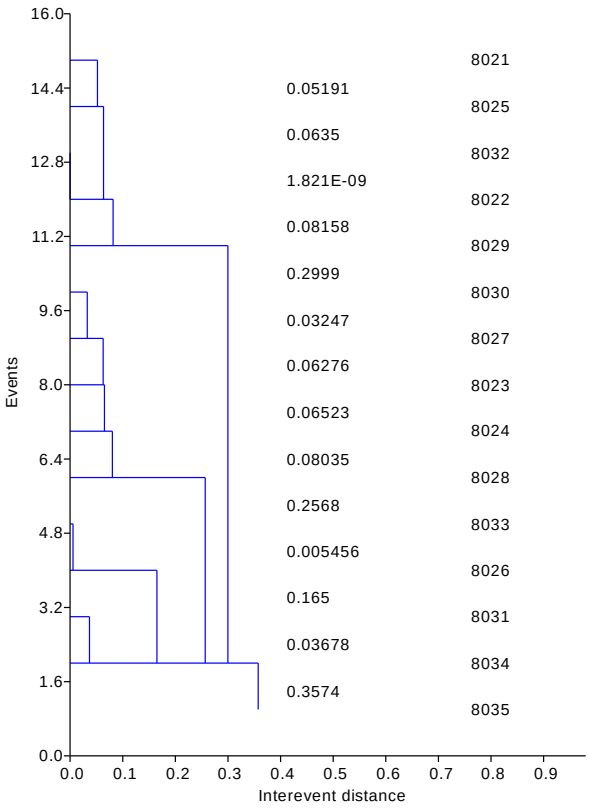


Fig. 7. Scaling dendrogram regarding the hierarchy of corn hybrids
Source: Original figure.

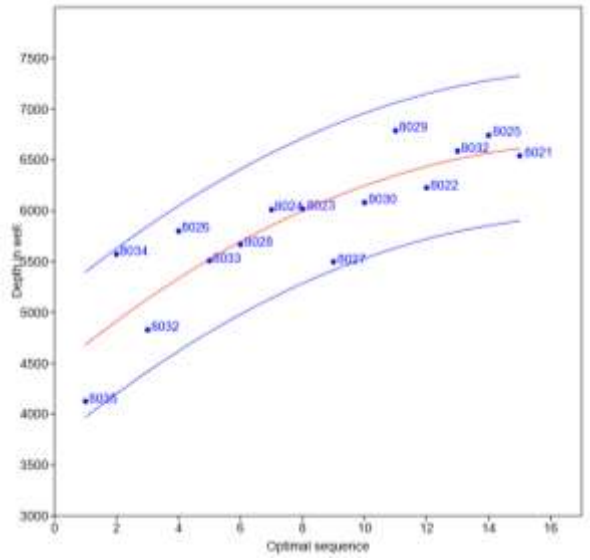


Fig. 9. Distribution of corn hybrids in relation to yield (Y) in scattergrams format
Source: Original figure.

Larger and heavier seeds have a more developed embryo, with advantages for seed lots (resulting in more vigorous plants upon germination - emergence, with advantages for the crop) [7, 18].
The size of the seeds also presents advantages for industrialization and utilization in food products, because they have a higher content of nutritional principles [14].
The corn hybrids (8025, 8029, 8022, 8021, and 8032) that provided larger seeds (TKW) in this study showed genetic advantage in relation to this trait, with useful effects for agricultural practice, for breeding programs, as well as for industrialization.
The HW parameter is important for the marketing of cereal production, for the quality of cereals and the quality of derived products [5].
In this study, five hybrids were positioned in the upper quartiles (8027, 8023, 8021, 8022, and 8032), with high values of the HW parameter, with advantages for production quality and market value of cereals.
Yield is important in all agricultural production systems, and the farm management system analyzes all elements of technology to optimize yields [8, 25].
In this study, four hybrids (8029, 8025, 8032, and 8021) were positioned in the upper quartiles and were associated in the same sub-cluster, with high yield values.
The overall analysis of the fifteen hybrids tested showed that in relation to the three parameters considered together (TKW, HW, Y), two hybrids were positioned in the upper quartiles in relation to all three parameters (8021 and 8032). In relation to TKW and Y parameters, two hybrids were positioned in the upper quartiles (8025 and 8029).

CONCLUSIONS

The corn hybrids tested in comparative crops, under uniform conditions of climate, soil and technology, expressed differentiated production potential for yield and seed quality parameters. For TKW, hybrid 8025 presented the highest value (TKW = 316.45 g), closely followed by hybrid 8029 (TKW = 315.54 g). For HW, hybrid 8027 was placed in first position with the value HW = 79.90 kg hl^{-1}, followed by hybrid 8023 with the value HW = 78.70 kg hl^{-1}. For yield, hybrid 8029 was positioned in first position, with Y = 6,786.00 kg ha^{-1}, followed by hybrid 8025 with Y = 6,741.00 kg ha^{-1}.
Multivariate analysis showed the association of

hybrids with the considered parameters, and the main components explained 89.38% of the total variance.

Cluster analysis showed the association of hybrids with each parameter, and within the dendrograms; hybrids with high values with respect to the analyzed parameter and with respect to the upper quartiles were highlighted. Based on the yield values and quality parameters, a ranking of the hybrids was made, with their positioning in conditions of statistical safety.

The recorded results facilitate the selection of hybrids with genetic advantages for parameters considered in the zonal cultivation conditions, and their promotion for agricultural practice, for other "multi-location" comparative studies, but also for corn breeding programs.

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REFERENCES

[1]Akdemir, Ş., Miassi, Y.E., Ismailla, I.S., Dossa, K.F., Oussou, K.F., Zannou, O., 2023, Corn production and processing into ethanol in Turkey: An analysis of the performance of irrigation systems at different altitudes on energy use and production costs, Journal of Agriculture and Food Research, 14:100740.

[2]Alam, M.A., Rahman, M., Ahmed, S., Jahan, N., Khan, M.A.-A., Islam, M.R., Alsuhaibani, A.M., Gaber, A., Hossain, A., 2022, Genetic variation and genotype by environment interaction for agronomic traits in maize (*Zea mays* L.) hybrids, Plants, 11(11):1522.

[3]Bhat, S.A., Qadri, S.A.A., Dubbey, V., Sofi, I.B., Huang, N.-F., 2024, Impact of crop management practices on maize yield: Insights from farming in tropical regions and predictive modeling using machine learning, Journal of Agriculture and Food Research, 18:101392.

[4]Bocianowski, J., Nowosad, K., Rejek, D., 2024, Genotype-environment interaction for grain yield in maize (*Zea mays* L.) using the additive main effects and multiplicative interaction (AMMI) model, Journal of Applied Genetics, 65:653-664.

[5]Clarke, L.C., Sweeney, T., Duffy, S.K., Rajauria, G., O'Doherty, J.V., 2019, The variation in hectolitre weight of wheat grain fed with or without enzyme supplementation influences nutrient digestibility and subsequently affects performance in pigs, Journal of Physiology and Animal Nutrition, 103(2):583-592.

[6]Erenstein, O., Jaleta, M., Sonder, K., Mottaleb, K., Prasanna, B.M., 2022, Global maize production, consumption and trade: trends and R&D implications, Food Security, 14:1295-1319.

[7]Fauzi, A.R., Junaedi, A., Lubis, I., Ghulamahdi, M., Aswidinnoor, H., 2021, Relationship of size and shape rice seed to early seedling vigor traits, IOP Conference Series: Earth and Environmental Science, 694:012039

[8]Gao, S., Liu, T., Wang, S., Li, Y., Ding, J., Liu, Y., Wang, D., Li, H., 2023, Optimizing fertilizer management practices in summer maize fields in the Yellow River Basin, Agronomy, 13(9):2236.

[9]Hammer, Ø., Harper, D.A.T., Ryan, P.D., 2001, PAST: Paleontological Statistics software package for education and data analysis, Palaeontologia Electronica, 4(1):1-9.

[10]Li, R., Zhang, G., Xie, R., Hou, P., Ming, B., Xue, J., Wang, K., Li, S., 2025, Dynamics of high-yielding maize genotypes under intensive management across multiple environments, European Journal of Agronomy, 162:127368.

[11]Meier, U., 2001, Growth stages of mono-and dicotyledonous plants e BBCH monograph. Federal Biological Research Centre for Agriculture and Forestry, 158 pp.

[12]Mircea, V., Aedin, C., Marin, D.I., 2023, Researches concerning the influence of the maize hybrid maturity and the irrigation regime on the thousand kernel weight and hectoliter mass, Scientific Papers. Series A. Agronomy, LXVI(1):431-440.

[13]Neagu, C., Crețu, D., Iova, A.R., Crețu, O.R., 2022, Analysis of the qualitative parameters of the main crops practiced at an agricultural company. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 22(4):465-470.

[14]Pers-Kamczyc, E., Mąderek, E., Kamczyc, J., 2022, Seed quantity or quality?–Reproductive responses of females of two dioecious woody species to long-term fertilisation, International Journal of Molecular Sciences, 23(6):3187.

[15]Popescu, A., Tindeche, C., Marcuta, A., Marcuta, L., Hontus, A., 2022, Cereals production between climate change and price boom in Romania, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 22(4):579-594.

[16]Rani, M., Singh, G., Siddiqi, R.A., Gill, B.S., Sogi, D.S., Bhat, M.A., 2021, Comparative quality evaluation of physicochemical, technological, and protein profiling of wheat, rye, and barley cereals, Frontiers in Nutrition, 8:694679.

[17]Ruiz, A., Archontoulis, S.V., Borrás, L., 2022, Kernel weight relevance in maize grain yield response to nitrogen fertilization, Field Crops Research, 286:108631.

[18]Snider, J.L., Collins, G.D., Whitaker, J., Chapman, K.D., Horn, P., 2016, The impact of seed size and chemical composition on seedling vigor, yield, and fiber quality of cotton in five production environments, Field Crops Research, 193:186-195.

[19]Vana, C.D., Varga, A., Călugăr, R.E., Ceclan, A., Tritean, N., Tărău, A., 2023, Study of phenotypic and genetic variability in maize crossings between Cycle I inbred lines and elite lines (Cycle II), AgroLife

Scientific Journal, 12(2):214-222.
[20]Vásquez, H.V., Vigo, C.N., Saravia, D., Valqui, L., Bobadilla, L.G., 2024, Agronomic performance of forage corn for cattle feeding in Amazonas, Peru, Heliyon, 10(9):e30790.
[21]Wang, K., Fu, B.X., 2020, Inter-relationships between test weight, thousand kernel weight, kernel size distribution and their effects on durum wheat milling, semolina composition and pasta processing quality, Foods, 9(9):1308.
[22]Wang, Z., Guo, Y., Wang, K., Zhang, G., Ming, B., Shen, D., Fang, L., Zhou, L., Sun, L., Liu, H., Liu, N., Xie, R., Li, S., 2023, Effects of planting density on test weight and related indexes of maize, Crop Science, 63(6):3470-3481.
[23]Wei, S., Wang, X., Li, G., Qin, Y., Jiang, D., Dong, S., 2019, Plant density and nitrogen supply affect the grain-filling parameters of maize kernels located in different ear positions, Frontiers in Plant Science, 10:180.
[24]Wendwessen, T., 2023, Cluster and principal component analysis of maize inbred lines in low moisture stress areas in Ethiopia, International Journal of Agricultural Science and Food Technology, 9(3):059-063.
[25]Zhu, L., Sun, H., Liu, L., Zhang, K., Zhang, Y., Li, A., Bai, Z., Wang, G., Liu, X., Dong, H., Li, C., 2024, Optimizing crop yields while minimizing environmental impact through deep placement of nitrogen fertilizer, Journal of Integrative Agriculture, https://doi.org/10.1016/j.jia.2024.05.012

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RECENT ISSUES AND TRENDS OF ECO-INNOVATION IN THE EUROPEAN UNION

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Abstract

The EU has set the move to the circular economy (CE) as a strategic goal. Therefore, eco-innovation initiatives are adopting a new strategy that combines environmental protection with concerns about resource and economic efficiency. Finding eco-innovation`s characteristics and trends for the shift to a circular economy is the aim of this paper. It begins with a conceptual analysis of eco-innovation and its tenets from the perspectives of sustainable development and the market circular economy. To highlight the importance of innovation and open eco-innovation (OI and OEI) for the development and efficient operation of circular economy enterprises in the food sector, examples of circular collaborative eco-innovative business models are studied. The main trends of the EU`s eco-innovation index from 2014 to 2024i s finally covered, along with state-to-state differences and Romania`s position. The conclusions suggest perspectives, challenges, and future research directions.

Key words**:** *circular economy, open innovation, business model, eco-innovation, eco-innovation index*

INTRODUCTION

The circular economy (CE) model seeks to recover and recycle material resources within production processes in order to maximize their value and utility.
Resources and raw materials are supplied to the economy via the circular economy, which also lessens the adverse environmental effects that social and economic advancement may have. It should be mentioned that one of the associated goals of the European Green Deal is the shift to the CE. (EC, 2021) [8].
For the purpose of implementing the EU Circular Economy Action Plan (CEAP 2020) [9], Member States are encouraged to promote circularity at national level by adopting policies and initiatives that go beyond EU regulations while preserving the Single Market. (EC, 2022) [8].
That is why, in recent years, more and more countries in the European Union have intensified their concerns and strategic directions for the implementation of CE, at local, sectoral and national level.
The green modernization theory contends that a kind of sustainability that does not substantially alter the status quo in terms of politics, norms, and power may be accomplished through the effective and efficient partnership between the market economy and ecology, or capitalism and the environment.
Therefore, the market economy or capitalist system must be considered when discussing the role of eco-innovation in connection to the circular economy. (Vence and Pereira, 2019) [27].
The circular economy is a family of particular ideas for a new production paradigm centered on reducing or even eliminating waste, as well as the use of material resources and energy, in the framework of rethinking the relationship between the market economy and the environment.
The primary goal of this article is to identify the traits and patterns of eco-innovation for the European Union's transition to a circular economy.

MATERIALS AND METHODS

Several steps form the basis of the methodology:
(a)In order to promote sustainable development, especially within the European Union, a review of the literature on the tenets, workings, and benefits of CE is conducted. Additionally, some of authors' earlier research findings are used;
(b)Conceptual review and synthesis of the key eco-innovation theories, traits, and precepts intended for the development and use of the circular economy;
(c)The analysis of the Circular Business Models (CBM) as cradles of open innovation and eco-innovation and the case-study of a food industry CBM with eco-innovation organized on a circular supply chain of waste as resource;
(d)The development and key patterns documented by the EU's eco-innovation index, a composite measure of eco-innovation, alongside the diverse outcomes among EU member states.
The Eurostat database and reports from the European Environment Agency both serve as data sources.
On the other hand, with the interactive access to the European Innovation Scoreboard (EIS interactive tool 2024), there was possible access to primary data regarding the annual eco-innovation scores of the EU Member States, used for data computation in the Table 1, for instance.
The analyses, comments and conclusions are made by the authors. There were no AI generative tools used to develop the sections of the paper.

RESULTS AND DISCUSSIONS

Conceptual background on the circular eco-innovation

There is currently a tendency in the scientific study of the Circular Economy (CE) that involves defining concepts from the viewpoint of sustainable development and examining how sustainable it is.
In view of a sustainable development and facing many natural capital challenges, the European Union has enforced demanding environmental legislation and policies mostly designed to promote higher resource efficiency and progress towards SDG 12 Sustainable production and consumption. These need adoption of good practices such as green procurement and increased research and development for eco-innovation. (Frone DF, Frone Simona, 2020) [14].
An outstanding study indicates six types of limits faced by the CE in its contribution to sustainability: thermodynamic, economic scale limits, circuit bottlenecks, governance/ management and even social and cultural limits (Korhonen et al., 2018a) [17].
The market system, which is supported by the constant development of capital and the quest of profits, must be taken into consideration when discussing the significance of eco-innovation in the emerging circular economy.
Innovation is critical in this constant development process.
The recognition of the severe environmental crisis affecting capitalism has led to different opinions on possible solutions. According to certain authors, the ecological issue is a systemic one, and some even come to the conclusion that whole capitalist framework has to be replaced (Bellamy Foster et al. 2011; Frone and Constantinescu, 2015) [3, 11].
The ecological modernization hypothesis, on the contrary hand, contends that ecology and the market system may coexist harmoniously and successfully.
Hawken & Lovins (2013) 16], found four ways to encourage system change: i) a sharp rise in resource productivity; ii) industrial ecology and biomimicry; iii) economic tertiarization; and iv) investments in the revival of natural capital.[16]
Other authors (Speth, 2008; Platon et al, 2006) [25, 21], trust in technological development is high, yet not enough to tackle the significant environmental challenges that currently arise. Though it just delays the rate of degradation, technological innovation can help repair some environmental damage and achieve a certain increase in resource productivity.
In this context of redefining the relationship between the market economy and the environment, CE represents a set of proposals for a novel paradigm of production centred on

limiting the use of material resources, energy, and decreasing or ultimately eliminating waste.
Another essential assumption is that following circular economy principles fosters long-term and more equal economic development. Fruchten and Eik (2020) [15] pointed out that a circular economic system might make a significant impact to achieving all SDG of the 2030 Agenda.
Nevertheless, the circular economy's features demonstrate that it is substantially more complex than the linear economy. In fact, the circular economy functions as a closed-loop economic system where resources are continuously consumed and reused, such that waste gets progressively less (Wilson et al., 2021) [29].
More in-depth analysis of some CE principles is required, this time from an entrepreneurial standpoint (of companies and businesses) rather than from a public one, in order to better understand the type of eco-innovation that the circular economy requires and ensure that the effects are advantageous for both the environment and the economy.
A first such principle is that the circular economy replaces added value with conservation value and residual value with use value, as it focuses on optimizing inventories (Stahel, 2013) [26].
Therefore, the entrepreneurial process of value creation must be expanded to also include optimizing and preserving value. In practice, the circular economy necessitates separating economic development from extracting resources and creating waste. It is thus stated that the circular economy focuses primarily on the management of existing stocks. The CE is based on three different loops: i) recycling of materials (secondary resources); reuse/ resale of products; ii) procedures to extend the life of products; and iii).
Actually, it may be stated that recycling of materials, reuse, repair and remarketing of goods, are the main activities of the Circular Economy.
According to a recent investigation, innovation and acquisitions in fields like recycling processes, eco-friendly design, or used materials are important parts of the shift to a circular economy. The circular economy is strongly related to the following areas: recycling, repair, and reuse.
The outcomes of the research showed a real connection of eco-investment with the amount of e-waste recycling in EU. (Constantinescu et. al., 2022) [6].
The study of (Platon et al., 2022) further illustrated the significant impact that eco-innovation plays in encouraging recycling and raising the rate of circular materials use in the European Union. [22]
The paper validates that the impact of eco-innovation on reprocessing is rather modest, but it is of greater importance when the baseline recycling status is weak. If the original state is unfavourable, innovation is highly vital in bringing recycling to positive values; however, the impact of innovation is not immediate, but with a two-year delay between its inception and adoption in actual operations, when the final effects can be quantified by recycling rates.
A further study reaffirmed how important recycling and eco-innovation are to advancing the circular economy and reducing the use of raw materials in EU nations. (Platon and others, 2023) [23].
More significant studies emphasized the discrepancy between circular economy theory and practice, coming to the conclusion that in order for organizations to make a greater contribution to the shift to a circular economy, they must enhance their efforts at recycling, reusing, remarketing, and waste reduction.
At the same time, as analysed in the next section of this paper, it is important for different stakeholders to work together more closely in order to operate circular business models holistically. (Lozano R., Barreiro-Gen. M., 2020) [2].

Circular business models (CBM) with open innovation and eco-innovation

Both the generation and capturing of value have been attempted to be explained by the business model. The business model serves as a bridge between the technologies of manufacture and consumption, or between the creation of technological artifacts, their actual use, and their final application.
Thus, in relation to eco-innovation, business models serve two main purposes (Vence &

Pereira, 2019) [27]: -assist in planning the strategic marketing of novel processes, goods, and services; -can alter the competitive landscape by reorganizing the value chain and creating new kinds of producer-consumer interactions, as well as altering customer usage patterns and culture.

However, business models as such do not say enough about the social and environmental consequences of creating and delivering value. Studies in this area propose a framework that integrates the elements of the business model for putting the circular economy's tenets into practice. [19] (Lewandowski, 2016).

The subsequent elements are, in theory, present in the ideal business model for putting the circular economy into practice:
(i) The clientele that a business caters to.
(ii) Appreciate products that aim to satisfy the demands and solve issues of customers.
(iii) The means by which a company delivers, conveys, and sells value offers.
(iv) The connections that a business makes and keeps with every group of customers.
(v) Income derived from effectively advertising value offerings to consumers.
(vi) Key resources are assets required to provide and execute the aforementioned components.
(vii) Important tasks that are completed in order to supply and transfer the afore mentioned things.
(viii) Current collaborations are an ecosystem of partners and suppliers who facilitate the business model's execution by conducting operations and supplying resources.
(ix) A cost structure that includes all of the expenses related to running a business model.

A number of businesses and organizations have attempted to categorize business strategies for a circular economy. For instance, Accenture (Lacy et al., 2014) [18] lists five categories or traits of a business model that is appropriate for the circular economy:
(a) Circular supplies include bio-based, renewable, or entirely recyclable inputs.
(b) Resources recovery is the process of extracting energy or valuable materials from waste or byproducts.
(c) Life cycle expansion: prolonging the lifespan of parts and items by reselling, modernizing, and repairing them.
(d) Collaborative platforms: by enabling shared use, access, and ownership, they enable a higher rate of product usage.
(e) Merchandise as a service: This method allows users to access products while maintaining ownership, allowing them to absorb the advantages of cyclical efficiency of resources.

A different classification was provided by IMSA Amsterdam (van Renswoude et al., 2015) [28], wherein six different archetypes are associated with Circular Business Models (CBMs):
(i) short cycle (such as pay-per-use or repair); (ii) extended cycle (performance-driven contracts); (iii) cascade (recycling, upcycling); (iv) pure circuits (from beginning to end); (v) dematerialized services (from tangible to virtual); (vi) on-demand products (custom-made items, 3D printing).

Conversely, the collaborative and open nature of circular business models is as essential. In this way, switching from a linear model to a CBM and embracing the circular economy is a significant company restructuring process. (Averina et al., 2022; Bocken et al., 2016) [1, 4].

Based on the literature, Figure 1 can offer a summary of circular economy (CBM) business models. It also depicts the intricate eco-innovation that can act as a catalyst for a circular economy at various CBM levels and loops.

In addition, other authors find that the transition to CE "refers to structural changes" and is "based on the introduction of transformative eco-innovation".

The study describes the main types of eco-innovation in CE and the share of description in specialized literature articles, respectively the product (23.2%), organizational (14.1%), processing (19.2%), marketing (2%), system and artificial intelligence (16.2%) eco-innovations, but it also mentioned the eco-innovation of the business model, with an important share (23.2%) (De Jesus et al., 2021) [7].

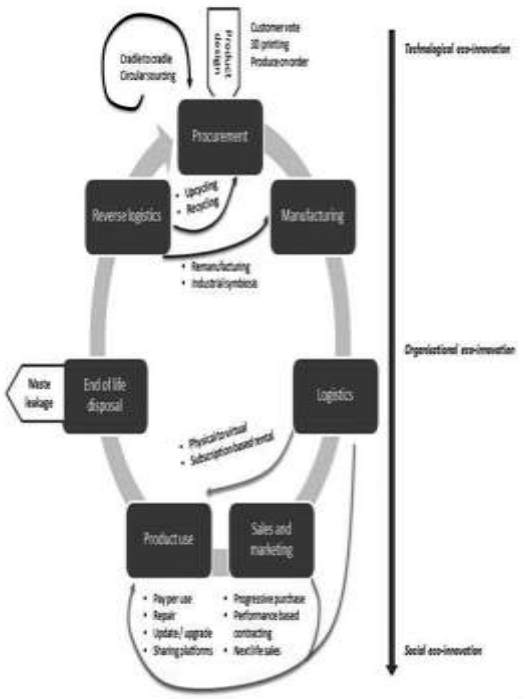

Fig. 1. A circular business model with eco-innovation
Source: Adapted from X. Vence & A. Pereira / Contaduría y Administración 64(1) Especial Innovación 2019, 1-19 [27].

However, we believe that it is absolutely necessary to become aware of the role of Open Innovation (OI), so there is a trend of recognition and analysis regarding Open Eco-innovation (OEI).This is the intentional use of outside resources and marketing channels to create or implement innovations that enhance the environmental performance of goods and procedures and lessen the environmental effect of production and consuming activities (Chistov V.et al., 2023) [5].

Open innovation becomes possible mainly through ICT and especially artificial intelligence (AI). Consequently, the econometric research results of a recent study have proven that artificial intelligence has the capacity to dramatically reduce the size of investments required to increase the circular economy. Besides, ICT and AI may improve a lot of older CE recycling facilities. (Platon et al., 2024) [24].

Next, we will provide an example of such collaborative circular business models, which were recently analysed in the study (Perotti et al., 2024) [20] in order to demonstrate the importance of innovation and open eco-innovation (IO and OEI) for the development and efficient operation of circular economy enterprises.

It is empirical research based on interviews of Italian companies that are particularly representative of the Italian economy, namely in the food industry, commerce, catering, chemical industry, pharmaceuticals, research and development. The data was collected from 13 organizations involved in two collaborative CBM networks, designed to establish recycling and creative transformation practices (upcycling) for the recovery/recycling of waste from the food and beverage industry.

As a result, the nature of two different collaborative approaches to pursue a regenerative production system through open innovation strategies was highlighted: a circular supply chain and a local industrial ecosystem with circular architecture.

The primary findings and conclusions make it possible to distinguish certain traits and patterns about how these cooperative circular business models have facilitated open eco-innovation and innovation access for the creation of circular economy mechanisms. These have resulted in significant cost and resource savings that align with the goals of the circular economy, besides a rise in the revenue of the enterprises involved in the joint CBM and mitigation of environmental effects.

Two strategic collaborative initiatives to encourage the adoption of the circular economy (CE) in businesses were identified through the examination of the case studies from Perotti et al. (2024) [20]. By implementing upcycling techniques in businesses, open eco-innovation (OEI) has demonstrated itself to be the solution to harnessing CE methods in both situations.

Due to the constraints of the scope of this work, we will only analyse the first case study, namely the circular system of the supply chain in the food sector.

It is crucial to understand the key conclusions of the analysis conducted using case studies pertaining to these circular CBM business models. These conclusions emphasize how a circular supply chain is an empirically supported strategy for businesses that can use

OEI and OI procedures in the circular economy to achieve sustainable development.

CBM case-study: circular supply chain of waste as a resource

The first case study describes how establishing partnerships along the food value chain can stimulate the adoption of circular practices based on the transformation of waste into new secondary raw resources.

In a previous paper analysing a regional circular eco-innovation of industrial synergy in the agri-food sector implemented within in Suceava County of Romania, the conclusions have emphasized many economic, social and environmental benefits as a successful good practice of CE (Frone DF, Frone S, 2017a) [12].

A crucial step in establishing the circular supply chain in the CBM case study below is the launch of an innovating start-up (Company A), which is distinguished by its goal to lessen food waste and its environmental impact in the form of decreased CO2 emissions (Figure 2).

Fig. 2. An illustration showing the circular supply network
Source: retrieved from (Perotti et al. 2024) [20].

Thus, Company A's business model was built on the (sustainability-oriented) objective of coordinating the recovery of resources from unsold goods and production waste (i.e. bread, pasta and spent barley malt) in order to assign them their new value as resources or factors of production for other production processes (i.e. beer and snacks). The key element in promoting a circular supply chain is the partnership established by the innovative start-up A (mentioned above) with upstream and downstream stakeholders.

The commitment to corporate sustainability and CE principles inspired and strengthened the organizations' desire to build new relationships with each other, but the lead coordinator was Company A. It is positioned between manufacturers and retailers and has played the role of central coordinator of the circular supply chain as a future-oriented company that recognizes opportunities through the transition to circular economy.

As coordinator, company A acted as an intermediary between heterogeneous economic entities, connecting them for the collection, recovery, processing and use of waste as new resources (Figure 2).

These collaborations demonstrate adaptable, medium-term connections in the circular supply chain, where participants generate value from resources and the information gathered to meld circular procedures and goods.

More precisely, it is seen how business A controlled the flow to serve as the circular supply chain's core node for resources and knowledge, also coordinating CBM's open innovation activities and strategies in relation to other actors.

The exchange was not limited to providing resources and markets for circular products. Indeed, the most important element is the knowledge collected from different actors and transmitted in the process of developing innovative circular processes and products.

From the perspectives offered by this case study, (Perotti et al., 2024) [20] conclude that a circular supply chain formation based on open eco-innovation practices underpins the effective implementation of CE strategies. Thus, managers should focus on creating an environment that encourages collaboration and the exchange of knowledge and resources across organizational boundaries.

In this regard, it is suggested to engage in strategic alliances to capitalize on resources, know-how, expertise and critical external capabilities, as well as to provide internal

knowledge necessary to implement and co-develop circular processes and products.

This circular CBM business model provides the basis for narrowing, slowing down and closing the resource loop by recovering waste from a value chain to reduce the resource input of similar value chains.

Trends of the eco-innovation index (EII) in the European Union

According to the European Environment Agency's definition, the eco-innovation index score at the national level shows each Member State's positive and negative characteristics and contrasts its ranking with the EU average on a number of eco-innovation metrics. The eco-innovation index aims to provide a thorough evaluation of the social, environmental, and economic performance of EU nations and supplements other techniques for gauging their inventive nature (such as the European Innovation Scoreboard).

The European Eco-Innovation Scoreboard, which comprises 12 indicators in five thematic areas, serves as the foundation for the eco-innovation index (EII). This takes into account the following themes of eco-innovation (EI):

(a)EI Inputs, such as monetary and human resources allocated to eco-innovation initiatives;

(b)EI activities, indicate how much a nation's businesses are involved in eco-innovation;

(c)EI outputs, quantify the quantity of patents and scholarly articles that result from eco-innovation efforts;

(d)Resource efficiency outcomes, showing the intensity of greenhouse gas emissions and a nation's resource efficiency;

(e)Socio-economic outcomes, quantify the beneficial social and economic effects of eco-innovation.

The Eco-Innovation Index (EII), a composite indicator, is calculated as the unweighted mean of the 12 indicators that make up the measuring framework.

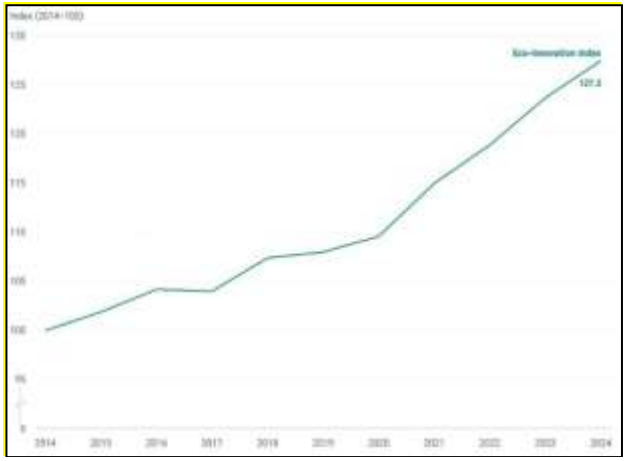

Fig. 3 Evolution of the EU-27 Eco-innovation Index, 2014–2024 (EU-27 Index = 100 in 2014).
Source: EEA website, accessed on January 2025 [10].

The steady rise in the EU Eco-Innovation Index score (from the 2014 baseline of 100) in Figure 3 shows the EU's strong EEI performance from 2014 to 2024. After the EU eco-innovation index grew by 21% in 2022 compared to 2013, increases in resource efficiency were the main factor behind the 27.5% growth in the European Commission's eco-innovation index between 2014 and 2024.

According to the European Commission's Eco-Innovation Index 2024 report, eco-innovation increased in all five parameters. The gain was mostly caused by advances in resource efficiency performance, specifically in terms of greenhouse gas (GHG) emissions productivity (i.e., the decrease in GHG emissions generated per unit of GDP).

According to the most recent eco-innovation report available (EU Eco-Innovation Index 2024) [10], the synthetic eco-innovation index, a composite indicator derived by taking an unweighted average of the 12 indicators included in the measurement framework, is used to assess the environmental innovation performance of EU Member States.

A Member State's score at time t is calculated as the ratio of its score to the EU Eco-Innovation Index score in a reference year (t-10), providing a standardized and long-term perspective on progress. The 2024 report uses 2014 as the reference year. In the following, all indicators, themes and aggregated indices are therefore compared to the EU-27 performance in 2014 (=100).(EC, 2024) [10].

Fig. 4. Eco-innovation Index score in EU-27 member countries, 2014 and 2024 (EU-27 Index=100 in 2014).
Source: EU Eco-Innovation Index Report 2024 [10].

Table 1. Eco-innovation index score for EU-27 member countries, in 2024
(EU-27 Index = 100 in 2014)

Order no.	EU Member Countries (descending order EII score 2024)	2014	2024
	EU-27	***100***	***127.5***
1	FI	161.9	180.8
2	DK	154	177.5
3	AT	141	177.1
4	LU	154.9	175.1
5	SE	145.2	165.2
6	IT	110.9	150.1
7	FR	106	144
8	DE	108.3	140.7
9	NL	94.6	133.1
10	ES	101.5	127.2
11	CZ	89.1	125.6
12	SL	85.4	121.5
13	IE	71.1	121.2
14	EE	90	116.5
15	LV	76.4	114.7
16	LT	61.4	114.7
17	PT	79	113.2
18	BE	81.2	109.2
19	MT	53.2	99.2
20	SK	63.9	98.9
21	CY	64	97.6
22	HR	64.9	96.6
23	EL	56.4	91
24	RO	84.7	80.2
25	PL	50.2	69.7
26	HU	59.4	64.4
27	BG	29.4	58.8

Legend:
Cluster 1-9=EU countries leading eco-innovation (Eco-I leaders).
Cluster 10-18=EU countries (Average Eco-I performers).
Cluster 19-27= EU countries catching up (Eco-I catching-up).

Source: Adaptation and own processing of primary data downloaded from Eco-Innovation Index, 2024 and Eco-Innovation Scoreboard interactive tool 2024 [10].

Therefore, Figure 4 and Table 1 show the dynamics of the eco-innovation index by EU Member States in 2024 in comparison to the 2014 level, conveyed in comparison to the EU-27 average reference EII level of 2014, taken into consideration 100, in order to provide a more pertinent view of the most recent advances of the EU Eco-Innovation Index. Based on the ranking of their EII ratings, the EU Member States are divided into three distinct performance clusters with equal dimensions, as shown in Figure 4.

The nine MSs in each cluster are categorized as "Eco-Innovation leaders" (those whose scores exceed the EU EII), "average eco-innovation performers" (those whose scores fall short of the EU EII but are still higher than 100), and "eco-innovation catching-up" countries (those whose EII scores fall below 100).

Examining how the eco-innovation index score has changed over the past ten years in relation to the EU and its member states is critical for comprehending both the advancements and difficulties facing eco-innovation. Accordingly, the 2014 EU27 Eco-Innovation Index score has been configured at 100 in Table 1.

Comparisons are based on how much the member states' score deviates from the EU27 level in 2014:

(i)Member states' EII scores above 127.5 indicate better performance than the EU 2014 eco-innovation index, so these 9 countries are in the cluster of the Eco-I leaders (with the highest scores, from highest 180.8 Finland, Denmark, Austria, Luxembourg, Sweden, Italy, Germany, France to 133.1 Netherlands, in descending order).

(ii)The next 9 EU countries with EII scores higher than 100 but lower than the EU EII of 127.5 are in the cluster of the average Eco-I performers, ranging in descending order from Spain 127.2, the Czech Republic, Slovenia, Ireland, Estonia, Latvia, Lithuania, Portugal, to Belgium 109.2.

(iii)The last cluster of 9 EU countries is that of the Eco-I catching-up, with their EII scores lower than 100, ranging from Malta 99.2, Slovakia, Cyprus, Croatia, Greece, Romania, Poland, Hungary to Bulgaria 58.8. Unfortunately, a serious issue is that only in

Romania, the eco-innovation index score was lower in 2024, respectively 80.2 compared to the 2014 reference level (84.7) and compared to the 2013 level (86).

Actually, Romania had a decline in the EII score over the last decade. According to the latest report Eco-Innovation Index 2024, the score of Romania was mainly induced by the weak performance in some significant indicators of eco-innovation topics: government environmental and energy R&D credits and expenditures, total R&D employment and research staff, eco-innovation involved patents, material and water productivity.

Consequently, in 2024, Romania's EII score is 48 points lower than the EU score (EU Report Eco-Innovation Index 2024, 2024) [10].

Unfortunately, the situation is a worsening of the one in 2015, when Romania had registered a progress from position 21 in 2013 and to 18 in 2015 in the EU composite eco-innovation scoreboard (although that was slightly different from the current Eco-Innovation Index ranking).

One of the main causes of the relatively poor eco-innovation performance in Romania, especially in view of a CE, was the low level of collaboration between enterprises – that is, low level of CBM development - as well as low investment in waste management and recycling infrastructure (Frone DF, Frone Simona, 2017b) [13].

CONCLUSIONS

Many authors have stated that technical progress and eco-innovation of dedicated to environmental protection and increasing the efficiency of resource use represent the solution to sustainable development, but numerous economic, climate, and health crises have shown that it might be also necessary to adopt a novel economic paradigm that reduces consumption of energy and material resources as well as limiting or completely eliminating waste.

Since the circular economy (CE) functions as a closed-loop economic system within which resources are continuously used and reused, waste and all environmental pressures are significantly reduced, fostering the faster and more efficient achievement of most sustainable development goals.

The transition to CE is an objective affirmed and assumed by EU strategic documents, including the European Green Deal. It may be achieved by implementing policies for institutional changes, as well as by promoting technological advances on an important scale, which is the object of eco-innovation dedicated to the circular economy.

In real terms, some of the fundamental tenets of the circular economy include recycling resources, reusing, repairing, and reselling things. Eco-innovation has been shown to have a major impact on waste recycling and circular reuse of materials in previous theoretical and practical studies.

At the same time, obstacles to the shift to the circular economy can be successfully reduced by implementing eco-innovation methods, particularly open eco-innovation (OEI), through circular business models (CBM). These allow problems to be solved collaboratively to overcome technical obstacles, reducing costs and risks in research and development processes, accessing a wide range of expertise from different sectors and discipline, raising resource efficiency and creating new market opportunities. Artificial intelligence is an important tool in fostering open eco-innovation (OEI).

An interesting distinction can also be seen when we take a close look at a collaborative CBM approach, in terms of the distribution of the economic value created by circular enterprises. This economic value includes revenues generated from the sale of circular products to consumers, the reduction of virgin raw material inputs in the production process, and the net expenses associated with the recovery of secondary raw resources and logistics; Supplier-customer interactions bind the actors in the case study under analysis, and the coordinator's and the other companies' commercial negotiations over by-products and end commodities determine how value is distributed.

As for the eco-innovation index (EII) score and the progress registered in the European Union, the analysis shows that, at the level of the EU,

there was a significant progress in the last decade 2014-2024, so that the EII has increased by more than 25%.

The EU Member States are grouped into three performance clusters of 9 countries, based on the ranking of their EII scores. The best performer of the Eco-I Leaders cluster in 2024 is Finland, ranking number 1; the leader of the average Eco-I performers is Spain, rank 10 while the leader of the Eco-I catching-up cluster is Malta.

Romania, ranking 24, is part of the last cluster of Eco-I catching-up countries. Nevertheless, the issues of lack of progress in eco-innovation in our country are more severe and important, since in the last ten years there has been a decline in the EII score.

Thus, the authors' future study will focus on a deeper examination of the obstacles to eco-innovation in Romania and the policies that are required to support it, particularly in light of a quicker shift to a circular economy and greater resource efficiency.

Nevertheless, there is a favourable outlook considering the National Plan of Recovery and Resilience, financed by the EU Recovery and Resilience Facility. Eco-innovation efforts for the transition to the circular economy are mainly addressed through reforms and investments under the first pillar, that of the green transition, namely in Green technologies and capacities, including biodiversity, energy efficiency, building renovation and the circular economy. They could also be included in interventions in other policy areas such as Digital innovations (technologies and infrastructure) in SMEs.

REFERENCES

[1]Averina, E., Frishammar, J., Parida, V., 2022, Assessing sustainability opportunities for circular business models. Business Strategy and the Environment, 31(4), 1464–1487.

[2]Barreiro-Gen, M., Lozano, R., 2020, How circular is the circular economy? Analysing the implementation of circular economy in organisations. Business Strategy and the Environment, 29(8), 3484-3494. https://doi.org/10.1002/bse.2590

[3]Bellamy Foster, J., Clark, B., York, R., (2011). Ecología: la hora de la verdad. Introducción, in: Aguilar, S., Oliveres, A., Pastor, J., Zeller, C. (Eds.), Ecología: La Hora de La Verdad. Icaria editorial, pp. 29-42.

[4]Bocken, N. M., De Pauw, I., Bakker, C., Van Der Grinten, B., 2016, Product design and business model strategies for a circular economy. Journal of Industrial and Production Engineering, 33(5), 308–320.

[5]Chistov, V., Carrillo-Hermosilla, J., Aramburu, N., 2023, Open eco-innovation. Aligning cooperation and external knowledge with the levels of eco-innovation radicalness, Journal of Open Innovation: Technology, Market, and Complexity, Vol. 9(2), 100049, https://doi.org/10.1016/j.joitmc.2023.100049.

[6]Constantinescu, A., Platon, V., Surugiu, M., Frone, S., Antonescu, D., Mazilescu, R., 2022, The influence of eco-investment on e-waste recycling-evidence from EU countries. Frontiers in Environmental Science, Sec. Environmental Economics and Management, 10, 928955.

[7]De Jesus, A., Lammi, M., Domenech, T., Vanhuyse, F., Mendonça, S., 2021, Eco-Innovation Diversity in a Circular Economy: Towards Circular Innovation Studies, Sustainability, 13(19), 10974, 1–22. https://doi.org/10.3390/su131910974

[8]European Commission, 2021, Directorate-General for Research and Innovation, European Green Deal – Research & innovation call, Publications Office of the European Union, 2021, https://data.europa.eu/doi/10.2777/33415

[9]European Commission, 2020, Circular economy action plan, European Commission, 2020 https://environment.ec.europa.eu/strategy/circular-economy-action-plan_en, Accessed on 5 February 2025.

[10]European Commission, 2024, Directorate-General for Research and Innovation, EU eco-innovation index 2024, Publications Office of the European Union, 2024, https://data.europa.eu/doi/10.2777/4878812

[11]Frone, S., Constantinescu, A., 2015, Ecosystem approach outcomes of a regional metabolism. Quality–Access to Success, 16(S1), 56.

[12]Frone, D.F., Frone, S., 2017a, Circular Economy in Romania: An Industrial Synergy in the Agri-Food Sector. Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development, 2017, 17(2), 103-110.

[13]Frone, D.F., Frone, S., 2017b, Eco-Innovation Park Promoting the Green Economy in Romania, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol. 17(2), 111-118.

[14]Frone, D. F., Frone, S., 2020, Issues and Trends of Progress Towards Sustainable Development Goals in Romania. Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development, 20(2).

[15]Fruchten S. V., Eik, F. V., 2020, Circular economy and SDGs. How circular economy helps to achieve the Sustainable Development Goals, The Netherlands Enterprise Agency, Holland Circular Hotspot.

[16]Hawken, P., Lovins, A.B., Lovins, L.H., 2013, Natural capitalism: The next industrial revolution. Routledge.

[17]Korhonen, J., Honkasalo, A., Seppälä, J., (2018a*)*. Circular Economy: The Concept and its Limitations, Ecological Economics143, https://www.sciencedirect.com/science/article/abs/pii/S0921800916300325 Accessed on February 5, 2025.
[18]Lacy, P., Keeble, J., McNamara, R., Rutqvist, J., Haglund, T., Cui, M., Cooper, A., Pettersson, C., Eckerle, K., Buddemeier, P., Sharma, A., Senior, T., 2014, Circular Advantage: Innovative Business Models and Technologies to Create Value in a World without Limits to Growth. Accent. Strateg. 24.
[19]Lewandowski, M., 2016, Designing the business models for circular economy-towards the conceptual framework. Sustainability, 8, 1–28. https://doi.org/10.3390/su8010043
[20]Perotti, F. A., Bargoni, A., De Bernardi, P., Rozsa, Z., 2024, Fostering circular economy through open innovation: Insights from multiple case study (Promovarea economiei circulare prin inovare deschisă: informații din mai multe studii de caz), Business Ethics, the Environment & Responsibility (Etica în afaceri, mediul și responsabilitatea). Wiley on-line https://doi.org/10.1111/beer.12657
[21]Platon, V., Turdeanu, A., 2006, The Sustainable Development in the EU and Romania: Comparative Analysis. Romanian Journal of Economics, 23(2 (32)), 91-99.
[22]Platon, V., Pavelescu, F. M., Antonescu, D., Frone, S., Constantinescu, A., Popa, F., 2022, Innovation and recycling—Drivers of circular economy in EU. Frontiers in Environmental Science, 10, 902651.
[23]Platon, V., Pavelescu, F. M., Surugiu, M., Frone, S., Mazilescu, R., Constantinescu, A., Popa, F., 2023, Influence of eco-innovation and recycling on raw material consumption; econometric approach in the case of the European Union. Sustainability, 15(5), 3996.
[24]Platon, V., Pavelescu, F. M., Antonescu, D., Constantinescu, A., Frone, S., Surugiu, M., Popa, F., 2024, New evidence about artificial intelligence and eco-investment as boosters of the circular economy. Environmental Technology & Innovation, 103685.
[25]Speth, J.G., 2008, The Bridge at the Edge of the World: Capitalism, the Environment, and Crossing from Crisis to Sustainability. Yale University Press. https://doi.org/10.1017/CBO9781107415324.004
[26]Stahel, W., 2013, Policy for material efficiency--sustainable taxation as a departure from the throwaway society. Philos. Trans. A. Math. Phys. Eng. Sci. 371, 20110567. https://doi.org/10.1098/rsta.2011.0567
[27]Vence, X., Pereira, Á., 2019, Eco-innovation and Circular Business Models as drivers for a circular economy. Contaduría y administración, 64(spe1), 1-19https://doi.org/10.22201/fca.24488410e.2019.1806
[28]van Renswoude, K., ten W., A., Joustra, D. J., 2015, Circular Business Models - Part 1: An introduction to IMSA's circular business model scan. Amsterdam. https://circular-future.eu/wp-content/uploads/2015/08/IMSA-Circular-Business-Models-April-2015-Part-1.pdf, Accessed on 5 February 2025.
[29]Wilson, M., Paschen, J., Pitt, L., 2021, The Circular Economy Meets Artificial Intelligence (AI) – Understanding the Opportunities of AI for Reverse Logistics. SSRN. Https://Ssrn.Com/Abstract=3802829

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PLANNING FOR A MORE SUSTAINED SOCIAL DEVELOPMENT OF RURAL AREAS IN ROMANIA

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Abstract

This paper examines the challenges and opportunities for sustainable social development in rural Romania, focusing on issues such as inadequate infrastructure, limited access to essential services, and lack of sustained economic development. It analyses the current socioeconomic landscape, identifies core challenges in rural service provision, and proposes strategic elements for development. The research synthesizes evidence from policy frameworks, funding mechanisms, and grassroots projects to outline strategic pathways for enhancing rural resilience. The findings indicate disparities in access to healthcare and social services, highlighting the correlation between infrastructural deficits and health outcomes in these communities. The implications suggest that interventions in infrastructure and service accessibility could improve health outcomes and quality of life in rural settings. This research contributes to the broader approach of healthcare by pointing out the connection between social development and equitable health support, advocating for integrated policy approaches to address rural challenges. Recommendations include decentralizing funding allocation, expanding social economy ecosystems, bridging urban-rural digital divides, and strengthening monitoring frameworks.

Key words**:** *policy framework, rural social development, education, health services, Romania*

INTRODUCTION

Romania's rural areas currently face a complex crisis that threatens their long-term social sustainability. According to recent data from (National Institute of Statistics, 2023) [10], three-quarters of Romanian villages have experienced continuous population decline over the past decade, with particularly dramatic losses in North-Eastern regions where some communities have seen over 40% of their working-age residents depart. This demographic collapse is both caused by and aggravates the deterioration of essential services, creating a vicious cycle of decline. The preliminary analysis reveals that 68% of villages that lose their last healthcare facility experience accelerated population decline within just three years (Institute for Life Quality, 2022) [6], underscoring the critical relationship between service providing and community sustainability. The situation presents a contradictory development challenge: despite Romania's access to substantial EU development funds since its 2007 accession, rural communities continue to struggle with maintaining basic social infrastructure and reversing negative demographic trends (European Commission, 2022) [2].

The current research materializes from systematic observation of divergent development paths across Romania's rural landscape. While most communities face severe challenges, approximately one-fifth have successfully stabilized or even grown their populations through innovative approaches in service provision. These exceptional cases, concentrated primarily in western and central regions, reveal three distinctive patterns that form the focus of this research (Popescu et al., 2022) [14]. First, they have established integrated multi-service hubs that combine education, healthcare, and digital services in single locations. Second, they demonstrate active involvement of diverse non-governmental actors in service delivery, including NGOs, private providers, and

community organizations. Third, they employ flexible, project-based development models that can be adapted to local contexts rather than relying on inflexible, top-down approaches (Ostrom, 2019) [13]. Understanding these success factors is particularly important as Romania in ongoing the 2023-2027 EU funding cycle, which allocates 14.2 billion Euro for rural development programs (European Commission, 2022) [2], presenting both an opportunity and essential for evidence-based policy making.

The significance of this research extends beyond academic circles to address pressing practical needs in rural development policy and practice. The research methodology includes secondary macro-level spatial analysis of service coverage gaps with secondary results from micro-level participatory action research in twelve representative communities, providing both comprehensive patterns and tailored implementation insights that previous studies have often failed to include (Sandu, 2021) [15]. Focusing on successful local innovations rather than exclusively documenting systemic failures, the research identifies transferable models for sustainable rural development under challenging demographic conditions (Woods, 2023) [19]. The moment is particularly important as Romania faces crucial decisions about managing EU funds to maximize their impact on rural communities during a period of significant demographic and economic challenges (Zaman & Cristea, 2022) [20].

The theoretical bases of this research integrate elements from three complementary academic domains that collectively enhance the understanding of rural development challenges in post-transition contexts like Romania. Contemporary rural development theory has evolved significantly from its traditional narrow focus on agricultural productivity to include more holistic approaches that recognize the complex interdependence of social, economic, and environmental factors in shaping community wellbeing (Woods, 2023) [19]. The sustainable rural development requires integrated solutions addressing multiple dimensions simultaneously, rather than sector-specific interventions (OECD, 2021) [11].

The Romanian context presents unique historical and institutional challenges that necessitate careful adaptation of international development models. The post-communist transition period's decentralization reforms, while democratically important, created severe and persistent territorial disparities in providing services, as documented by (Mitlin's, 2022) social infrastructure theory [9]. While urban areas benefited disproportionately from EU-funded modernization programs, rural regions experienced catastrophic withdrawal of state services between 1990-2010. Official statistics reveal dramatic reductions including a 61% decline in rural pharmacies (Ministry of Health, 2023), 53% closure of village schools (Ministry of Education and Research, 2023) [7], and 72% decrease in public transport routes during this period. These dramatic changes created the grounds for further depopulation and service collapse that continue to challenge rural communities today (Stanculescu, 2022) [16].

The research builds on Ostrom's institutional analysis of common-pool resources (Ostrom, 2019), demonstrating how some Romanian communities have developed innovative service solutions despite operating within generally unfavourable policy environments [13]. The European LEADER program's implementation in Romania provides compelling evidence that participatory, bottom-up approaches can yield superior results to traditional top-down development models. Recent evaluation data shows that villages with active NGO and community participation in the LEADER program achieved 35% better service outcomes than those relying solely on municipal authorities (EU Rural Observatory, 2023; Popescu et al., 2022) [3, 14]. These findings are in line with the secondary case studies results showing that polycentric governance structures demonstrate significantly greater adaptability and effectiveness in addressing Romania's complex rural challenges than conventional hierarchical systems (OECD, 2022) [12].

Recent research on rural wellbeing emphasizes the importance of adopting multidimensional approaches to development assessment that

capture aspects often missed by traditional economic indicators (OECD, 2021). Conventional elements like GDP growth or agricultural output frequently fail to account for critical dimensions of rural quality of life including service accessibility, social capital development, environmental conditions, and wellbeing (Sandu, 2021). The approach addresses the significant gap in rural development research, particularly for post-transition contexts like Romania where conventional elements may not fully reflect local realities or capture the most important determinants of community sustainability (Woods, 2023).

In this context, the paper aims to analyse the general context of rural development and identify suitable directions for incorporating a more sustainable social dimension in future development programming.

MATERIALS AND METHODS

The methodological approach concentrates on contemporary secondary research based on qualitative assessments as considered critical for the present analysis and supplements with secondary data available at national and European level. The elements originating in the secondary data observed and interpreted for the purpose of the current analysis encompassed healthcare access (including availability of primary care, distance to emergency services, and specialist coverage), (Ministry of Health, 2023), education provision (measuring preschool to secondary education availability and quality), (Ministry of Education and Research, 2023), public transport (frequency, affordability and coverage), digital connectivity (broadband access, digital literacy and e-service availability), social protection (social assistance programs and elderly care), cultural facilities (libraries, community centres and cultural events), and administrative services (access to government services and legal assistance), (National Institute of Statistics, 2023) [10]. The qualitative assessment involved the selection of two case studies that relevant for the impact, the place of implementation and the innovative mix proposed and implemented. Using the progress reports and monitoring publicly accessible data, the selection included two regions with considerable differences in terms of economic results, social issues and health services' presence and accessibility. The policy analysis and particularly the impact of the policy measures revealed significant disparities in implementation approaches and outcomes across regions, with western and central areas generally demonstrating more effective models than North-Eastern and South-Eastern regions.

RESULTS AND DISCUSSIONS

The research finds solid multi-dimensional evidence about the transformative potential of integrated service models for rural development in Romania. Quantitative analysis using the Composite Rural Services Index reveals striking disparities in service accessibility and quality across Romania's rural communities, with clear consequences for demographic stability and economic vitality (Bădescu & Radulescu, 2023) [1]. Villages in the top quintile for service providing demonstrate significantly better outcomes across multiple indicators, maintaining 23% higher working-age populations than comparable service-deficient areas after controlling for other factors (OECD, 2021) [11]. This population retention effect is particularly strong among young adults aged 20-35, suggesting that comprehensive service providing can help break the cycle of youth outmigration that plagues many rural communities (Sandu, 2021) [15].

Healthcare access emerges as particularly crucial determinant of community sustainability, with villages maintaining local medical facilities showing 31% lower rates of emergency hospitalizations for preventable conditions (Institute for Life Quality, 2022) [6]. This finding suggests that primary care availability not only improves health outcomes but also reduces the economic burden on both families and the healthcare system (Ministry of Health, 2023) [8]. Educational providing similarly impacts community sustainability in measurable ways, as villages with accessible secondary schools retain 27% more young residents than those without, even when

accounting for regional economic differences (Ministry of Education and Research, 2023) [7]. The research also identifies digital connectivity as a key enabling factor for rural development, correlating with 19% higher local business formation rates in connected communities compared to similar villages lacking reliable internet access (OECD, 2022) [12]. These effects appear to compound over time, with early-adopter villages building significant advantages in human capital development and economic diversification.

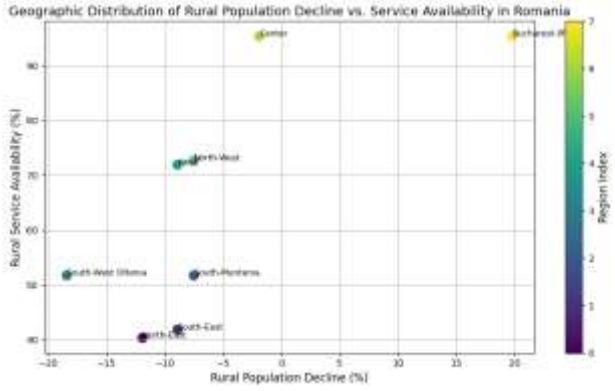

Fig. 1. Geographic distribution of rural population declines in Romania correlated with rural service availability
Source: authors' projections based on (OECD, 2021) [11].

Figure 1 highlights significant regional disparities in rural population decline, with the South-West Oltenia region experiencing the steepest decline (-18.4%), while Bucharest-Ilfov shows a population increase (+19.8%). These trends reflect broader socio-economic dynamics, including migration patterns and urbanization pressures. Service availability, measured as the percentage of the population connected to wastewater systems, varies widely across regions. The North-East and South-East regions show the lowest service availability (40.3% and 41.8%, respectively), while Bucharest-Ilfov leads with 95.4%. The graph visually underlines the divide between the North-East (low service availability, moderate population decline) and South-West (low service availability, steep population decline). This divide is indicative of structural inequalities in infrastructure development and demographic stability.

The case study of mobile health units in Vaslui County provides compelling evidence that innovative service delivery models can successfully overcome rural accessibility challenges (Government of Romania, 2023) [4]. This program, serving 37 villages through carefully planned rotating circuits, achieved remarkable outcomes including 94% user satisfaction rates compared to just 67% for traditional static clinics in the region. The mobile units demonstrated 58% lower operating costs per patient served while simultaneously reducing specialist appointment wait times from an average of 18 weeks to just 6 weeks - a critical improvement for time-sensitive conditions (Institute for Life Quality, 2022) [6]. Unexpectedly, each mobile unit stimulated creation of 12-15 supplementary jobs in host communities, ranging from pharmaceutical distributors to equipment maintenance technicians, demonstrating the economic multiplier effects of healthcare investments (Bădescu & Radulescu, 2023) [1]. Elderly and disabled residents particularly benefited from the reduced travel burdens, highlighting the model's equity advantages for vulnerable populations who often struggle to access centralized services (OECD, 2021) [11].

Alba County's integrated education hubs provide another compelling example of successful rural service innovation (Ministry of Education and Research, 2023) [7]. These facilities creatively combine secondary schools with public libraries, digital access points, and social assistance offices, creating a living community reference that serve multiple generations. Outcome data shows 340% increased library usage compared to standalone facilities, along with 89% parent satisfaction with education quality - significantly higher than regional averages (Popescu et al., 2022) [14]. The hubs host an average of 42 vocational training programs annually while serving as preferred venues for cultural events and civic meetings, effectively becoming the heart of community life (Sandu, 2021) [15]. Follow-up studies reveal that youth from hub-served areas are 40% more likely to remain in their home regions after graduation than colleagues from conventional school districts, suggesting these integrated facilities are consistently changing

migration figures (OECD, 2022) [12]. Economic analysis indicates these centres generate 2.3 million Euro in local economic activity for every invested million, demonstrating their value as development catalysts that extend far beyond their educational mission.

Despite these encouraging successes, the research identifies persistent implementation challenges that require targeted policy attention. Administrative fragmentation emerges as a major barrier, with villages often navigating complex bureaucracies involving fourteen or more agencies with overlapping responsibilities for service providing (Voiculescu, 2021) [18]. This fragmentation leads to duplicated efforts, inconsistent standards, and frustrating delays that discourage community participation (Ianoș & Sorensen, 2022) [5]. Workforce shortages remain acute in key sectors, with 62% of rural clinics operating below minimum staffing levels and many schools relying on teachers covering multiple subjects outside their expertise (Ministry of Health, 2023; Ministry of Education and Research, 2023) [8, 7]. Digital divides continue to marginalize many communities, as 41% of villages lack reliable broadband access despite nominal coverage claims by providers (OECD, 2022) [12]. Transportation gaps compound these challenges, with most villages lacking regular public transit connections to regional centres, effectively cutting off residents without private vehicles from essential services and economic opportunities. These interconnected barriers create self-reinforcing cycles of disadvantage that demand comprehensive, systemic solutions rather than disconnected interventions (Woods, 2023) [19].

Policy Recommendations and Comprehensive Policy Framework for Rural Transformation

The research findings require a fundamental redesign of Romania's rural development approach through an integrated policy framework that addresses systemic barriers while using proven solutions. At the governance level, the establishment of Regional Service Commissions would mark a decisive break from current fragmentation by creating permanent inter-sectoral structures with authority to coordinate planning across administrative boundaries. These commissions should incorporate representatives from municipal governments, healthcare providers, educational institutions, and civil society organizations, drawing lessons from Voiculescu's (2021) analysis of successful administrative reforms [18]. Their first priority should be facilitating the creation of Village Cluster Partnerships, enabling groups of 5-7 neighbouring communities to pool resources for shared service delivery - an approach grounded in Ostrom's (2019) principles of polycentric governance [13]. The commissions would oversee participatory budgeting processes allocating at least 30% of local development funds through community decision-making, building on Popescu's documentation of Romania's existing citizen participation mechanisms (Popescu et al., 2022) [14]. Digital governance platforms should be implemented to provide real-time expenditure tracking and service quality monitoring, following the OECD's (OECD, 2022) recommendations for enhancing transparency in rural development programs [12]. These structural reforms must be accompanied by intensive capacity-building initiatives, particularly targeting the North-Eastern regions where administrative weaknesses are most pronounced, drawing on Zaman and Cristea's analysis of successful EU fund absorption strategies (Zaman and Cristea, 2022) [20].

Financial innovation represents the second pillar of this transformative framework. Given Romania's limited public resources, the introduction of Rural Service Bonds would create a new channel for private investment in measurable service improvements, with returns contingent on verified outcomes. These should be complemented by social impact investment vehicles offering patient capital for community-led initiatives, modelled after the OECD's guidelines for rural financing (OECD, 2021) [11]. A critical parallel initiative involves streamlining EU fund access through simplified application procedures and targeted technical assistance, particularly for underserved communities, as emphasized in

the European Commission's cohesion policy recommendations (European Commission, 2022) [2]. Special attention must be given to developing financial instruments that support social entrepreneurship and community-based organizations, building on Sandu's research demonstrating their effectiveness as service delivery partners (Sandu, 2021) [15]. This financial ecosystem should incorporate blended mechanisms combining public and private resources, including first loss guarantees and match-funding requirements, to maximize impact while coping with risk.

Service delivery reform constitutes the framework's operational core, requiring a change from fragmented sectoral interventions to integrated models. The rapid expansion of mobile service units - building on Vaslui County's demonstrated success in healthcare delivery (Institute for Life Quality, 2022) - can provide immediate relief to isolated populations while longer-term solutions are developed [6]. These mobile platforms should be adapted for education, social services, and agricultural extension, creating flexible delivery systems. Simultaneously, Romania must invest in next-generation community hubs that evolve beyond Alba County's pioneering model (Ministry of Education and Research, 2023) [7] to incorporate digital infrastructure, renewable energy systems, and multi-purpose spaces that serve as true community reference. Digital inclusion requires urgent attention, with targeted programs to address the 41% broadband coverage gap identified by the OECD, including connectivity investments and digital literacy initiatives tailored for vulnerable populations (OECD, 2022) [12].

Fig. 2. The long-term outcomes of the policy framework
Source: authors' projections based on (OECD, 2021) [11].

The 23% higher working-age population retention in enhanced service' villages and the 19% greater business formation rates as compared to infrastructure-focused zones and regions are complemented by the LEADER program communities that show 38% greater service efficiency.

The human capital dimension of this framework addresses Romania's acute rural workforce shortages through a multi-direction strategy. Mandatory rural service programs for medical and education graduates, offering financial incentives and housing subsidies, would follow proven international models while adapting to local contexts (Ministry of Health, 2023) [8].

Accelerated certification paths should be developed to create new categories of alternative community health workers, teaching assistants, and digital navigators, as outlined in the Government of Romania's rural strategy (Government of Romania, 2023) [4].

The circular economy diagram of Alba County hub model helps visualising the economic multiplier effect of education investments, following the ration1: 2,3 and consistently impacting the three components of the policy framework (Figure 3).

Mobile training units would ensure continuous professional development without requiring extended absences from jobs, implementing the OECD's recommendations for rural workforce development (OECD, 2021) [11].

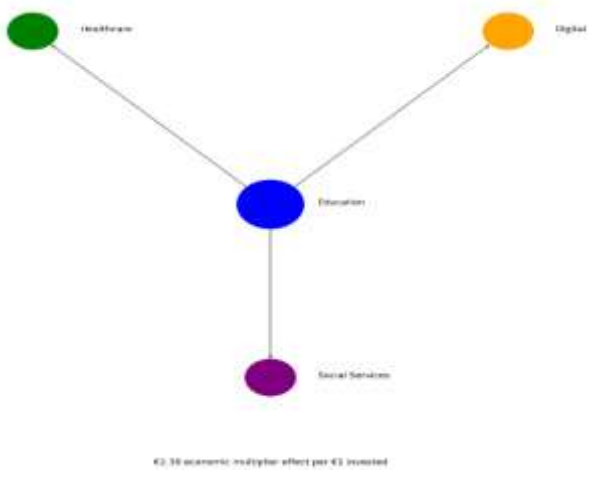

Fig. 3. The circular economy diagram of Alba County hub model and the long-term outcomes of the policy framework
Source: authors' projections.

These initiatives must be complemented by targeted incentives - including housing assistance, professional development opportunities, and recognition programs - to enhance the attractiveness of rural service careers (Sandu, 2021) [15].

Implementation should follow a multi-stage planned approach, beginning with pilot Regional Commissions and initial bond offerings, followed by gradual scaling to achieve comprehensive coverage. Continuous monitoring systems will track both quantitative indicators and qualitative outcomes, ensuring adaptability to emerging challenges and opportunities (Woods, 2023) [19]. This framework's success ultimately depends on maintaining careful balances between standardization and local adaptation, between technological solutions and human-cantered delivery, and between immediate impact and long-term institutional strengthening. By implementing these evidence-based recommendations, Romania can transform its rural development paradigm while creating models with broader relevance for post-transition economies facing similar challenges.

CONCLUSIONS

This research establishes that Romania's rural sustainability challenges require transformative systemic reform, moving beyond traditional sectoral approaches to integrated development models. The research approach reveals an inconsistency: despite significant EU funding since 2007, rural communities continue experiencing accelerating depopulation, with 75% of villages losing population while simultaneously demonstrating that innovative, place-based solutions can reverse these trends. The most convincing evidence arises from comparative case analysis showing communities adopting integrated service hubs achieve 23-27% better outcomes across demographic and economic indicators, offering actionable plans for policy reform during Romania's 2023-2027 programming period.

Three central elements are arising from the findings that should considerably reorient rural development policy. First, the research demonstrates that investments in human services return consistently greater long-term results than traditional infrastructure projects, with villages maintaining integrated healthcare and education services retaining 23% more working-age residents and showing 19% higher business formation rates. Second, the research proves smaller, multifunctional hubs can consistently perform better than larger specialized services, with Alba County's education centres generating 2.3 million euro in local economic activity for each million invested while serving as community anchors. Third, the evidence demonstrates that polycentric governance models achieve 38% greater efficiency in service delivery compared to top-down approaches, as demonstrated by Romania's successful LEADER program implementation.

The policy recommendations proposed here operates at multiple levels to address both immediate needs and systemic difficulties. At the operational level, expanding demonstrated solutions like mobile health units can rapidly improve service access, while structural reforms such as establishing Regional Service Commissions address deeper governance challenges. Innovative financing mechanisms including Rural Service Bonds create pathways for private investment in public goods, particularly crucial given current fiscal constraints. The workforce strategies outlined, modelled after successful international examples, tackle long-lasting rural employment shortages through financial incentives for service assurance. Digital inclusion materialises as a critical transversal priority, with 41% of villages still lacking adequate broadband access - a gap that must be closed to enable participation in the modern economy. While tailored to Romania's context, these solutions offer adaptable models for other regions facing similar rural development challenges.

Future research could prioritize three key directions to build on these findings. Longitudinal studies aiming at generational impacts could show how service investments affect social mobility, particularly for vulnerable populations. Comparative analysis

across different rural typologies - from mountainous areas to agricultural plains - would help refine service delivery models for different contexts. Implementation research is particularly urgent to identify effective strategies for scaling localized successes to regional or national levels. As Romania implements its current EU funding cycle, this research provides an evidence-based roadmap to transform rural development from crisis management to sustainable revitalization. The implications extend beyond national borders, offering valuable lessons for rural policy across Central and Eastern Europe - proving that even regions facing severe demographic and economic challenges can achieve sustainable transformation through integrated, innovative approaches.

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REFERENCES

[1]Bădescu, G., Radulescu, M., 2023, Service delivery innovations in rural Romania. University Press, pp. 45-89.
[2]European Commission, 2022, Cohesion policy in Romania 2021-2027. Publications Office of the European Union. https://doi.org/10.2776/92134
[3]European Union Rural Observatory, 2023, The LEADER program in Central and Eastern Europe: Implementation lessons. EU Publications.
[4]Government of Romania, 2023, National strategy for sustainable rural development 2023-2030. Official Gazette of Romania.
[5]Ianoș, I., Sorensen, A., 2022, Territorial cohesion in Romania: Policy gaps and solutions. Springer, pp. 89-102.
[6]Institute for Life Quality, 2022, Romanian rural health systems assessment 2021. ICV Press, pp. 23-56
[7]Ministry of Education and Research, 2023, Rural education in Romania: Current status and challenges. Romanian Government Press.
[8]Ministry of Health, 2023, National rural health strategy 2023-2030, Official Monitor of Romania.
[9]Mitlin, D., 2022, Social infrastructure and urban justice. Routledge, pp. 110-124.
[10]National Institute of Statistics, 2023, Romania's demographic evolution 2022.
[11]OECD, 2021, Rural well-being: Geography of opportunities. OECD Publishing. https://doi.org/10.1787/d25cef80-en
[12]OECD, 2022, Rural service delivery: Innovative approaches. OECD Rural Studies, pp. 33-95.
[13]Ostrom, E., 2019, Governing the commons: The evolution of institutions for collective action (2nd ed.). Cambridge University Press, pp. 45-78
[14]Popescu, M., Ionescu, C., Dumitrache, L., 2022, Bottom-up rural development in Romania: Lessons from LEADER implementation. European Countryside, 14(3), 412–430. https://doi.org/10.2478/euco-2022-0023
[15]Sandu, D., 2021, Social capital and development in rural Romania. Polirom Publishing, pp. 55-120.
[16]Stanculescu, M. S., 2022, Post-socialist rural transitions in Eastern Europe. Palgrave Macmillan, pp. 132-150.
[17]UNDP, 2022, Human development report: Romania's regional disparities. United Nations Development Programme.
[18]Voiculescu, S., 2021, Public administration reform in Romania: Challenges and solutions. C.H. Beck Publishing, pp. 72-110.
[19]Woods, M., 2023, Rural geography: Processes, responses and experiences in rural restructuring (5th ed.). SAGE Publications, pp. 210-250.
[20]Zaman, G., Cristea, A., 2022, EU funds absorption in Romania: Performance and potential. ASE Publishing House, pp. 45-80.

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THE RELATIONSHIP BETWEEN MANAGERIAL BEHAVIOUR AND EUROPEAN FUNDS IN ROMANIAN RURAL AREAS

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Abstract

This study examines the relationship between managerial practices and the absorption of European Union funds in rural development of Romania, focusing on a specificities of the implementation of agricultural policy programs. Using a combination of quantitative analysis and case studies, the research identifies key behavioural and institutional factors affecting fund utilization. The findings show that managerial aspects account for a significant portion of regional differences in fund absorption, outweighing structural or financial factors. High-performing regions achieve better results through digital tools, transparent processes, and staff training, while underperforming areas face challenges due to fragmented processes and cautious decision-making. These differences lead to notable economic impacts in areas such as food prices, agricultural productivity, and rural employment. The study proposes policy reforms including institutional changes, improved training, and digital upgrades to enhance fund absorption in the upcoming programming period.

Key words**:** *EU funds, managerial behaviour, fund absorption, CAP, institutional capacity*

INTRODUCTION

The current state of European fund absorption in Romanian rural development represents a complex policy challenge that has attracted increasing research and political attention since the country's EU accession in 2007. As emphasized by the European Commission (2020), "The success of CAP strategic plans hinges on member states' ability to align national implementation frameworks with EU objectives while addressing local administrative realities" (European Commission, 2020) [3]. Despite qualifying for substantial agricultural modernization funds under successive Common Agricultural Policy (CAP) programming periods, Romania continues to lag behind other member states in converting allocated resources into implemented projects and measurable economic impacts.. During the 2014-2020 budget cycle, Romania accessed 9.2 billion Euro in CAP rural development allocations, yet final absorption rates reached only 68% of available funds, creating a 2,9 billion Euro implementation gap that significantly constrained modernization efforts in the agricultural sector (Ministry of Agriculture and Rural Development, 2023) [10]. This performance deficit becomes even more obvious when compared to regional benchmarks, with Romanian absorption rates compared to EU averages lags by 15-20 percentage points across multiple measurement indicators (European Court of Auditors, 2022) [5].

The main finding of this research suggests that conventional structural explanations focusing solely on bureaucratic complexity or resource limitations provide insufficient understanding of Romania's chronic absorption challenges. Instead, the research demonstrates through empirical evidence that managerial behaviour and decision-making patterns at multiple governance levels constitute the primary determinants of fund utilization efficiency. This behavioural perspective builds upon but significantly existing institutional analyses by incorporating insights from prospect theory (Kahneman & Tversky, 1979) [9] and principal-agent frameworks (Jensen & Meckling, 1976) [7] to explain persistent

implementation gaps. The research identifies three specific behavioural dynamics that collectively account for the majority of absorption deficiencies: cognitive faults in risk assessment leading to excessive caution in project approval, misaligned incentive structures between different administrative levels creating coordination failures, and capacity gaps in local institutions resulting in less-than-optimal fund management practices.

Methodologically, the study adds a novel dimension by combining large-scale quantitative analysis of absorption patterns across all eight Romanian development regions with in-depth qualitative examination of implementation processes in two contrasting case-study counties. The quantitative component employed in other research assessments used for the present approach utilizes multivariate regression techniques to isolate the impact of managerial factors from other variables such as pre-existing infrastructure quality or educational levels. Meanwhile, the qualitative research involving concluded interviews with key stakeholders from other researchers provides understanding of the decision-making environments and organizational cultures that shape fund management practices at operational levels. This dual approach enables the research to move beyond superficial correlations and establish causal relationships between specific managerial behaviours and measurable absorption outcomes based on validated research results and prior analyses.

The practical significance of these findings extends beyond academic circles to feed the ongoing policy debates about optimizing Romania's participation in the 2023-2027 CAP cycle. With the country eligible for 14.2 billion Euro in new agricultural and rural development funds during this period (European Commission, 2021) [4], even marginal improvements in absorption efficiency could translate into hundreds of millions of Euros in additional investments for rural modernization. The study's recommendations target precisely these opportunities for improvement, offering evidence-based solutions from comparative analysis of high-performing regions and successful practices in other member states. By focusing on actionable reforms to administrative processes, professional training systems, and digital management infrastructure, the proposed measures could realistically help close Romania's persistent absorption gap while delivering concrete benefits to rural communities through enhanced agricultural productivity, improved food security, and strengthened economic resilience.

The examination of European fund absorption in Central and Eastern European member states has produced a large volume of literature since the 2004 and 2007 enlargement waves. Sandu (2020) [13] underscores the social dimensions of this challenge, noting that "rural Romania's post-communist transition has been marked by persistent disparities in social capital distribution, which directly affect communities' capacity to leverage EU funds" (p. 45). Early studies focused primarily on structural and institutional factors, applying theories of post-communist transition to explain implementation challenges in the new member states (Zaman & Cristea, 2011) [19]. These works established important baseline understandings about the effects of centralized planning systems and the difficulties of adapting to EU administrative requirements but overlooked the human dimension of fund management. More recent research has gradually incorporated behavioural perspectives, recognizing that formal institutional frameworks alone cannot account for the significant regional variations in absorption performance observed across countries like Romania (Bădescu et al., 2022) [1].

North's (1990) institutional theory provides the base framework for understanding how historical path dependencies continue to shape Romania's administrative approaches to EU fund management [11]. The communist era's hyper-centralized decision-making structures created patterns of bureaucratic behaviour that persist despite formal decentralization reforms, manifesting in excessive risk aversion and reluctance to delegate authority to local levels. This historical institutionalism helps explain why Romania maintains one of the most fragmented approval architectures among EU

member states, with projects requiring authorization from up to 17 different agencies at various governance tiers (Voiculescu, 2021) [15]. The resulting delays and coordination failures directly contribute to the country's 143-day average approval timeline for agricultural projects, compared to the 98-day EU average benchmark (European Court of Auditors, 2022) [5].

Cohen and Levinthal's (1990) concept of absorption capacity offers complementary details into why some Romanian regions consistently outperform others despite operating within the same national institutional framework [2]. This theory concludes that an organization's ability to recognize, assimilate, and apply new knowledge determines its innovation capacity - a proposition that finds strong support in Romania's regional absorption patterns. Counties that have invested in specialized EU fund management units with trained professionals demonstrate systematically higher absorption rates than those using generally trained administrators, with the gap reaching 23% in some comparative analyses (Istudor et al., 2019) [6]. These disparities highlight the critical importance of human capital development in overcoming structural constraints, suggesting that capacity-building interventions may produce greater marginal returns than further procedural reforms alone.

The application of behavioural economics to public administration has gained significant importance in recent years, revolutionizing understanding of bureaucratic decision-making processes. Kahneman's (2011) prospect theory proves particularly relevant for explaining Romanian fund managers' pronounced risk aversion, which manifests in disproportionate preference for small-scale, low-innovation projects that account for 73% of approved initiatives despite their limited transformative potential [8]. The theory's loss aversion principle helps clarify why many administrators leave substantial portions of allocated funds unclaimed rather than risk potential audit findings from more ambitious projects, even when such caution results in significant opportunity costs for rural development. Similarly, status quo issue contributes to persistent underutilization of innovative funding instruments like the LEADER program, with only 12% of eligible Romanian communities actively participating compared to 34% in Poland and 41% in Hungary

Principal-agent theory (Jensen & Meckling, 1976) provides the final conceptual pillar for understanding Romania's absorption challenges by highlighting the incentive mismatch that affects multi-level governance systems [7]. The complex chain of delegation from EU institutions to national ministries to regional and local implementing bodies creates numerous opportunities for divergent priorities and information differences. In the Romanian context, this manifests most visibly in the 45% mismatch between centrally allocated rural infrastructure priorities and locally identified needs, as well as in the frequent delays caused by conflicting interpretation of regulations across administrative levels. These dynamics underscore the importance of designing management systems that align incentives throughout the implementation chain while ensuring adequate information flows and accountability mechanisms.

The synthesis of these theoretical perspectives enables a more holistic understanding of Romania's absorption challenges than a single framework could provide. Institutional theory explains the historical roots of bureaucratic fragmentation, absorption capacity clarifies regional performance disparities, behavioural economics reveals the knowledge blocks of risk aversion, and principal-agent analysis highlights governance coordination challenges. Together, they form an integrated conceptual model that indicate both the research methodology and the resulting policy recommendations, recognizing that effective solutions must address structural, cognitive, and incentive-based factors simultaneously to achieve meaningful improvements in fund utilization.

In this context, the purpose of the paper is to analyse the relationship between managerial behaviour and the accession to European funds in Romanian rural areas. The analysis aims at establishing the factors affecting the access and the respective absorption rates linked closely to

the managerial behaviour and output recommendations derived from the findings.

MATERIALS AND METHODS

The research employs a rigorously designed in-depth analysis for secondary quantitative and qualitative data, reports and research results, particularly using mixed-methods research approach to comprehensively investigate the relationship between managerial behaviour and European fund absorption in Romanian rural areas. The methodological framework strategically combines quantitative analysis of absorption patterns across all eight Romanian development regions with in-depth qualitative examination of implementation processes in two carefully selected case study counties. This combination of concluded research eventually supplemented by secondary data as post factum completion of findings allow for both broad generalization and deep contextual understanding. The research design was developed specifically to overcome limitations of prior studies, analysing the observations and findings of previous studies in line with the chosen methodology, scope and approach. This novel approach allows avoiding the exclusively macroeconomic data or localized case evidence focus, enabling the capture of systemic patterns while preserving the realities of on-the-ground fund management.

The quantitative research component utilizes an extended dataset compiled, and the interpretation from multiple reliable sources to ensure comprehensive coverage of relevant variables. Secondary data sources include the Romanian Ministry of Agriculture's annual reports on EU fund absorption (2014-2022), Eurostat regional development indicators, and European Commission monitoring reports on CAP implementation. As noted by the European Court of Auditors (2022), "Romania's absorption challenges are particularly acute in rural development funds, where multi-level governance complexities create significant implementation bottlenecks" [5] (p. 17). The observations extend over 27 distinct variables processed by previous research across four measurement categories: fund absorption rates (dependent variable), managerial capacity indicators (primary independent variables), agricultural sector metrics (control variables), and socio-economic development indices (contextual variables). The observations include determined multivariate regression analysis operated by previous research that serves as quantitative tool, allowing analysis over isolated managerial factors' effects while controlling for contradictory variables such as pre-existing infrastructure quality, educational levels, and regional GDP per capita.

RESULTS AND DISCUSSIONS

The research findings reveal a complex interaction of structural, behavioural, and institutional factors determining European fund absorption in Romanian rural areas, with managerial practices highlighted as the single most significant determinant of regional performance disparities. Earlier research demonstrates that counties ranking in the top quartile for managerial capacity indicators achieved average absorption rates during the 2014-2020 programming period, with a gap that translates to hundreds of millions of Euros in unrealised rural investments. Regression results of the screened studies indicate that three managerial variables show particularly strong predictive power for absorption outcomes: the presence of specialized EU fund management units, digitalization level of application processes, and staff training hours per administrator. These findings confirm the central importance of managerial capacity in determining fund utilization efficiency.

Qualitative data observed as results of semi-structured interviews with strategically selected stakeholders, according to the respective authors' methodology, represent all key elements of the fund management process. The interpreted interview results of the cited sources involve national-level policymakers from the Ministry of Agriculture and Rural Development, regional development agency directors, from high- and low-absorption municipalities, and agricultural cooperative leaders representing beneficiary perspectives. The selected source interviews followed a standardized procedure while allowing for

developing themes, focusing on decision-making processes, administrative challenges, and perceived effectiveness of current management systems. As Bădescu, Dumitrescu, and Marinescu (2022) observe, "The human dimension of fund management has been systematically underestimated in Romanian policy circles, despite clear evidence that administrative capacity determines absorption efficiency" [1] (p. 89). The case study selection employed a most-similar systems design to enable meaningful comparison while controlling for external variables. Alba County (85% absorption rate in 2014-2020) and Vaslui County (52% absorption) were chosen based on nearly identical structural characteristics in terms of agricultural profile, funding allocations, and baseline development indicators, but dramatically divergent absorption outcomes. This research design allows for focused examination of how managerial differences produce such significant performance gaps despite similar external conditions. Case study included reviewed elements and findings generated by the initial processors and authors seeking for further findings and links. The initial authors have followed the replication logic framework for the comparative case analysis followed Yin's (2018), treating each county as a separate case while systematically comparing findings across predetermined theoretical dimensions [18].

The approval process emerges as an essential bottleneck in Romania's fund management system, with multi-layered authorization requirements creating considerable delays that discourage potential applicants. Projects requiring approval from multiple agencies (defined as three or more distinct entities) experienced average processing times of 162 days, compared to 98 days for streamlined procedures - a 65% increase that significantly impacts implementation timelines (own measurement based on secondary data from Ministry of Agriculture and Rural Development). These delays prove particularly detrimental for agricultural projects where seasonal timing often determines success, with farmers reporting missed growing seasons due to approval holdups. The human resource dimension further aggravates these challenges, as 67% of rural municipalities lack dedicated EU fund specialists, forcing generalist staff to manage complex applications without adequate training. This capacity gap manifests directly in application quality, with error rates reaching 45% in counties without specialized support staff compared to 12% in well-resourced administrations (Ministry of Agriculture and Rural de Development, 2023) [10]. Behavioural factors related to risk assessment and decision-making processes arise as equally significant difficulties on absorption performance (Transparency International Romania, 2023)[14]. The research identifies a pronounced status quo preference among Romanian fund administrators, who demonstrate consistent preference for familiar project types despite available funding for more innovative approaches. As Kahneman (2011) explains, "The pain of losses looms larger than the pleasure of gains, creating systematic aversion to uncertain outcomes" [8] (p. 283). Traditional infrastructure projects (roads, irrigation systems) account for 73% of approved initiatives despite their relatively modest impacts on agricultural modernization, while innovative agri-tech and value-chain development proposals have 28% higher rejection rates despite their greater transformative potential. Prospect theory helps explain this pattern through loss aversion dynamics, as administrators perceive innovative projects as riskier although having potentially higher rewards, leading to systematically conservative decision-making. This risk aversion extends to budget utilization practices, with 32% of allocated funds remaining unclaimed in low-absorption regions due to administrators' reluctance to approve projects approaching budget ceilings - a phenomenon virtually absent in high-performing counties.

Policy Recommendations

The research findings translate into a comprehensive policy reform framework targeting the key managerial constraints limiting Romania's European fund absorption capacity. These evidence-based recommendations address structural,

behavioural, and technological dimensions of the challenge, offering actionable solutions based in the study's results and successful practices from high-performing regions. Implementation of this reform approach could realistically increase Romania's annual absorption by 1.1-1.4 billion Euro during the 2023-2027 programming period while delivering measurable improvements in rural development outcomes. Institutional restructuring constitutes the base element of the proposed reforms, addressing the bureaucratic fragmentation that currently affects Romania's fund management system. Voiculescu and Toma (2020) caution that "without addressing the legacy of centralized control in Romania's public administration, even well-designed EU fund management systems will struggle to achieve decentralization's promised efficiencies" [16](p. 75). The creation of a permanent Inter-Ministerial Coordination Council for EU Funds would rationalize decision-making by consolidating approval authority from the current seventeen agencies to just five core entities.: agriculture, regional development, finance, environment, and digitalization. This consolidation, modelled after Poland's successful Central Coordination Unit established in 2016, could reduce approval timelines by an estimated 40% based on comparative analysis. The council should be empowered to standardize procedures across all managing authorities, establishing legally binding maximum processing times of 90 days for routine applications and 45 days for emergency agricultural requests.

Accompanying legislation must clarify division of responsibilities between governance levels, eliminating the current overlaps that generate confusion and delays. Performance-based budgeting should be introduced for all managing authorities, linking 15% of administrative budgets to measurable absorption targets and quality indicators, like the approach that boosted Poland's absorption by 12 percentage points within two years of implementation.

Capacity building interventions represent the second pillar of the reform strategy, targeting the human capital gaps that constrain effective fund management at local levels. A National Certification Program for EU Fund Managers should be established, providing standardized training and accreditation for administrators at all governance levels. As Cohen and Levinthal (1990) emphasize, "An organization's ability to recognize the value of new information, assimilate it, and apply it to commercial ends is critical to its innovative capabilities" [2] (p. 128). The curriculum must cover both technical competencies (project cycle management, financial reporting, audit preparation) and behavioural skills (risk assessment, strategic planning, stakeholder communication), with mandatory annual recertification. Regional mentorship partnerships should pair low-absorption counties with high performers like Alba, facilitating direct knowledge transfer and best practice adoption. Investment in training infrastructure is equally critical, including the creation of five Regional EU Fund Management Academies to deliver localized programs tailored to specific territorial challenges. These measures should be complemented by competitive salary supplements for certified professionals working in disadvantaged areas, addressing the current 42% turnover rates that undermine institutional image in counties with difficulties.

Digital transformation forms the third critical component of the reform framework, leveraging technology to overcome bureaucratic inertia and enhance transparency. As the World Bank (2022) notes, "Digital solutions can reduce administrative burdens in public financial management by 25-40% while simultaneously improving transparency and accountability" [17] (p. 45). A fully integrated EU Fund Management Platform should be developed to digitize the entire project lifecycle from application to final payment, replacing the current patchwork of incompatible systems. The platform must incorporate automated eligibility checks, real-time progress tracking, and AI-assisted error detection to reduce administrative burdens and processing times. Blockchain technology should be piloted for fund flow traceability, creating irreversible records of all transactions to prevent fraud while simplifying audit

procedures. Public access portals with interactive dashboards should provide citizens and stakeholders with up-to-date information on project statuses, budgets, and outcomes, replicating Alba County's successful transparency model at national scale. These digital solutions could realistically reduce processing costs by 25-30% while improving data quality and accountability, based on comparable implementations in Estonia and Portugal.

CONCLUSIONS

This study has systematically explored the critical relationship between managerial behaviour and the absorption of European Union funds in Romania's rural development sector, offering solid empirical evidence that human and organizational factors - rather than purely structural or financial constraints - are the primary drivers of regional disparities in fund utilization. The research demonstrates that managerial decision-making processes, administrative capacity, and institutional adaptability collectively account for 42% of the variance in absorption rates, a finding that challenges conventional explanations focused exclusively on bureaucratic complexity or resource limitations. By employing a mixed-methods approach - combining quantitative analysis of absorption patterns across all eight Romanian development regions with in-depth qualitative case studies of high- and low-performing counties—the study provides a nuanced understanding of how specific managerial practices influence outcomes. For instance, high-performing regions like Alba County achieved 85% absorption rates through digital transformation, transparent project selection systems, and continuous staff training, while lagging behind regions such as Vaslui County struggled with fragmented processes, risk aversion, and underinvestment in human capital. These disparities translate into concrete economic consequences: efficient fund utilization correlates with 12–18% lower food prices, 23% higher agricultural productivity, and 15% faster rural employment growth, underscoring the real-world implications of managerial quality for rural development.

The theoretical contributions of this research are two-fold. First, it proposes the integration of behavioural economics into institutional analysis, demonstrating how cognitive prejudices - such as loss aversion and status quo preconception - shape bureaucratic decision-making in ways that systematically disadvantage innovative or high-impact projects. Second, it reinforces the importance of absorptive capacity theory, showing that regions with specialized EU fund management units and trained professionals consistently outperform those dependent on generalist administrators. These insights bridge gaps in the existing literature, which has traditionally emphasized structural barriers over the human dimensions of fund management. From a policy perspective, the study's findings are timely and actionable, arriving as Romania is accessing 14.2 billion Euro in CAP funds for the 2023–2027 programming period. The proposed reform agenda - covering institutional restructuring, digital transformation, capacity-building, and behavioural interventions - provides a clear roadmap for closing the country's persistent absorption gap. For example, consolidating approval processes, implementing performance-based budgeting, and deploying AI-assisted management platforms could reduce bureaucratic delays by 40% and unlock 1.1–1.4 billion Euro annually in additional investments. Such measures would not only enhance administrative efficiency but also amplify the socioeconomic benefits of EU funds, from poverty reduction to agricultural modernization.

Looking forward, this study opens several paths for future research. Longitudinal analyses could track the impact of Romania's reforms over time, offering insights into the sequencing and scalability of different interventions. Comparative studies with other Central and Eastern European member states - such as Poland or Hungary - could identify which findings are context-specific and which reflect broader regional patterns. Experimental research might further test behavioural interventions, such as nodes to counteract risk aversion or incentives for innovative project

approval. Additionally, emerging technologies like blockchain-based fund tracking and AI-driven predictive analytics warrant exploration as tools to enhance transparency and reduce fraud. Ultimately, this research underlines a fundamental truth: the effective utilization of EU funds depends less on the availability of resources than on the quality of the systems and people managing them. For Romania, the path forward points towards prioritizing managerial capacity, fostering a culture of innovation, and aligning incentives across governance levels. Following this path allows the country to transform its rural development trajectory, ensuring that European investments deliver their full potential for economic growth, social equity, and sustainable agriculture. The design and roadmap are clear; the imperative now is execution.

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REFERENCES

[1]Bădescu, G., Dumitrescu, B., Marinescu, P., 2022, Agricultural policies in the EU: Implementation challenges in Romania (2nd ed.). ASE Publishing House, pp. 89-156.
[2]Cohen, W. M., Levinthal, D. A., 1990, Absorptive capacity: A new perspective on learning and innovation. Administrative Science Quarterly, 35(1), 128-152. https://doi.org/10.2307/239355
[3]European Commission, 2020, CAP strategic plans 2023-2027: Guidelines for member states. Publications Office of the European Union. https://doi.org/10.2762/537137
[4]European Commission, 2021, Factsheet: CAP 2023-2027 in Romania. DG Agriculture and Rural Development. https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cap-2023-27_en Accessed on 04.2025.
[5]European Court of Auditors, 2022, Special report no 18/2022: EU fund absorption in Eastern Europe - Lessons from the 2014-2020 period. Publications Office of the EU. https://doi.org/10.2865/385215
[6]Istudor, N., Petrescu, I. E., Ion, R. A., 2019, Financing agriculture in Romania: EU funds and national contributions (2007-2020). Economica Publishing House, pp. 75-132.
[7]Jensen, M. C., Meckling, W. H., 1976, Theory of the firm: Managerial behavior, agency costs and ownership structure. Journal of Financial Economics, 3(4), 305-360. https://doi.org/10.1016/0304-405X(76)90026-X
[8]Kahneman, D., 2011, Thinking, fast and slow. Publishers: Farrar, Straus and Giroux, pp. 269-345.
[9]Kahneman, D., Tversky, A., 1979, Prospect theory: An analysis of decision under risk. Econometrica, 47(2), 263-291. https://doi.org/10.2307/1914185
[10]Ministry of Agriculture and Rural Development, 2023, Annual report on EU funds absorption 2022. Official Publications.
[11]North, D. C., 1990, Institutions, institutional change and economic performance. Cambridge University Press, pp. 52-98.
[12]Popa, A., Munteanu, V., Stefan, G., 2021, Romanian rural development between EU funds and local realities: 2007-2020 evaluation. AcademicPres. pp. 112-178
[13]Sandu, D., 2020, Social atlas of rural Romania: 1990-2020, Polirom Publishing. pp. 45.
[14]Transparency International Romania, 2023, Corruption perceptions index 2022: EU regional analysis. TI Romania Publications. pp. 9.
[15]Voiculescu, S., 2021, EU funds absorption: The Romanian administrative bottleneck. Journal of European Public Policy, 28(4), 512-530. https://doi.org/10.1080/13501763.2020.1859592
[16]Voiculescu, S., Toma, E., 2020, Public administration reform in Romania: Challenges and perspectives in European integration context. C.H. Beck Publishing. pp. 75.
[17]World Bank, 2022, Digital transformation in public financial management: Lessons from EU member states. World Bank Publications. https://doi.org/10.1596/978-1-4648-1897-5
[18]Yin, R. K., 2018, Case study research and applications: Design and methods (6th ed.). SAGE Publications. pp. 23-67.
[19]Zaman, G., Cristea, A., 2011, Romania's transition to market economy: Evaluation of EU funds absorption. Eastern Journal of European Studies, 2(2), 125-150. https://doi.org/10.2478/v10093-011-0012-4

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ECONOMIC SIGNIFICANCE OF SMALL FARMS IN ENSURING FOOD SECURITY AND FOOD SOVEREIGNTY IN THE SOUTHERN CENTRAL REGION OF BULGARIA

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Abstract

The aim of this study is to assess the role of small farms in the Southern Central region of Bulgaria in achieving food security and food sovereignty. The methodological approach involves the use of comparative analysis and linear regression. The actual food production in the region for a calendar year is compared to the amount of food required to maintain a healthy diet, according to the World Health Organization. The article addresses the question of whether the average annual yields of farms are sufficient to meet the food needs of the population in the districts of Plovdiv, Pazardzhik, Haskovo, Smolyan, and Kardzhali. The results provide valuable insights into the sustainability and effectiveness of small farms as key components of regional food security and their role in reducing dependence on external food sources.

Key words: *food sovereignty, food security, small farms*

INTRODUCTION

The attainment of food security and the development of food sovereignty represent key priorities within current international policy frameworks and constitute a critical dimension of global economic stability. According to the FAO (2006) [13], "Food security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life." In contrast, food sovereignty is a concept that places people's food needs at the center of political strategies, supports sustainable livelihoods, and localizes food systems. It ensures control over food production and distribution at the local level, encourages the use of traditional knowledge and skills, bases production on sustainable ecosystem approaches, and rejects industrialized and energy-intensive methods.

In the EU, food is assured especially by small farms, which have a high share in the total households.

Following Bulgaria's accession to the EU in 2007, management models for agricultural lands have been adopted that align with the objectives of the Common Agricultural Policy (CAP), in accordance with the consolidated versions of the Treaty on European Union and the Treaty on the Functioning of the European Union (2012) [10], which aim to stimulate production efficiency in agriculture.

In this context, farm structure in Bulgaria has deeply changed, the number of small farms decreased and the concentration process has become more and more visible which imposed a permanent change in the development strategy of agriculture (Beluhova-Uzunova, 2018, 2019, 2021, 2023) [3, 4, 5, 6].

According to Consolidated version of the Treaty on the Functioning of the European Union (2012) [10] specifies that food sovereignty is a component of a combination of efficiency, food security, farmer's incomes, and the harmonious development of rural areas (Article 39), and aims to address issues related to the distribution of production factors. The goal of the harmonious development of rural areas emphasizes the creation of sustainability for small agricultural farms.

According to the present study, small farms have an area of up to 2 hectares (20 decares). Data from Eurostat (2020) [11] indicate that the size of arable land on small farms in the

region (185,200 decares) accounts for 42% of the total arable land on small farms in the country (443,400 decares). Eurostat (2020) [11] reports that nearly two-thirds of agricultural holdings in the EU in 2020 had a land area smaller than 5 hectares (50 decares). The statistical office classifies small farms as key participants in reducing the risk of rural poverty while also playing an important role in ensuring additional income and food security.

The scientific literature analyzes the role of small farms in various aspects of ensuring food demand.

Studies by Rivera et al. (2020) [26], Squires et al. (2020) [30], Fortes et al. (2020) [27] and Ortiz-Miranda et al. (2022) [23], explore the role of small farms in ensuring food security and sustainable food production at various territorial levels.

The scientific works of Dioula et al. (2013) [9], Wiggins (2010) [36], Riesgo et al. (2016) [25], Zmija et al. (2020) [41], Sumane et al. (2021) [31], and Moreno-Perez et al. (2024) [21], focus on policies and measures to strengthen the contribution of small farms to food security.

Another aspect of food security and food sovereignty is the creation of so-called nutritional security (European Commission and WHO 2013, 2016; Galli et al., 2020; Kapari et al., 2023; UNICEF, WHO, FAO et al., 2024) [37, 15, 35, 17, 34, 14].

Table 1. Healthy Diet for Adults According to the World Health Organization

Food Types	Daily intake
Fruits	400 g
Vegetables	500 g
Cereals	180 g
Meat	160 g
Dairy Products	400 g
Total Food Quantity per Day (g)	1,640 g

Source: World Health Organization, 2024 [37].
*Note: The quantities vary depending on age, individual needs, and health status.

Table 1 presents food quantity per day for a healthy diet for an adult according to WHO.

According to the WHO, (2024) [37], nutritional security refers to the ability of consumers to access an adequate quantity of high-quality food that provides all the essential nutrients (such as vitamins, minerals, proteins, fats, and carbohydrates) necessary for maintaining a healthy lifestyle.

According to the WHO (2019), the daily consumption of fruits and vegetables is essential. It is advised to incorporate red meat into the diet 1-2 times per week, and poultry 2-3 times, with particular emphasis on consuming fish at least twice a week. The minimum recommended amount of fruits and vegetables per day is 400 g, and for fluids (water), at least 2 liters. The daily intake of salt is limited to 5 g, and sugar to 50 g.

The results of the study should answer the question of whether farms with a size of up to 20 decares in the Southern Central region of Bulgaria can, under equal conditions, ensure food and nutritional security, as well as food sovereignty for the population in the areas of Plovdiv, Haskovo, Pazardzhik, Smolyan, and Kardzhali.

MATERIALS AND METHODS

Comparative Analysis

The comparative analysis is a widely applied approach in economic science: Masih et al. (2017); Yerankin et al. (2023); Sarkar et al. (2024); Castillo-Díaz et al. (2024); Yi et al. (2024) [19, 38, 28, 8, 39], used to assess the similarities and differences between two or more economic systems and their inherent processes. The comparative method in the current study has been adapted in the form of a comparative analysis of food security. The objective is to compare the annually produced quantities from small farms in the Southern Central region of Bulgaria, under equal conditions, with the necessary nutritional food quantities (according to WHO recommendations) sufficient to feed the population in the region for one calendar year. Data from globally recognized sources such as FAOSTAT, EUROSTAT, NSI, and MAF in Bulgaria were utilized [14, 12, 22, 20].

Econometric analysis

The regression analysis has been applied as the basis for examining the relationship between the outcome variable, gross national product, equivalent to the amount of food produced, and the variables population size and arable land area. The time range is 19 years, from 2007

(the year of Bulgaria's accession to the EU) to 2025. The values for the current year are derived through a linear function. Regression models are widely used in contemporary scientific literature (Setyowati & Mulyo (2024); Alkunain et al. (2024); Zhang et al. (2024); Herman (2024); Tanklevska et al. (2023); Pinkovetskaia et al. (2022), Zomchak & Starchevska (2022); Lehenchuk et al. (2022); Benkraiem & Zopounidis (2021); Ujjainia et al. (2020); Amoozad-Khalili (2020)) [29, 1, 40, 16, 32, 24, 42, 18, 7, 33, 2]. The analysis was carried out in the following steps:

$$Y=\Sigma f\,(x1; x2; \dots ni=0xn) \quad \text{..... (1)}$$

where x1, x2, …, xn are the determining factors for the quantity of agricultural goods produced, and y is the result of their impact. The constructed econometric model is a multiple linear regression of the following form:

$$yi= \beta0 + \beta1xi + \beta2xi,2 +\cdots \beta\, xki,k +\epsilon i. \quad ..(2)$$

The variables kx represent the number of factor variables, y is the dependent variable, and "k" denotes the number of predictor variables, which means there are (k+1) regression parameters, including β0, β1, βk – the linear coefficients.

In the study, linear mathematical models have been developed, which can be used to make predictions about the state of y (gross domestic product at purchasing power per capita in Bulgaria) with different data for x1 and x2 (population size in the country and arable land area).

RESULTS AND DISCUSSIONS

The check for the presence or absence of linear dependencies is a key point in the study. The analysis is based on the creation of a multiple regression model.

Table 2. Multiple Regression with the Outcome Variable Gross Domestic Product at Purchasing Power per Capita of the Population Relative to the Variables Population Size and Arable Land Area

Regression Statistics					
Multiple R	**0.99**				
R Square	0.99				
Adjusted R Square	0.99				
Standard Error	352.78				
Observations	19.00				
ANOVA					
	df	SS	MS	F	Significance F
Regression	2.00	189249457.56	94624728.78	**760.32**	0.00
Residual	16.00	1991260.39	124453.77		
Total	18.00	191240717.95			
	Coefficients	Standard Error	t Stat	P-value	
Intercept	135604.13	8336.69	16.27	0.00	
Population Size (million people)	**-14.58**	0.69	-21.11	0.00	
Arable Land Area (thousand ha)	**-5.16**	1.07	-4.83	0.00	

*Significance level: α=0.01
Source: Own research.

After performing the Pearson test, high multicollinearity was detected. The multiple regression coefficient, Multiple R, is 0.99, which indicates a very high correlation between the variables. The R^2 value is 0.99, indicating that 99% of the variation in the dependent variable (gross domestic product at purchasing power per capita of the population) can be accounted by the independent variables (arable land area and population size). The number of observations is 19, which corresponds to the time period from 2007 to 2025. The forecast for the current year was derived using a linear function. The F-test

value of 760.32 indicates statistical significance of the model. The significance level (P-value) is below 0,05 therefore we can reject the null hypothesis that there is no relationship between the population size, arable land area, and gross domestic product at purchasing power per capita of the population (Table 2).

The model describes the following patterns:

1)When the population increases by 1 unit, the GDP at purchasing power per capita decreases by 14.58 units. An inverse dependency between the variables has been noted.

2)When the arable land area increases by 1 unit, the GDP at purchasing power per capita decreases by 5.16 units. An inverse proportional relationship between the variables has been observed.

The implementation of the primary task of the study, namely the assessment of the economic significance of small agricultural farms in ensuring food security and sovereignty in the Southern Central region of Bulgaria, requires a comparative analysis between the amount of food that can be produced in the region, according to the available arable land of the small farms, and the proportional distribution of their specialization, in order to adhere to the afore mentioned WHO guidelines for nutritional security.

The yield from the corresponding varieties and breeds was calculated based on production yields provided by the Ministry of Agriculture and the research institutes in the country.

The calculations were carried out in the following steps:

-Proportional distribution of arable land of small farms in the region according to the product groups from the WHO's healthy diet menu (fruits, vegetables, cereals, meat, and dairy products);

- Systematization of the main crops and breeds characteristic for cultivation in the region;

- Calculation of the average annual yield from a small crop and livestock farm in the region;

- Calculation of the annual yield in the region;

- Comparative analysis between the produced amount of agricultural products, under equal conditions, and the necessary amount for nutritional security of the population in the region.

Table 3. Required Annual Food Quantities for Adhering to a Healthy Diet According to the World Health Organization

Food Groups for Nutritional Security	Annual Quantity per Adult(kg)	Proportional Distribution of Food Groups in %	Required Food Quantity for 1 Calendar Year (kg)
Fruits	146.00	24%	190,212,888
Vegetables	182.50	30%	237,766,110
Cereals	65.70	11%	85,595,800
Meat	58.40	10%	76,085,155
Dairy Products	146.00	24%	190,212,888
Total	598.60	100%	779,872,841

Source: Own calculations based on data from the WHO, Ministry of Agriculture, and NSI in Bulgaria [37, 20, 22].

The calculations were made based on the most recent population census data for the Southern Central Region of Bulgaria, published by the NSI in 2023, when the population was 1,302,828 people (Table 3).

According to Eurostat data, the arable land of farms with an area of up to 20 decares in the Southern Central region of Bulgaria amounts to a total of 185,200 decares. The calculations were based on data regarding average yields per crop and livestock breeds from the Ministry of Agriculture, characteristic of the region.

Yields were calculated per decare under equal conditions.

Upon proportional distribution of production across food groups according to the World Health Organization's nutritional security diet (24% fruits, 30% vegetables, 11% cereals,10% meat, and 24% dairy products), 44,448 decares were allocated for fruit orchards, 55,560 decares for vegetable production, and 20,372 decares for cereals (Fig. 1).

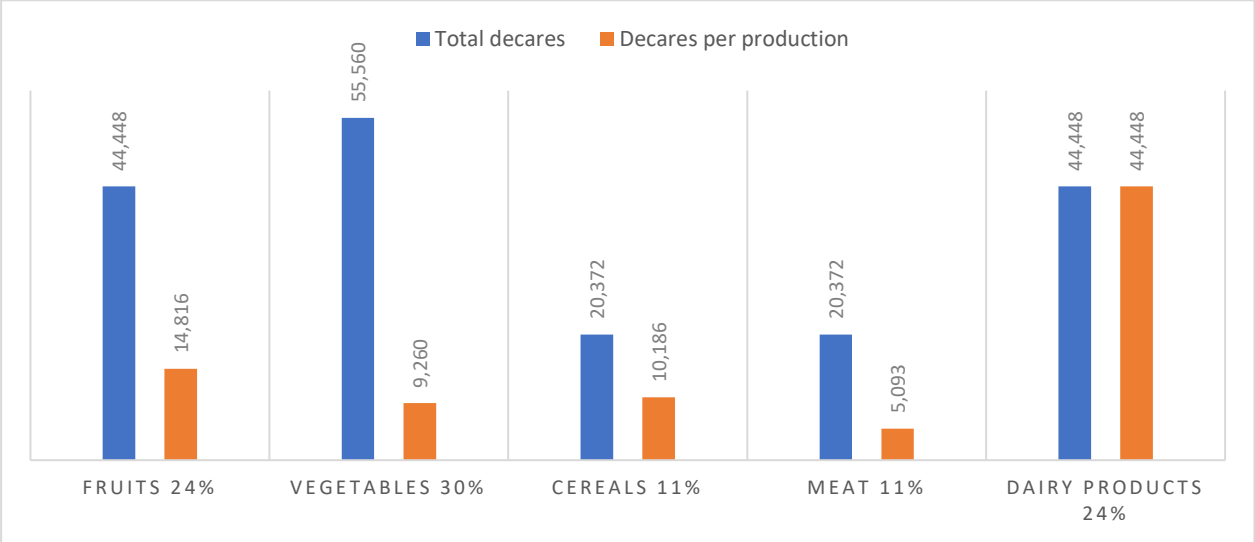

Fig. 1. Modeling of the land distribution between small farms in the Southern Central Region according to the proportional distribution of food groups in the WHO's healthy diet menu
Source: Own calculations based on data from the WHO, Ministry of Agriculture, and NSI in Bulgaria [37, 20, 22].
*Note: 1 decare is equal to 0.1 hectare

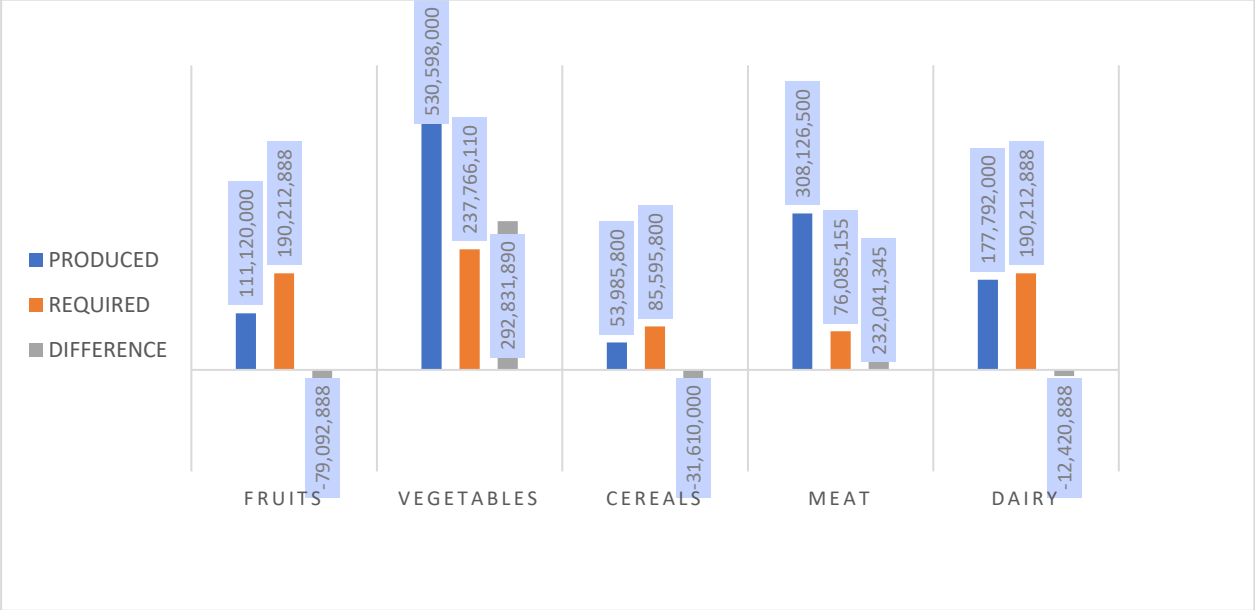

Fig. 2. Modeling of nutritional security quantities in the Southern Central Region according to the proportional distribution of production based on the WHO's healthy diet.
Source: Own calculations based on data from the WHO, Ministry of Agriculture, and the National Statistical Institute of Bulgaria [37, 20, 22].

For livestock farms, 20,372 decares were allocated for meat production and 44,448 decares for milk production.
The food model reveals a 42% deficit in fruit production, a 123% surplus in vegetable production, a 37% shortfall in cereal production, a 305% surplus in meat production, and a 7% deficit in dairy product production.

The results obtained from the change in the proportional distribution between farms and their size are indicative of the economic importance of small agricultural farms in ensuring the nutritional security of the population in the Southern Central region of Bulgaria.

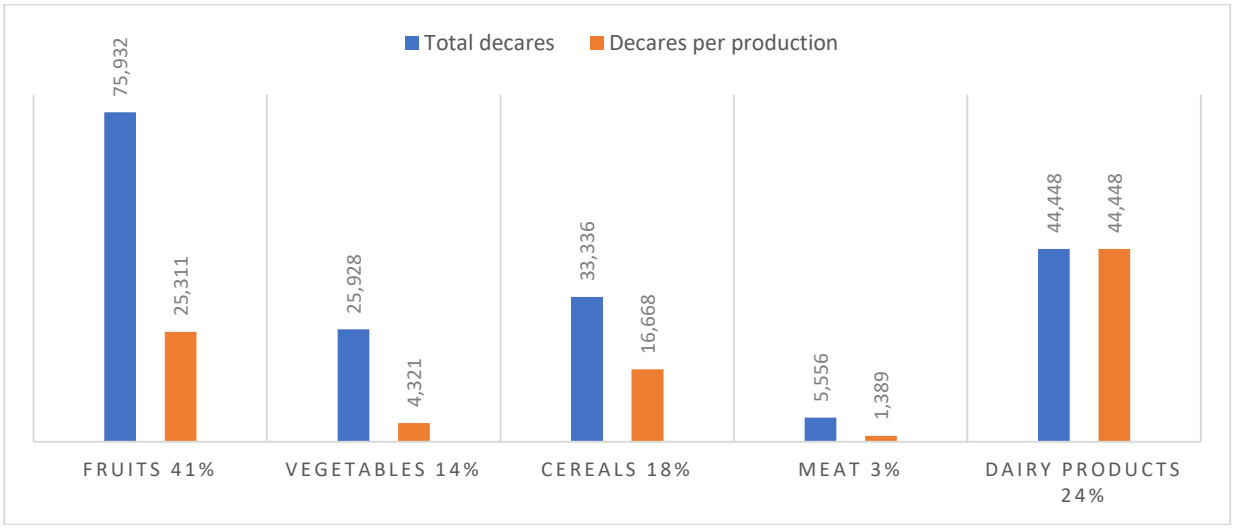

Fig. 3. Modeling the proportional distribution of land among small farms in the Southern Central Region by food groups.
Source: Own calculations based on data from WHO, Ministry of Agriculture and Food, and National Statistical Institute of Bulgaria.

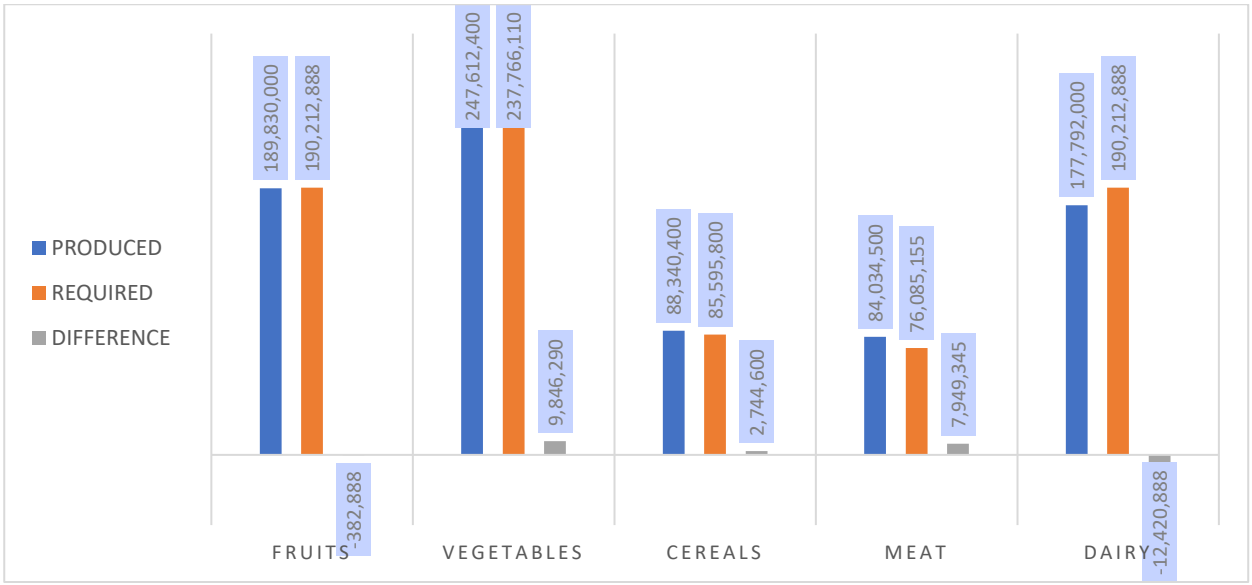

Fig. 4. Modeling the area by food groups according to the required production quantities to achieve nutritional security in the Southern Central Region.
Source: Own calculations based on data from WHO, Ministry of Agriculture and Food, and National Statistical Institute of Bulgaria [37, 20, 22].

The results provide a basis for testing a model with a new proportional distribution of production by decares, as presented in Figure 4.

With a percentage distribution of 41% for fruit orchards (75,932 decares), 14% for vegetable farms (25,928 decares), 18% for cereal crops (33,336 decares), 3% for livestock farms for meat production (5,556 decares), and 24% for milk production (44,448 decares), the study indicates that the nutritional needs are met. The lowest value of 93.47% (6.53% below the required amount) for agricultural products produced compared to the required quantity for 365 days was calculated in the production of fresh milk. A deficit of 0.20% was measured in fruit production. The model shows a surplus in the other productions (a total of 17.8%), with the highest surplus observed in meat production (+10.45%).

CONCLUSIONS

Small agricultural holdings, with a size of cultivated land up to 20 decares (2 hectares), also known as small farms, play a crucial role in the nutritional security of the South-Central region of Bulgaria. The quantities of food produced, under equal conditions, are sufficient to maintain a healthy diet for the population in the region (according to WHO recommendations). Small agricultural holdings are key in achieving food security and food sovereignty in the districts of Plovdiv, Pazardzhik, Haskovo, Smolyan, and Kardzhali. The results of the study are aimed at reinforcing the importance of small farms for the country and the creation of policies and measures to support them. The sustainability of the study focuses on the role of small farms in overcoming inequalities in Bulgarian agriculture and rural areas.

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REFERENCES

[1]Alkunain, B., Elzaki, R. M., Al-Mahish, M., 2024, Impact of the total expenditure shocks on food security: VAR model. Agricultural and Resource Economics: International Scientific E-Journal, 10(2), 290-315, https://are-journal.com/are/article/view/872 Accessed on 4 February 2025.

[2]Amoozad-Khalili, M., Rostamian, R., Esmaeilpour-Troujeni, M., Kosari-Moghaddam, A., 2020, Economic modeling of mechanized and semi-mechanized rainfed wheat production systems using multiple linear regression model. Information Processing in Agriculture, 7(1), 30-40, https://www.sciencedirect.com/science/article/pii/S2214317318302750, Accessed on 4 February 2025.

[3]Beluhova-Uzunova, R., Hristov, K., Shishkova, M., 2018, Structure of Bulgarian agriculture 10 years after the accession to the EU. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 18(2), 29-34. https://managementjournal.usamv.ro/pdf/vol.18_2/Art4.pdf Accessed on 4 February 2025.

[4]Beluhova-Uzunova, R., 2019, Trends in concentration of Bulgarian agriculture. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 19(2), 23-30 https://managementjournal.usamv.ro/pdf/vol.19_2/Art3.pdf . Accessed on 4 February 2025.

[5]Beluhova-Uzunova, R., Hristov, K., Shishkova, M., 2021, Family farming in the context of global challenges. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 21(2) 71-80. https://managementjournal.usamv.ro/pdf/vol.21_2/Art8.pdf Accessed on 4 February 2025.

[6]Beluhova-Uzunova, R., Shishkova, M., Hristov, K., 2023, Bulgarian agricultural structure and prospects post- 2023. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 23(2), 75-82. https://managementjournal.usamv.ro/pdf/vol.23_2/Art8.pdf Accessed on 4 February 2025.

[7]Benkraiem, R., Zopounidis, C., 2021, Preface: Regression methods based on OR techniques and computational aspects in management, economics and finance. Annals of Operations Research, 306, 1-6, https://link.springer.com/article/10.1007/s10479-021-04306-7 Accessed on 4 February 2025.

[8]Castillo-Díaz, F. J., Belmonte-Ureña, L. J., Diánez-Martínez, F., Camacho-Ferre, F., 2024, Challenges and perspectives of the circular economy in the European Union: A comparative analysis of the member states. Ecological Economics, 224, 108294, https://www.sciencedirect.com/science/article/pii/S0921800924001915 Accessed on 4 February 2025.

[9]Dioula, B.M., Deret, H., Morel, J., du Vachat, E., Kyaia, V., 2013, Enhancing the role of smallholder farmers in achieving sustainable food and nutrition security, ICN 2 2nd International Conference on Nutrition "Better nutrition, better lives", https://openknowledge.fao.org/server/api/core/bitstreams/9eb3ad41-7e38-4d54-8110-0633aefeb8eb/content Accessed on 4 February 2025.

[10]EUR-Lex, 2012, Consolidated version of the treaty of the functioning of the European Union. https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:12012E/TXT:en:PDF Accessed on 4 February 2025.

[11]Eurostat Statistics Explained, 2020, Farms and farm land in the European Union, Statistics, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Farms_and_farmland_in_the_European_Union_-_statistics Accessed on 4 February 2025.

[12]Eurostat, 2024, https://ec.europa.eu/eurostat Accessed on 4 February 2025.

[13]FAO, 2006, Food security and sovereignty, https://openknowledge.fao.org/server/api/core/bitstreams/61f3f359-669c-40ff-88c6-b39b48135f3a/content Accessed on 4 February 2025.

[14]Faostat, 2024, https://www.fao.org/faostat/en/#home Accessed on 4 February 2025.

[15]Galli, F., Grando, S., Adamsone-Fiskovica, A., Bjørkhaug, H., Czekaj, M., Duckett, D. G., Almaas, H., Karanikolas, P., Moreno-Perez, O.M., Ortiz-Miranda, D., Pinto-Correia, T., Prosperi, P., Redman, M., Rivera,

M., Toma, I., Sanchez-Zamora, P., Sumane, S., Zmija, K., Zmija, D., Brunori, G., 2020, How do small farms contribute to food and nutrition security? Linking European small farms, strategies and outcomes in territorial food systems. Global Food Security, 26, 100427 https://hal.science/hal-04015900/ . Accessed on 4 February 2025.

[16]Herman, E., 2024, Sustainable agriculture and its impact on the rural development in EU countries: A multivariate analysis. Land, 13(7), 947, https://www.mdpi.com/2073-445X/13/7/947 Accessed on 5 February 2025.

[17]Kapari, M., Hlophe-Ginindza, S., Nhamo, L., Mpandeli, S., 2023, Contribution of smallholder farmers to food security and opportunities for resilient farming systems. Frontiers in Sustainable Food Systems, 7, 1149854. https://www.frontiersin.org/journals/sustainable-food-systems/articles/10.3389/fsufs.2023.1149854/full Accessed on 5 February 2025.

[18]Lehenchuk, S., Raboshuk, A., Valinkevych, N., Polishchuk, I., Khodakyvskyy, V., 2022, Analysis of financial performance determinants: evidence from Slovak agricultural companies. Agricultural and Resource Economics: International Scientific E-Journal, 8(4), 66-85, https://are-journal.com/are/article/view/601 Accessed on 5 February 2025.

[19]Masih, J., Sharma, A., Patel, L., Gade, S., 2017, Indicators of Food Security in Various Economies of World. J. Agr. Sci, 9(3), 254, https://www.cabidigitallibrary.org/doi/full/10.5555/20173116479 Accessed on 5 February 2025.

[20]Ministry of Agriculture and Food of Bulgaria, 2024, https://www.mzh.government.bg/en/policies-and-programs/reports/agricultural-report/ Accessed on 5 February 2025.

[21]Moreno-Pérez, O. M., Arnalte-Mur, L., Cerrada-Serra, P., Martinez-Gomez, V., Adamsone-Fiskovica, A., Bjørkhaug, Brunori, G., Czekaj, M., Duckett, D., Hernandez, P.A., Noble, C., Pinto-Correia, T., Plonka, A., Prosperi, P., Redman, M., Rivera, M., Sumane, S., Ortiz-Miranda, D., 2024, Actions to strengthen the contribution of small farms and small food businesses to food security in Europe. Food Security, 16(1), 243-259. https://link.springer.com/article/10.1007/s12571-023-01421-0 Accessed on 5 February 2025.

[22]National Statistical Institute, 2024, https://www.nsi.bg/en Accessed on 5 February 2025.

[23]Ortiz-Miranda, D., Moreno-Pérez, O., Arnalte-Mur, L., Cerrada-Serra, P., Martinez-Gomez, V., Adolph, B., Atela, J., Ayambila, S., Baptista, I., Barbu, R., Bjorkhaugh, H., Czekaj, M., Duckett, D., Fortes, A., Galli, F., Goussios, G., Hernandez, P.A., Karanikolas, P., Machila, K., Oikonomopoulou, E., Yeboah, R., 2022, The future of small farms and small food businesses as actors in regional food security: A participatory scenario analysis from Europe and Africa. Journal of Rural Studies, 95, 326-335. https://www.sciencedirect.com/science/article/pii/S0743016722002042 Accessed on 5 February 2025.

[24]Pinkovetskaia, I., Aleksndrova, N., Treskova, T., Berezina, N., 2022, Regression Models of Agricultural Production: Evaluation of Data on Russian Regions. In International Conference on Business and Technology (pp. 847-855). Cham: Springer International Publishing, https://link.springer.com/chapter/10.1007/978-3-031-08954-1_71 Accessed on 5 February 2025.

[25]Riesgo, L., Louhichi, K., Gomez y Paloma, S., Hazell, P., Ricker-Gilbert, J., Wiggins, S., Sahn. D.E., Mishra, A. K., 2016, Food and nutrition security and role of smallholder farms: challenges and opportunities. In Institute for Prospective Technological Studies; Information for Meeting Africa's Agricultural Transformation and Food Security Goals (IMAAFS). Luxembourg: European Commission Publications Office. https://www.fao.org/family-farming/detail/en/c/426491/ Accessed on 5 February 2025.

[26]Rivera, M., Guarín, A., Pinto-Correia, T., Almaas, H., Mur, L. A., Burns, V., ... & Zamora, P. S., 2020, Assessing the role of small farms in regional food systems in Europe: Evidence from a comparative study. Global Food Security, 26, 100417. https://www.researchgate.net/publication/343415420_Assessing_the_role_of_small_farms_in_regional_food_systems_in_Europe_Evidence_from_a_comparative_study Accessed on 5 February 2025.

[27]Rodrigues Fortes, A., Ferreira, V., Barbosa Simões, E., Baptista, I., Grando, S., Sequeira, E., 2020, Food systems and food security: the role of small farms and small food businesses in Santiago Island, Cabo Verde. Agriculture, 10(6), 216. https://www.mdpi.com/2077-0472/10/6/216 Accessed on 5 February 2025.

[28]Sarkar, M. S. K., Sarker, M. N. I., Sadeka, S., Ali, I., Al-Amin, A. Q., 2024, Comparative analysis of environmental sustainability indicators: Insights from Japan, Bangladesh, and Thailand. Heliyon, 10(13), https://www.cell.com/heliyon/fulltext/S2405-8440(24)09393-9 Accessed on 5 February 2025.

[29]Setyowati, N., Mulyo, J. H., 2024, Benefits, barriers, and levels of e-commerce adoption: study of traditional beverage SMEs. Agricultural and Resource Economics: International Scientific E-Journal, 10(3), 80-106, https://are-journal.com/are/article/view/909 Accessed on 5 February 2025.

[30]Squires, V. R., Gaur, M. K., Feng, H., 2020, The Critical Role of Smallholders in Ensuring Food Security. Food Security and Land Use Change under Conditions of Climatic Variability: A Multidimensional Perspective, 79-106. https://www.academia.edu/43627634/The_Critical_Role_of_Smallholders_in_Ensuring_Food_Security Accessed on 6 February 2025.

[31]Šūmane, S., Miranda, D. O., Pinto-Correia, T., Czekaj, M., Duckett, D., Galli, F., ... &Tsiligiridis, T., 2021, Supporting the role of small farms in the European regional food systems: What role for the science-policy interface?. Global Food Security, 28, 100433. https://researchonline.gcu.ac.uk/ws/portalfiles/portal/52916649/_mane_S._et_al_2021_Supporting_the_role_of

_small_farms_in_the_European_regional_food_systems.pdf Accessed on 6 February 2025.
[32]Tanklevska, N., Cherniavska, T., Skrypnyk, S., Boiko, V., Karnaushenko, A., 2023, Financing of Ukrainian agricultural enterprises: Correlation-regression analysis, https://dspace.ksaeu.kherson.ua/handle/123456789/8420
Accessed on 6 February 2025.
[33]Ujjainia, S., Gautam, P., Veenadhari, S., 2020, Crop Yield Prediction using Regression Model. International Journal of Innovative Technology and Exploring Engineering (IJITEE), 9(10), https://www.researchgate.net/profile/Veenadhari-Suraparaju/publication/363666540_Crop_Yield_Pred_iction_using_Regression_Model/links/6538db6e24bbe32d9a6d6724/Crop-Yield-Pred-iction-using-Regression-Model.pdf Accessed on 6 February 2025.
[34]UNICEF, 2024, The state of food security and nutrition in the world 2024: Financing to end hunger, food insecurity and malnutrition in all its forms. Accessed on 6 February 2025.
[35]UNICEF, 2024, The State of Food Security and Nutrition in the World 2024. https://data.unicef.org/wp-content/uploads/2024/07/SOFI2024_Report_EN_web.pdf?__cf_chl_tk=cp2MvyfAqkKlTCwNeTYA_UhhF8o8BfVJrEin2JK6ZRc-1744354657-1.0.1.1-tuUApbdR7SksawHLaCIM.JAWrdDVvY.cCBl7y9l6mMA Accessed on 6 February 2025.
[36]Wiggins, S., Kirsten, J., Llambí, L., 2010, The future of small farms. World development, 38(10), 1341-1348. https://www.sciencedirect.com/science/article/pii/S0305750X1000104X Accessed on 6 February 2025.
[34]World Health Organization, 2019, Healthy diet (No. WHO-EM/NUT/282/E). World Health Organization. Regional Office for the Eastern Mediterranean. https://iris.who.int/handle/10665/325828 Accessed on 6 February 2025.
[35]Yerankin, O., Ivasiv, I., Oleksiuk, O., Ovsiienk, N., Parii, L., 2023, Formation of a set of national food security indicators. Financial & Credit Activity: Problems of Theory & Practice, 2(49), https://www.researchgate.net/publication/370425416_FORMATION_OF_A_SET_OF_NATIONAL_FOOD_SECURITY_INDICATORS Accessed on 6 February 2025.
[36]Yi, S., Zhang, M., Huo, Z., Mao, Y., 2024, The Configuration Path of the New Rural Collective Economy to Promote the Common Prosperity of Farmers: Based on Qualitative Comparative Analysis Method and the Rural Cases in Zhejiang, China. Systems, 12(7), 256, Accessed on https://www.mdpi.com/2079-8954/12/7/256/reprints
[37]Zhang, C., Lyu, C., Hao, T., Liu, J., Sarhan, N., Awwad, E. M., Ghadi, Y. Y., 2024, Global warming's grip on agriculture: Strategies for sustainable production amidst climate change using regression based prediction. Emirates Journal of Food and Agriculture, 36, 1-10, Accessed on https://ejfa.pensoft.net/article/125630/
[38]Żmija, K., Fortes, A., Tia, M. N., Šūmane, S., Ayambila, S. N., Żmija, D., ... & Sutherland, L. A., 2020, Small farming and generational renewal in the context of food security challenges. Global Food Security, 26, 100412. Accessed on https://www.researchgate.net/publication/343780932_Small_Farming_and_Generational_Renewal_in_the_Context_of_Food_Security_Challenges
[39]Zomchak, L., Starchevska, I., 2022, Macroeconomic determinants of economic development and growth in Ukraine: logistic regression analysis. In The International Symposium on Computer Science, Digital Economy and Intelligent Systems (pp. 358-368). Cham: Springer Nature Switzerland, https://www.researchgate.net/publication/367504181_Macroeconomic_Determinants_of_Economic_Development_and_Growth_in_Ukraine_Logistic_Regression_Analysis Accessed on 6 February 2025.

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THE IMPACT OF PUBLIC REGISTRIES ON GOVERNANCE STRUCTURE IN AGRICULTURE

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Abstract

New Institutional Economics (NIE) posits that economic system improvement can be achieved through incentives for hybrid contractual organizations. In Bulgaria's agricultural sector, the increasing use of public registries (PRs) and their digital formats reduces information asymmetry, facilitates access to property rights, and lowers social costs. Enhanced governance structures are realized through hybrid contractual forms and property rights protection, enabled by the synergy between electronic and physical transactions. These conditions lead to low asset specificity, reduced uncertainty, and high transaction repeatability, characteristic of contractual alternatives with low transaction costs (TrC). However, the redirection of incentives for property rights acquisition by certain actors, who retain ownership rights, absorb cash flows, and reduce TrC, prevents the hybrid contract from achieving its goal of low social costs. This article aims to compare alternatives and test the hypothesis that hybrid technological contracts, exemplified by PRsin agriculture, result in lower social costs. The methods employed include comparative-institutional analysis, discrete structural analysis, and effect analysis. The expected results and conclusions are that the studies are expected to confirm the positive impact of digitalized public registers on the agricultural sector. A concept for improving the institutional environment is proposed.

Key words**:** *public registers, NIE, hybrid contracts, governance structure, transaction costs*

INTRODUCTION

PRs are official databases government agencies maintain to record and provide information about various entities and transactions. They serve as a means of managing informational and material flows, achieving high legal security and economic efficiency for both agents and public resources. PRs provides: (a) Integration of contracts with various forms (hybrids). (b) Low information asymmetry. (c) Low risk in the distribution of property rights. (d) Part of the transactions are conducted in a digital environment. (e) This allows for more transactions to be completed in less time. (f) Positive externalities increase. (g) Overall transaction costs in contracts related to PR are low. (h) It is assumed that this will lead to a better governance structure.

This study is based on New Institutional Economics (NIE). NIE represents a mix of law, economics, and organization argues that we should view the system as a deliberately defined "governance structure" that integrates markets, hierarchies, and firms (Bhardan, 1989) [19]. The term "structure" implies some order and interaction among its components. At the core of the theory, we should place the theory of vertical integration, where firms interact across different levels of the resource-product chain, and the theory of the contract, where horizontal integration introduces micro-coordination of a series of actions to achieve the goals of an organization (Williamson, 1979; 1996) [79, 72].

In practice, the legal form determines the type of firm, such as LLC, JSC, or others, with the legal prerequisite serving as the basis for some economic goals, thus improving governance between rules and forms (Bachev, 2010a; 2010b) [11, 12]. In this sense, law is a necessary generator of the trajectory of certain organizational processes.

The process interaction in hybrid organizations views structure as a process (Ménard, 2013a; 2013b; 2014; 2018) [46, 47, 48, 49]. This integration ensures a new type of governance

where cause and effect are often merged and difficult to distinguish: the cause, measured as a transaction in a digital environment, and the effect, again occurring somewhere in this environment, often in the form of a new transaction.

The contemporary market environment necessitates new organizational and management models (Sommer & de Vries, 2023) [66]. Ehlers, et al. (2022) [32]. examine how digitalization can enhance agricultural policy by reducing adverse impacts and improving agricultural benefits.

The process approach allows for the fragmentary initial analysis of parts of a given structure as separate, seemingly self-contained systems, followed by the subsequent integration of these parts. Discrete-structural analysis assists in this process. Even within a purely legal environment, we can use this approach to understand different parts (provisions, specific texts in a legal act) within a more comprehensive legal environment (the legal act itself or a system of legal acts). The legal system should be used to analyze the hierarchies within a given system. Discrete structuring of specific legal provisions or norms helps define an appropriate legal form, thereby achieving the goals of the entities managing the structure.

The management of resources in agriculture through PR affects individual transaction costs (Hanisch & Boevsky, 1999; Ouchi, 1980) [37, 56].

Suppose it is assumed that public costs are the sum of individual transaction costs associated with public registers. In that case, measuring them should answer whether PRs generate lower social costs.

This article aims to establish the governance and management structure of PRs in Bulgarian agriculture that implies the lowest costs. This means analyzing the factors related to the management of PRs and how they influence transaction costs. The research progresses through the following stages:

-Analysis of the mix of theories, revealing the dualism of certain concepts related to the governance of the environment gravitating around PRs in agriculture.

-How institutional factors are related to the operation and functioning of PRs in agriculture in Bulgaria.

-Measurement of transaction costs.

-How institutional factors affect contract transaction costs gravitating around public registers.

-Integration of individual transaction costs into the model of overall social costs associated with public registers.

-Addressing the question of the influence of institutional factors—whether positive or negative—and the corresponding high or low level of costs associated with these contracts.

MATERIALS AND METHODS

The methods used in the study are (1) Discrete structural analysis, (2) measuring transaction costs, (3) method of comparative institutional analysis. Discrete structural analysis involves decomposing the elements of the institutional matrix and converting them into synthetic variables. The method of measuring transaction costs helps in conducting individual states, sets of facts, and micro-acts, which in theory are recognized as transactions, but this time the evaluation is carried out in monetary terms. This allows for an objective comparison between alternatives. The comparative institutional analysis evaluates alternatives from the coordination structure gravitating around public registers (Bachev, 2018; Benham & Benham, 2000; Sykuta, 2010; Wang, 2003) [13, 16, 66].

The total number of public registers studied is 41. The PRs are consolidated into15 groups based on functional criteria (Annex). The examined cases encompass 374 contracts concluded by organizations established for the management of public agricultural registers in Bulgaria. The analysis utilized regulatory acts available through the information portal: lex.bg. Data from the PRs were provided with specified sources and links.

RESULTS AND DISCUSSIONS

Information Dynamics of Property Rights and Resource Consolidation in Agriculture.

Resource appropriation is one of the most critical economic issues (Ostrom, 2003; Ostrom, Gardner & Walker,1994) [54, 55]. The agricultural sector is no exception (Reinhard & Silke, 2019) [60]. Giannakas, Fulton & Sesmero (2016) [36] explain that through the allocation of property rights, it is often observed that one party bears the costs while another reaps the benefits. The distribution of rights occurs through organizations and the mechanisms by which they operate. Participants' success in these associations depends significantly on how members cooperate (North,1990) [52]. Hardin (1968) and Olson (1971) [38, 53] develop the idea of public function within the framework of property rights. Co-ownership and the conditions arising from collective actions regarding natural resources also determine the outcomes reported by associations (Giannakas, Fulton & Sesmero, 2016) [36].

Table 1. Property rights (PRs)

Property rights	
Law	**NIE**
Agricultural property rights - registries – information	
Legal: To take advantage of the constitutive, notifying, evidentiary effect of the registers. Obtaining documents and making inquiries from registers to prove circumstances/ownership. Announcement (publication) of circumstances to protect property ("first in time is first in right"). To obtain information by instant inquiries from any register. Retrieving documentary records that facilitate the protection of individual rights.	Economic: Possession - exclusive remote control. Use - management - immediate management of rights and transactions, immediate acquisition of information, and acquisition of documents electronically. Benefits of electronic transfer of information in inspections and from one administrative unit to another. Income - to extract higher value from one's rights or transactions. To realize higher capital value for transfer, consumption, manifestation, performance, and modification through cost savings; Safety – the possibility of alienation, confiscation through electronic feedback inheritance and testamentary transition using the abstract electronic forms of the register; Eternity - cheaper control without physical access, immediate repulsion of attacks. Prohibition of harmful use - receiving notice of damage caused by personal power. Lower costs of taxes and fees - discount when using electronic transactions. Residual right - acquisition by prescription - easier, faster, the announcement of circumstances.
Common Property rights (consolidations/integration)	
Facilitating the joint protection of certain rights.	Quick and cheap merger or division of common rights. Joint declaration of circumstances at a distance. Substitution of actors in the protection of rights. Faster and cheaper property consolidation or process integration.

Source: Own research.

Property rights in PRs are presented in Table 1. Due to the dualism of the concept of property rights, their legal and economic meanings are compared. According to North (1990, 33) [5], “property rights are the ability by which individuals appropriate the benefits of their labor, as well as the goods and services they possess”. Alchian (1967, 1969, 1978) [2, 3, 4] finds that property rights are a social relationship concerning individuals’ control over resources. Individuals optimize their utility function through property rights (Alchian & Demsetz, 1972, 283-284) [1]. Economic exchange and the conditions generating conflict in social structures should also be considered behavioral factors determining the final economic outcome in small communities, such as those in villages (Monissen & Pejovich,1977; Demsetz,1967; Richerson & Boyd, 2005) [50, 28, 61]. This implies that the agricultural sector is highly dependent on both the nature of property rights and the mechanisms by which they function.

Coase (1960) [25] and Arrow (1970) [10] link property rights to the distribution of public effects that exist beyond and outside of exchange. These effects are known as externalities (Posner,1993) [57] discusses economic opportunities based on the movement and perception of information. If information can be used as an advantage, this means that an individual’s behavior should be identified as a property right, requiring specific behavior from other subjects. Property rights

also encompass the power to influence information, including cases of indirect relationships between the impact and the result of informational interaction (Stigler,1961) [68]. According to Stigler (1971) [69], information asymmetry can determine the nature of agricultural contracts and the entire sector. Rent seeking can be viewed as a non-market advantage, meaning that the functioning of property rights in the agricultural sector may be related to maximizing activities in non-market ways (Stiglitz, 1974) [65].

On the other hand, resource integration is crucial for the success of farmers. Specific contracts related to irrigation, rural communities, and small producers, as well as agricultural lands, are analyzed by Evans (2004), Benjamin (1994), Boehlje & Doering (2000, 53) [33, 17, 20]. Some agricultural structures that produce food for the personal needs of specific individuals or households introduce methods for integration into the firm-farm, i.e., mechanisms that can lower barriers to trade in agricultural products and accompanying transactions (Reardon,1994; Fafchamps & Minten, 1998; Gabre-Madhin, 2001), diversify some risks (Meinzen-Dick, Raju & Gulati, 2000) [58, 34, 35, 45]. Stiglitz (2010, 178) [67], increase the mobility of agricultural capital (Dorward, Kydd & Poulton, 1998; Berkes, Colding & Folke, 2003) [29, 18], and reduce the specificity of agricultural assets (Alchian, 1978) [4].

In practice, the consolidation of resources has been replaced by the integration of informational property rights.

Governance and Integration of Public Registry Systems.

North (1990) [51] posits that institutions are the essence of the "rules of the game" (ibid, 3). These include constitutions, laws, social norms, and constraints, all serving to reduce uncertainty. The concept of economic organization relates to individuals as part of groups with unified goals [ibid, 5]. However, Klein (2000) [42], argues that a distinction must be made between the "institutional environment" and "institutional arrangements" [ibid, 458]. Institutional background is part of the structure where organizations exist. Can these organizations be considered institutions if such a structure can influence individual behavior and determine the final social outcome.

Table 2. Agricultural contracts -modes and forms in agriculture (Public registries)

Registries - contract features					
Hierarchy (modes)		**Exchange (market/non-market)**		**Hybrids**	
Complete contract The execution stops (ends).	Incomplete contract The execution continues, and if it has stopped, it can be resumed	Classical contract Self-termination Does not self-terminate	Neoclassical contract Does not self-terminate	Relational contract Continuous renegotiation	Digital and quasi-forms Management of common brands. Management of common property and common rights, franchise. Technological contracts. A mix of administrative procedures and market agreements. Organization around arbitrators – jurisdictions.
Examples of agricultural contracts - forms/modes					
Extracting a document information.	Refusal of information from the registry.	Document extract from the register	Publication, entry, announcement, Declaration of new	Disputes about circumstances incorrectly entered the register.	Extracting documents electronically. Information transfer procedures

			circumstances in the register.	New declaration of old circumstances.	Feedback from the registry via automated email.

Source: Own research.

Table 2 presents PRsas contracts. The main forms/modes (NIE aspect) are also explained. Coase (1937) [24] raises the question of the boundaries of the economy, particularly the overlap between the market and the firm. The market itself is also a type of institution. Jensen & Meckling (1976) [41] discuss the diffusion between market and firm relations, as more firms are managed on market principles. What does it mean for the firm, as a classic format of economic organization, and the market, as a collection of exchanges, to merge as institutions?

Williamson (1985,15) [71] considers the contract one of the most important institutions. Contractual exchange shapes an entire level of social architecture (Williamson,1998, 26) [73]. This concept raises the question of the place of bilateral economic structures within the system of institutional relations. Williamson (1996,105) [72] explains reality as an intertwining of institutions and organizations. The mix of "markets, hybrids, hierarchies" (ibid, 14) is a means of vertical integration (Williamson, 1975) [69] known as "governance structure" (Williamson (1996, 93) [72]. Regarding the firm, it is viewed as a collection of property rights that are exchanged, appropriated, or lost through contractual exchange (Williamson, 2002) [74]. Williamson (1979) [70] provides an institutional qualification of the contract. Contractual exchange can be of classical, neoclassical, and "relational contract" (ibid, 236-238) types. Masten (1999) [44], describes contracts as complete and incomplete. Cheung (1969b) [23] examines agreements that mix contract forms as hybrids. These are complex relationships involving inter-firm cooperation, agreements from administrative hierarchies, private and public unions, and technical, physical, and digital forms (North & Wallis, 1994) [52], functioning on transferred rights (Alchian, 1978; Eccles, 1981) [4, 31].

Ménard (2013b) [47] and Rubin (1978) [63] view these types of contracts as a social process related to the transfer of rights, serving as a means for the collective use of resources. Hybrid contracts combine opposing functions and create integration between institutional structures and technological processes (Dwyer & Oh,1988; Balakrishnan & Wernerfelt, 1986; Harrigan, 1986; Robertson & Gatignon,1998) [30, 14, 39, 62]. According to Ménard (2014, 262) [48], due to the unification of process approaches in contract analysis, they have acquired somewhat technological significance. The use of the hybrid format of PRs creates a synergistic effect between the legal and technological aspects of contract behavior, which in turn reduces uncertainty and specificity while increasing the repeatability of certain types of transactions.

Reducing TrC in Public Registry Systems.

Coase (1937:38) [24] raises the question of organizational boundaries, referring to them as social costs impacting price mechanisms. TrC in this context are implicit and explicit (Stiglitz, 2010:187-189) [65]. Some costs arise directly from existing institutions.

Alchian & Demsetz (1972) [1] place TrC within the economic organization of exchange and resource allocation. TrC can include information costs. Besides bargaining costs, "transaction costs include those necessary for formulating and monitoring contracts" (Barzel, 1977: 292) [15]. Monitoring costs for principals, agent performance, and "residual losses" (Jensen & Meckling, 1976:308) [41] are computational costs for obtaining information. Allen (1993, 1997) [7,8] refers to them as "establishment and maintenance" costs, which may extend beyond property rights protection.

Williamson (2002) [74] proposes measuring TrC by dividing the economic system into a transaction sector and production, with "transaction professions" (Davis, 1986,100) [27]. This method surprisingly avoids criticism (ibid: 152), despite not accounting for the positive value of labor, even when it merely redistributes goods. Buchanan (1979) [21] defines TrC based on the nature of choice, dividing them into costs determined by choice

and costs that determine choice. The costs determining the choice are also related to the costs of bounded rationality (Selten, 1990; Simon, 1955) [64, 65] and economizing on opportunism (Williamson,1985,32) [71] introducing opportunity costs and higher-cost process alternatives. TrC should be seen as a negative effect of regulatory mechanisms, leading to transaction-related payments (Stiglitz, 2010; Stigler, 1961,) [67, 68].

Williamson's approach to measuring TrC is based on the functional nature of transactions, which are the "basic unit of analysis" (Commons, 1931, 3-4) and "micro acts" (Willamson, 1985, 15) [71]. Transactions serve the technological interface of the environment (Williamson, 1996, 379) [72]. This raises the question of measuring inactivity during transactions. Including abstract elements like time may be crucial for blending objective and subjective theories in institutional environment assessment (Littlechild, 2002) [43].

Regmi (2006) [59] examines the "biophysical world" and its technological dependence, with technology significantly impacting the biophysical world (Anderies, Janssen & Ostrom, 2004; Berkes, Colding & Folke, 2003; Hayes & Ostrom, 2005) [6, 9, 18, 40].

Allen & Lueck (1992a; 1992b; 1993) [5, 7] and Cheung (1969a) [22] studies agricultural contract design, linking it to TrC size. Cheung (1969b) [23] ties it to economic rents from joint land use.

Table 3 presents the transaction costs in the PR for agriculture in Bulgaria. Determining TrC when they are part of property rights protection and involve productive labor is complex.

Legal and factual actions mix, with the same action being a transaction and production. Considering transaction professions and sectors, should mixed production activities and transactions be measured separately? For instance, drone spraying and monitoring involve production and information gathering, making it hard to separate TrC from institutional and production effects. Should we account for "downtime" in production if it leads to inactivity in other transaction-related activities? Should the object's price be included in the total TrC?

TrC depends on resource allocation and transaction prices, sometimes objectively determined (e.g., notary fees). Costs for one participant are income for another, reducing total TrC if some prices are lowered.

Table 3. TrC in Agricultural contracts (Public Registries)

Transaction cost (TrC)			
Cost of the principal (Information)		**Cost of the agent (information)**	
Bargaining costs (communications between actors) Acquisition of information through the registry. Information (monitoring) Information through representatives Information through documents Inquiries through in-person transactions Information is a type of "feedback" in case of violation of property rights.			
Market costs	Non-market costs	Market costs	Non-market costs
Non-electronic acts (transactions):	Evidence costs:	Bargaining, Negotiating	Loss from unnecessary movement
Documents, Sketches, Diagrams, References, Licenses, Certificates, Extract from the register, Payments	To acquire a document in case of a dispute with a Public Administration (Public Body)	Some of the communication transactions	Movement without transport costs

Source: Own research.

Some authors note the positive role of TrC in risk reduction (Stigler,1971, 78) [69], capital mobility, and contract scale (North, 1990) [51]. This neoclassical view aligns with Coase's theorem.

Measuring TrC without resource prices allows trend comparison and TrC reduction proposals,

leading to new qualitative states of the environment—an NIE approach to measurement.

Transaction costs can be influenced by replacing physical transactions with digital ones.

Figure 1 illustrates the average number and duration of transactions conducted in processes related to Public Registers.

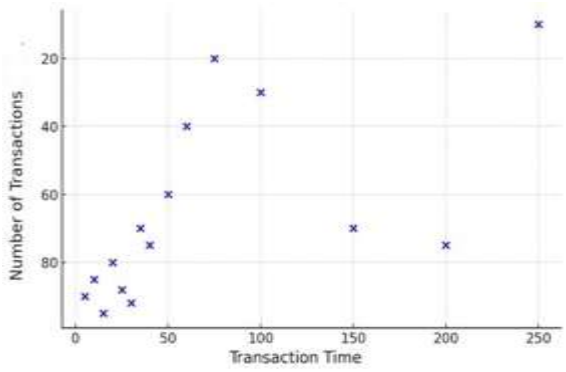

Fig. 1. Transactions (N)/ Transaction (Time / Min) in PRs
Source: Own research.

The ordinate represents the number of transactions, while the abscissa indicates the duration of the processes measured in minutes. Many transactions are grouped within the range of 20 to 80, with a process duration of 100 minutes. This indicates that the use of PR is a prerequisite for increasing the number of actions by agricultural entities and reducing the overall duration of processes for protecting their property rights.

Figure 2 shows the average transaction costs in various registry processes.

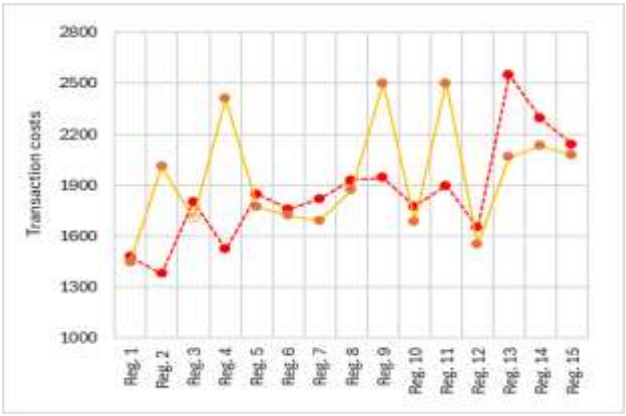

Fig. 2.Transaction costs (BGN)
Not. 1 Euro = 1,95 BGN
Source: Own research.

The yellow line represents electronic transactions accounting for 10% of the total transactions in the process. The red line indicates transactions where electronic transactions exceed 10%. Transaction costs are lower where the use of electronic transactions is higher. Cases with lower transaction costs despite a small number of electronic transactions are explained by the fact that some registers do not allow electronic transactions. These include registers that indirectly serve farmers and their families, such as *Civil Status Registers*. These registers exist in all 265 municipalities in the country but are not mutually integrated. Another explanation for high transaction costs is the technology not being adapted to farmers' needs. In many cases, when transactions of the same type do not repeat, farmers prefer the standard method of action.

The standard method without electronic transactions is familiar and does not require behavioral change. Initial costs supporting electronic transactions (e.g., electronic signature certificates) can also be a barrier to using digital technologies in public registers.

CONCLUSIONS

(a) PRs in agriculture should be managed as informational, technological, and legal resources, aiming for integration at all levels of the governance structure. They can be viewed as hybrid contracts that facilitate agricultural processes.

(b) The number of transactions in PR is increasing, but this does not lead to an overall increase in the duration of agricultural processes. Despite the higher frequency of transactions, the specificity and uncertainty of agricultural processes decrease, property rights are better protected, and non-productive agricultural risks are limited.

(c) Alternatives involving a higher number of transactions, particularly electronic transactions, should reduce the cost of protected rights. The costs for obtaining information, extracting documents, and addressing opportunistic behavior between farmers and administration decrease. Individual transaction costs for farmers are

low. PRs in agriculture create incentives for reducing public expenses.

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REFERENCES

[1]Alchian, A., Demsetz, H., 1972, Production, Information Costs, and Economic Organization, The American Economic Review. 62 (5) 777-795.
[2]Alchian, A., 1967, Property Rights, The Concise Encyclopedia of Economics, http://www.econlib.org/library/Enc/PropertyRights.html, Accessed on 21 July 2016.
[3]Alchian, A., 1969, Corporate Management and Property Rights, In Economic Forces at Work. Indianapolis: Liberty Press. 1977.
[4]Alchian, A., 1978, Economic Forces at Work. Publisher: Liberty Fund Inc. (1977) p. 524.
[5]Allen, D., Lueck, D., 1992a, Contract Choice in Modern Agriculture: Cash Rent versus Cropshare. The Journal of Law & Economics, 35(2), 397–426. http://www.jstor.org/stable/725546, Accessed on 21 July 2024.
[6]Allen, D., Lueck, D., 1992b, The Back Forty on a Handshake: Specific Assets, Reputation and the Structure of Farmland Contract, JLEO, 8, April 1992.
[7]Allen, D., Lueck, D., 1993, Transaction Costs and the Design of Crop share Contracts, Land Journal of Economics 24, 78-100.
[8]Allen, D., 1999, Transaction cost, Simon Fraser University, https://www.sfu.ca/~allen/WhatAreTransactionCosts.pdf.,.
[9]Anderies, J. M., Janssen, M. A., Ostrom, E., 2004, A Framework to Analyze the Robustness of Social-ecological Systems from an Institutional Perspective. Ecology and Society, 9(1). http://www.jstor.org/stable/26267655, Accessed on July 27, 2024.
[10]Arrow, K., 1970, Political and Economic Evaluation of Social Effects and Externalities, NBER Chapters, in: The Analysis of Public Output, pages 1-30, National Bureau of Economic Research, Inc.
[11]Bachev, H., 2010a, Governance of agrarian sustainability, Nova Science Publishers, New York.
[12]Bachev, H., 2010b, Management of Farm Contracts and Competitiveness, VDM Verlag Dr. Muller, Germany and USA.
[13]Bachev, H., 2018, The Impact Of Market, Private, Collective And Hybrid Modes Of Governance On Agrarian Sustainability In Bulgaria, 8 (2-ENG), 124-165.
[14]Balakrishnan, S., Wernerfelt B., 1986, Technical change, competition and vertical integration, Strategic Management Journal, https://doi.org/10.1002/smj.4250070405.
[15]Barzel, Y., 1977, Some Fallacies in the Interpretation of Information Costs, Journal of Law and Economics, 291-307.
[16]Benham, Al., Benham, L., 2000, Measuring the Costs of Exchange Reprinted by permission (with minor revisions) from Claude Ménard, editor (2000), Institutions, Contracts and Organizations: Perspectives from New Institutional Economics, Cheltenham, UK: Edward Elgar, 367-375.
[17]Benjamin, P., Lam, W.F., Ostrom, E., Shivakoti, G., 1994, Institutions, Incentives, and Irrigation in Nepal, Decentralization: Finance & Management Project Report, Burlington, VT: Associates in Rural Development.
[18]Berkes, F., Colding, J., Folke, C., 2003, Navigating Social-Ecological Systems: Building Resilience for Complexity and Change, Cambridge: Cambridge University Press.
[19]Bhardan P. K., 1989, The New Institutional Economics and Development Theory: A Brief Critical Assessment. World Development, Vol. 17 (9), 1389-1395.
[20]Boehlje, M ., Doering, O., 2000, Farm Policy in an Industrialized Agriculture. Journal of Agribusiness, Vol 18 (1), Special Issue, March 2000, 53-60.
[21]Buchanan, J., 1979, The Collected Works of Vol. 6 „Cost and Choice: An Inquiry in Economic Theory", published by University Of Chicago Press, 85, Liberty Fund, Inc.
[22]Cheung, S. N.S., 1969a, Transaction costs, risk aversion, and the choice of contractual arrangements. Journal of Law and Economics 12, 23–42.
[23]Cheung, S.N.S., 1969b, The Theory of Share Tenancy, Chicago: University of Chicago Press, 188.
[24]Coase, R., 1937, The Nature of the Firm, Economica, 4 , 386-405.
[25]Coase, R., 1960, The Problem of the Social Cost, Journal of Law and Economics,3, 1-44.
[26]Commons, J., 1931, Institutional Economics, History of Economic Thought Articles, 21, 648-657.
[27]Davis, E., 1986, Comment (on North and Wallis), in: Engerman, S.L.; Gallman, R.E. (eds.): Long-Term Factors in American Economic Growth", Chicago and London: University of Chicago Press, 149-161.
[28]Demsetz, H, 1967, Toward a Theory of Property Rights. The American Economic Review, 57(2), 347–359. http://www.jstor.org/stable/1821637. Accessed on July 27, 2024.
[29]Dorward, A., Kydd, J., Poulton, C., 1998, Smallholder Cash Crop Production under Market Liberalization: A new Institutional Economics Perspective. CAB International, Wallingford, UK.
[30]Dwyer, F. R., Oh, S., 1988, A Transaction Cost Perspective on Vertical Contractual Structure and Interchannel Competitive Strategies. Journal of Marketing, 52(2), 21–34. https://doi.org/10.2307/1251262.

[31]Eccles, R.G., 1981, The quasifirm in the construction industry, Journal of Economic Behavior& Organization, 2 (4), 335-357, https://doi.org/10.1016/0167-2681(81)90013-5.
[32]Ehlers, M.H., Finger, R., El Benni, N., Gocht, A., Sørensen, C.G., Gusset, M., Pfeifer, C., Poppe, K.J., Regan, Á., Rose, D.C., Wolfert, S., Huber, R.A., 2022, Scenarios for European agricultural policymaking in the era of digitalisation. Agricultural Systems. https://doi.org/10.1016/j.agsy.2021.103318
[33]Evans, P., 2004, Development as Institutional Change: The Pitfalls of Monocropping and the Potentials of Deliberation, 39(4) Studies in Comparative International Development, 30–52.
[34]Fafchamps, M., Minten. B., 1998a, Returns to Social Capital among Traders. Markets and Structural Studies Division (MSSD) Discussion Paper No. 23. The International Food Policy Research Institute (IFPRI), Washington, D.C.
[35]Gabre-Madhin, E., 2001, Understanding How Markets Work: Transaction Costs and Institutions in the Ethiopian Grain Market. Draft Research Report. IFPRI, Washington, DC.
[36]Giannakas K., Fulton M., Sesmero J., 2016, Horizon and Free-Rider Problems in Cooperative Organizations. Journal of Agricultural and Resource Economics 41 (3), 372-392.
[37]Hanisch, M., Boevsky, I., 1999, Political, Institutional and Structural Developments Accompaning Land Reform and Privatization in Bulgarian Agriculture, in: Sudost-Institut (Hrsg.), Sudosteuropa, Jg. 48, Heft 7-8, Zeitschrift fur Gegenwartsforschung, Oldenbourg Verlag Munchen (in Englisch), 446-464.
[38]Hardin, G., 1968, The Tragedy of the Commons, Journal of Natural Resources Policy Research, DOI:10.1126/SCIENCE.162.3859.1243.
[39]Harrigan, K. R., 1986, Matching vertical integration strategies to competitive conditions, Strategic Management Journal, https://doi.org/10.1002/smj.4250070605.
[40]Hayes, T., Ostrom, E., 2005, Conserving the World's Forests: Are Protected Areas the Only Way?,38(3) Indiana Law Review, 595–617.
[41]Jensen, M., Meckling, W., 1976, Theory of the firm: Managerial behavior, agency costs and ownership structure, Journal of Financial Economics, V. 3, Iss.4, pp. 305-360, https://doi.org/10.1016/0304-405X(76)90026-X.
[42]Klein, P., 2000, 0530 New Institutional Economics, Encyclopaedia of Law and Economics (Cheltenham, U.K.: Edward Elgar, 2000), 456-89. https://tinyurl.com/284k479d. Accessed on Jult 10, 2024.
[43]Littlechild, S.C., 2002, Buchanan and Shackle on Cost, Choice and Subjective Economics. In: Brennan, G., Kliemt, H., Tollison, R.D. (eds) Method and Morals in Constitutional Economics. Studies in Economic Ethics and Philosophy. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-662-04810-8_7
[44]Masten, S., 1999, A revised version of this working paper is forthcoming, In Encyclopaedia of Law & Economics, B. Boukaert & G. De Geest (eds.), Edward Elgar Publishing & the University of Ghent, 1999), 1-35.
[45]Meinzen-Dick, R., Raju, K.V., Gulati, A., 2000, What Affects Organization and Collective Action for Managing Resources? Evidence from Canal Irrigation Systems in India. EPTD Discussion Paper No. 61, International Food Policy Research Institute, Washington, DC.
[46]Ménard, C., 2013a, Plural Forms of Organization: Where Are We? Managerial and Decision Economics, 34, 3–5, 124–139. DOI: 10.2307/23464295.
[47]Ménard, C., 2013b, Hybrid ways of organization. Alliances, joint ventures, networks and other "strange" animals. In R. Gibbons, & J. Roberts (Eds.), Handbook of organizational economics (pp. 1066–1108). Princeton: Princeton University Press. Ch. 26.
[48]Ménard, C., 2014, Embedding organizational arrangements: Towards a general model, Journal of Institutional Economics, 10 (4) (2014), pp. 567-589.
[49]Ménard, C., 2018, Research frontiers of new institutional economics, RAUSP Management Journal, 53(1), 3-10.
https://doi.org/10.1016/j.rauspm.2017.12.002.
[50]Monissen, H. G., Pejovich, S., 1977, Property Rights, FU-eihcit and economical EffiJzIieTIlz. In: Borders on Freedom. Vienna: Europe Publisher.
[51]North, D., 1990, Institutions, Institutional Change And Economic Performance, Cambridge University Press
[52]North, D. C., Wallis, J. J., 1994, Integrating Institutional Change and Technical Change in Economic History A Transaction Cost Approach. Journal of Institutional and Theoretical Economics (JITE) / Zeitschrift Für Die GesamteStaatswissenschaft, 150(4), 609–624. http://www.jstor.org/stable/40751753;
[53]Olson, M., 1971, The Logic of Collective Action: Public Goods and the Theory of Groups. Shocken Books, New York.
[54]Ostrom, E., Gardner, R., Walker, J., 1994, Rules, Games, and Common Pool Resources, Ann Arbor: University of Michigan Press.
[55]Ostrom, E., 2003, How Types of Goods and Property Rights Jointly Affect Collective Action. Journal of Theoretical Politics, 15(3),239-270, DOI: 10.1177/0951692803015003002.
[56]Ouchi, W. G, 1980, Markets, Bureaucracies, and Clans. Administrative Science Quarterly, 25(1), 129–141. https://doi.org/10.2307/2392231.
[57]Posner, R. A., 1993, The New Institutional Economics Meets Law and Economics. Journal of Institutional and Theoretical Economics (JITE) / Zeitschrift Für Die GesamteStaatswissenschaft, 149(1), 73–87. http://www.jstor.org/stable/40751582.
[58]Reardon, T., Codron J. M., Busch L., Bingen, J., Harris, C., 1999, Global Change in Agrifood Grades and Standards: Agribusiness Strategic Responses in Developing Countries." International Food and Agribusiness Management Review, Vol. 2(3), 421-435, https://doi.org/10.1016/S1096-7508(01)00035-0.

[59]Regmi, Ash., 2006, The Role of Heterogeneity in Collective Action: A Look at the Intertie between Irrigation and Forests. Case Studies from Chitwan, Nepal, Unpublished thesis, Indiana University.
[60]Reinhard, U., Silke, H., 2019, The free-rider deficit in the demand for farm animal welfare-labelled meat, European Review of Agricultural Economics, Volume 46, Issue 2, April 2019, Pages 291–318, https://doi.org/10.1093/erae/jby025.
[61]Richerson, P.J., Boyd, R, 2005, Not by Genes Alone: How Culture, Transformed Human Evolution, Chicago: University of Chicago Press.
[62]Robertson, T. S., Gatignon, H., 1998, Technology Development Mode: A Transaction Cost Conceptualization. Strategic Management Journal, 19(6), 515–531. http://www.jstor.org/stable/3094044. Accessed on 01.04.2024.
[63]Rubin, P.H., 1978, The theory on hard and the structure of on franchise contract. The Journal on law and Economics, 21 (1): 223–233.
[64]Selten, R., 1990, Bounded Rationality. Journal of Institutional and Theoretical Economics (JITE) / Zeitschrift Für Die Gesamte Staatswissenschaft, 146(4), 649–658. http://www.jstor.org/stable/40751353, Accessed on July 25, 2024.
[65]Simon, H.A., 1955, A behavioral model of rational choice. Q. J. Econ. 69, 99–118.
[66]Sommer, F., de Vries, W. T., 2023, Values and representations in land registers and their legal, technical, social effects on land rights as an administrative artefact, Land Use Policy, 135, (2), https://doi.org/10.1016/j.landusepol.2023.106946.
[67]Stiglitz, J., 2010, Freefall: free markets and the Sinking of the global Economy.New York: Norton, 2010. pp. 361.
[68]Stigler, G., 1961, The Economics of Information. Journal of Political Economy, Vol. 69 (June 1961), pp. 213-225.
[69]Stigler, G. J., 1971, The Theory of Economic Regulation. The Bell Journal of Economics and Management Science, 2(1), 3–21. https://doi.org/10.2307/3003160
[65]Stiglitz, J., 1974, Incentives and Risk Sharing in Sharecropping. Review of Economic Studies. 41, pp. 219-255.
[65]Stiglitz, J., 2010, The Stiglitz Report: Reforming the International, Monetary and Financial Systems in the Wake of the Global Crisis, 2010, p.204. https://tinyurl.com/4kwfbkb8, Accessed on July 5, 2024.
[66]Sykuta, M. E., 2010, Empirical Methods in Transaction Cost Economics. The Elgar Companion to Transaction Cost Economics.https://doi.org/10.4337/9781849806909.00023
[67]Wallis, J., North, D., 1986, Measuring the transaction Sector in the American Economy, 1870-1970', in Gallman (ed.), Long Term Factors in American Economic Growth, Chicago, University of Chicago Press, 95-148.
[68]Wang, N., 2003, Measuring Transaction Cost an incomplete Survey, Paper presented at the conference on transaction Costs organized by the Ronald Coase Institution on Feb 21-23 Chicago Illinois.; 5-14
[69]Williamson, O.E., 1975, Markets and Hierarchies: Analyses and Antitrust Implications, New York: Free Press, 31-37.
[70]Williamson, O.E., 1979, Transaction-cost economics: The governance of contractual relations, Journal of Law and Economics, 22 (2), 233-261.
[71]Williamson, O.E., 1985, The Economic Institutions of Capitalism, New York, NY, Free Press.
[72]Williamson, O.E., 1996, The Mechanisms of Governance, New York, NY, Oxford University Press.
[73]Williamson, O.E., 1998, Transaction Cost Economic: How It Works; Where It Is Headed, De Economist 146, (1), 1-58.
[74]Williamson, O.E., 2002, The Theory of the Firm as Governance Structure: From Choice to Contract. Journal of Economic Perspectives, 3, 171-195. http://dx.doi.org/10.1257/08953300276027877.

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SYNERGIES BETWEEN ECONOMICS AND MARKETING IN AGRITOURISM: A WEB OF SCIENCE BOOLEAN SEARCH-BASED SCIENTOMETRIC EXAMINATION OF AGROTOURISM POTENTIAL

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Abstract

Agritourism plays an important role in rural development, economic diversification, and sustainable tourism, yet research on its intersection with economics and marketing remains fragmented. This study employs a Boolean search-based scientometric analysis using the Web of Science database to systematically examine existing literature. Bibliometric techniques, including co-occurrence analysis, co-citation mapping, factorial analysis, and thematic mapping, were applied using Bibliometrix and Biblioshiny in RGui to identify key research trends, influential works, and thematic structures. The results highlight tourism, agritourism, and rural tourism as central themes, with increasing emphasis on visitor experience, sustainability, and policy frameworks. Findings also reveal the interdisciplinary nature of agritourism research, integrating economics, marketing, and environmental sustainability. The study identifies emerging research gaps, particularly in consumer behavior, digital marketing, and technological integration. By providing a structured overview of agritourism's knowledge landscape, this research offers valuable insights for academics, policymakers, and practitioners, supporting evidence-based strategies for sustainable agritourism development and enhanced rural economies.

Key words**:** *agritourism, rural development, scientometric analysis, economic sustainability, marketing strategies*

INTRODUCTION

Agritourism is situated at the crossroads of agriculture and tourism, offering a unique opportunity to support rural economies while providing visitors with authentic experiences [18, 2]. As interest in sustainable travel and local food systems continues to grow, agritourism has gained attention as a way to diversify farm revenues and promote rural development [15, 10]. However, despite its increasing significance, much of the existing research treats economic and marketing aspects as separate entities, rarely exploring how they influence each other. Taking into consideration this aspect, our study aims to bridge that gap by conducting a scientometric analysis, using a Boolean search within the Web of Science database, in order to uncover the connections between these two critical dimensions of agritourism.

The need for this research results from a recurring challenge in the field: while economic studies focus on profitability, employment, and policy incentives, marketing research often delves into branding, consumer behavior, and promotional strategies. In reality, these aspects are deeply intertwined—effective marketing can drive economic success, just as a sound economic model can enhance marketing efforts [22, 12]. Nevertheless, a comprehensive framework that integrates these perspectives remains underdeveloped. By systematically mapping

the existing literature, the study seeks to provide a clearer picture of how economic and marketing factors work together to shape agritourism's growth and sustainability.

The fact that makes this research different is its methodological approach. By applying scientometric tools, including co-citation analysis and thematic mapping, a structured assessment of trends and knowledge gaps in agritourism research is settled. Unlike broader reviews, we consider that the research employs a refined Boolean search strategy to pinpoint the most relevant studies, ensuring a more precise and insightful examination of the literature, and at the same time, we consider that this rigorous approach enhances the reliability of the findings, providing a meaningful contribution to both academic discourse and practical applications [7].

Beyond theoretical insights, the literature review has a significant potential regarding the implications for stakeholders—farmers, tourism operators, and policymakers alike [6, 27, 23]. Understanding the synergies between economics and marketing can inform strategies that enhance the competitiveness of agritourism businesses, improve rural livelihoods, and promote sustainable tourism practices [17]. For instance, the insights could help small farm-based tourism ventures tailor their marketing strategies in ordet to attract the right audience while maintaining financial viability [16, 26].

Moreover, because of the holistic view of agritourism, besides the gap filling in the existing literature, the results could also lays the groundwork for future interdisciplinary research, while serving as a foundation for developing integrated business models that balance economic goals with effective marketing, ultimately supporting the long-term sustainability of agritourism units [25]. Through this research strategy, our study contributes to a deeper understanding of how agritourism can serve as a viable pathway for rural economic development in an increasingly experience-driven tourism market [21].

MATERIALS AND METHODS

Data collection and search strategy

In order to comprehensively examine the intersection between economics and marketing in agritourism, we employed a Boolean search methodology (Wang et al., 2012; Karimi et al., 2010; Broander et al., 2004) [28, 13, 8].

Given the dual nature of the research focus, Boolean search proved to be the most effective tool, allowing us to precisely filter relevant literature while capturing a broad range of interdisciplinary studies. This method enables the combination of multiple keywords using logical operators (AND, OR) to refine search results, ensuring that only studies directly related to agritourism and its economic and marketing dimensions were selected [29].

The bibliometric analysis covered a 20-year period with the aim of ensuring a thorough examination of research trends over time. Was conducted the search in the Web of Science database, selecting all available fields to maximize the relevance and breadth of retrieved studies. The search was formulated as follows:

(a) ("Agritourism" OR "Agrotourism") AND ("Economics" OR "Economic impact" OR "Economic sustainability" OR "Financial performance");

(b)("Agritourism" OR "Agrotourism") AND ("Marketing" OR "Consumer behavior" OR "Tourist perception" OR "Branding");

(c)("Agritourism" OR "Agrotourism") AND ("Potential" OR "Development" OR "Opportunities").

This systematic approach resulted in a total of 1,167 scientific papers:

-124 scientific papers related to agritourism and economics;

-156 scientific papers examining agritourism and marketing;

-887 scientific papers discussing agritourism opportunities and development.

Justification for the Boolean search method

Boolean search is particularly well-suited for this type of researches due to its ability to enhance the precision and comprehensiveness of literature retrieval [9]. By structuring queries with logical connectors, we ensured that the selected studies aligned closely with the research objective, because the flexibility of this approach allowed us to include variations of key terms, accounting for

differences in terminology across disciplines and ensuring that the dataset reflected the full spectrum of relevant research.

Furthermore, Boolean search mitigates the risk of retrieving irrelevant studies by filtering results based on specific thematic intersections, characteristic considered being particularly important given the interdisciplinary nature of the study, where economic and marketing aspects often appear in separate academic discussions, and by implementing a structured and targeted approach, we managed to maximize the accuracy and relevance of the dataset.

Data processing and analysis employing Bibliometrix and Biblioshiny

Following the identification of the relevant scientific papers through the Boolean search in the Web of Science database, the next step was the conducting of a detailed bibliometric analysis using Bibliometrix, a comprehensive R package designed for quantitative research in bibliometrics. This tool allows for an in-depth examination of scientific literature, enabling the identification of research trends, influential studies, and key thematic areas within a given field.

To facilitate data processing and visualization, we utilized Biblioshiny, a web-based graphical interface for Bibliometrix, which runs through RGui (R Graphical User Interface), and that provides an accessible, user-friendly environment which simplifies complex bibliometric analyses without requiring extensive programming expertise. Through this interface, we were able to efficiently execute various scientometric analyses, including co-citation mapping, bibliographic coupling, factorial mapping, and keyword trend analysis, further optimizing the workflow, allowing to generate interactive visual representations that enhance the interpretability of the findings.

Scientometric tools and analysis

For the analyze process regarding the retrieved literature, was applied scientometric tools in order to evaluate research trends, thematic connections, and knowledge structures within the field of agritourism. The analysis included the following key components, considered as being the most relevant:

(i)Scientific production by country;
(ii)Co-citation analysis;
(iii)Most cited words;
(iv)Most cited countries;
(v)Factorial analysis;
(vi)Co-occurrence network;
(vii)Trending topics and thematic map.

Research Period and Scope

The study covered a period of 20 years (2003–2023), covering a broad timeframe, necessary in capturing the evolving research perspectives and emerging trends. The geographic scope was global, ensuring an inclusive analysis of studies from diverse academic and regional contexts, while the use of Web of Science as the primary database ensured access to high-quality, peer-reviewed literature, strengthening the reliability of the findings.

Methodological rigor and reproducibility

In order to maintain transparency and allow for replication of the study structure or insights, we adhered to established bibliometric research protocols. All search parameters, filtering criteria, and analytical techniques were systematically applied, ensuring consistency in data collection and processing, while the use of widely recognized scientometric tools further reinforced the robustness of the research approach. By employing a structured Boolean search strategy and applying rigorous scientometric techniques, the research provides a comprehensive and data-driven analysis of the synergies between economics and marketing in agritourism, and the methodological framework outlined ensures the reliability and replicability of the findings, contributing to a deeper understanding of agritourism's potential for sustainable development.

RESULTS AND DISCUSSIONS

Scientific production by country

The geographical distribution of agritourism research reveals the fact that certain countries play a leading role in advancing the field. Among them, Romania (436), the USA (382), and China (250) stand out as the most prolific contributors. Romania's strong presence

suggests a high academic interest in agritourism, possibly influenced by its rural development policies and economic strategies. Secondly, the USA, known for its well-established research infrastructure, contributes extensively to agritourism studies, often linking them to broader tourism and sustainability discourses; meanwhile, China's growing focus reflects its policies aimed at rural revitalization and economic diversification.

Other European countries such as Italy (231), Poland (223), and Spain (127) also rank high, highlighting agritourism's significance within the continent.

Italy, in particular, has long integrated agritourism into its rural economy, benefiting from supportive regulations and a strong tourism industry (Piras & Pedas, 2025) [20]. In contrast, Poland and Spain demonstrate increasing research interest, likely driven by EU agricultural and tourism funding initiatives.

Outside of the European countries, Indonesia (90), Australia (56), and Thailand (52) emerge as key players, indicating agritourism's rising importance in Asia and the Pacific, and we consider that their research output may be linked to government efforts to develop agritourism as a sustainable economic alternative for rural communities. Additionally, South Africa (32), Canada (29), and Brazil (28) contribute to the global conversation, albeit to a lesser extent, focusing on agritourism's role in regional economic development and community empowerment.

Overall, the dominance of European countries, coupled with Asia's growing presence, underscores agritourism's relevance in both developed and emerging economies.

While certain regions, such as Africa and Latin America, remain underrepresented, the increasing global research output indicates a broader recognition of agritourism's potential for sustainable development, while future research could further explore regional disparities and encourage cross-border collaborations to enhance the field's impact worldwide (Table 1).

Table 1. Scientific production by country

	Country	Freq
1	ROMANIA	436
2	USA	382
3	CHINA	250
4	ITALY	231
5	POLAND	223
6	SPAIN	127
7	INDONESIA	90
8	CROATIA	70
9	RUSSIA	67
10	SERBIA	64
11	GREECE	60
12	AUSTRALIA	56
13	CZECH REPUBLIC	52
14	THAILAND	52
15	UK	44
16	IRAN	42
17	SLOVAKIA	42
18	JAPAN	35
19	UKRAINE	34
20	SOUTH AFRICA	32

Source: authors' elaboration based on the Biblioshiny in RGui research results [30].

Co-citation analysis

To examine the intellectual structure of agritourism research, was analyzed the co-citation network, which maps the relationships between frequently cited academic works. Co-citation analysis helps identify foundational studies, influential authors, and thematic clusters that have shaped the field over time [5]. The results reveal that Arroyo CG (2013) [3] is the most central study in the co-citation network, with a betweenness score of 353.149, indicating its significant role in linking various research themes. Other highly influential works include Flanigan (2011)[11], Lupi, C. (2017) [14], and Ammirato S (2020) [1], suggesting that recent studies are gaining traction and shaping contemporary discussions. The presence of Barbieri C (2016) [4] in multiple clusters highlights a sustained research focus on agritourism development, management strategies, and rural diversification. Additionally, classic works by Tew C (2012) [24] and Phillip S (2010) [19] remain highly cited, demonstrating their continued relevance in agritourism research frameworks and typologies.

In the co-citation network analysis, a Romanian researcher, Ramona Ciolac (Ciolac R, 2019) [7], holds a position within Cluster 1, with a betweenness centrality of 8.053, closeness of 0.013, and PageRank of 0.013. While her position is not among the most dominant nodes in the network, her presence in

the analysis suggests a level of influence within the agritourism research discourse and underscores Romania's increasing contribution to agritourism research, aligning with the broader bibliometric findings that highlight Romania as a leading country in scientific production on the subject and her research remains relevant and contributes to the expanding knowledge base in agritourism, potentially influencing future studies in the field.

Taking into consideration this results, we can affirm that the network clusters further emphasize key thematic areas. One cluster focuses on rural development and diversification, including studies on the economic and policy dimensions of agritourism.

Table 2. Co-citation analysis results

Node	Cluster	Betweenness	Closeness	Page Rank
Arroyo, C.G., 2013 [3]	1	353.149	0.016	0.028
Lupi, C., 2017 [14]	1	40.038	0.015	0.015
Ammirato, S., 2020 [1]	1	20.419	0.014	0.013
Ciolac, R., 2019 [10]	1	8.053	0.013	0.013
Barbieri, C., 2016 [4]	1	18.241	0.014	0.011
Flanigan, S., 2015 [11]	1	32.084	0.015	0.012

Source: authors' elaboration based on the Biblioshiny in RGui research results [30].

Lastly, a methodological cluster is observed, comprising studies that define typologies, assess agritourism impacts, and explore governance structures. In the following table we can visualize the first 10 positions of the network (Table 2).

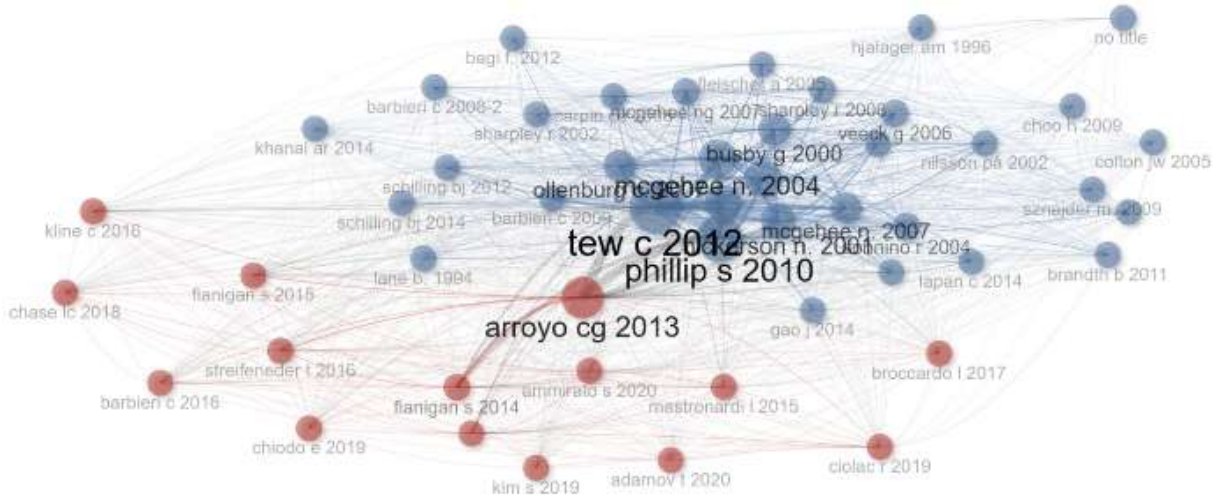

Fig. 1. Co-citation analysis connections map
Source: Biblioshiny in RGui research results [30].

The co-citation network analysis underscores the evolution of agritourism research, highlighting both foundational works and emerging studies that shape the field. The presence of recent influential publications alongside established studies indicates a dynamic and expanding research landscape, and the identification of key thematic clusters reinforces the interdisciplinary nature of agritourism, bridging economics, sustainability, tourism management, and rural development. By visualizing these connections, this analysis provides a structured understanding of the knowledge base in agritourism studies, offering insights for future research directions and potential areas for deeper exploration.

Most cited words

To understand the core themes and dominant discussions in agritourism research, we focused on the most cited words in the academic literature, analyze that guided the identification of the key topics shaping the

field and highlights areas of strong research focus.

The results reveal that "tourism" (154 citations) and "agritourism" (152 citations) are the most referenced terms, reaffirming the central role of these themes. Closely following are "rural tourism" (94 citations), "agriculture" (70 citations), and "diversification" (69 citations), emphasizing the strong link between agritourism and rural economic strategies. Additional key terms such as "typology," "impact," "performance," and "model" suggested a growing focus regarding the classifying agritourism activities, assessing their outcomes, and developing structured frameworks for their sustainable growth. The presence of "food" (44 citations) highlights the increasing integration of culinary and gastronomic experiences into agritourism The most cited words analysis reinforces the interdisciplinary nature of agritourism research, with strong connections to tourism, rural development, and agricultural sustainability. The prevalence of terms related to economic impact, diversification, and performance evaluation suggests an ongoing interest in measuring agritourism's contributions to rural economies. Meanwhile, the inclusion of terms such as "food" and "typology" points to expanding research into visitor experiences and the classification of agritourism models. By identifying the most influential research themes, this analysis provides a foundation for future studies and highlights the ongoing evolution of agritourism as a field of academic inquiry (Fig. 2).

Fig. 2. The most cited words
Source: Biblioshiny in RGui research results [30].

Most cited countries

To highlight the global impact and influence of agritourism research, we analyzed the most cited countries in the field (Figure 3).

Citation metrics provide insights into which countries produce research that is widely referenced and contributes significantly to academic discourse. Higher citation counts suggest strong research networks, influential publications, and the extent to which findings are integrated into broader discussions on agritourism's economic, environmental, and social dimensions.

The results indicate that the USA leads with the highest citation count, reinforcing its role as a central hub for agritourism research. The USA (2740 citations) is followed by Italy (1,370 citations), the United Kingdom (723 citations), and Romania (659 citations), reflecting Europe's dominant academic engagement with agritourism. Poland, China, and Spain also feature prominently, emphasizing their growing

research contributions. Countries such as Norway, Australia, and Greece round out the top 10, demonstrating the global scope of agritourism-related studies and their influence in different regional contexts.

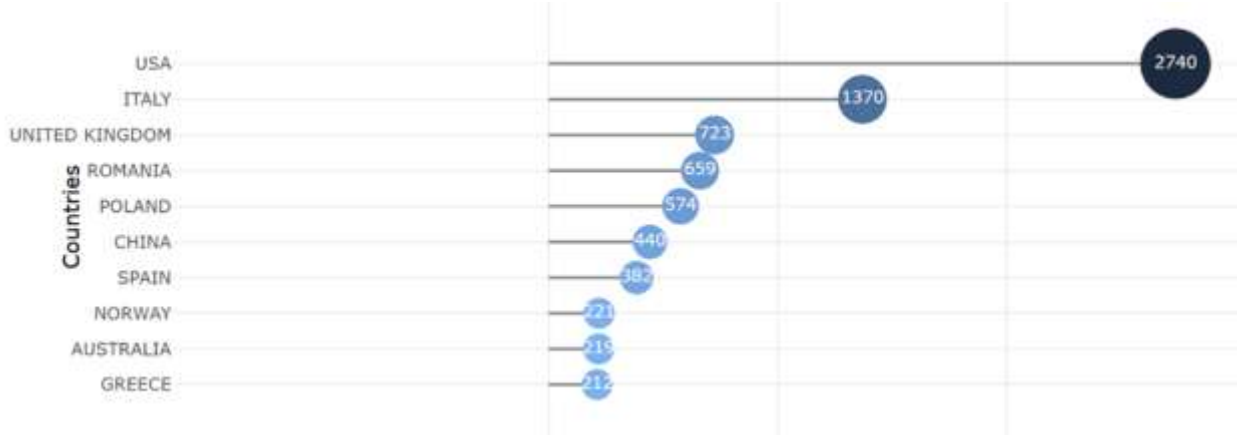

Fig. 3. The most cited countries
Source: Biblioshiny in RGui research results [30].

The most cited countries analysis confirms the USA and several European nations as key contributors to agritourism literature, shaping policy discussions and theoretical advancements, and their high citation counts underscore the relevance of their research in both academic and applied contexts. The inclusion of diverse geographical regions in the ranking highlights the expanding international dialogue on agritourism, with emerging economies gaining recognition for their contributions.

Factorial analysis

To further explore the thematic structure of agritourism research, we conducted a factorial analysis, which facilitated the identification of key conceptual dimensions and their relationships within the academic literature. This method reduces complex data into key factors, making it easier to interpret the primary areas of focus and the interconnections between different research themes (Figure 4).

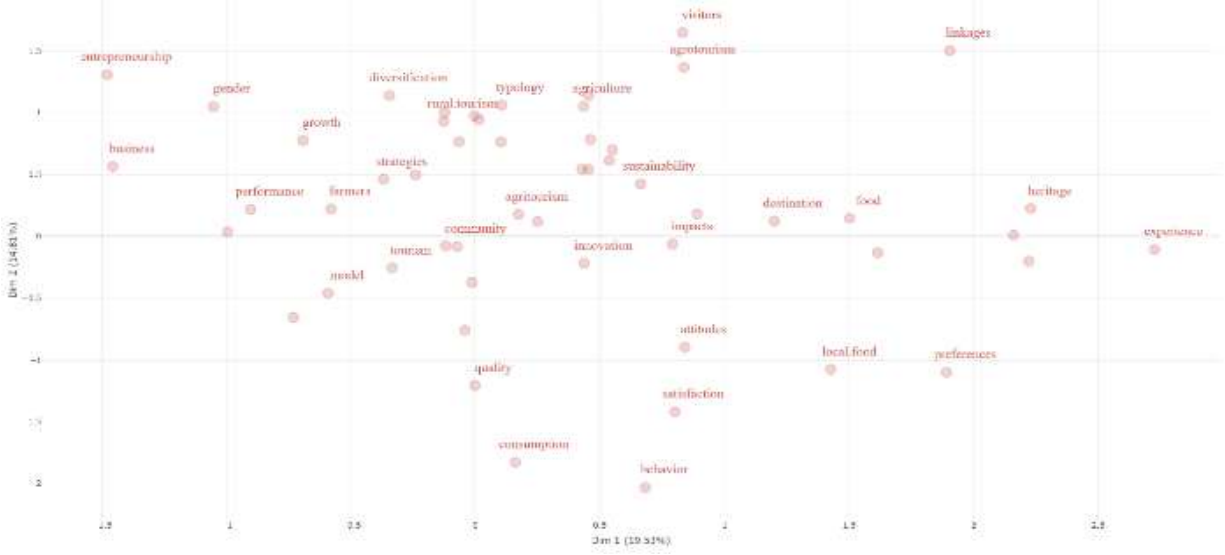

Fig. 4. Factorial analysis word map
Source: Biblioshiny in RGui research results [30].

The findings reveal the presence of clearly defined thematic clusters within the existing body of agritourism research. One notable grouping centers around concepts such as “rural tourism,” “diversification,” and “typology,” underscoring a scholarly emphasis on agritourism’s role in fostering rural development and enhancing economic resilience through diversification strategies. Another thematic axis prioritizes terms such as “sustainability,” “impacts,” and “agriculture,” highlighting a growing academic concern with

the environmental sustainability of agritourism practices and their broader ecological implications. Furthermore, the appearance of themes such as "experience," "food," and "heritage" illustrates an expanding interest in the cultural and experiential dimensions of agritourism, particularly concerning visitor interaction and local identity. The placement of keywords such as "innovation" and "community" within the analytical framework suggests a parallel trajectory of inquiry into the technological and social dynamics influencing agritourism's evolution. Overall, the factorial mapping provides a coherent lens through which to interpret the principal dimensions shaping the field, highlighting the economic, environmental, and socio-cultural pillars of agritourism scholarship.

Co-occurrence network

The analysis regarding the co-occurrence network offers a nuanced understanding of the conceptual landscape shaping contemporary agritourism research field. By mapping the frequency and relational proximity of terms within the specific literature, our study identifies core thematic concentrations and highlights both established areas of inquiry and also emergent research directions. The terms "agritourism" and "tourism" occupy central positions within the network, as evidenced by their high betweenness (282.495 and 171.968, respectively), closeness (0.019 and 0.018), and PageRank values (0.091 and 0.075), underscoring rhe pivotal function they have in anchoring related discussions. In addition, the recurring prominence of concepts such as "rural tourism" (betweenness: 99.75) and "agriculture" (betweenness: 61.105) further illustrate the intrinsic connection between rural development strategies and the agricultural foundations of this sector.

These metrics (as shown in Table 3) reflects the structural cohesion of the research domain and point to the interdependence of tourism and agricultural dynamics in shaping the evolution of agritourism as an interdisciplinary field.

The network reveals three primary thematic clusters. The first cluster focuses on economic aspects and sustainability, including terms such as "economy," "innovation," "consumption," and "local food", which align with agritourism's role in rural economic development and sustainable agricultural practices.

Table 3. Co-occurrence network results

Node	Cluster	Betweenness	Closeness	PageRank
Tourism	1	172.974	0.019	0.078
Agritourism	1	258.084	0.02	0.091
Rural tourism	1	97.98	0.018	0.06
Agriculture	1	59.25	0.017	0.058
Diversification	1	50.893	0.016	0.053
Typology	1	16.511	0.014	0.035
Impact	1	13.127	0.014	0.028
Performance	1	14.286	0.014	0.029
Model	1	7.847	0.013	0.021
Management	1	4.757	0.013	0.019

Source: authors' elaboration based on the Biblioshiny in RGui research results [30].

The second cluster pertains to tourism and management, where keywords such as "diversification," "impact," "performance," "model," and "management" highlight the strategic planning and economic viability of agritourism businesses. The third cluster revolves around visitor experience and perception, incorporating terms like "food," "perceptions," "experience," and "quality", which suggest an increasing research focus on consumer behavior, branding, and visitor satisfaction in agritourism.

Emerging themes such as "sustainability" (betweenness: 19.2), "authenticity" (betweenness: 1.991), and "innovation" (betweenness: 1.209) indicating a growing academic interest in sustainable tourism models and authentic agritourism experiences. Additionally, the relatively high PageRank of "policy" and "strategies" suggests ongoing discussions about regulatory frameworks and governance in agritourism. The co-occurrence network analysis highlights the interdisciplinary nature of agritourism research, emphasizing its strong economic, managerial, and experiential dimensions. As agritourism continues to evolve, future research may further explore the balance between sustainability, visitor engagement, and economic performance to support the sector's long-term growth.

To provide a visual representation of the conceptual relationships within agritourism

research, we included a co-occurrence network map (Figure 5).

This map illustrates how frequently certain keywords appear together in the literature, helping to identify key themes and research clusters. By analyzing these connections, we gain insights into the dominant topics shaping agritourism studies, as well as emerging trends that indicate future research directions.

The inclusion of the co-occurrence network map enhances the visualization of the complex relationships between research themes in agritourism and by mapping these connections, we highlight the interdisciplinary nature of the field, illustrating how economic, managerial, and experiential dimensions intersect. Also, as agritourism continues to evolve, the co-occurrence network serves as a valuable tool for identifying knowledge gaps, thematic intersections, and emerging areas of study in this rapidly developing field.

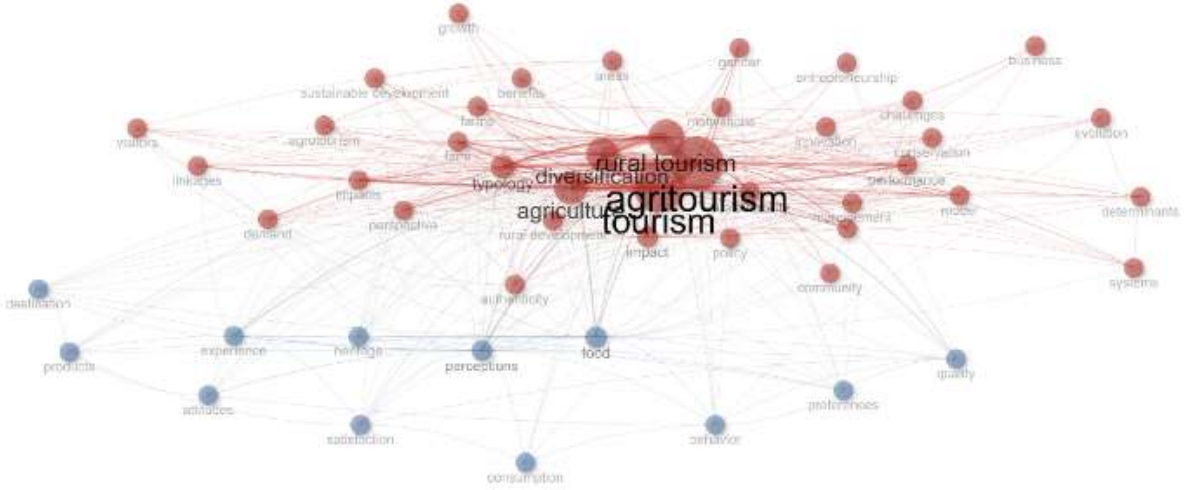

Fig. 5. Co-occurrence connection cluster map
Source: Biblioshiny in RGui research results [30].

Trending topics and thematic map

In order to course the evolving research directions in agritourism, we analyzed trending topics using a thematic map, which categorizes themes based on their relevance and development stage, allowing us to identify core research areas, emerging trends, and niche topics that shape the field.

The central themes, such as "tourism," "agritourism," and "rural tourism," are well-developed and fundamental to the discourse, reinforcing their role in rural economic strategies and sustainability discussions. Basic themes, including "impact," "model," and "perceptions," highlight ongoing efforts to assess agritourism's effects and establish standardized evaluation frameworks. Niche themes, like "identification" and "planned behavior," focus on specific aspects such as consumer decision-making and behavioralpatterns. Meanwhile, emerging or declining themes, such as "Romania trends" and "landscape policies," suggest regional perspectives and policy-driven research that could gain traction with further exploration (Figure 6).

The thematic map provides a structured view of agritourism research, highlighting dominant areas while pinpointing gaps and emerging interests. While tourism-related themes remain foundational, topics related to policy, sustainability, and visitor engagement are gaining prominence.

The above results provided a comprehensive overview of the interdisciplinary landscape of agritourism research, highlighting key thematic areas and emerging trends. The scientific production analysis reveals that leading countries such as the USA, Italy, and Romania have significantly contributed to the field, shaping agritourism's theoretical and practical advancements. Co-occurrence and co-citation network analyses further underscore the strong links between tourism,

rural development, and sustainability, reinforcing agritourism's role in economic diversification. Factorial analysis and thematic mapping demonstrate a shift toward impact assessment, visitor experience, and sustainability policies, indicating evolving research priorities. By identifying core research themes and main focus areas, this study offers valuable insights for future academic exploration and practical applications, ensuring agritourism continues to develop as a dynamic and sustainable sector.

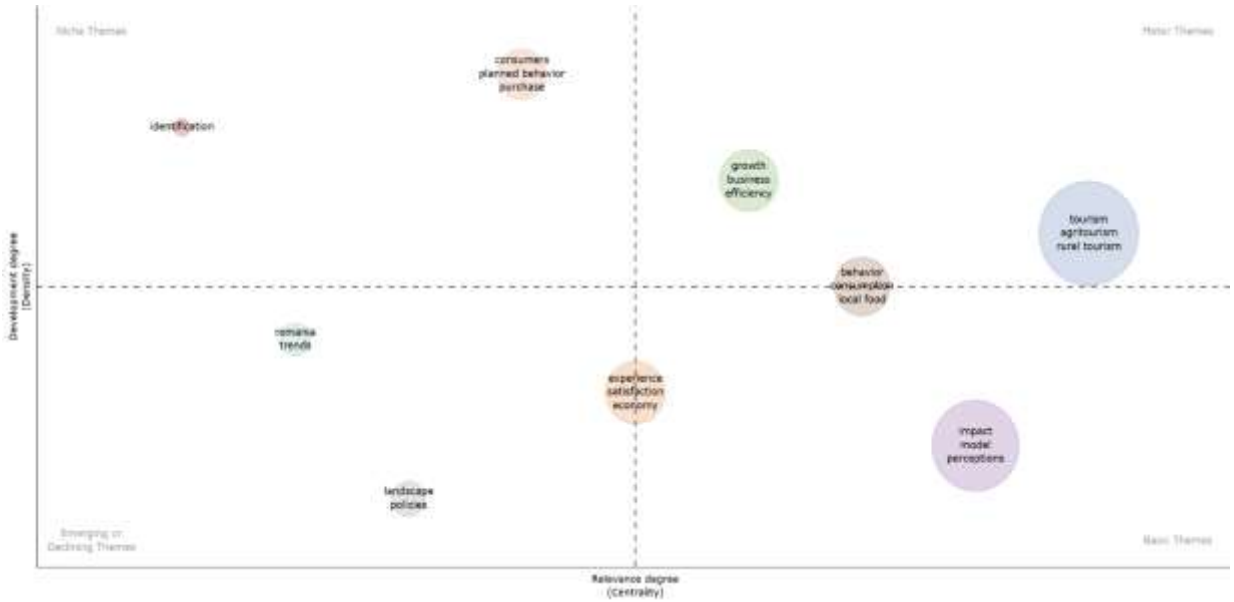

Fig. 6. Thematic map of the trending topics
Source: Biblioshiny in RGui research results [30].

CONCLUSIONS

The research outlined a structured evaluation of agritourism's intellectual landscape, emphasizing its role in rural development, economic diversification, and sustainable tourism. The result of our analysis underscores the central position of themes such as tourism, agritourism, and rural tourism within the broader landscape of academic research inquiry, positioning them as focal points in international academic research discourse. The increasing emphasis on visitor experiences, sustainability considerations, and policy frameworks suggests a notable evolution in the sector's priorities, moving toward a more integrated view of agritourism's broader socioeconomic contributions. Moreover, the identification of the leading countries and seminal publications reflects the global reach of this research domain, while also bringing attention to the diverse, region-specific strategies shaped by national policy environments of each country. The structural examination of keyword co-occurrence and citation linkages further reveals the field's inherently interdisciplinary character, bridging insights from economics, environmental science, and marketing. Also, we consider that thematic mapping additionally points to emerging lines of investigation, particularly those related to consumer preferences, digital engagement tools, and the adoption of technological innovations aimed at enriching the agritourism experience and enhancing its appeal.

We consider that, by mapping the research trends and thematic clusters, our study offers a valuable reference for academics and practitioners, supporting informed decision-making, strategic policy development, and future research directions. As agritourism continues to expand globally, we encourage further research labs to explore regional adaptations, long-term sustainability measures, and the integration of innovative business models to enhance the sector's resilience and impact. Considered in its entirety, the insights derived from this research could have a real contribution to a deeper understanding of

agritourism's potential, paving the way for evidence-based strategies that foster sustainable rural economies and enriching visitor experiences.

REFERENCES

[1]Ammirato, S., Felicetti, A. M., Raso, C., Pansera, B. A., Violi, A., 2020, Agritourism and sustainability: What we can learn from a systematic literature review. Sustainability, 12(22), 9575, https://www.mdpi.com/2071-1050/12/22/9575, Accessed on 04 April 2025.

[2]Ariyawardana, S. S., 2024, A Crossroad for Sustainable Development in Sri Lanka: Embracing Sustainability Through Agro-Tourism Initiatives in Nuwara Eliya. A Crossroad for Sustainable Development in Sri Lanka: Embracing Sustainability Through Agro-Tourism Initiatives in Nuwara Eliya., https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4781982, Accessed on 1 January 2025.

[3]Arroyo, C. G., Barbieri, C., Rich, S. R., 2013, Defining agritourism: A comparative study of stakeholders' perceptions in Missouri and North Carolina. Tourism Management, 37, 39-47, https://www.sciencedirect.com/science/article/abs/pii/S0261517712002427, Accessed on 04 April 2025.

[4]Barbieri, C., Xu, S., Gil-Arroyo, C., Rich, S. R., 2016, Agritourism, farm visit, or...? A branding assessment for recreation on farms. Journal of travel research, 55(8), 1094-1108, https://journals.sagepub.com/doi/abs/10.1177/0047287515605930, Accessed on 04 April 2025.

[5]Bernatović, I., Slavec Gomezel, A., Černe, M., 2022, Mapping the knowledge-hiding field and its future prospects: a bibliometric co-citation, co-word, and coupling analysis. Knowledge Management Research & Practice, 20(3), 394-409, https://www.tandfonline.com/doi/full/10.1080/14778238.2021.1945963, Accessed on 1 January 2025.

[6]Bhatta, K., Ohe, Y., 2020, A review of quantitative studies in agritourism: The implications for developing countries. Tourism and Hospitality, 1(1), 23-40, https://www.mdpi.com/2673-5768/1/1/3, Accessed on 1 January 2025.

[7]Brata, A., 2008, Perspective of world agriculture. Bulletin UASVM, 65, 2, https://ftp.fruit-technology.ro/index.php/horticulture/article/view/1057 Accessed on 1 January 2025.

[8]Bronander, K. A., Goodman, P. H., Inman, T. F., Veach, T. L., 2004, Boolean search experience and abilities of medical students and practicing physicians. Teaching and Learning in Medicine, 16(3), 284-289, https://www.tandfonline.com/doi/abs/10.1207/s15328015tlm1603_12?casa_token=aEwYoj3nW58AAAAA:hdLG8G0_LSr , Accessed on 1 January 2025.

[9]Chen, P., Yi, W., Su, D., Tan, Y., Zhou, J., Chen, X., 2025, Simulating excavation processes for large-scale underground geological models using dynamic Boolean operations with spatial hash indexing and multiscale point clouds. Automation in Construction, 171, 105966, https://www.sciencedirect.com/science/article/abs/pii/S0926580525000068, Accessed on 1 January 2025.

[10]Ciolac, R., Adamov, T., Iancu, T., Popescu, G., Lile, R., Rujescu, C., Marin, D., 2019, Agritourism-A Sustainable development factor for improving the 'health'of rural settlements. Case study Apuseni mountains area. Sustainability, 11(5), 1467, https://www.mdpi.com/2071-1050/11/5/1467, Accessed on 1 January 2025.

[11]Flanigan, S., Blackstock, K., Hunter, C., 2015, Generating public and private benefits through understanding what drives different types of agritourism. Journal of rural studies, 41, 129-141, https://www.sciencedirect.com/science/article/pii/S0743016715300140, Accessed on 04 April 2025.

[12]Kalinina, L. A., Vlasenko, O. V., Zelenskaya, I. A., 2020, Methodological approach to evaluating the prospects of agrotourism development. European Proceedings of Social and Behavioural Sciences, https://www.europeanproceedings.com/article/10.15405/epsbs.2020.10.03.24, Accessed on 04 April 2025.

[13]Karimi, S., Pohl, S., Scholer, F., Cavedon, L., Zobel, J., 2010, Boolean versus ranked querying for biomedical systematic reviews. BMC medical informatics and decision making, 10, 1-20, https://link.springer.com/article/10.1186/1472-6947-10-58 , Accessed on 1 January 2025.

[14]Lupi, C., Giaccio, V., Mastronardi, L., Giannelli, A., Scardera, A., 2017, Exploring the features of agritourism and its contribution to rural development in Italy. Land use policy, 64, 383-390, https://www.sciencedirect.com/science/article/pii/S0264837715302933, Accessed on 04 April 2025.

[15]Ma, D., Sun, D., Wang, Z., 2024, Exploring the Rural Revitalization Effect under the Interaction of Agro-Tourism Integration and Tourism-Driven Poverty Reduction: Empirical Evidence for China. Land, 13(1), 60, https://www.mdpi.com/2073-445X/13/1/60, Accessed on 1 January 2025.

[16]Maerescu, M. C., Chereji, A. I., Mintas, S.O., Marele, C.D., Gitea, A.M., 2021, Challenges and Opportunities for a Sustainable Agriculture in the Context of the Green and Digital Twin Transition. How Can We Increase the Resilience of the Agriculture in the Current Context? Analele Universitatii din Oradea, Fascicula Ecotoxicologie, Zootehnie si Tehnologii în Industria Alimentara, 20, https://openurl.ebsco.com/EPDB%3Agcd%3A10%3A30376634/detailv2?sid=ebsco%3Aplink%3Ascholar&id=ebsco%3Agcd%3A155566132&crl=c&link_origin=scholar.google.com, Accessed on 1 January 2025.

[17]Moshtaghian, H., Bolton, K., Rousta, K., 2021, Challenges for upcycled foods: Definition, inclusion in the food waste management hierarchy and public acceptability. Foods, 10(11), 2874, https://www.mdpi.com/2304-8158/10/11/2874. Accessed on 04 April 2025.

[18]Ndhlovu, E., Dube, K., 2024, Agritourism and sustainability: A global bibliometric analysis of the state

of research and dominant issues. Journal of Outdoor Recreation and Tourism, 46, 100746, https://www.sciencedirect.com/science/article/pii/S2213078024000148, Accessed on 1 January 2025.
[19]Phillip, S., Hunter, C., Blackstock, K., 2010, A typology for defining agritourism. Tourism management, 31(6), 754-758, available at: https://www.sciencedirect.com/science/article/pii/S0261517709001423, Accessed on 04 April 2025.
[20]Piras, F., Pedes, F., 2025, The Impact of Socio-Economic Factors on the Development of Rural Tourism: Italian Case Based on a Regional Analysis. Tourism and Hospitality, 6(1), 3, https://www.mdpi.com/2673-5768/6/1/3, Accessed on 1 January 2025.
[21]Popescu, A., 2016, The position of tourist and agrotourist guesthouses in Romania's accommodation structures, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.16(1), 417-424, https://managementjournal.usamv.ro/pdf/vol.16_1/Art65.pdf, Accessed on 1 January 2025.
[22]Sheth, J. N., Parvatiyar, A., 2021, Sustainable marketing: Market-driving, not market-driven. Journal of macromarketing, 41(1), 150-165, https://journals.sagepub.com/doi/abs/10.1177/0276146720961836 , Accessed on 1 January 2025.
[23]Smedescu, D., Fîntîneru, G., 2013, Tourism phenomenon in the post-crisis economy, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.13(3), 392-396.
https://ibn.idsi.md/sites/default/files/j_nr_file/Vol_13_2_2013.pdf#page=393, Accessed on 1 January 2025.
[25]Tew, C., Barbieri, C., 2012, The perceived benefits of agritourism: The provider's perspective. Tourism management, 33(1), 215-224, https://www.sciencedirect.com/science/article/pii/S0261517711000495, Accessed on 04 April 2025.
[25]Tindeche, C., Mărcuță, A., Mărcuță, L., 2014, Importance of the agricultural sector as a branch of the national economy, https://www.managementjournal.usamv.ro/pdf/vol14_4/art45.pdf, Accessed on: 16 January 2025
[26]Torre, A., 2015, New challenges for rural areas in a fast moving environment. European Planning Studies, 23(4), 641-649, https://www.tandfonline.com/doi/full/10.1080/09654313.2014.945811, Accessed on 04 April 2025.
[27]Waligo, V. M., Clarke, J., Hawkins, R., 2013, Implementing sustainable tourism: A multi-stakeholder involvement management framework. Tourism management, 36, 342-353, https://www.sciencedirect.com/science/article/abs/pii/S0261517712001884, Accessed on 1 January 2025.
[28]Wang, R. S., Saadatpour, A., Albert, R., 2012, Boolean modeling in systems biology: an overview of methodology and applications. Physical biology, 9(5), 055001,
https://iopscience.iop.org/article/10.1088/1478-3975/9/5/055001/meta, Accessed on 1 January 2025.
[29]Wolfram, D., Dimitroff, A., 1998, Hypertext vs boolean-based searching in a bibliographic database environment: A direct comparison of searcher performance. Information processing & management, 34(6), 669-679, https://www.sciencedirect.com/science/article/abs/pii/S0306457398000351, Accessed on 1 January 2025.
[30]***Biblioshiny in RGui.

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AGRICULTURAL YIELDS AND CLIMATE CHANGE: HOW DOES ROMANIA MAINTAIN ITS EXPORT COMPETITIVENESS?

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Abstract

Climate change is one of the greatest challenges facing global agriculture, impacting yields and the competitiveness of agricultural exports. This study examines the impact of climate change on Romanian agriculture and how it influences export competitiveness compared to other exporting countries in the region, such as Ukraine, Russia, and Hungary, over a 10-year period (2013-2023). The results indicate that climatic variability has reduced the yields of key crops in Romania, particularly during years marked by drought or irregular precipitation. Compared to the analysed countries, Romania's adaptability to new climatic conditions has proven limited, affecting the sustainability of its comparative advantage. To demonstrate the correlation between climatic conditions and exports, a multiple linear regression was constructed. The study highlights the importance of investments in agricultural infrastructure, modern technologies, and effective policies to sustain the competitiveness of Romanian agriculture in international markets.

Key words**:** *climate change, exports, competitiveness, sustainability, yields*

INTRODUCTION

Climate change has a deep negative impact on agriculture emphasizing crises and affecting food security at the global level [5, 22]. Romania, a major agricultural player in Eastern Europe, has been significantly impacted by climate change [19]. Frequent droughts, unpredictable rainfall, and shifting seasonal patterns have disrupted agricultural productivity, particularly for key export crops like wheat, maize, and sunflower [16, 17]. These fluctuations have not only reduced yields but also increased uncertainty in production, making it difficult for Romania to maintain a stable presence in international markets. The growing unpredictability of agricultural output has led to export volatility, weakening the country's competitive advantage [1].

Compared to other major agricultural exporters in Eastern Europe—Ukraine, Russia, and Hungary—Romania has struggled to adapt to the growing challenges posed by climate change (FAO) [3]. While Ukraine and Russia leverage extensive farmland and large-scale investments in modern agriculture, and Hungary has successfully implemented advanced irrigation and adaptation measures, Romania has lagged behind. The lack of substantial investment in irrigation infrastructure, slow adoption of new technologies, and inconsistent policy initiatives have left Romanian agriculture particularly vulnerable to climate-induced disruptions, reducing its resilience and competitive standing [18].

This study underscores the pressing need for targeted strategies to strengthen Romania's agricultural resilience. To counteract the adverse effects of climate change, significant investments in climate-smart technologies, efficient water management systems, and sustainable agricultural practices are necessary. Furthermore, comprehensive policy reforms are needed to support farmers in adopting adaptive techniques, securing financial assistance, and advancing research on climate-resistant crop varieties. These measures are essential for maintaining Romania's long-term competitiveness in an increasingly volatile agricultural landscape [6].

In this context, the purpose of the paper is to assess the impact of climate change on yields of the main crops in the Romanian agriculture and the way in which how the export competitiveness is affected compared to other exporting countries in the region.

MATERIALS AND METHODS

To analyse the impact of climate change on Romanian agriculture and its influence on export competitiveness, this study employs a combination of climatic, agricultural, and economic data over a 10-year period (2013-2023). The study relies on data obtained from multiple authoritative sources:

-***Climatic Data:*** Collected from the National Administration of Meteorology of Romania [9, 10, 11, 12, 13, 14], including annual precipitation levels, average temperatures, and occurrences of extreme weather events such as droughts and heatwaves.

-***Agricultural Data*** provided by the Ministry of Agriculture and Rural Development (MARD) [8] and the National Institute of Statistics (NIS) [15], covering crop yields for key agricultural products (wheat, maize, sunflower) and changes in cultivated land.

-***Economic and Trade Data***: Extracted from the World Bank Group [24], and Food and Agriculture Organization of the United Nations (FAO) [3], focusing Romania's agricultural export volumes, trade balances, and global market competitiveness.

The methods used have been: graphical representation, calculation of the differences of between the average temperatures compared to the meteorological normals for longer periods, regression analysis between temperatures and precipitations and yield. The results were tabled and commented.

RESULTS AND DISCUSSIONS

This section presents an analysis of cultivated areas, average yields (kg/ha), and their trends over the years 2015-2023, highlighting key patterns and implications for the future.

Wheat

The cultivated area for wheat remained relatively stable over the years, fluctuating between 2.1 to 2.3 million hectares. However, wheat yields varied significantly, showing sensitivity to climatic conditions [8].

-2017 recorded the highest yield (4.89 kg/ha), likely due to favorable weather conditions [8].

-2020 was a particularly difficult year for wheat (2.97 kg/ha), reflecting one of the lowest productivity rates in recent history, coinciding with a drought period [8].

-In 2022, yields stagnated at 4.00 kg/ha, signaling prolonged effects of arid conditions [8].

-These trends indicate that although wheat remains a primary crop, extreme weather conditions can substantially impact production levels [8].

Maize

Corn production exhibits strong fluctuations in both cultivated area and yields, making it one of the most unstable crops in Romania.

-2018 recorded the highest yield (7.64 kg/ha), indicating exceptional conditions for corn that year [8].

-In contrast, 2022 marked one of the worst years, with yields plummeting to 3.30 kg/ha, primarily due to extreme drought [8].

-Additionally, cultivated areas have been shrinking, from 2.67 million hectares in 2019 to just 2.19 million hectares in 2023, suggesting that farmers may be moving away from corn due to its susceptibility to dry conditions and unreliable rainfall [8].

Corn's dependence on rainfall makes it highly vulnerable to climate change, requiring significant irrigation investment to ensure consistent yields [8].

Sunflower

Sunflower, another staple of Romanian agriculture, shows clear signs of stress in response to droughts [8].

-The highest yield was recorded in 2018 (3.04 kg/ha), suggesting optimal rainfall and temperature conditions [8].

-However, 2022 and 2023 showed clear signs of decline (1.93 and 1.87 kg/ha), likely due to prolonged drought periods [8].

-The cultivated area also fluctuated, peaking at 1.28 million hectares in 2019, then dropping to 1.07 million hectares by 2023 [8].

-This downward trend in both yield and cultivation suggests that sunflower is

becoming increasingly difficult to grow under current climate patterns, and farmers may be switching to other crops [8].

Rape

Rapeseed production has shown the most growth in cultivated area, increasing from 368 hectares in 2015 to 641 hectares in 2023 However, yield patterns remain inconsistent [8].

-2021 registered the highest rapeseed yield (3.08 kg/ha), likely due to better water availability [8].

-2019 and 2020 had the lowest yields (2.26 and 2.15 kg/ha), likely due to dry conditions affecting the flowering phase [8].

Although rapeseed is becoming increasingly popular, its sensitivity to climatic variations means that future production stability depends on improved farming techniques and climate adaptation strategies.

Table 1 and Fig. 1 presents the production carried out by wheat, maize, sunflower and rape in Romania (2015-2023).

Table 1. Cultivated areas and production for wheat, maize, sunflower and rape, Romania (2015-2023)

	WHEAT		MAIZE		SUNFLOWER		RAPE	
	Area (ha)	Average Yield (to/ha)	Area (ha)	Average Yield (to/ha)	Area (ha)	Average Yield (to/ha)	Area (ha)	Average Yield (to/ha)
2015	2,106,591	3.78	2,605,165	3.46	1,011,527	1.77	368	2.5
2016	2,137,731	3.94	2,580,975	4.16	1,039,823	1.96	456	2.84
2017	2,052,917	4.89	2,402,082	5.96	998,415	2.92	598	2.8
2018	2,116,154	4.79	2,439,842	7.64	1,006,994	3.04	633	2.55
2019	2,168,370	4.75	2,678,504	6.5	1,282,697	2.78	718	2.26
2020	2,155,254	2.97	2,537,104	3.98	1,142,841	1.86	363	2.15
2021	2,175,077	4	2,549,281	5.8	1,123,960	2.53	446	3.08
2022	2,168,662	4	2,431,106	3.3	1,093,265	1.93	469	2.62
2023	2,317,692	4.36	2,195,344	3.98	1,077,867	1.87	641	2.79

Source: MARD [8], NIS [15].

Fig. 1. Evolution of wheat, maize, sunflower and rape seed yields in Romania, 2015-2023, (ton/ha)
Source: NIS [15].

Years with the highest temperatures (2024, 2023, 2019, 2020, and 2022) coincide with declining crop yields and increasing agricultural challenges (National Administration of Meteorology [9, 10, 11, 12, 13, 14], MADR, Annual Reports) [8], NIS [15].

The year 2022 was particularly difficult for agriculture (National Administration of Meteorology, MADR, Annual Reports) [13, 8]:

-Temperature: 10.58°C, with a 1.52°C deviation from the 1981-2010 average (Table 2).

-Corn yields dropped dramatically to 3.30 kg/ha, one of the lowest recorded, reflecting severe drought conditions.
-Sunflower yield also plummeted to 1.93 kg/ha, showing that high temperatures negatively impact oilseed crops.
-2023 experienced an even higher temperature (11.38°C), but agricultural production slightly recovered compared to 2022.
-Wheat yields improved to 4.36 kg/ha, indicating that wheat is more resistant to heat than other crops.
-Corn production remained low at 3.98 kg/ha, confirming its vulnerability to drought and high temperatures.
The years 2019 and 2020, two of the hottest years, also saw significant production impacts (National Administration of Meteorology, MADR, Annual Reports): [9, 10, 8],
-Corn production dropped from a record 7.64 kg/ha (2018) to 3.98 kg/ha (2020), highlighting a clear correlation between extreme heat and lower yields.
-Sunflower yields also fell from 3.04 kg/ha (2018) to 1.86 kg/ha (2020), proving that oilseed crops are highly susceptible to heat stress.
-Wheat appears to be the most stable crop, maintaining moderate yield variations.
-Despite temperature spikes in 2019 and 2020, wheat yield remained around 4.00-4.75 kg/ha.
-However, 2020 saw a significant drop to 2.97 kg/ha, indicating that even wheat is not immune to prolonged heat stress.
-Rape register a very low yield year by year with the lowest level 2.15 tons/ha in 2015 [23].

Table 2. Average temperature and its deviations from the median reference interval 1981-2010 and 1991-2020

No.	Year	Average Temperature (°C)	Deviation from Median Reference Interval 1981-2010 (°C)	Deviation from Median Reference Interval 1991-2020 (°C)
1	2024	11.62	2.52	1.99
2	2023	11.38	2.31	1.78
3	2019	11.6	2.5	1.76
4	2020	11.4	2.3	1.04
5	2022	10.58	1.52	1.02
6	2015	10.53	1.46	0.93
7	2018	10.35	1.35	0.75
8	2014	10.35	1.28	0.75

Source: Collected from the National Administration of Meteorology of Romania [9, 10, 11, 12, 13, 14].

The regression analysis reveals a clear relationship between rising temperatures and crop production trends in Romania. While some crops show resilience or even slight gains under higher temperatures, others exhibit significant declines, particularly corn and rapeseed signaling long-term threats to agricultural stability in the country.
Corn production is the most affected by rising temperatures, with a strong negative correlation (-2.14 coefficient). This means that for each additional degree Celsius in average temperature, corn yields drop substantially. Given that corn is one of Romania's key agricultural exports, its vulnerability to extreme heat and drought represents a serious economic and food security concern.
The decline in 2022's corn production, a year with record-high temperatures, aligns with this trend, confirming that Romania's ability to sustain corn cultivation without improved irrigation and climate adaptation is at risk
Rapeseed production also shows a negative relationship with temperature (-0.24 coefficient), indicating that while it is less affected than corn, it still experiences yield reductions in hotter years. This suggests that prolonged heat stress negatively impacts plant growth, particularly during flowering and seed-setting stages.
In contrast, wheat shows a small positive correlation (+0.39 coefficient), suggesting that moderate temperature increases may actually benefit yields to some extent (Fig. 2).

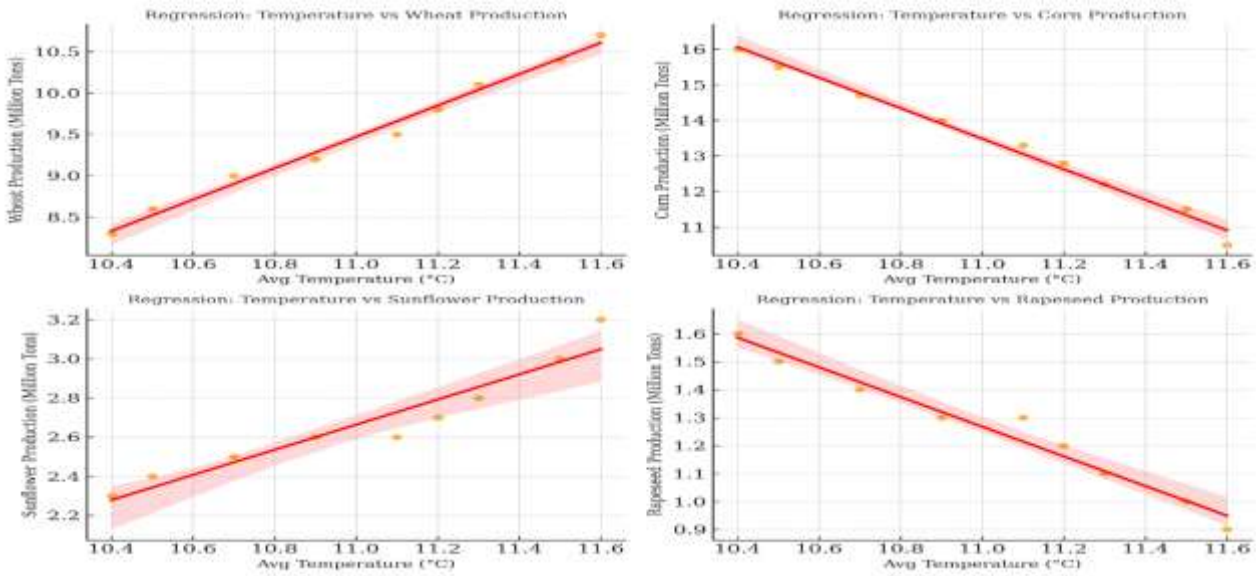

Fig. 2. The Impact of Temperature on Agricultural Production in Romania: A Regression Analysis
Source: Authors own calculation.

Wheat is more temperature-resilient than other crops, and its growing season allows it to avoid the worst heat waves of mid-summer. However, long-term warming and extended droughts could still impact its stability, especially in regions lacking sufficient rainfalls.

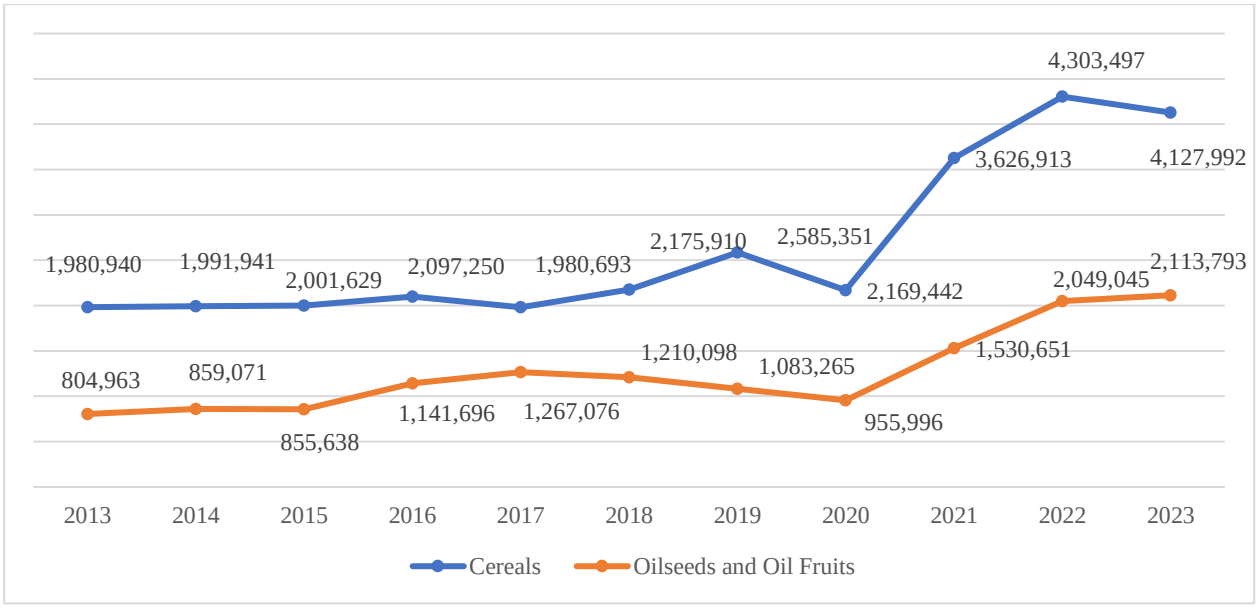

Fig. 3. Romania's of cereals and oilseeds and Oil fruits market (2013-2023) (billion euros)
Source: NIS [15].

Sunflower production appears to be the least affected by temperature changes, as indicated by a near-zero regression coefficient (0.01). This suggests that other climatic factors, such as precipitation levels and soil moisture availability, play a larger role in determining sunflower yields rather than temperature alone. This regression analysis confirms that Romania's agricultural sector is increasingly vulnerable to rising temperatures, particularly for corn and rapeseed production. If warming trends continue, without improved irrigation, drought-resistant crop varieties, and better soil moisture management, the country will face major losses in key agricultural outputs. While wheat and sunflower may remain relatively stable, the overall agricultural landscape is shifting, and farmers will need to adapt their

strategies to remain competitive in a rapidly changing climate.

At first glance, Romania's sharp increase in agricultural exports in 2021-2023, despite extreme drought conditions, might suggest a strengthening of its competitiveness. However, a deeper analysis reveals a paradox: while exports have risen, Romania's long-term agricultural competitiveness is actually at risk due to structural weaknesses, increasing production volatility, and external geopolitical influences.

Key factors behind the export surge [2]:

-Drought conditions severely impacted domestic production in 2022, yet high global grain prices compensated for lower output.

-The Ukraine war disrupted global grain supply chains, forcing international markets to seek alternative suppliers, including Romania.

-Romania's strategic location along the Black Sea and access to the Port of Constanța made it a critical export route, especially after Russia's blockade of Ukrainian ports.

Despite these favourable conditions for exports, Romania's farmers struggled with rising production costs, water scarcity, and reliance on outdated infrastructure. The country's competitiveness in the long run is being eroded by factors beyond short-term export gains.

Romania's Declining Competitiveness in the Regional Context

Ukraine [21, 22]: A Direct Competitor Turned Dependent on Romania

-Before the war, Ukraine was the world's fourth-largest grain exporter, with vast, highly mechanized farms producing at lower costs than Romania.

-Since 2022, Ukraine has been forced to reroute exports through Romania's ports, particularly Constanța.

-This situation temporarily boosted Romania's export infrastructure but also created competition as Ukrainian grain flooded European markets at lower prices, threatening Romanian farmers' profitability.

Russia: Dominating Global Markets While Romania Struggles [7]:

-Russia has aggressively expanded its agricultural exports, benefiting from subsidies and strategic partnerships with markets like China and the Middle East.

-Russian grain is often cheaper than Romanian grain, making it a preferred choice for major importers.

-Unlike Romania, Russia's investment in irrigation and large-scale production efficiency has helped stabilize its yields, even during climate challenges.

Hungary: A More Resilient and Subsidized Neighbour [4].

-Hungary has a stronger irrigation infrastructure, making it less vulnerable to drought than Romania.

-The country benefits from more EU subsidies per farmer, enabling investments in precision agriculture, while Romanian farmers often struggle with bureaucratic delays in accessing funds.

-As a result, Hungarian agricultural productivity remains more stable, while Romania's fluctuates sharply with climate changes.

While short-term exports have increased, Romania's agricultural sector is losing competitiveness due to deeper structural challenges:

Lack of Modern Irrigation Systems:

-Only about 10-15% of Romania's farmland is irrigated, compared to 50% in Hungary and extensive irrigation systems in Russia.

-Without water security, Romania remains highly dependent on rainfall, making its yields unreliable.

-Aging Infrastructure and Logistics Bottlenecks:

-The Port of Constanța handled record grain volumes in 2022-2023, but its capacity is limited, and railway logistics remain underdeveloped, increasing transport costs.

-Hungary and Poland have better railway networks, reducing the cost of moving grain to export markets.

Dependence on Price Volatility Rather Than Production Strength:

-The 2022-2023 export boom was driven by high global prices, not by increased production.

-If prices fall or Ukraine fully regains its Black Sea routes, Romania will struggle to compete

without substantial production efficiency improvements.

CONCLUSIONS

While Romania has capitalized on global disruptions to maintain high export volumes, its long-term agricultural competitiveness is at risk. The combination of climate change, weak irrigation, rising costs, and geopolitical shifts means that, without structural reforms, Romania may struggle to remain a key player in the global grain market.

To ensure competitiveness, Romania must:

-Invest heavily in irrigation systems to protect yields from extreme weather.

-Modernize transport infrastructure, particularly railway and port logistics.

-Secure better EU subsidies and support farmers to adapt to climate challenges.

-Prepare for post-war competition from Ukraine, as its return to full export capacity will reduce Romania's current trade advantages.

Without urgent action, Romania risks being outcompeted by its neighbours, despite its temporary success in export markets.

REFERENCES

[1]Bakhtmina, Z., Muhammad, R., Shahab, E. S., & Muhammad, A. (2022). Agricultural Market Competitiveness in the Context of Climate Change. In Agricultural Economics Review, 6(2), 45–59. https://www.mdpi.com/2071-1050/14/7/3721

[2]European Commission, 2022, EU agricultural outlook report 2022–2032. ec.europa.eu/agriculture/outlook.

[3]Food and Agriculture Organization (FAO), 2023, The evolution of agricultural exports in Eastern Europe. www.fao.org/agriculture, Accessed on February 10, 2025.

[4]Harsányi, E., Bashir, B., Alsilibe, F., Alsafadi, K., Alsalman, A., Széles, A., ur Rahman, M.H., Bácskai, I., Juhász, C., Ratonyi, T., Mohammed, S., 2021, Impact of Agricultural drought on sunflower production across Hungary, Atmosphere, 12, 1339. https://www.mdpi.com/2073-4433/12/10/1339, Accessed on February 10, 2025.

[5]Intergovernmental Panel on Climate Change (IPCC), 2022, Climate change impacts on global agriculture. www.ipcc.ch/reports, Accessed on February 10, 2025.

[6]Jitea, M.I., Incze, L., Cosciug, A., Voinescu, C., 2023, Raport de analiză a practicilor și politicilor relevante în domeniul European, E-Agricultura, 2023, DOI:10.13140/RG.2.2.17453.46565 https://www.researchgate.net/publication/375497658_Raport_de_analiza_a_practicilor_si_politicilor_relevante_in_domeniul_european_E-Agricultura, Accessed on February 10, 2025.

[7]Kuhla, K., Puma, M.J., Otto, C., 2024, International cooperation was key to stabilize wheat prices after the Russian Invasion of Ukraine. Common Earth Environ 5, 481. https://www.nature.com/articles/s43247-024-01638-7#citeas, Accessed on February 10, 2025.

[8]Ministry of Agriculture and Rural Development (MADR), 2023, Strategies for agricultural development and the impact of climate change. www.madr.ro, Accessed on February 10, 2025.

[9]National Administration of Meteorology (ANM), 2021, Annual Report. https://www.meteoromania.ro, Accessed on February 10, 2025.

[10]National Administration of Meteorology (ANM), 2022, Annual Report. https://www.meteoromania.ro, Accessed on February 10, 2025.

[11]National Administration of Meteorology (ANM), 2023, Annual Report. https://www.meteoromania.ro, Accessed on February 10, 2025.

[12]National Administration of Meteorology (ANM), 2024, Annual Report. https://www.meteoromania.ro, Accessed on February 10, 2025.

[13]National Administration of Meteorology, 2022, Interview with Elena Mateescu, This agricultural year is one of the driest in history. https://www.agerpres.ro/mediu/2022/07/20/interviu-elena-mateescu-anm-acest-an-agricol-este-unul-dintre-cei-mai-secetosi-din-istorie--952068, Accessed on February 10, 2025.

[14]National Meteorological Administration Romania (Meteo Romania), 2023, Annual report on climate change in Romania. www.meteoromania.ro. Accessed on February 10, 2025.

[15]National Institute of Statistics Romania (INSSE), 2023, Agricultural production and trade balance in Romania. www.insse.ro. Accessed on February 10, 2025.

[16]Popescu, A., Dinu, T. A., Stoian, E., Serban, V., 2023, Climate change and its impact on wheat, maize and sunflower yield in Romania in the period 2017-2021. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 23(1), 587-602.

[17]Popescu, A., Tindeche, C., Marcuta, A., Marcuta, L., Hontus, A., 2022, Cereals production between climate change and price boom in Romania. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 22(4), 579-594.

[18]Sutton, W. R., Block, R. I., Srivastava, J., Adaptation to Climate Change in Europe and Central Asia Agriculture. https://openknowledge.worldbank.org/server/api/core/bitstreams/cf4bc995-52fc-5eb5-9f3e-ef82ad4d4266/content, Accessed on February 10, 2025.

[19]The impact of disasters and crises on agriculture and food security, 2023, https://www.fao.org/publications/fao-flagship-publications/the-impact-of-disasters-on-agriculture-and-food-security/en, Accessed on February 10, 2025.
[20]Ukraine grain pushes Romanian Constanta port to record volumes in 2023. https://www.reuters.com/markets/commodities/ukraine-grain-pushes-romanian-constanta-port-record-volumes-2023-2024-01-10/, Accessed on February 10, 2025.
[21]Ukrainian grain exports explained (2022). https://www.consilium.europa.eu/en/infographics/ukrainian-grain-exports-explained/
[22]United Nations Environment Programme (UNEP) (2022). Agricultural sustainability in a changing climate. www.unep.org/agriculture. Accessed on February 10, 2025.
[23]What are the likelihoods of Romania repeating last season's record rapeseed exports? https://commodity-board.com/what-are-the-likelihoods-of-romania-repeating-last-seasons-record-rapeseed-exports/, Accessed on February 10, 2025.
[24]World Bank (2023). Global agricultural market trends and challenges. www.worldbank.org/agriculture. Accessed on February 10, 2025.

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THE DEGREE OF INCOME DIVERSIFICATION AMONG RURAL HOUSEHOLDS IN THE POLOG AND PELAGONIA REGIONS OF NORTHMACEDONIA

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Abstract

Rural development in North Macedonia has traditionally been closely linked to agricultural growth, reflecting the sector's vital role in the country's economy. However, contemporary strategies increasingly recognize the role of non-farm rural activities in improving rural livelihoods. This research examines how rural households in the Polog and Pelagonia regions diversify their income streams. To assess the extent of diversification, the Shannon Equitability Index, which considers the variety and balance of income sources, was employed. Data were collected through field interviews with 140 rural households in 2018, categorizing income into five groups: plant production, livestock production, non-agricultural activities, off-household income and transfers. Monetary poverty status was assessed, distinguishing households above and below the poverty line. Findings reveal low-income diversification levels, with Shannon Index values of 32.9% for Pelagonia and 35.2% for Polog. Notably, poorer households (42.9%) tend to distribute their income sources more evenly as a strategy to mitigate risk, unlike wealthier households (32.3%), which are more dependent on specific income streams. These findings emphasize the critical role of income diversification in promoting rural development and alleviating poverty in North Macedonia.

***Key words*:** *Shannon Index, equitability, poverty, rural households*

INTRODUCTION

People in rural areas primarily rely on farming, where the key inputs and factors for profitable agriculture are directly dependent on nature. Agriculture is widely regarded as a high-risk sector due to its vulnerability to natural conditions, including unpredictable rainfall, extreme weather events, soil variability, crop diseases, price fluctuations and the perishable nature of agricultural products. These uncertainties make agricultural livelihoods particularly challenging and unpredictable.Therefore, any disturbance in the supply chain of these inputs may make the production process very costly (Hossain, 2024) [11]. Due to some unavoidable risks and uncertainties, people involved with farming are losing interest in agriculture, and this scenario is acute in disaster-prone areas. Increasing the sources of income, therefore, has become an important component of the risk management strategy among rural households (Sultana, 2015) [25]. Agriculture has been changing in meaning and functioning over the past few decades. The tendency to adopt and implement a multiple strategy (engaging in various rural economic activities besides agriculture) to improve the well-being of rural households has been continuously increasing (Dharmawanand Manig, 2000) [6]. The high poverty rate and uneven rural development, along with intensified urbanization, have increased the focus on the rural non-agricultural economy as a bridging sector,connecting urban industrial development with traditional agricultural livelihoods (Bogdanov, 2015) [4].

Dharmawan and Manig (2000) [6], in their research on the development of rural household strategies for livelihood and well-being, demonstrate that rural household welfare strategies based on farm activity diversification have significant socioeconomic and environmental impacts, not only on people living in rural areas but also on those outside these rural areas.On the other hand, as urban

life becomes unhealthier and more stressful, there is a growing interest among city dwellers in seeking rural services for relaxation, recreation and a healthier lifestyle (Gjosheva Kovachevikj, 2021)[10].

Findings by Ellis and Bahigwa (2001) [9] in their research on rural well-being indicate that rural poverty is strongly linked to a lack of land and livestock, as well as the inability to secure alternative farm-based income sources that are not related to agriculture.

Scientific knowledge about models and types of diversification remains insufficiently conceptually defined. As a developmental concept, the rural non-farm economy is commonly described as:

"The rural non-farm economy refers to a set of economic activities in rural areas, excluding those related to primary agricultural production" (Lanjouwand Lanjouw, 1997) [16]; and *"The rural non-farm economy also includes activities linked to agriculture, such as processing agricultural products, other types of small businesses, income from social transfers, interest, dividends, rent, and remittances from urban areas"* (Davisand Pearce, 2001) [5]. Start and Johnson (2001) [20], recognizes two distinct concepts for defining the term and meaning of rural economic diversification: the multifunctionality concept and the non-agricultural linkage concept.

The multifunctionality concept includes activities carried out both on and off rural family farms, such as agricultural production, tourist accommodation, machinery rental, processing of primary products, renewable energy production, and others (*ibid*).

In contrast, the non-agricultural linkage concept refers to diversification activities that are not directly related to primary agricultural production but are still directly or indirectly connected to available resources of the rural family farms. These include hospitality services, rural tourism, sports, cultural and recreational activities, handicrafts, food processing, aquaculture, wild plant foraging, and more (*ibid*).This study adopts the non-agricultural linkage concept.

The European Union has been supporting the improvement of living standards and the establishment of economic stability for rural households through the development of rural non-farm economies (RNFE) for several decades.Expanding non-farm rural employment (NFRE) and diversifying income sources are key policy objectives as they enhance livelihood security and living standards (Pearce and Bank, 2001) [17]. Economic theory suggests that risk-neutral farmers allocate labor between farm and non-farm jobs to equalize expected marginal returns. In contrast, risk-averse farmers prioritize less risky jobs, even at lower wages (risk premium). Non-farm labor helps farmers either to reduce income variability (risk mitigation) or to increase overall labor returns (*ibid*)

Considering the context in which the RNFE concept develops, the diversification of economic activities in rural areas addresses numerous issues, such as:

-Absorbing the surplus rural labor force and reducing hidden unemployment.

-Reducing the risk for agricultural households by engaging them in activities that complement or replace agricultural income.

-Ensuring the survival of households when agricultural production is destroyed or threatened by adverse weather conditions and other risks.

-Contributing to the increase and efficient use of the comparative advantages of rural areas (natural and physical resources, low labor costs, etc.).

-Contributing to faster economic growth in rural areas (Sultana, 2015) [25].

The diverse range of non-farm activities aimed at meeting the needs of rural populations, encompass the production of specialty foods with traditional flavors, the collection of medicinal, aromatic and ornamental plants, rural tourism, the valorization of natural resources and the traditional character of rural communities, as well as craftsmanship focused on handmade products and artisanal services, etc. (Schwarze and Zeller, 2005) [18].

The level and type of income diversification in rural households depend on the availability and accessibility of various income sources and how different household types respond to them. This, in turn, may be influenced by

geographic location, access to labor markets and factories, human and social capital and periodic policy changes. Empirical studies indicate that education and access to infrastructure are strong determinants of diversification (Barrett et al., 2001; Block and Webb, 2001) [2, 3].

Agriculture and rural income diversification in North Macedonia

Approximately 40% of the population resides in rural areas.Agriculture is one of the major economic sectors of North Macedonia, like in other Balkan countries like Greece, Romania, Albania and Bulgaria, where vegetables, fruit, cereals and vine are among the most important crops (Dimova, 2022) [7].

However, in North Macedonia, agricultureshows a significant decreasein its share in the total Gross Value Added (GVA) (from 11.7% in 2014 to 8.1% in 2023) (Kotevska, et al., 2024) [15].

The structural weaknesses of Macedonian agriculture stem from the predominance of small and semi-subsistence family farms characterized by low economic activity. Investment levels are insufficient, unemployment rates remain high and the workforce generally has a lower level of education.Family farms use in average 1.80 ha of agricultural land, have 2.14 livestockunits, and among them farmers are predominantly over 55 years old (39%), with a low educationalbackground (45% have none or only primary education) (Kotevska et al., 2024) [15]. Agricultural producers have weak marketpower that leads to additional pressure on farm income.These challenges have led to intensified abandonment of thesector and depopulation of rural areas, especially by younger people. All these factors limit the adaptive capacityof the agri-food sector and additionally contribute to the deterioration of the situation during crises,visible decrease in the use of arable agricultural land, declined number of livestock and reduced production (Kotevska et al., 2024) [15].

In this context, the development of agriculture requires substantial financial support for farmers, especially for the small family farms (Janeska Stamenkovska and Simonovska, 2021) [13], initiatives and innovations for implementing the Agriculture Knowledge and Innovation System (AKIS) as proposed Simonovska et al (2022) [19].

Another aspect is related to the economic challenges, which in the rural areas are reflected in the high poverty rates and income inequality, which are crucial for understanding the broader socioeconomic context. According to official data from the State Statistical Office (SSO, 2025) [24], the poverty rate in the country in 2021 stood at 23%, with pre-social transfer poverty reaching 43.9%. Income inequality, as measured by the Gini coefficient, was 30.3% in 2021.Similar to global trends, poverty rates in rural areas of the country remain higher than in urban areas.

The main sources of income for rural households remain agriculture and related processing activities (Gjosheva Kovachevikj, 2021) [10]. However, the non-agricultural sector has the potential to play a critical role in reducing poverty, stimulating economic growth, and addressing rural-urban migration. Rural households earn, on average, 10% less than their urban counterparts, with lower employment-based income but higher earnings from self-employment (*ibid*). Entrepreneurial skills and investments in non-agricultural activities could improve rural incomes and reduce dependence on primary agriculture (Gjosheva Kovachevikj, 2021) [10].The non-farm activities are also noticeable in Macedonia, where rural tourism is developing through the utilization of local capacities for accommodation, hospitality, hiking trails and sightseeing, but with very modest progress. According to the latest statistical data, in 2013 there were 25,176 agricultural farms, accounting for 15% of all individual farms (178,125), that were involved in activities beyond primary agricultural production. By 2016, this figure had risen by 3,535 farms to a total of 28,711, marking a 14% increase; however, more recent data is not available (Gjosheva Kovachevikj, 2021) [10].

Official statistical data (2015, 2017) [21, 22] show that, non-agricultural activities in Macedonian rural areas are generally focused on processing primary livestock products (10,467 agricultural farmsin 2013 and 11,771 agricultural farmsin 2016), collecting forest

plants (6,543 agricultural farms in 2013 and 8,354 in 2016 and processing plant production (5,735 agricultural farmsin 2013 and 7,829 agricultural farmsin 2016). A very small proportion of farms are engaged in tourism and accommodationrelated activities (106 farms or 0.4% in 2013; 472 farms or 1.3% in 2016), while home crafts accounted for only 0.3% in 2013 (98 farms) and 0.5% in 2016 (189 farms) (Table 1).

Table 1. Number of individual agricultural farms by additional activity type, 2013 and 2016

Year	2013	2016	2016/2013 (%)	Share in 2013 (%)	Share in 2016 (%)
Handicrafts	98	189	93	0.3	0.5
Tourism and accommodation	106	472	345	0.4	1.3
Aquaculture	128	272	113	0.4	0.8
Wood processing	176	2,309	1.21	0.6	6.6
Forestry activities	1,484	1,403	-5	5.1	4.0
Other gainful activities	2,388	496	-79	8.2	1.4
Processing of plant production	5,735	7,829	37	19.7	22.3
Picking forest plants	6,543	8,354	28	22.5	23.8
Processing of animal production	10,467	11,771	12	35.9	33.5
Total	29,138	35,111	20	100	100

Source: SSO, 2015; 2017 [21, 22].

Regarding the share of rural non-agricultural income in total rural income in the country, the statistical data (SSO, 2017) [22] show that income-generating activities from non-agricultural production accounted for up to 10% of total income in 71% of rural households. Non-agricultural income with a share of 10% to 50% in total income was present in 25% of agricultural households. The lowest share, only 4%, was recorded for non-agricultural income contributing 50% or more to total farm income (Table 2).

Table 2. Income shares of non-farm activities in total rural income, by targeted regions, 2016

Regions	Total	Up to 10%	Share (%)	From 10% to 50%	Share (%)	Over 50%	Share (%)
North Macedonia	28.711	20.347	71	7.283	25	1.081	4
Pelagonia	3.001	2.103	70	704	23	194	6
Polog	3.059	1.963	64	1.008	33	88	3

Source: SSO, 2017 [22].

The data reveal that non-agricultural activities contribute only minimally to total household income, even among families involved in such work. Notably, Pelagonia has a larger proportion of households where non-farm earnings make up a significant portion of income compared to Polog. To better understand the dynamics of rural household economies, this study will specifically address the following research questions:

(1)What is the income composition of rural households?

(2)How does the degree of income diversification differ between poor and wealthier households?

MATERIALS AND METHODS

Data collection

The data for this study was collected through structured interviews conducted in the Polog and Pelagonia regions in 2018, involving a total of 140 farm households, 70 from each region.

Representative micro-units were carefully selected to account for the inherent heterogeneity among households. The selected regions differ significantly in their main characteristics, including demographic structure, economic development, ethnic composition, natural resources, and cultural and historical heritage. Data collection was carried out using pre-tested questionnaires through direct field visits and face-to-face interviews with respondents.

Measurement of rural poverty

The study examines rural monetary poverty to assess the impact of household diversification strategies on poverty reduction, in the targeted regions, Pelagonia and Polog. To measure the poverty of thehouseholds in the sample, the most widespread method based on income was used,by comparing the income of the household with the poverty threshold, which isequivalent to 60 percent of the median national equivalent income of the personsliving in the household (SSO, 2018) [23]. To enable comparisons between households of different sizes and demographic compositions, an equivalence scale was used as a deflator to adjust for these variations. The equivalence scale utilized in this analysis aligns with the one adopted by the State Statistical Office,based on the OECD equivalent scale with weights of 1.0 for the first adult, 0.5 for any other household member aged 14 or over and 0.3 for each child below age 14 (SSO, 2018) [23]. The poverty threshold is calculated as follows:

$$gEI = \frac{THI}{HES} \quad (1)$$

where:

EI - Equivalent income

THI - Total household income

HES - Household equivalence size calculated on the basis of the equivalence scale

$$PT = 0.6 * MNEI * HES \quad (2)$$

where:

PT – Poverty threshold

MNEI – Medial national equivalent income

Classification of income sources

This study develops a classification for rural household income to meet research objectives. Existing literature features numerous classification systems for rural income. While terms like 'off-farm income' and 'non-farm income' are often used interchangeably, they represent distinct concepts. Ellis (2000) [8] specifically defines off-farm income as income derived from wages from other farms, while Barrett et. al. (2001) [2] define these incomes as household income from activities outside the property. As previously emphasized, this study adopts the concept of non-agricultural linkage economies – non-farm income, which implies that in the Rural Non-Farm Economy (RNFE), there are activities not directly related to primary agriculture, but are still linked to the resources available to rural households as economic units in rural areas (Start and Johnson, 2001) [20]. In this analysis there are considered five groups of income sources: 1. income from plant production, 2. income from livestock production, 3. income from non-agricultural activities, 4. income earned outside the household and 5. income from transfers.To get a realistic picture of income from agriculture and rural activities, the net incomes from these two sources were considered, calculated as the difference between gross incomes and fixed and variable costs.

Measurement of income diversification

There are several methods to measure the diversification of rural incomes, including the Shannon Index (Wan et al., 2016) [26],Simpson Index (Koiry et al., 2024) [14] and Herfindahl-Hirschman Index (HHI) (Banerjee and Mistri, 2019) [1].

In this study, the Shannon Index is used as it effectively captures both richness and evenness. Unlike the Simpson Index and HHI, the Shannon Index is sensitive to variations in smaller income sources and applies logarithmic weighting, preventing dominance bias. The Shannon Equitability Index (E), adapted from ecological applications where it measures the structure of species stability (Wan et al., 2016) [26], is employed to analyze income distribution equity among households. This index accounts for both the number of income sources and evenness (proportional distribution) of income sources, providing a robust measure of household-level diversification.Following Schwarze and Zeller (2005) [18], the index is calculated as:

$$E = \left[\frac{H_{income}}{-\sum_{i=1}^{S}\left[\left(\frac{I}{S}*\ln\left(\frac{1}{S}\right)\right)\right]}\right] * 100 \text{.....(3)}$$

$$H_{income} = -\sum_{i=1}^{S}[(incshare_i) * ln(incshare_i)] \text{.....(4)}$$

E – Shannon index for equality
S – Number of income sources
$incshare_i$– The share of income from activity i in the total household income
Ln – Natural logarithm
H_{income}– Shannon index for income diversity within a household,quantifying two dimensions: the number of income sources, and the equitability of their distribution.
The Shannon Equitability Index (E) ranges from 0 to 100, quantifying the percentage of achieved income diversification relative to its theoretical maximum. Higher index values indicate greater income diversification at the household level, reflecting a more balanced distribution across multiple revenue sources.

RESULTS AND DISCUSSIONS

According to the obtained data for the structure of the income sources, it is observed that the highest share of income in the entire sample comes from primary agricultural production, accounting for 37% (4,228 EUR), followed by income from transfers (35%, 4,080 EUR), which include pensions, social transfers, assistance from other individuals and government financial support or subsidies (Figure 1).
This indicates a high dependency of households on this type of income, which is also known as unearned income.
Net income from non-agricultural activities realized by the household ranks third in importance, with a share of 17% (1,910 EUR). This type of income is not primary, but can represent a solid additional source of funds for the household.

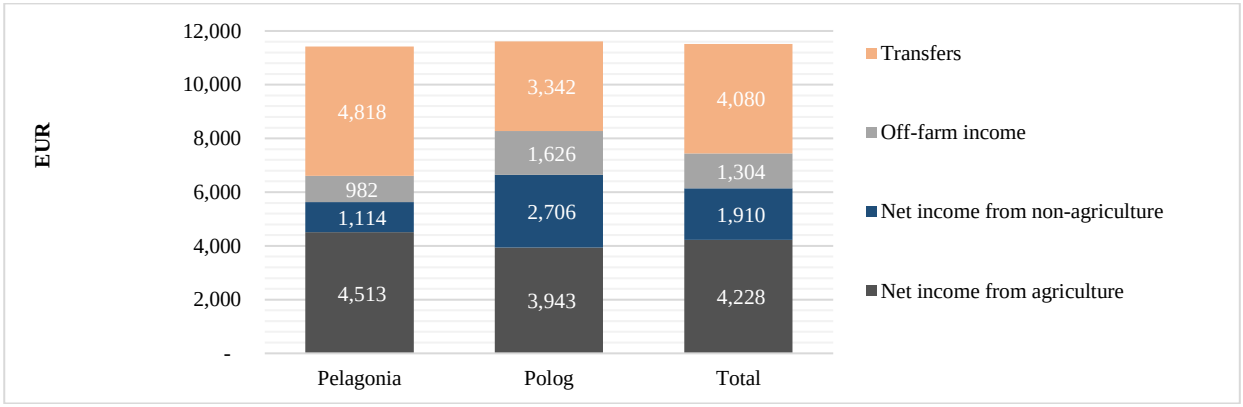

Fig. 1. Structure of average annual income of rural households by regions
Source: own calculations.

Income from wages and seasonal labor outside the household are the lowest, with a share of 11% (1,304 EUR). According to Jakimovski (Jakimovski, 1984) [12], the category of households where a significant part of the income originates outside the farm is less tied to agricultural production, that is, to the productive way of agricultural production, intensification, specialization and expanded reproduction. These households are more oriented towards agricultural production for self-consumption. They offer their products very little on the market and use their monetary resources to purchase industrial goods to raise personal standards and save within the household. Analyzing by regions, the income from transfers in households in the Pelagonia region has the highest values, with a share slightly less than half of the total income, accounting for 42% (4,818 EUR). Agricultural income follows closely at 39% (4,513 EUR), demonstrating near parity with transfer income sources. On third place are incomes from non-agricultural activities within households,

which are approximately the same as incomes from wages and from seasonal hired labor, with a share of 9% (982 EUR) and 10% (1,114 EUR) respectively (Figure 1). In the Polog region, the structure of income in rural households shows smaller differences compared to the Pelagonia region, with the highest share being from agriculture at 34% (3,943 EUR), followed by income from transfers at 29% (3,342 EUR), net income from non-agricultural activities at 23% (2,706 EUR) and lastly, wages and seasonal labor accounted for the smallest share at 14% (1,626 EUR).

To examine the income structure at a household level, the distribution of income sources across the entire sample was analysed. The results of the poverty level calculations for households below the poverty line reveal that the overall poverty rate within the entire sample is 17%, which includes 24 rural households. Of these, 14 households are from the Pelagonia region, representing a 20% poverty rate, while 10 households come from the Polog region, accounting for 14% of the households in that region (Table 3). These findings indicate notable regional differences in poverty levels, with the Pelagonia region exhibiting a higher poverty rate compared to Polog.

Table 3. Income level and poverty rate among poor rural households

Regions	Pelagonia	Polog	Total
Number of households	14	10	24
Poverty rate	20%	14%	17%
Mean (EUR)	4,960.38	7,118.72	6,039.55
Maximum (EUR)	24,892.36	27,792.49	27,792.49
Minimum (EUR)	-2,182.11	-1,850.00	-2,182.11
Standard Deviation (EUR)	3,997.74	5,791.29	5,091.67
Coefficient of Variation	81%	81%	84%
t test = -2.548, p<0.05 (0.012)			

Source: own calculations.

A significant income disparity exists between poor households in Pelagonia (mean = 4,960.38 EUR) and Polog (mean = 7,118.72 EUR), with Pelagonia households earning 30.3% less annually(t = -2.548, p = 0.012). Both regions show a large variation in income levels, with the standard deviation of 3,997.74 EUR for Pelagonia and 5,791.29 EUR for Polog indicating considerable income disparities among these households.

Table 4 presents the income diversification results for rural households, as measured by the Shannon Equitability Index. The Shannon Index of Equality is slightly higher in Polog (35.2%) than in Pelagonia (32.9%), indicating a marginally more diversified income structure. However, compared to other studies, these values remain relatively low, reflecting limited income diversification in both regions.

Table 4. Shannon index of equality by regions

Indicator	Total	Pelagonia	Polog
Number of households	140	70	70
Shannon Index of Equality	30.7%	32.9%	35.2%
Shannon Index below the poverty threshold	42.9%	41.9%	43.2%
Shannon Index above the poverty thresholds	32.3%	30.2%	33.7%

Source: own calculations.

Notably, the Shannon Index below the poverty threshold is higher (42.9%) than above (32.3%) in both regions. Households below the poverty line show a more balanced income distribution across the five rural income sources (41.9% in Pelagonia, 43.2% in Polog), whereas wealthier households rely more on specific income sources (30.2% and 33.7%, respectively).

This finding implies that poorer households tend to rely more equally on multiple income sources, whereas wealthier households are more dependent on specific dominant sources of income.

CONCLUSIONS

The analysis of income diversification among rural households in Pelagonia and Polog highlights significant differences in income distribution patterns, particularly concerning poverty status. These observed disparities likely stem from fundamental differences between the two study regions, including variations in: natural conditions, economic structures, demographics and traditional practices. The results indicate that households below the poverty threshold have a more evenly distributed income structure across

various sources, as reflected in the higher Shannon Index values (42.91% in total, 41.98% in Pelagonia, and 43.20% in Polog). In contrast, households above the poverty threshold exhibit lower Shannon Index values (32.28% in total, 30.2% in Pelagonia, and 33.7% in Polog), suggesting that higher-income households tend to have a more specialized income structure with dominant income sources.

These findings reinforce the importance of well-structured diversification strategies in reducing rural poverty. While diversification can serve as a mechanism to stabilize income, excessive fragmentation across multiple sources may limit the potential for specialization and long-term economic growth. This suggests that overly diversified income structures can have negative effects, as households may struggle to achieve efficiency and scale in any single activity, ultimately hindering their economic advancement. Policies should therefore focus on promoting balanced diversification, where one dominant income source, such as agriculture, is supported by complementary activities, rather than an entirely equal distribution of income across all sources.

To enhance rural household resilience and economic sustainability, policy measures should encourage access to non-farm activities by improving rural infrastructure, facilitating access to markets, providing financial support, and investing in education and skill development tailored to the needs of the rural economy. By fostering a strategic mix of income sources, rural households can achieve greater financial stability while maintaining opportunities for growth and specialization in key sectors.

REFERENCES

[1]Banerjee, R., Mistri, B., 2019, Impact of coal mining in diversification of rural livelihoods: A case study in the Barjora Colliery Area of Bankura District, West Bengal. Space and Culture, India, 6(5), 228–240. https://doi.org/10.20896/SACI.V6I5.335.

[2]Barrett, C. B., Bezunh, M., Aboud, A., 2001, Income diversification, poverty traps and policy shocks in Cote d'Ivoire and Kenya, J. Food Policy. 26(4): 367-84.

[3]Block, S., Webb, P., 2001, The dynamics of livelihood diversification in post-famine. Ethiopia, Food Policy 26(4): pp.333-350.

[4]Bogdanov, N. (2015) Ruralni razvoj i ruralna politika. Poljoprivredni fakultet, Beograd.

[5]Davis, J., Pearce, D., 2001, The Non-Agricultural Rural Sector in Central and Eastern Europe. Report, 2630, Natural Resources Institute, UK.

[6]Dharmawan, A. H., Manig, W., 2000, Livelihood strategies and rural changes in Indonesia: Studies on small farm communities.Proceedings of the International Agricultural Research Conference, University of Hohenheim, Session: Assessment of Poverty and Livelihood Strategies. pp.1-9.

[7]Dimova, D., 2022, Statistical assessment of the average yields of cucumbers and gherkins in some Balkan countries. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 22(1), 175-180.

[8]Ellis, F., 2000, Rural livelihood and diversity in developing countries. Oxford University Press, UK.

[9]Ellis, F.,Bahiigwa, G., 2001, Livelihoods and rural poverty reduction in Uganda. LADDER Working Paper No. 5, pp. 1–29.http://www.foodnet.cgiar.org/SCRIP/docs&databases/ifpriStudies_UG_nonScrip/pdf. Accessed on 28.02.2025.

[10]Gjosheva Kovachevikj, M., 2021, Resource management and their socio-economic impact on rural households in the Republic of Macedonia – Case study in Polog and Pelagonia Region in the Republic of Macedonia. Institute for Sociological, Political and Juridical Research (ISPPI), University Ss. Cyril and Methodius in Skopje.

[11]Hossain, M. R., 2024, Evaluating household's risk management strategies considering heterogeneities in the livelihood diversification: Evidence from farm households of Bangladesh. Social Sciences and Humanities Open, 9. https://doi.org/10.1016/j.ssaho.2023.100785.

[12]Jakimovski J., 1984, Income and income distribution of individual agricultural holdings in the Republic of Macedonia. Yearbook of the Institute for Sociological and Political-Legal Research, 247-262, Skopje. In Macedonian (Доходот и распределбата на доходот на индивидуалните земјоделски стопанства во СР Македонија. Годишник на Институтот за социолошки и политичко-правни истражувања, 247–262, Скопје).

[13]Janeska Stamenkovska, I., Simonovska, A., 2021, Smallholders' priorities in financing: mathematical applications in the context of a post-transition economy. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 21(1), 405-412.

[14]Koiry, S., Kairi, B., Pooja, P., 2024, Impact of income diversification on multidimensional poverty: Household level evidence from tea estates in Bangladesh. Heliyon, 10(5). https://doi.org/10.1016/j.heliyon.2024.e26509.

[15]Kotevska, A., Martinovska Stojcheska, A., Erjavec, E., 2024, European integration and agriculture in the Western Balkans: Current trends and challenges.Regional Rural Development Standing Working Group in South-East Europe (SWG).
[16]Lanjouw, J. O., Lanjouw, P., 1997, The rural non-farm sector: An update. Paper presented at the XXIII International Conference of Agricultural Economists (IAAE) on Food Security, Diversification and Resource Management: Refocusing the Role of Agriculture, Sacramento, USA, August 10–16, 1997.
[17]Pearce, D., Bank, W., 2001, The Non-Agricultural Rural Sector in Central and Eastern Europe. https://www.researchgate.net/publication/242310704. Accessed on 06.03.2025.
[18]Schwarze, S., Zeller, M., 2005, Income diversification of rural households in Central Sulawesi, Indonesia. Quarterly Journal of International Agriculture, 44(1), DLG-Verlag Frankfurt/M.
[19]Simonovska, A., Tuna, E., Gjoshevski, D., 2022, Responsible innovation in agriculture: a case study from North Macedonia. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 22(3), 665-674.
[20]Start, D., Johnson, C., 2001, Transformation, well-being, and the state: Rural livelihoods diversification in South Asia. Overseas Development Institute, London, England.
[21]SSO, 2015, Typology and structure of agricultural holdings, 2013. State Statistical Office, Republic of North Macedonia, Skopje. https://www.stat.gov.mk/Publikacii/5.4.15.01.pdf. Accessed on03.03.2025.
[22]SSO, 2017, Structure and typology of agricultural holdings, 2016. State Statistical Office, Republic of North Macedonia, Skopje. https://www.stat.gov.mk/Publikacii/5.4.17.02.pdf. Accessed on 27.02.2025.
[23]SSO, 2018, Survey of income and living conditions, 2017. State Statistical Office, Republic of North Macedonia, Skopje. Accessed on 26.02.2025.
[24]SSO, 2025, MAKSTAT database, Sustainable Development Goals SDG 2030. State Statistical Office, Republic of NorthMacedonia, Skopje. https://makstat.stat.gov.mk/PXWeb/pxweb/mk/MakStat/MakStat__OdrzlivRazvoj__CeliNaOdrzlivRazvojCOR2030/125_OdrzRaz_Mk_SDG_01_Nopoverty_ml.px/?rxid=46ee0f64-2992-4b45-a2d9-cb4e5f7ec5ef. Accessed on 25.02.2025.
[25]Sultana, N., 2015, Income diversification and household well-being: A case study in rural areas of Bangladesh. International Journal of Business and Economics Research, 4(3), 172. https://doi.org/10.11648/j.ijber.20150403.20.
[26]Wan, J., Li, R., Wang, W., Liu, Z., Chen, B., 2016, Income diversification: A strategy for rural region risk management. Sustainability (Switzerland), 8(10). https://doi.org/10.3390/su8101064.

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COMPARATIVE ANALYSIS OF AWARD-WINNING WINES FROM ROMANIA VERSUS THE TOP WORLDWIDE PRODUCING COUNTRIES

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Abstract

This study investigates award trends in international wine competitions, comparing the performance of Romanian wines to those from top global wine-producing countries. By analysing the number and distribution of awards, the research highlights Romania's positioning in the global wine industry. The findings reveal patterns that show top wine producing countries participation in specific international competitions and their performance, as well as showcasing the growing presence of Romanian wines in these prestigious fairs and the type of medals won. Tableau was used for data organization and analysis to identify trends and patterns, where the outcomes show that despite competing with established wine-producing nations, Romania demonstrates significant progress, with notable achievements linked to its unique varietals and improving quality standards. Additionally, a concentration analysis was conducted to gain a deeper insight into the competitive landscape and the distribution of medals among countries. The study underscores the importance of strategic promotion and continued innovation to sustain and enhance Romania's competitive edge in the global wine market.

Key words**:** *wine industry, international competitions, award-winning, top producing wine countries*

INTRODUCTION

Wine competitions worldwide are usually known as opportunities for wine producers to have a better visibility in the international wine market. Some of the competitions have a long history, where usually there are a significant number of participants worldwide that are eager to receive a medal. On the other side, [9] state that some wineries are hesitant to participate in such type of wine competitions claiming the subjectivity of the judging process. Furthermore, other papers [19] are demonstrating that some of the consumers are sceptical as well regarding the judging process. However, the potential of marketing and reputational gains after a wine competition are much more significant.

Wine fairs have become essential for the global wine industry, serving as key pillars for wineries to enhance their reputation, differentiate their products [15], and achieve premium prices. The medals from the international wine competitions show to the consumers the quality of the wine, introduce the specific winery in the global market, and bring the competitive advantage through other trade partners. For instance, medals awarded at wine competitions give the winery the opportunity to significantly increase the prices of the wine, highlighting the direct benefits of participation for the producers [22].

Additionally, the benefits of competing in international wine competitions extend beyond pricing, as there are some studies emphasising that usually consumers perceive the awarded wines as more qualitative. [23] in their research demonstrate that a factor of high importance is the country of origin of the wine and its reputation in participating in wine competitions. For example, if a country is known for its old tradition in winning medals in international wine fairs, this has a significant influence in consumer perception regarding all the wines in general from that specific country [8], which includes further effects in purchasing decisions [27]. Besides, the acknowledged positive effects for consumer behaviour in wine purchasing, according to [21], the medals and awards reinforce the branding efforts of the winery, where the participation in wine fairs is used as a

marketing tool for penetrating new markets, especially for emerging wineries with limited recognition.

Wine competitions are events where wines are evaluated and judged by panels of experts through blind tastings to determine their quality [20]. Wines are enrolled by the winery in these competitions, where in general a fee is charged for each wine that the producers submit. Furthermore, all the enrolled wines are divided in various categories, for example by type, regions, grape variety, and vintage [25]. The judging process is based on wine professionals and experts that are tasting in blind each wine considering flavour, colour, aroma, balance, and afterwards the judges are assigning some scores. In the end, the total scores are consolidated, and each rank corresponds to awards like Gold, Silver, or Bronze medals depending of each competition [26]. These wine fairs aim to recognize excellence, provide feedback to producers, and guide consumers in selecting qualitative wines [14]. Moreover, worldwide there are many wine competitions organized across the globe, giving the wine producers the opportunity to choose from a large list where to expose their products.

These competitions, for example Mundus Vini, International Wine & Spirit Competitions, Decanter World Wine Awards or Berliner Wine Trophy play a crucial role in the global wine industry, offering producers the opportunity to showcase their wines while helping consumers identify the best wines in the market [2].

Therefore, this study aims to analyse viticultural competitions and their impact on the wine industry, comparing Romania with the top wine-producing countries during the period 2020-2024. It explores the role and significance of these competitions, assesses Romania's participation and performance, and compares the results with those of leading wine-producing nations. The study concludes with key findings and potential implications for the Romanian wine sector.

MATERIALS AND METHODS

This study examines the results between the world's top wine-producing countries compared to Romania in regard to their success in major international wine competitions.

The research focuses on six prestigious competitions: Mundus Vini (summer tasting), Vinarium International Wine Contest, International Wine & Spirit Competition (IWSC), Berliner Wine Trophy (winter tasting), Decanter World Wine Awards (DWWA), and Asia Wine Trophy.

The objective is to analyse which countries win the most awards and identify potential trends in global wine excellence.

Data was gathered from both primary and secondary sources, such as official competition results – award winners from the past five years were collected from competition websites and wine industry reports as statistics regarding wine production allowing for recent trends to be considered. Going further, OIV (International Organisation of Vine and Wine) report was used to identify the world's largest wine producing countries where the first ten (France, Italy, Spain, United States of America, Chile, Australia, South Africa, Argentina, Germany, Portugal) were chosen for the comparison to Romania.

For each country the number of medals depending on the type that were won per competition was recorded and the results were evaluated using Tableau.

Tableau is a tool for data visualization and analysis that helps to interpret the distribution of wine competition awards. This tool allows for the creation of interactive dashboards, enabling efficient exploration of trends, comparisons, and patterns, while for the statistics, Pearson's correlation coefficient was used, which measures the linear relationship between two continuous variables, in this case being number of medals won and wine production. Additionally, a concentration analysis (CR4 - Concentration Ratio 4 and HHI - Herfindahl-Hirschman Index) wasused to better understand the competitive landscape and concentration of medals won across countries.

RESULTS AND DISCUSSIONS

The Table 1 below allows for a clear comparison of the competitions, outlining their founding year, location, organizer, frequency, approximate no. of participants, evaluation criteria, and award distinctions. By analysing these aspects, we can assess Romania's positioning in the global wine competition landscape relative to top wine-producing nations.

Table 1. Competitions overview

Competition	Year Founded	Country	Organizer	Frequency	Participants & Representativity	Judging Panel	Tasting Process	Awards & Criteria
Mundus Vini	2001	Germany	Meininger Verlag	Twice a year (Feb, Aug)	11,000+ wines globally	Sommeliers, winemakers, journalists, traders	Blind tasting	Silver, Gold, Grand Gold
Vinarium International Wine Contest	-	Romania	ASER Consulting & ADAR	Annually	Global participation, focus on Eastern & Central Europe	Sommeliers, wine critics	Blind tasting	Grand Gold, Gold, Silver
International Wine & Spirit Competition (IWSC)	1969	United Kingdom	IWSC Ltd.	Annually	Global participation	International experts	Blind tasting + technical analysis	Bronze, Silver, Gold, Trophies
Berliner Wine Trophy	2004	Germany	OIV (International Organisation of Vine and Wine)	Twice a year (Winter, Summer)	Thousands of producers worldwide	International wine experts	Blind tasting	Grand Gold, Gold, Silver
Decanter World Wine Awards (DWWA)	2004	United Kingdom	Decanter Magazine	Annually	Global participation	200+ Masters of Wine, Master Sommeliers, critics	Blind tasting	Commended, Bronze, Silver, Gold, Platinum, Best in Show
Asia Wine Trophy	2013	Asia	OIV (International Organisation of Vine and Wine) & UIOE (International Union of Oenologists)	Annually	Thousands of global producers	Asian & international experts	Blind tasting	Grand Gold, Gold, Silver

Source: [12], [13], [18], [25], [29], [30].

The analysis of wine competitions awards reveals that Italy (24,835 medals), France (21,762 medals) and Spain (17,076 medals) receive the highest number of awards in the last 5 years. Firstly, these 3 countries emerge as the leading nations, this dominance can be attributed to the cultivated surfaced area with grapes, where Spain, France and Italy are the first 3 in Europe, and in top 4 globally [11] (Fig. 1).

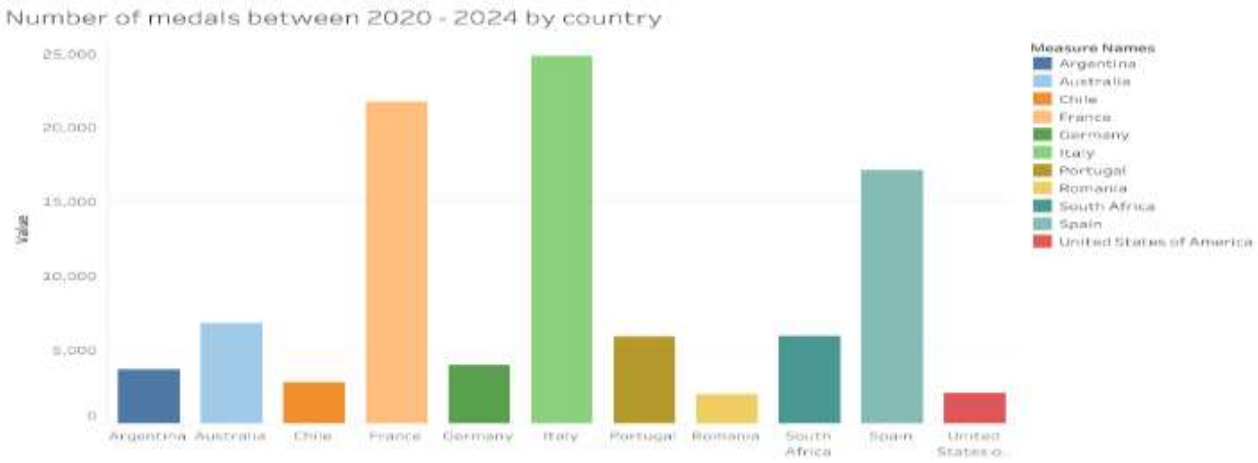

Fig. 1. Number of medals between 2020 – 2024 by country
Source: Processed information from competitions websites.

Moreover, their consistent success in international wine competitions can be attributed to centuries of winemaking traditions, diverse terroirs, and stringent quality standards [3]. These countries continue to dominate both old world and new world wine markets, reinforcing their position as industry leaders. From the European market, Portugal demonstrates significant success in wine competitions, accumulating a substantial number of medals, almost 6,000 medals for the analysed period of the chosen competitions.
Australia and South Africa show notable performances in wine competitions, coming strong behind the top 3 main wine producing countries. These countries, known for their distinctive terroirs and innovative winemaking, techniques [1], continue to gain international recognition. Romania has earned the least number of medals in international competitions, summing only 1,968 medals from the analysed countries. However, the country is positioning itself as a rising player in the global wine industry. Although it does not yet compete with the high medal counts of Italy or France, its performance suggests steady progress in international recognition as showed in the following figures.

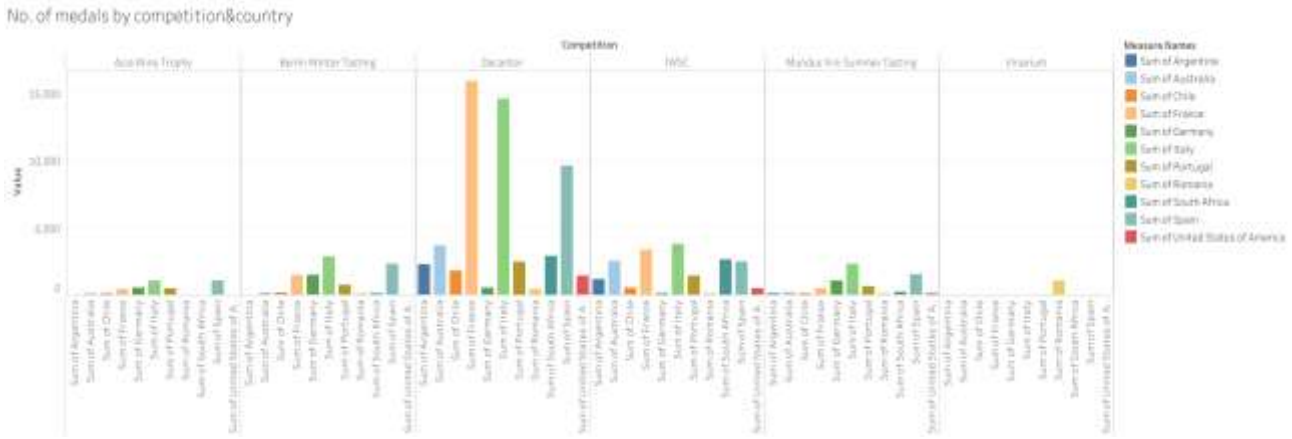

Fig. 2 Number of medals by competition and country
Source: Processed information from competitions websites

On the other side, in regard to which wine competition has awarded the highest number of medals, it seems that in Decanter were won 96,138 medals, being the competition with the most diversity of medals as well. The countries that stand out are France and Italy, where these 2 continue to dominate international wine awards, particularly in the Decanter Wine Awards, where they have secured the highest number of medals. Germany, Portugal, and Australia show strong results, mostly in competitions like Mundus Vini, IWSC and Berliner Winter Tasting. However, The United States, despite being a major wine producer [11], has gained a relatively lower representation in some European competitions, while Chile is cumulating with 15% more medals than the United States. For Romania a moderate number of medals across different competitions were won, demonstrating a growing presence in the international wine scene. In competitions such as Mundus Vini and Berliner Winter Tasting, Romania performs relatively well, with medal counts comparable to or exceeding those of some established wine nations. However, in highly prestigious events like Decanter, Romania's medal count (442 medals) is significantly lower than that of France (15,879 medals), Italy (14,570 medals), or Spain (9,617 medals). In terms of trends between 2020 – 2024 as per figure no. 3, when considering each competition and type of medal, France leads in Decanter and IWSC, winning 29.98% Gold medals in 2023 only in Decanter competition, while Italy achieved 17.02%. At the same time, Italy dominates Mundus Vini and Berliner Winter Tasting, achieving34.57% Gold medals in 2024 at Mundus Vini, and 32.47% Gold medals in 2022 at Berliner Winter Tasting. Spain demonstrates consistent growth in various competitions, particularly in Decanter

(9,617 medals in total) and the Berliner Winter Tasting (2,344 medals in total). Meanwhile, Australia and South Africa have emerged as strong contenders in the Silver (e.g. 2,484 medals Australia and 2,519 medals South Africa) and Bronze (3,388 medals Australia and 2,839 medals South Africa) categories mostly in Decanter and the IWSC. Romania, with its focus on Vinarium were it won 1,092 medals in total, it has found success in this competition area mainly because it is the competition host and that most contenders are coming from Romania, but it falls short in global representation when compared to the more dominant presence of France, Italy, and Spain. Countries such as Chile and Argentina occupy not so strong positions in global wine competitions, as can be seen in Table 2.

Table 2. Distribution of total medals

Country	% Total No. of medals
Argentina	3.77
Australia	7.03
Chile	2.95
France	22.45
Germany	4.09
Italy	25.62
Portugal	6.12
Romania	2.03
South Africa	6.13
Spain	17.62
United States of America	2.19

Sources: Processed information from wine competitions websites.

However, while they do not achieve the same number of Gold medals as France, Italy, or Spain, they perform strongly in the Silver and Bronze categories, particularly in prestigious events like Decanter and the IWSC same as Australia and South Africa.

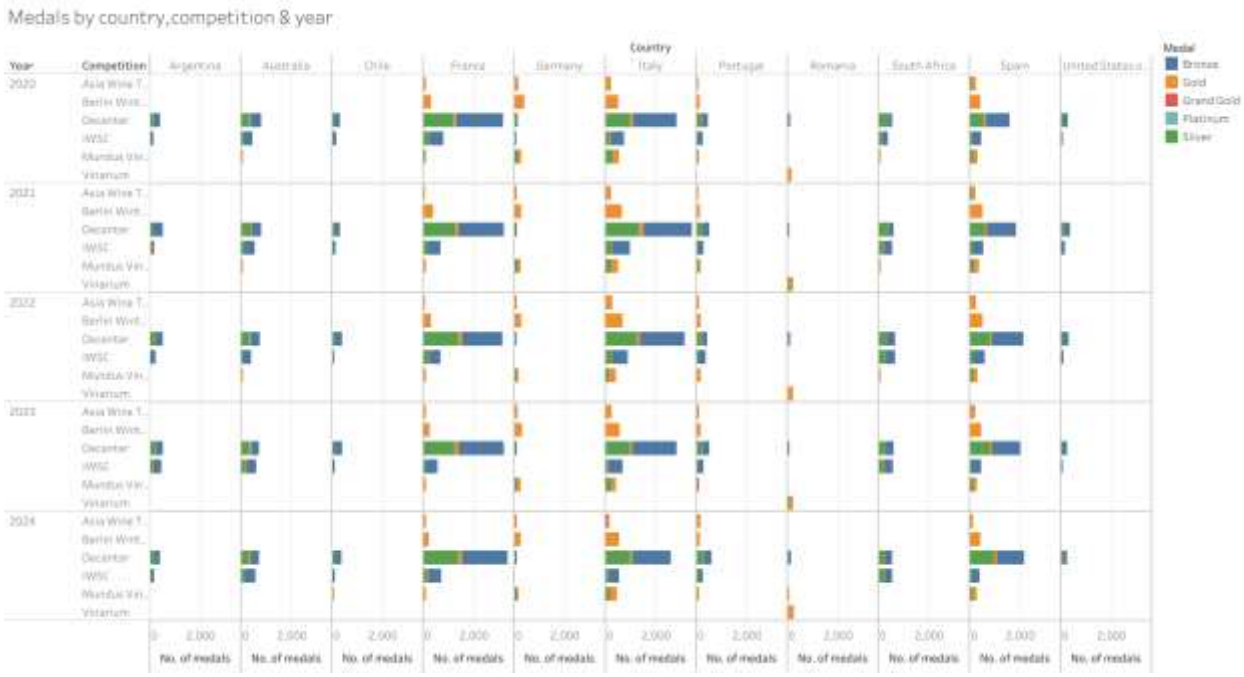

Fig. 3. Type of medals by country, competition and year
Source: Processed information from competitions Websites.

For instance, Argentina secured 154 (17%) Silver medals at the IWSC in 2023, while Chile earned 136 Bronze medals in 2021.

In regards, to the most special awards like Platinum from Decanter or Grand Gold from Mundus Vini Summer Tasting, Berliner Winter Tasting, Asia Wine Trophy and Vinarium, Romania also achieves several Grand Gold medals at Vinarium, reaching a few medals in 2023, while for the rest of the competitions with Grand Gold medals in the analysed period, the country won at least one per competition.

In regard to the participation, it can be noticed from the below Fig. 4 the wide participation of the countries in various wine competitions; considering the number of medals won this is a clear indication of their active involvement in such type of events. Additionally, the range of competitions indicates different focuses, such as regional preferences, for instance the case of Romania with the Vinarium competition or a broad interest in international wine competitions. Old world wine-producing countries such as France, Italy, and Spain maintain a dominant presence in major wine competitions, including Decanter, Mundus Vini Summer Tasting, and Berliner Winter Tasting, reflecting their established position in the global wine industry. Australia, South Africa, Chile, and Argentina are increasingly active in these competitions, like Decanter or IWSC, signalling their rising influence as prominent countries from new world wine producers. Decanter and Mundus Vini Summer Tasting stand out as the most widely entered competitions, drawing participation from nearly all countries, while Vinarium remains an event with a lower participation of the top wine-producing countries. Romania's involvement in all major competitions might be considered a strong asset where the country tries to consolidate its position among the leaders.

For a deeper comprehension of the analysis, wine production was included as it plays a crucial role in understanding the dynamics of wine competitions, as it offers valuable context for assessing the scale and influence of various wine-producing countries.

It refers to the total volume of wine produced of the analysed countries in the period of 2020 – 2024, measured in hectolitres (hl) (Fig. 5).

This metric reflects the capacity of a country's wine industry, its economic significance, and its competitiveness on the global stage.

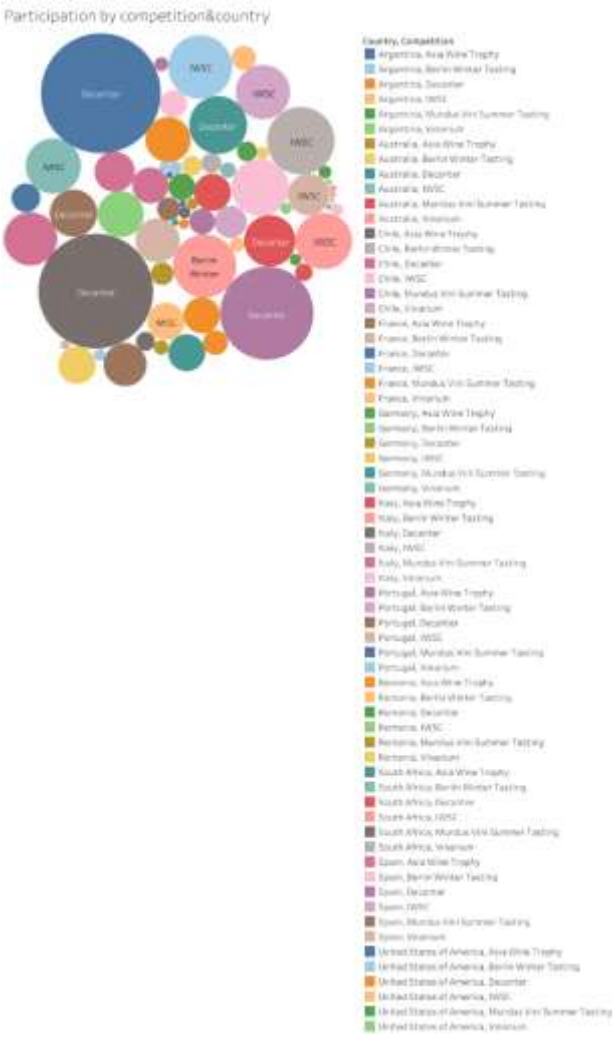

Fig. 4. Participation by competition and country
Source: Processed information from competitions websites

France, Italy, and Spain consistently lead global wine production, a trend that reflects their dominance in international wine competitions. These wine-producing countries benefit from large-scale production, long-established winemaking traditions, and a broad variety of wines [4], enabling them to perform well across multiple competition categories. Meanwhile, new world wine nations like Australia, Chile, and Argentina are

experiencing strong and increasing production levels, which bolster their growing presence and success in competitions, driven by investments in quality and innovation [16]. In contrast, countries such as Germany, and Romania produce smaller quantities but focus on high-quality, specialized wines that excel in local competitions, e.g. Germany at Berliner Wine Tasting, while Romania at Vinarium. However, some countries, including Spain, face notable fluctuations in production from year to year, which can affect their ability to compete consistently at the highest level.

Fig. 5. Wine production (1,000 hl)
Source: Processed information from [11].

The relationship between wine production volumes and the number of medals awarded in international wine competitions offers significant insights into the dynamics of the global wine industry. Countries with high wine production, such as France, Italy, and Spain, benefit from their substantial production capacities, which allow them to submit a diverse range of wines to competitions, thereby increasing their likelihood of securing medals across various categories.

In addition, Australia, Chile, and Argentina, exhibit a positive correlation between increasing production levels and rising medal counts as Figure 6 shows. With moderate to high production volumes, combined with ongoing investments in viticulture and winemaking innovations [7], these nations have positioned themselves as competitive contenders in international competitions. This trend emphasizes the importance of both quantity and quality in achieving success on the global stage.

In contrast, countries with smaller production volumes [11], such as Germany, Portugal, and Romania, despite their lower production levels, these countries achieve considerable success in niche categories. For example, Romania's notable performance in the Vinarium competition since is the main winner (81.56% medals won), despite its relatively modest production levels, demonstrates how targeted excellence can provide significant competitive advantages. Fluctuations in production, as seen in Spain, can impact a country's consistency in competition outcomes. Spain's sharp decline in production from 40,949 thousand hectoliters in 2020 to 23,834 thousand hectoliters in 2023 may account for variations in its medal number during this period. Such variability illustrates the challenges posed by external factors, including climate change [28] and economic shifts, which can influence both production levels and competitive performance.

In addition, while high wine production volumes often correlate with success in international competitions, the role of quality, specialization, and strategic focus should not be overlooked. While traditional wine-producing countries maintain their leadership, rest of the players countries in wine market are increasingly competitive, reflecting the evolving nature of the global wine industry. If we are to look at the United States, the country does not follow the trend, meaning that even it has a significant wine production, the count of medals is quite low.

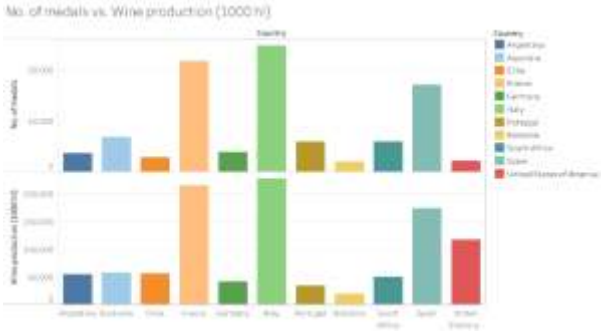

Fig. 6. No. of medals vs. Wine production (hl)
Source: Processed information from [11] and competitions websites

For a deeper understanding of the relationship between number of medals and wine production, a correlation between the two has been performed. The value of the correlation r = 0.918064670 (Fig.7) reveals a general positive correlation between wine production

volumes and the number of medals awarded in international competitions.

Oldword wine countries such as France, Italy, and Spain are positioned in the upper-right quadrant, reflecting their high production levels alongside substantial medal counts. This pattern aligns with their long-established reputations, large-scale production capabilities, and ability to produce a wide range of wines. The United States demonstrates moderate performance, with notable high production and a reasonable number of medals, reflecting its growing influence in the global wine industry.

Australia, Chile, and Argentina, occupy the middle range of the graph, indicating moderate production levels and an increasing number of medals. This suggests that these nations are becoming more competitive. In contrast, countries such as Germany and Portugal have lower production volumes but still achieve a significant number of medals, underscoring their focus on producing high-quality, specialized wines rather than prioritizing volume [24].

Romania emerges as an outlier, with relatively low wine production but a higher number of medals, likely due to its dominance in local competitions like Vinarium. Similarly, South Africa shows moderate production levels and medal counts, reflecting its growing presence and recognition on the global wine stage.

The scatter plot above (Fig. 7) highlights that, while higher wine production is generally associated with greater success in competitions, other factors might be also critical. Countries with smaller production volumes can still achieve significant success by targeting specific markets or prioritizing quality over quantity.

This analysis emphasizes the dynamic relationship between production capacity and competitive success, offering a nuanced perspective on the factors that drive performance in international wine competitions.

Furthermore, a concentration analysis has been conducted for medal-winning countries in wine competitions that helps to assess the competitiveness and dominance of certain nations in the global wine market.

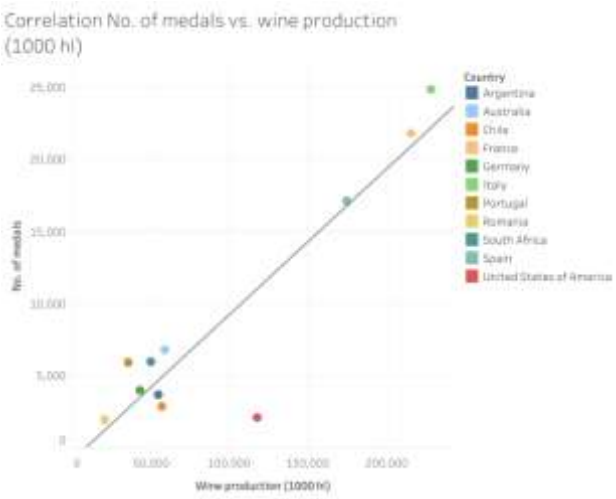

Fig. 7. Scatter plot – correlation between no. of medals and wine production (hl)
Source: Processed information from [11] and competitions websites.

For the concentration analysis the CR4 coefficient was calculated considering the top 4 countries with the highest number of medals won, as per below formula:

$$CR4 = \frac{M1+M2+M3+M4}{Total\ Medals} x\ 100 \text{.....(1)}$$

where:
M1, M2, M3, M4 are top 4 countries in terms of number of medals
Total medals are the sum of all medals for the analysed countries.

$$CR4 = \frac{24{,}835 + 21{,}762 + 17{,}076 + 6{,}810}{96{,}922} x\ 100$$

The result of CR4 72.72% indicates that top 4 countries (France, Italy, Spain and Australia) in terms of medals receive a large share of the awards, this shows a high level of concentration.

On the other side, HHI was calculated considering the formula below:

$$HHI = \sum_{i=1}^{n} g \left(\frac{Mi}{Total\ medals}\ x\ 100\right)^2 \text{.....(2)}$$

where:
Mi is the number of medals won by each country i
Total medals is the sum of all medals by all countries
N is the number of participants
The result of HHI is 1,644.05 that indicates a moderate concentration, where a few participants are winning a significant number of medals.
Overall, the concentration analysis shows moderate competition between the countries that participate in such types of events, few leaders maintain a strong position, while the rest of the countries have a moderate contribution to the results.

CONCLUSIONS

The analysis of international wine competitions results highlights distinct performance patterns among the analysed countries. France, Italy, and Spain continue to dominate, consistently securing the highest number of medals across various competitions. Their success is driven by large-scale production, long-standing winemaking traditions, and the ability to compete across multiple categories. While France and Italy maintain relatively stable medal counts, Spain exhibits more fluctuations, likely influenced by variations in production.
In contrast, new world wine countries such as Australia, South Africa, Chile, and Argentina show increasing competitiveness, particularly in Silver and Bronze categories. These countries, though not yet rivalling the medal counts of oldworld leaders, benefit from growing investments in viticulture and winemaking innovation. On the other side, for the United States the number of medals won have decreased from 2021 to 2024, but still performs better in international competitions than Romania.
Germany and Portugal, despite producing smaller volumes than France, Italy, or Spain, maintain a strong presence in the participation to international competitions, showing great resilience. Romania, however, presents a unique case, unlike the big wine producers, the country has a relatively low overall wine production yet achieves a notable number of medals. This isprimarily due to its participation in Vinarium, a competition where it dominates, whereas its presence in globally recognized competitions such as Decanter and IWSC remains limited.Compared to Germany and Portugal, which secure medals across multiple competitions, Romania's success is highly concentrated in a single event. This contrasts with Australia and South Africa, which, despite having similar or slightly higher production volumes, compete successfully across a broader range of international competitions, while Romania's strong performance in Vinarium highlights the impactful participation in its local competition.
The concentration analysis reveals a moderately concentrated competitive environment, where a few leading countries dominate the medal distribution, while the rest of the countries contribute moderately to the results.
Overall, while high wine production volumes generally correlate with greater competition success, Romania demonstrates that the participation in local competitions can also yield competitive advantages. However, to achieve broader international recognition, expanding its presence in prestigious competitions like Decanter or IWSC may be necessary to further focus on more visibility on the global wine market.

REFERENCES

[1]Anderson, K., Pinilla, V., 2018,. Old and New Producing Countries in the International Wine Market, 1850-1938. Academia.edu. https://www.academia.edu/69038191, Accessed on February 16, 2025.
[2]Beverage Trade Network, https://beveragetradenetwork.com/, Accessed on February 15, 2025.
[3]Charters, S., Gibb, C., 2019, Viticulture and Oenology Scientific Research: The Old World versus the New World Wine-Producing Countries. Academia.edu. https://www.academia.edu/87573543, Accessed on February 16, 2025.
[4]Cholette, S., Castaldi, R., 2005, The Globalization of the Wine Industry: Implications for Old and New World Producers.
https://www.researchgate.net/publication/265748503 Accessed on February 17, 2025.

[5]Decanter.com, https://www.decanter.com/, Accessed on January 7, 2025.
[6]Depetris Chauvin, N., Valentin, D., Behrens, J. H., Rodrigues, H., 2024, Country-of-Origin as bias inducer in experts' wine judgments - A sensory experiment in a world wine fair. International Journal of Gastronomy and Food Science, No. 35.
[7]Fleming, E., Mounter, S., Grant, B., Griffith, G. and Villano, R., 2014, The New World challenge: Performance trends in wine production in major wine-exporting countries in the 2000s and their implications for the Australian wine industry. Wine Economics and Policy, Vol. 3(2), 115 – 126.
[8]Guțan, V., Zugravu, C.L., Turek Rahoveanu, M.M., Zugravu, G.A., 2024, Trends regarding development the sustainable wine tourism in the Republic of Moldova. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol. 24(3), 395-401.
[9]Herbst, F. J., von Arnim, C., 2009, The role and influence of wine awards as perceived by the South African wine consumers. Acta Commercii, Vol. 9, 90–101.
[10]Hopfer, H., Heymann, H., 2014, Judging wine quality: Do we need experts, consumers or trained panelists? Food Quality and Preference, No. 32, 221 – 233.
[11]International Organisation of Vine and Wine (OIV), 2025, www.oiv.int, Accessed on January 23, 2025.
[12]IWCB.ro, https://www.iwcb.ro/, Accessed on January 7, 2025.
[13]IWSC.net, https://iwsc.net/, Accessed on January 7, 2025.
[14]Karlsson, P., 2024, What good are wine competitions? BKWineMagazine, https://www.bkwine.com/opinion/good-and-bad-with-wine-competitions/?utm_source=chatgpt.com, Accessed on January 23, 2025.
[15]Lădaru, R.G., Beciu, S., 2014, Marketing research on wine consumers preferences in Romania. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol. 14(3), 127-130.
[16]Lehram, E., 2017, Argentina vs. Australia Wine Industries: A Reasonable Comparison? https://www.vineconnections.com/argentina-vs-australia-wine-industry-comparison/, Accessed on February 17, 2025.
[17]Livat, F., Remaud, H., Fernandez-Olmos, M., 2024, Factors explaining differences in wine experts' ratings: The case of gender, credentials, occupation and peer effects. Food Research International, No. 191.
[18]Mundus Vini, https://www.meininger.de/, Accessed on January 7, 2025.
[19]Neuninger, R., Mather, D., Duncan, T., 2017, Consumer's scepticism of wine awards: A study of consumers' use of wine awards. Journal of Retailing and Consumer Services, Vol. 35, 98–105.
[20]New York Wines, n.d.. How a Wine competition works. New York Wine & Grape Foundation. https://newyorkwines.org/how-a-wine-competition-works/?utm_source=chatgpt.com, Accessed on January 23, 2025.
[21]Niklas, B., 2024, The effect of South African wine certifications on price premiums and marginal costs: A two-stage hedonic approach. Economic Modelling, no. 132.
[22]Paroissien, E., Visser, M., 2018, The causal impact of medals on wine producers' prices and the gains from participating in contests. American Association of Wine Economists, AAWE Working Paper, No. 223.
[23]Rodrigues, H., Rolaz, J., Franco-Luesma, E., Sáenz-Navajas, M.-P., Behrens, J., Valentin, D., Depetris-Chauvin, N., 2020, How the country-of-origin impacts wine traders' mental representation about wines: A study in a world wine trade fair. Food Research International, No. 137, 109480.
[24]Singh, R., 2022, Pinot & Port: Germany & Portugal shine bright. https://rumasingh.com/2022/06/13/pinot-port-germany-portugal-shine-bright/, Accessed on February 28, 2025.
[25]Sommelier Wine Awards. The judging process. https://www.sommelierwineawards.com/about/the-judging-process, Accessed on January 23, 2025.
[26]Tach, L., 2024, Inside The Secretive World Of Wine Competitions. Forbes. https://www.forbes.com/sites/lizthach/2024/03/12/a-glimpse-inside-the-secret-world-of-wine-judging-competitions/, Accessed on January 23, 2025.
[27]Turek Rahoveanu, M., M., Turek Rahoveanu, A., 2024, Marketing and innovation in the Romanian wine market. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol. 24(1), 999-1011.
[28]van Leeuwen, C., Sgubin, G., Bois, B., Ollat, N., Swingedouw, D., Zito, S., Gambetta, G., 2024, Climate change impacts and adaptations of wine production. Nature Reviews Earth&Environ, No. 5, 258–275.
[29]Wine-Searcher, https://www.wine-searcher.com/, Accessed on February 15, 2025.
[30]Wine-trophy.com, https://www.wine-trophy.com/, Accessed on January 7, 2025.

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THE EUROPEAN UNION LONG TERM VISION FOR RURAL AREAS - PROSPECTS FOR BULGARIA

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Abstract

The European Union's long-term vision for rural areas outlined the challenges, opportunities and prospects for rural Europe until 2040. The initiative resulted from a broad discussion among main stakeholders, institutions and the rural community. The CAP strategic plans also contribute to the main priorities of the EU vision. The study aims to outline the main trends in rural areas, focusing on Bulgaria and highlighting recommendations for future balanced and sustainable development of rural territories. The research follows the main action areas set in the strategic paper and analyses tendencies and possible paths until 2040. The results indicate that rural areas are lagging behind in main aspects such as access to essential services, infrastructure, and challenges of depopulation and ageing. In addition, there is a lower quality of life, job opportunities, and career prospects. The balanced development of rural areas requires capacity building based on local community members' participation and increased inclusion to boost innovation implementation and green transition.

Key words**:** *revitalization, rural development, strategic plans, local community*

INTRODUCTION

Rural areas are a vital part of the European Union. They are vibrant territories that face many challenges, but have untapped potential for sustainable and balanced development. In order to transform and continue to have an important role in ensuring income, employment and food security, maintaining ecosystems and biodiversity, the European Commission presented a long-term vision for the EU's rural areas by 2040 [11]. The document highlighted the future of these territories and their importance in society.
The rural regions in the EU are diverse, and so are the challenges they face [9]. In the context of global issues, rural areas are part of the academic and political discussions [3, 30]. A common approach to rural policy at the European level is needed. Several studies have explored various aspects of the rural region's potential for generation renewal, implementation of digital technologies and achieving a green and just transition [1, 10, 24, 27, 28, and 32].
As part of multicultural Europe, Bulgarian rural areas have their features and specifics. Different researches outlined the trends and perspectives for rural Bulgaria [2, 4, 7, 20, 22, 25, 26, and 33]. The new rural vision of the EU represents an essential step toward a green future and opportunities for Bulgarian rural areas to address the emerging challenges.
The study aims to outline the main trends in rural areas, focusing on Bulgaria and highlighting recommendations for future balanced and sustainable development of rural territories.

MATERIALS AND METHODS

The study follows the main action areas set in the strategic document of the EU "A long-term vision for the EU's rural areas", and analyses tendencies and possible paths for these territories until 2040. Therefore, the survey is based on the Eurostat methodology [17].
Regulation (EC) No 1059/2003 and Regulation (EU) 2017/2391 set up the common classification of territorial units for statistics and territorial typologies.

The survey is based on the definition provided by EUROSTAT "for urban-rural typology (predominantly urban regions, intermediate regions, predominantly rural regions) and the degree of urbanisation (cities, towns, suburbs and rural areas)" [18].

RESULTS AND DISCUSSIONS

In order to ensure the sustainable development of rural areas in the EU, the European Commission launched the EU Rural Vision based on the debate between main stakeholders, institutions and the rural community. It outlines "ten shared goals, summarised by four areas of action, embodying a long-term vision for stronger, connected, resilient and prosperous rural areas by 2040". [11]

In 2021, the Rural Pact was established as part of the EU's long-term vision for rural areas. The Pact was complemented by a Rural Action Plan, which includes four building blocks and nine initiatives [12].

The survey observes these four areas of action, with a focus on Bulgarian prospects and opportunities.

Stronger rural areas

Rural depopulation and the issues with generation renewal are key challenges in rural areas. Therefore, population distribution based on the degree of urbanisation and urban-rural typology is important in shaping rural policies. Germany has 83 million inhabitants in the EU and is the most populous country. By contrast, the least population is registered in Malta (around 500,000 inhabitants) [17].

Based on the Eurostat data [17], in 2021, 39% of the EU population is concentrated in the cities, followed by those living in towns and suburbs (37%) and rural areas (25%).

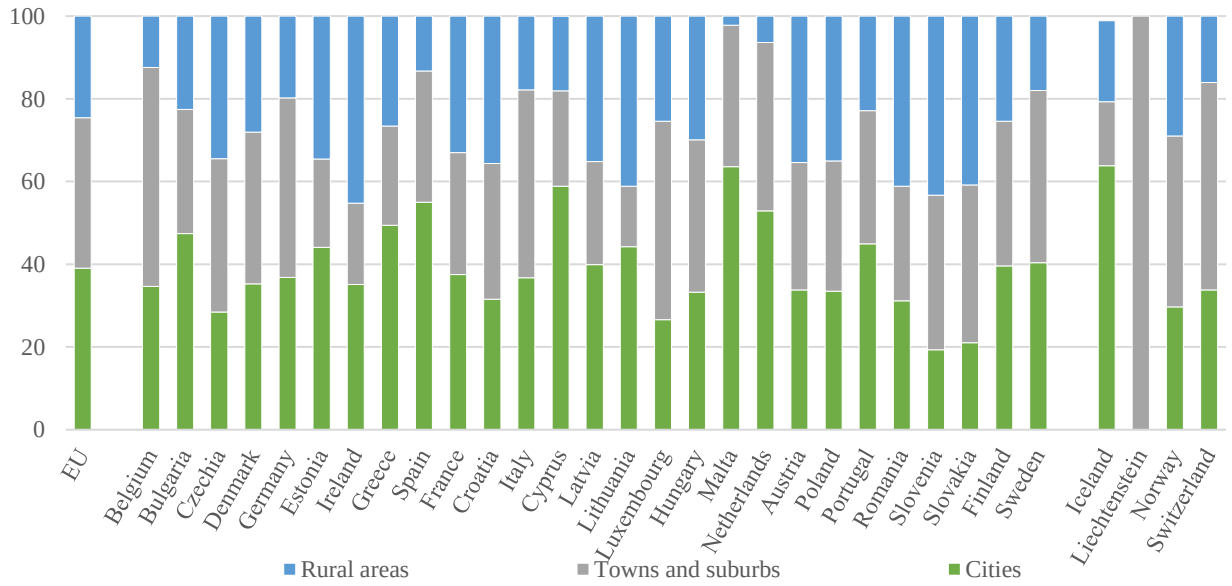

Fig. 1. Distribution of population by degree of urbanization (% share of total population, 2021)
Source: [17].

Population distribution based on urban-rural classification across urban, intermediate, and rural areas differs significantly across European countries. The highest concentration of city inhabitants is found in Malta (63%), Cyprus (59%), Spain (55%), and the Netherlands (53%). The rural areas are home to 45% of Ireland's population, followed by Slovenia, Lithuania, and Romania. Towns have the largest share of residents in Belgium, Luxembourg, and Italy. In Bulgaria, 47% of the population is in cities, while 22% live in rural areas, according to the degree of urbanization [17].

Eurostat data [17] indicates that 38% of people live in predominantly urban areas, while 21% are in predominantly rural.

Apart from Malta, where the entire country is urbanized, the Netherlands has the highest share of residents in predominantly urban

territories (78%). In contrast, over half of Ireland and Slovenia's citizens live in predominantly rural regions. Hungary and Latvia have the most significant proportion of people residing in intermediate regions, a trend also recorded in Bulgaria. In the country, more than 80% of the population is included in this category, while 17% lives in predominantly rural areas [17].

It can be concluded that most people are concentrated in cities and towns, while rural regions face challenges such as depopulation and migration.

The educational level is crucial for achieving social and economic development [14]. Education investments are considered one of the most essential in developing human resources and capital [31].

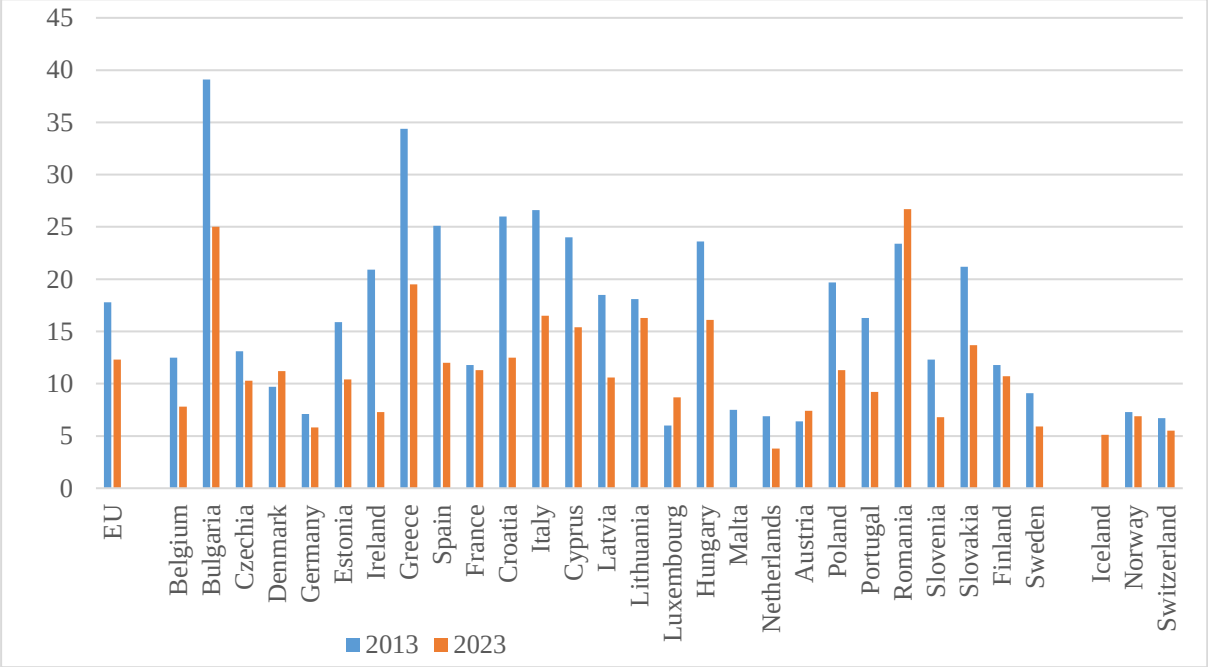

Fig. 2. Young people neither in employment nor in education and training in rural areas
Source: [17].

According to EU data [17], many young people between 15 and 29 are outside the labour force. The European pillar of social rights highlights the essential indicator that people are "not employed or are not in education and training (NEET)" [17].

In 2023, 11% of all young people in the EU are neither in employment nor in education and training. The indicator is higher in rural areas (12%) and towns and suburbs compared to cities (10%) [17].

Regarding gender – the NEET is higher for females (12%) than males (10%). This trend is observed in all three categories based on the degree of urbanisation. However, the most significant difference is registered in rural areas (4.1 points) [17].

There were three EU countries where the share of people neither in employment nor in education and training was higher among young males than young females in 2023. In Estonia, Belgium and Portugal, the tendencies are reversed, and the NEET rate is higher for young males, while the there is no difference in Spain and Finland. In Eastern Europe, the most significant gender gaps in this direction are in Czechia, Romania, Hungary and Poland. In Bulgaria, the difference is 6.1 points [17].

In 2023, the highest rates of NEET are in Romania, Italy and Greece. The share is particularly high among young females living in rural areas, especially in Romania (35%), Bulgaria (28%) and Greece (22%) [17].

The results show that the higher share of the indicators is recorded not only in rural areas but also in cities and towns. However, in rural territories the biggest difference based on gender is observed. Therefore, serious investments and targeted policy measures are needed.

The comparison of the NEET rate between 2013-2023 shows a decline of 4.9 percentage points at the EU level. The reduction is registered in all urbanization levels: rural (-5 points), towns (-4.8 points) and cities (-4.2 points).

Only Germany, Luxembourg, and Austria did increase their share of NEET. In Lithuania, there was growth in the indicator for suburbs and towns. On the other hand, it has risen in rural Romania.

The highest decrease of NEET is recorded in Greece (-14.9 points in rural areas), Bulgaria (-12.1 points), Ireland (-13.6 points.).

Although there are positive trends in Bulgarian rural regions observed for 2013-2023, in Bulgaria and Romania, the share of NEET rate is two times higher than the EU- average. In addition, the biggest difference between the indicator in cities and rural areas is registered.

The NEET rate as a vital indicator for the renewal and revitalisation of rural areas shows challenging trends in Bulgaria.

Connected rural areas

Digitalisation and digital technologies give opportunities for new business models, job creation, and connection beyond location [8]. However, issues are also linked with this digital transformation that must be considered.

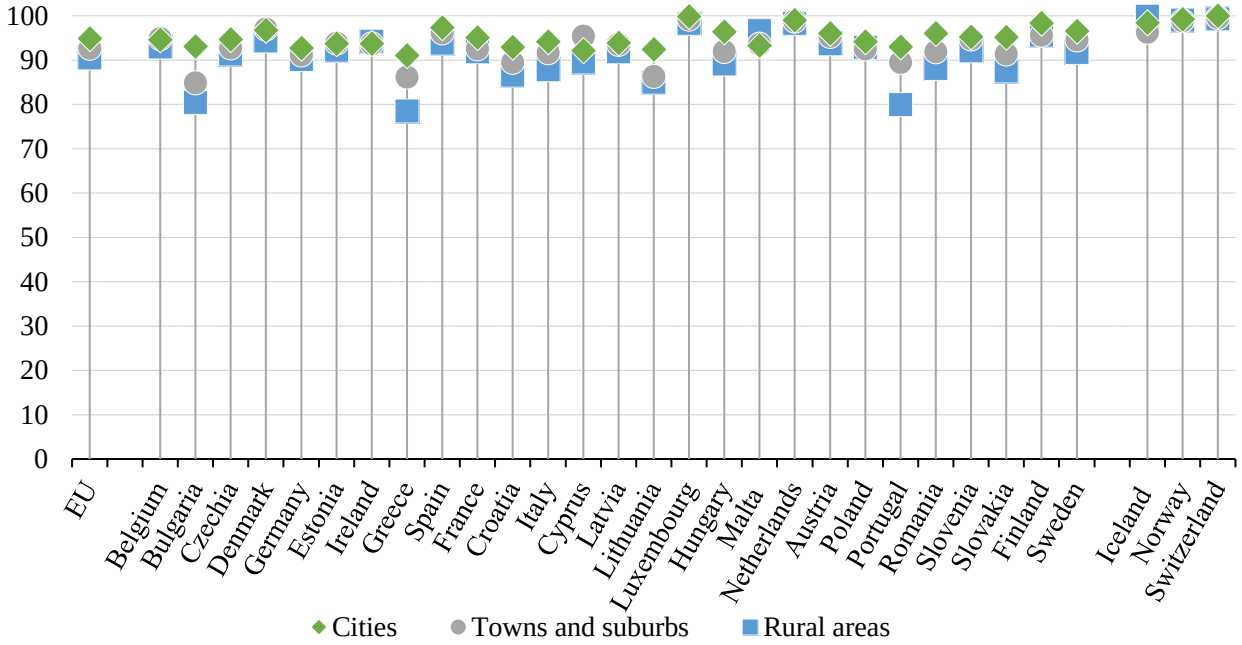

Fig. 3. Households with internet access, by degree of urbanisation, 2023
Source: [17].

The number of households in the EU connected to the Internet is an important indicator in the field of digitalization. The share has increased in recent years [17].

In 2023, 93.1% of the households in the EU have internet access - the share is slightly higher in cities (95%) compared to towns and suburbs (93%) and rural areas (91%).

In most EU countries, the highest share of households with internet access is observed in cities. The most significant level is recorded in Luxembourg (99.9%) and the Netherlands (99%).

In Malta (96%) and Ireland (94%), rural households have the highest internet access. On the other hand, there are countries with a lower share of rural areas, Portugal (80%) and Greece (79%). In Bulgaria, the indicator is 81%, around 10 points lower than the EU average.

The data shows positive trends, however, Bulgarian rural areas lag behind the average EU results.

Digital skills are currently part of everyday life and crucial for today's labour market and job opportunities [15].

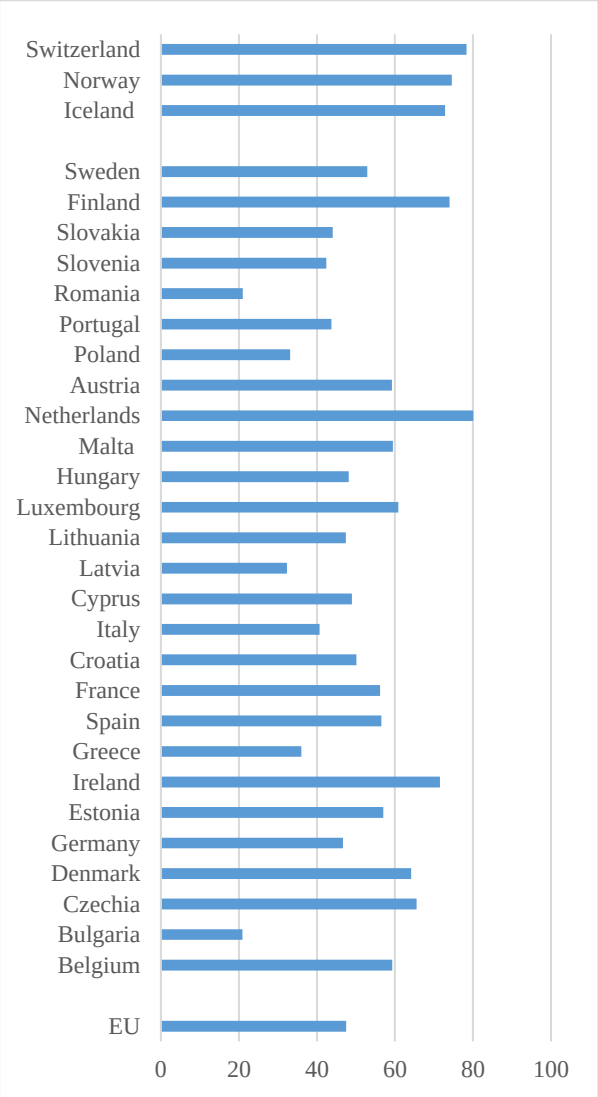

Fig 4. Share of population (16–74 years) with at least basic overall digital skills in rural areas, 2023 (%)
Source: [17].

The EU policy is directed toward developing digital skills and society. It has set a target "at least 80% of people aged 16–74 years should have at least basic digital skills by 2030." [16]. According to Eurostat [17], in 2023, almost 90% of EU citizens had at least basic communication and collaboration digital skills. The share is higher in cities (more than 91%) compared to rural territories (85%).

In 2023 [17], 56% of the EU population have at least basic overall digital skills, a 24 points lower target for 2030. The results show that the set goal is ambitious and unlikely to be achieved in the following years. The share is higher in cities (63%) compared to towns and suburbs (53%) and in rural areas (48%).

According to Eurostat data [17], in almost all Member-States, the highest indicator level is recorded in cities except Belgium, Ireland and Cyprus.

In Scandinavian countries and the Netherlands are registered the greatest level of the indicator in the cities – Finland (89%), the Netherlands (84%), and Denmark (77%). By contrast, the lowest share is observed in Romania (38%) and Bulgaria (46%) [17].

In 2023, the share of people with basic digital skills is the highest in Finland, the Netherlands and Ireland. The lowest level is indicated in Bulgaria and Romania, around 21%.

The data show serious challenges related to digital skills in Bulgaria's rural areas. In addition, the country is lagging behind the EU average in the other two categories based on the degree of urbanization.

Depopulation, age structure, and generation renewal are only part of the challenge. Bulgaria is facing a number of issues related to digitalization, especially in agriculture and rural areas [4].

Resilient rural areas

Rural areas, as part of the EU's ambitious vision for green transformation and just transition, have to be resilient to climate change and economic crises and to ensure equal rights and social protection to all citizens of the EU.

Despite the support provided by the European social model, 21% of the EU population remained at risk of poverty or social exclusion in 2023 [17]. According to Eurostat data [17], between 2015 and 2019, this rate declined, but the COVID-19 crisis in 2020 caused a slight increase. In the following years, 2021 and 2022, mixed trends are noticed, while 2023 registered a decline in the indicator.

Eurostat data for 2023 [17] shows no significant differences between categories; the indicator is around 22%. While the disparities at the EU level are relatively minor, there are notable contrasts among member states.

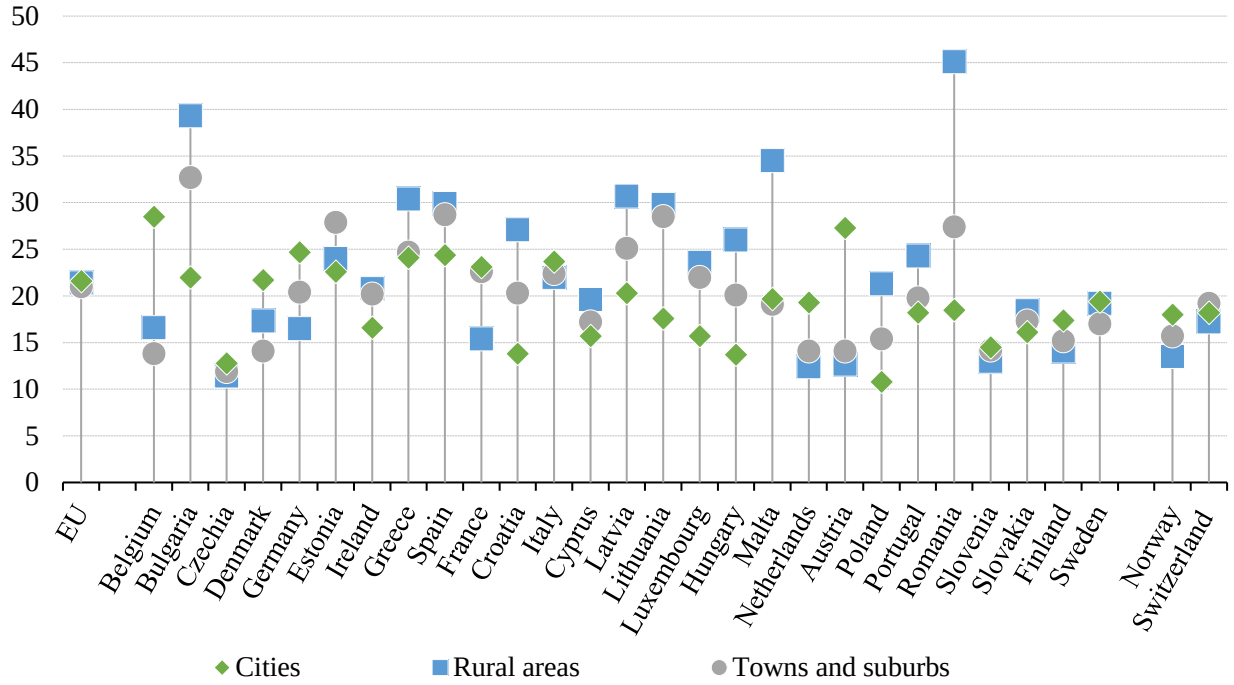

Fig. 5. People at risk of poverty or social exclusion, 2023
Source: [17].

In Romania, the share of people at risk of poverty or social exclusion is 27 points bigger in rural territories compared to the considerably lower level in cities. The tendencies are similar in Bulgaria, where the rate is 17 points higher in rural territories than individuals in the cities.

The highest level of the indicators is observed in the rural areas of eastern and southern countries, such as Romania (45%) and Bulgaria (39%) [17].

The reverse trends are registered in some Western and Scandinavian countries, where the most considerable risk of poverty or social exclusion shares are in the cities. Belgium, Germany, and Austria are among the Member states with the most substantial share of the population at risk of poverty or social exclusion in cities.

The lowest indicator level in cities is observed in Ireland, Romania and Poland, while in the towns and suburbs, the share of people at risk of poverty or social exclusion is the lowest in Czechia, Denmark and Belgium. The smallest rate in rural areas is recorded in Czechia, Denmark, Austria and Finland.

The results in Romania and Bulgaria outline the contrasts between cities and rural regions. The data indicate a low capacity for boosting economic potential, which leads to higher poverty and inequality [5].

The uneven income distribution can hinder economic development and lead to various negative processes, such as higher levels of unemployment and a bigger share of the population at risk of poverty and social exclusion.

According to Eurostat [17], in 2023, almost 20% of people in the EU had an income of at least 150% of the median income. The most unequal was the distribution in cities (24%) compared to towns and suburbs (18%) and rural areas (14%). The data indicates that the most significant inequalities are recorded in the cities.

In Romania (37%), Bulgaria (36%), and Lithuania (34%), the level of inequality in the cities is the highest [17]. The indicator is not the biggest in the cities, only in five Member-states. In Ireland, Malta and Latvia, the uneven distribution is concentrated mainly in towns, while in the Netherlands, the most significant level is registered for people living in rural territories.

Gender equality and the gender pay gap are crucial aspects of social resilience and significant global challenges.

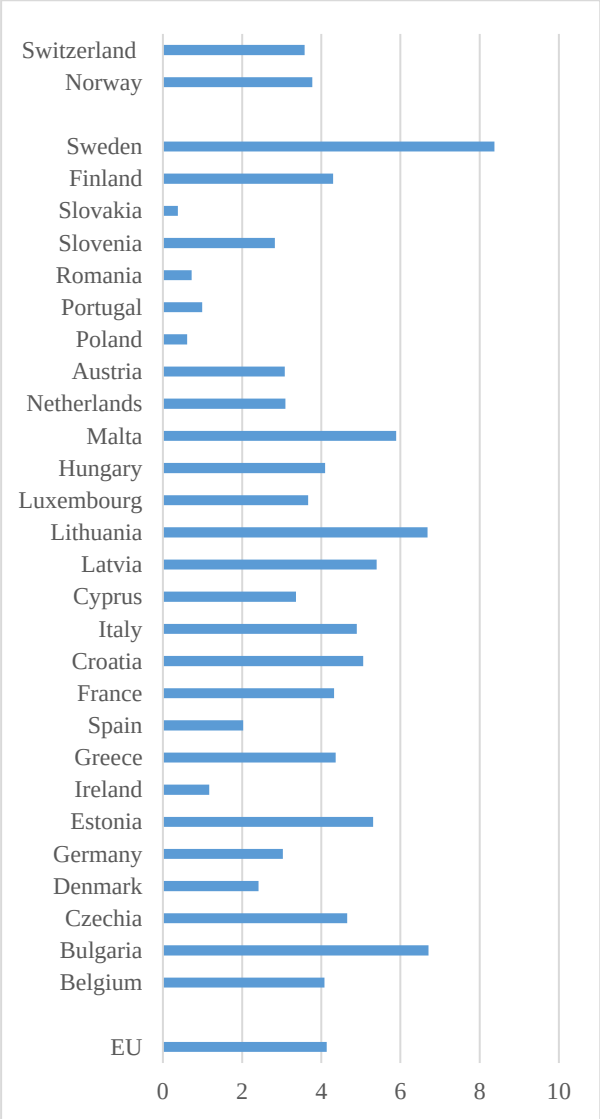

Fig. 6. Gender gap for median equivalised net income in rural regions, 2023 (%)
Source: [17].

Considerable progress has been achieved in fostering gender equality in the labour market, with the EU playing a key role in advancing women's rights and opportunities [19, 23, and 29].

All Member-states share the commitment and prioritize the reduction of the gender pay gap. The Directive 2006/54/EC on equal opportunities and treatment of men and women is the right step towards fair opportunities. According to Eurostat data [17], in 2023, the median equalised net income for males was €20 867 compared to €19,858 for females. The figure 6 represents an average rate that includes the total population, also the unemployed, and gives different insight than gender pay gap statistics.

The indicator in the EU average shows a slight difference in the three categories based on urban typology.

In all Member-states, median equivalised net incomes for males are higher than for females. Only in Slovakia the trend is reversed, and the indicator for females was bigger than for males.

The most significant gaps are registered in the three Baltic countries and Hungary among the cities' population. The indicator is the highest in towns and suburbs in Latvia, Lithuania and Czechia. In rural areas, the differences between median equivalised net incomes for males and females are the smallest. However, the indicators are highest in Sweden, Bulgaria, and the Netherlands. By contrast, the differences are the slightest in Slovakia, Poland and Romania [17].

The data shows that the gender gap is the smallest in rural areas, a positive trend indicating more equal opportunities for males and females.

Prosperous rural areas

Economic development is a major aspect of revitalising rural areas. The EU's cohesion policy is focused on supporting the lagging regions [13].

GDP per inhabitant (PPS) is a key measure of economic development, growth, and living standards [35].

In 2021, GDP/inhabitant in the EU in predominantly urban territories is 28% higher than the indicator in intermediate and predominantly rural areas.

Most member states, predominantly urban territories, record the highest GDP/per capita. However, Austria is an exception, where GDP/inhabitant in intermediate was 2% higher than in predominantly urban areas.

At the EU level, GDP/inhabitants in predominantly urban areas is 1.65 times greater than in rural regions [17].

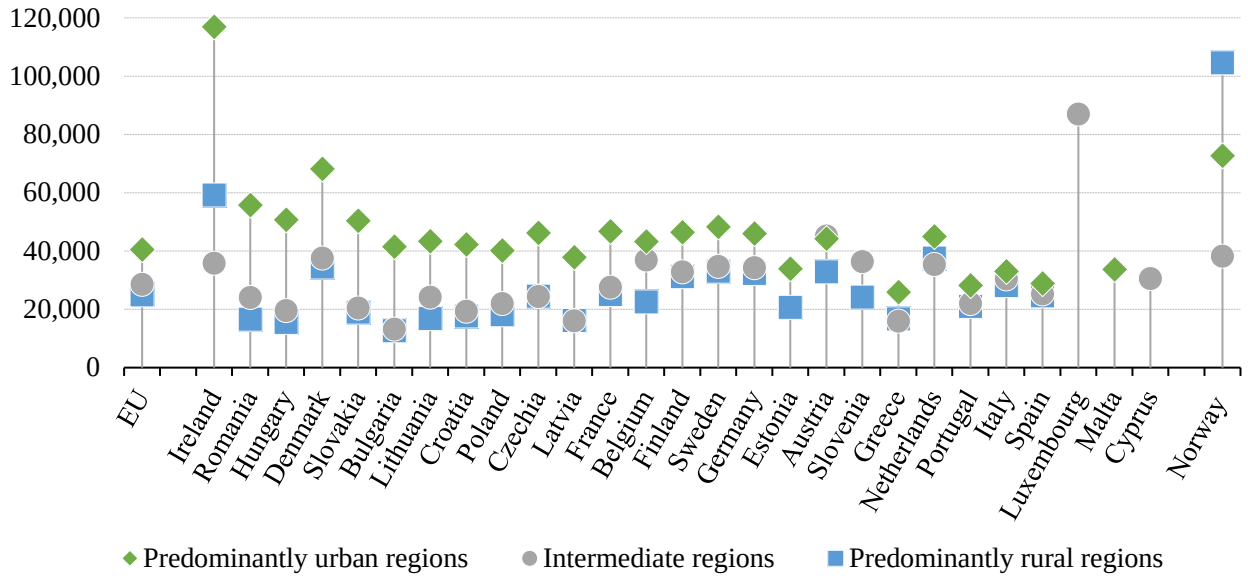

Fig. 7. GDP per inhabitant, 2021 (PPS)
Source: [17].

Significant intraregional disparities are outlined in some member states. In Bulgaria, Romania and Hungary, GDP per capita in urban regions is more than three times higher than in rural areas. Conversely, the smallest differences are observed in Portugal, Austria, the Netherlands, and Italy, where GDP per capita in urban territories is only 1.4 times bigger than in rural regions [17].

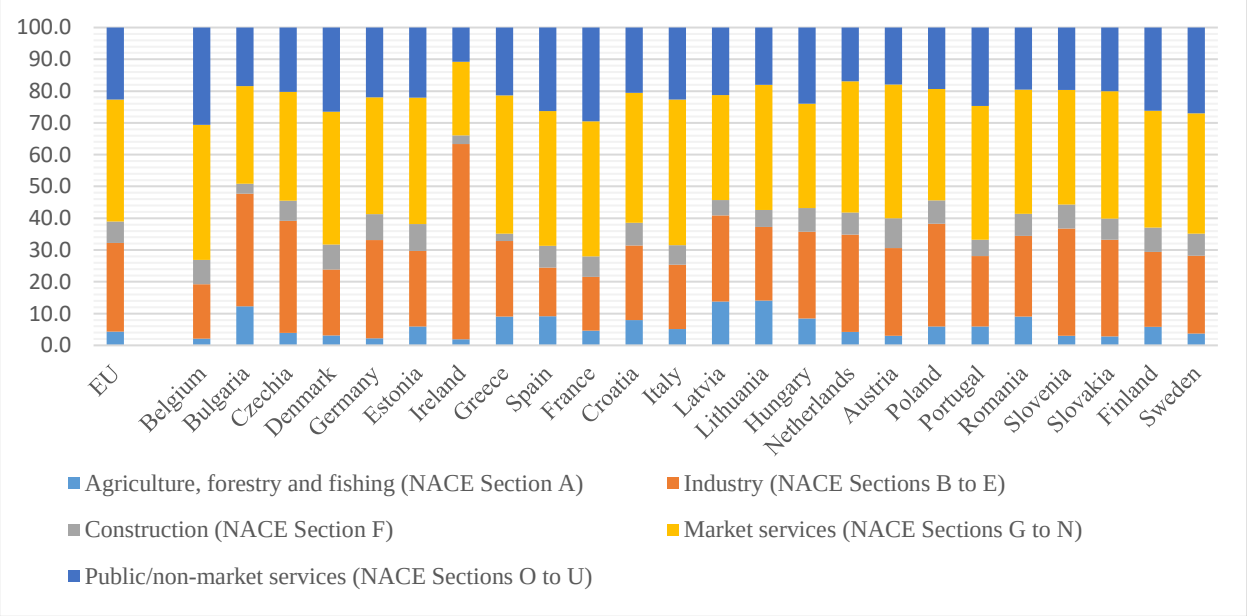

Fig. 8. Gross value added in predominantly rural areas, 2021
Source: [17].

The gross value added by sectors is also an important indicator of the regional economy structure. The analysis is based on the NACE methodology [17]. According to Eurostat data [17], the market services dominate GVA in the EU in all three categories based on urban-rural typology. The sector plays a crucial role in urban regions, generating 58% of the GVA.
On the other hand, agriculture, forestry and fishing account for the most significant part of GVA in rural areas. They have the highest share in Latvia (14.1%), Lithuania (13.8%) and

Bulgaria (12.3%) [17]. In Bulgarian rural regions, industry is the most important in generating GVA (35%). However, the sector accounts for more than 65% of GVA in Ireland [17]. The main reasons for the observed trends are related to the pharmaceutical companies in the Irish rural areas. In Ireland, Bulgaria, and Czechia, the industry is leading in the rural economy, while market services have the biggest share in the other Member-states. In Bulgaria, rural tourism is also important in generating the GVA [34]. Based on the results, it can be summarized that agriculture still plays an important role in the Bulgarian rural economy. The sector is the main source of income and employment.

Prospects and scenarios for Bulgarian rural areas

Rural areas are vital for the sustainability and green transformation of the EU. In addition to maintaining biodiversity and ecosystems, rural territories care for the country's heritage, traditions, and culture.

In Bulgaria, rural areas are facing a number of challenges. Policy efforts have to be well-targeted and directed to overcome the current issues. The EU published a report [6] as a starting point for debate on rural development and implementation of the long-term vision for rural areas.

The report highlighted four scenarios in this regard: (1) Rurbanities scenario is linked to limited governance coordination, less cohesion and more diverse population with a lack of sense of local community (2) Rural renewal scenario is associated with sustainable solutions, bioeconomy and circular economy development (3) Rural connections scenario is related to declining population and establishment of rural hubs with digital infrastructure, agricultural digitalisation and implementation of precision technologies. (4) The Rural specialisation scenario is linked to structural transformation, lower economic and social possibilities, declining population and land concentration in a few large stakeholders. These future paths have advantages and disadvantages. The scenarios are imaginary tools that could support better policy solutions and help to avoid the negative processes related to their characteristics. As for Bulgaria, all the scenarios are possible paths. However, Rural specialisation and Rural renewal scenarios are closer to Bulgarian reality. Both of the paths have negative effects on local communities and agricultural development. On the other hand, [21] outline four models of rural development. The first is a sectoral, followed by a multisectoral approach prioritising agriculture. The territorial model highlights broader cooperation in the rural economy, while the local model considers regional differences and local features. The local approach is at the heart of the new CAP strategic plans and outlines sustainable and balanced rural development opportunities. However, the new model requires building administrative capacity, better coordination, and cooperation among different governance levels.

CONCLUSIONS

Based on the analysis, some conclusions can be highlighted:

(1)Key indicators related to the EU's Long-term rural vision show serious differences between Bulgaria and the EU average. Bulgarian rural areas are lagging in terms of social and economic development.

(2) Agriculture is still the main sector in the Bulgarian rural economy. Therefore, it is essential to implement sustainable practices and digital solutions proposed by the new CAP 2023-2027

(3) Better coordination and improved administrative capacity are crucial drivers for boosting the rural economy and addressing the gaps related to skills and education.

(4) Local models linked to the Pillar II Strategic plans are important steps towards overcoming the emerging issues. However, they require a clear vision for rural areas and better coordination among main stakeholders.

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REFERENCES

[1]Ahlmeyer, F., Volgmann, K., 2023, What Can We Expect for the Development of Rural Areas in Europe?—Trends of the Last Decade and Their Opportunities for Rural Regeneration. Sustainability, 15(6), p.5485.
[2]Aleksandrova-Zlatanska, S., 2019, A territorial approach for economic development of rural areas. Case of Bulgaria. Scientific Papers. Series Management, Economic Engineering in Agriculture and rural development, Vol. 19(3), 39-48.
[3]Andersen, L.S., 2020, Rural Areas; Nova Science Publishers Incorporated: New York, NY, USA.
[4]Bachev, H., 2020, Digitalisation of Bulgarian agriculture and rural areas. Ikonomika i upravlenie na selskoto stopanstvo, 65(2), pp.3-24.
[5]Beluhova-Uzunova, R., Shishkova, M., Hristov, K, 2022, Socio-economic challenges for regions and agriculture in the new Member-States. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural development, 22(2), 89-96 .
[6]Bock, A., Krzysztofowicz, M., 2021, Scenarios for EU Rural Areas 2040, EUR 30755 EN, Publications Office of the European Union, Luxembourg, doi:10.2760/29388, JRC125368.
[7]Borisov, P., Petrov, K., Tsonkov, N., 2024, Integration perspectives for improving regional policy in rural areas of Bulgaria. Agricultural and Resource Economics: International Scientific E-Journal, 10(1), 260-283.
[8]Brunori, G., 2022, Agriculture and rural areas facing the “twin transition”: principles for a sustainable rural digitalisation. Italian Review of Agricultural Economics (REA), 77(3), 3-14.
[9]Cagliero, R., Licciardo, F., Legnini, M., 2021, The Evaluation Framework in the New CAP 2023–2027: A Reflection in the Light of Lessons Learned from Rural Development. Sustainability 2021, 13, 5528. https://doi.org/10.3390/ su13105528
[10]Cambra-Fierro, J.J., Pérez, L., 2022, (Re) thinking smart in rural contexts: A multi-country study. Growth and Change. 2022 June: 53(2), 868-889.
[11]Council of the European Union, 2021, Conclusions on the Long-term vision for the EU’s rural areas, 15631/23; European Parliament, Report on the long-term vision for the EU’s rural areas, 2021/2254(INI), p.3.
[12]Council of the European Union, 2024, The European Economic And Social Committee And The Committee Of The Regions The long-term vision for the EU’s rural areas: key achievements and ways forward, Brussel, 2024
[13]Di Caro, P., Fratesi, U., 2022, One policy, different effects: Estimating the region-specific impacts of EU cohesion policy. Journal of Regional Science, 62(1), 307-330.
[14]Drescher, J., Podolsky, A., Reardon, S.F., Torrance, G., 2022, The geography of rural educational opportunity. RSF: The Russell Sage Foundation Journal of the Social Sciences, 8(3), 123-149.
[15]Dunchev, D., Atanasov, D., 2019, Impact of innovations on technical efficiency of soft fruits production, Agricultural science, 11(26), 41-45.
[16]European Commission, 2021, Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee Of The Regions 2030 Digital Compass: the European way for the Digital Decade, Brussels, 9.3.2021 COM(2021) 118 final, p.4.
[17]Eurostat Statistics Explained, 2024, Rural Europe, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Rural_Europe, Accessed on 3 March, 2025.
[18]Eurostat Statistics Explained, n.d., https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Category:Glossary, Accessed on 3 March, 2025.
[19]Guerrina, R., Masselot, A., 2018, Walking into the footprint of EU law: unpacking the gender consequences of Brexit. Social Policy and Society, 17(2), 319–330.
[20]Harizanova, H., Stoyanova, Z., 2012, Development of the Rural Regions in Bulgaria under the Period of Relocating of CAP, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Vol.12 (3),65-68.
[21]Hodge, I., Midmore, P., 2008, Models of Rural Development and Approaches To Analysis Evaluation And Decision- Making. Economie rurale, 2008, 307, 23-38.
[22]Ivanov, B., Sokolova, E., 2017, June. The role of agriculture for income and employment in Bulgarian rural areas. In Proceeding of the International Scientific Conference" Strategies for the Agri-Food Sector and Rural Areas-Dilemmas of Development, pp. 19-21.
[23]Kenny, M., Luca, D., 2021, The urban-rural polarisation of political disenchantment: An investigation of social and political attitudes in 30 European countries. Cambridge Journal of Regions, Economy and Society, 14(3), 565-582.
[24]Mahon, M., Woods, M., Farrell, M., Jones, R. and Goodwin-Hawkins, B., 2023, A spatial justice perspective on EU rural sustainability as territorial cohesion. Sociologia Ruralis, 63(3), 683-702.
[25]Mutafov, E., Marinov, P., 2022, Population migration processes and digital coverage in rural areas of Bulgaria. Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development, 22(2), 515-522.
[26]Petrov, K., 2021, The regional development of the rural areas in Bulgaria and the support of the European Union. European Countryside, 13(1), 208-221.
[27]Popescu, A., Tindeche, C., Mărcuță, A. , Mărcuță, L., 2022, Rural Areas in Romania-Discrepancies Versus Urban Areas And European Union. Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development, 22(1), 515-532.
[28]Sadłowski, A., Wrzaszcz, W., Smędzik-Ambroży, K., Matras-Bolibok, A., Budzyńska, A., Angowski, M., Mann, S., 2021, Direct payments and sustainable agricultural development—The example of Poland. Sustainability. 2021 Nov 26;13(23):13090.

[29]Shortall, S., Marangudakis, V., 2022, Is agriculture an occupation or a sector? Gender inequalities in a European context. Sociologia Ruralis, 62(4), 746-762.
[30]Steinführer, A., Heindl, A.-B., Grabski-Kieron, U., Reichert-Schick, A., 2020, New Rural Geographies in Europe: Actors, Processes, Policies; LIT: Münster, Germany, 2020.
[31]Van Maarseveen, R., 2021, The urban–rural education gap: do cities indeed make us smarter? Journal of Economic Geography, 21(5), 683-714.
[32]Wieliczko, B., Kurdyś-Kujawska, A., Floriańczyk, Z., 2021, EU rural policy's capacity to facilitate a just sustainability transition of the rural areas. Energies, 14(16), p.5050.
[33]Yarkova, Y., Mutafov, E., 2017, Rural areas in Bulgaria–investigation on some factors for development. Eastern European Countryside, 23, pp.51-70.
[34]Yoncheva, T., 2023, Pravnoto regulirane na turizma – instrument za ustoychivo razvitie. Plovdiv, Fast Print Books.
[35]Zlatinov, D., 2018, Macroeconomic Challenges for the Transition to the Economy 4.0 in Bulgaria. The Scientific Papers of the University of National and World Economy, 2018, Issue 3, 153–163.

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STUDY ON THE IMPACT OF AGRICULTURAL POLICIES ON THE ECONOMIC EFFICIENCY OF FARMS IN ROMANIA

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Abstract

The Common Agricultural Policy (CAP) constitutes a key element of the European Union's agricultural framework, providing financial support and regulatory measures aimed at improving the economic efficiency and sustainability of farms, including those in Romania. This research investigates the implications of the CAP on the profitability and economic performance of farms in Romania, considering their diversity It examines the distribution of CAP subsidies and how farmers can influence their value by meeting certain regulations and criteria. The methodology combines quantitative and qualitative methods, such as: analysis of official farm financial data and information on subsidies received, complemented by interviews and questionnaires with farmers to assess the impact of CAP regulations on farmers. The results show to what extent CAP regulations contribute to increasing subsidies and improving farm profitability, depending on how they are implemented. The conclusions highlight the significance of the Common Agricultural Policy (CAP) for Romanian farms and propose strategies to improve its implementation, contributing to the long-term sustainability of the agricultural sector.

Key words**:** *CAP, subsidy, economic efficiency, farm*

INTRODUCTION

The Common Agricultural Policy (CAP) is fundamental to the European Union's agricultural framework, principally aimed at assisting farmers and guaranteeing food security throughout the region. From 2023 to 2027, a total budget of EUR 387 billion has been designated for the CAP, with over EUR 21 billion explicitly allocated for Romania's agricultural and rural development requirements (European Commission, 2023) [10]. These funds are essential for supporting farmers and developing the rural environment.
The implementation of the CAP in Romania has had a significant impact on the agricultural sector. The subsidies granted have helped to increase farmers incomes and modernize farming practices. However, the distribution of these funds has, in some cases, favored large farms to the detriment of small and medium-sized farms (Alexandri & Luca, 2019) [5]. According to Brînaru and Dona (2016), subsidies in the South-Muntenia region have contributed directly to farm modernization and profitability, particularly for larger agricultural enterprises [6].

The CAP 2023-2027 focuses on ten key objectives, including ensuring a decent income for farmers, developing competitiveness, combating climate change and protecting the environment (European Commission, 2023) [9]. These objectives reflect a cohesive strategy to address the challenges currently facing the agricultural sector. As highlighted by Chitea (2024), the National Rural Development Program has played an essential role in supporting small farms by providing the financial assistance needed to improve productivity and better integrate them into the European market [7].
Subsidies provided through the CAP have also significantly influenced crop specialization in Romanian farms. According to FADN data, Galluzzo (2016) emphasizes that subsidy allocation has driven a more specialized approach to agricultural production, leading to greater efficiency and profitability [11]. Similarly, Lascăr (2014) highlights the crucial role of subsidies in supporting rural development, particularly in less developed regions such as South-Muntenia, where these funds have contributed to farm modernization

and improved infrastructure [12]. Submeasure 6.1. is destined to help young farmers [8].
These objectives embody a cohesive strategy to tackle the prevailing issues in the field of agriculture.
In this regard, it is essential to evaluate the influence of the CAP on the profitability of farms in Romania. Consequently, indicators pertaining to income generated, subsidy amounts, and operational expenses have been examined. This research will enhance the comprehension of the economic sustainability of Romanian farms and offer recommendations for optimizing subsidy utilization.
Furthermore, as Galluzzo (2016) and Brînaru & Dona (2016) point out, the efficient management of European funds is an essential element in maximizing the benefits of CAP subsidies [11, 6]. These funds must be allocated in an efficient manner, so as to support the development of farms, increase their competitiveness and promote environmentally sustainable agriculture. The implementation of CAP strategies must take into account their impact on the environment, while promoting agricultural practices that are both economically viable and environmentally friendly.

MATERIALS AND METHODS

This study aims to assess the impact of the Common Agricultural Policy (CAP) on the economic efficiency of farms in Romania, through the correlated analysis of data on agricultural production, subsidies received and operating expenses.
The main objective is to determine the degree of influence of subsidies on the profitability of farms, thus contributing to a better understanding of their economic sustainability.
In order to achieve this objective, the study pursues specific objectives, as follows:
-To determine farm incomes by analyzing agricultural production and market prices for the main crops.
- Calculation of gross margin and profit without subsidies, followed by assessment of the impact of CAP financial support on the economic performance of farms.
-Recommendations for optimizing the use of subsidies to increase the economic efficiency and sustainability of Romanian farms.
The study uses a complex methodological approach, combining quantitative and qualitative methods, structured as follows:
-*Data collection*: in addition to data from official sources, questionnaire interviews were conducted with farmers to obtain information on production expenditure and their perception of the efficiency of CAP subsidies.
This qualitative data provided a direct insight into the challenges faced and possible solutions for optimizing financial support. The data used came from official sources, such as the National Institute of Statistics (NSI) and the database on subsidies granted to farmers (Agency for Payments and Intervention for Agriculture, APIA) [1].
-*Statistical analysis*: Relevant economic indicators such as income per hectare, average production expenditure and gross profit were calculated using descriptive and comparative methods.

RESULTS AND DISCUSSIONS

This research investigated the impact of changes in agricultural production and financial support under the Common Agricultural Policy (CAP) on Romanian farms from 2020 to 2023 [10].
The analysis utilized official data from the National Statistical Institute (NSI) - Tempo Online [15]. and the Ministry of Agriculture and Rural Development (MADR) [13, 14]..
These data were used to assess the dynamics of cultivated areas, agricultural production and prices of the main agricultural crops.
For each crop analyzed, the following information was collected: total cultivated area (S), average production (qm), total output (Qt) and average price (Pr_{med}).
The calculated indicators answer the question "What is the impact of CAP subsidies on farmers' incomes and profitability of agricultural production?"

The analysis of cultivated areas and agricultural production provides a clear picture of trends in the Romanian agricultural sector. The data in Table 1 show the evolution of wheat and maize production. Thus, the area cultivated with wheat has shown an increasing trend, while the area cultivated with maize has shown a significant decreasing trend.

Table 1. Evolution of cultivated area, production and average price for wheat and maize, (2020-2023).

Year	S [ha]	q_m [kg/ha]	Q_t [to]	$P_{r\ med}$ [lei/kg]
WHEAT				
2020	2,155,254	2,966	6,392,369	0.79
2021	2,175,077	4,797	10,433,751	0.96
2022	2,168,662	4,004	8,684,237	1.49
2023	2,317,692	4,364	9624074	1.1
MAIZE				
2020	2,537,104	3,977	10,096,689	0.7
2021	2,549,281	5,802	14,820,693	0.9
2022	2,431,106	3,298	8,037,134	1.31
2023	2195344	3982	8743995	1.08

Source: Own calculations.

This dynamic is explained by the impact of climate change on the structure of agricultural production (the share of fall crops is increasing at the expense of spring crops) and the different pace of price increases between wheat and maize.

For sunflower and rapeseed, the data suggest a reversal of farmers' interest in their importance in the crop rotation and income structure.

Table 2 presents the details for these crops.

In this regard, the area under sunflower has decreased by about 65,000 hectares in favor of rapeseed.

The area under rapeseed increased by more than 270,000 hectares during the period under review.

Average yields have also decreased for sunflower and increased for rapeseed, and prices are clearly in favor of rapeseed production.

Assessing the economic performance of the main agricultural crops in Romania requires a detailed analysis of the expenditure and income structure before considering the impact of subsidies.

Table 2. Evolution of cultivated area, production and average price for sunflower and rapeseed (2020-2023).

Year	S [ha]	q_m [kg/ha]	Q_t [to]	$P_{r\ med}$ [lei/kg]
SUNFLOWER				
2020	1,142,841	1,858	2,122,865	1.5
2021	1,123,960	2,530	2,843,531	1.99
2022	1,093,265	1,927	2,106,573	2.88
2023	1,077,867	1,870	2,015,621	1.98
RAPESEED				
2020	362,865	2,150	780,155	1.61
2021	445,918	3,084	1,375,067	1.96
2022	468,870	2,622	1,229,532	2.76
2023	641,425	2,790	1,789,667	2.12

Source: Own calculations.

Table 3 presents the evolution of production expenses (C_p), operating expenses (C_o), average revenue (V_m), gross margin (M_B) and profit (P_R).

This approach allows an objective assessment of the economic performance of each crop and provides a comparative basis for analyzing the impact of subsidies on agricultural profitability.

Figure 1 illustrates the variation in profit per hectare for the main agricultural crops in the period 2020-2023, before CAP support.

It can be seen that 2020 and 2023 were the most difficult years, with significant losses in wheat (-1,891.8 lei/ha in 2020) and sunflower (-1,533 lei/ha in 2020 and -970.4 lei/ha in 2023).

In contrast, in 2021 and 2022, crops were more profitable, with the highest gains recorded for rapeseed (2,794.72 lei/ha in 2022) and maize (2,559.74 lei/ha in 2021).

These fluctuations emphasize the importance of agricultural yields and market prices in determining farm profitability.

These trends also underline the importance of financial support in maintaining farmers profitability, analyzed in detail in the following scenarios.

Table 3. Economic performance before application of CAP financial support, (2020-2023)

Year	Cp [lei/ha]	C_o [lei/ha]	V_m [lei/ha]	M_B [lei/ha]	P_R [lei/ha]
WHEAT					
2020	1,700	2,535	2,343.1	643.1	-1,891.8
2021	1,750	2,640	4,605.1	2,855.1	215.1
2022	1,775	2,710	5,965.9	4,190.9	1,480.9
2023	1,845	2,780	4,800.4	2955.	175.4
MAIZE					
2020	1,810	2,535	2,783.9	973.9	302.7
2021	1,870	2,640	5,221.8	3,351.8	2,559.7
2022	1,910	2,710	4,320.3	2,410.3	1,555.4
2023	2,030	2,780	4,300.5	2,270.5	1,335.4
SUNFLOWER					
2020	1,785	2,535	2,787.0	1,002.0	-1533
2021	1,798	2,640	5,034.7	3,236.7	596.7
2022	1,851	2,710	5,549.7	3,698.7	988.7
2023	1,893	2,780	3,702.6	1,809.6	-970.4
RAPESEED					
2020	1,670	2,535	3,461.5	1,791.5	-743.5
2021	1,695	2,640	6,044.6	4,349.6	1,709.6
2022	1,732	2,710	7,236.7	5,504.7	2,794.7
2023	1,778	2,780	5,914.8	4,136.8	1,356.8

Source: Own calculations.

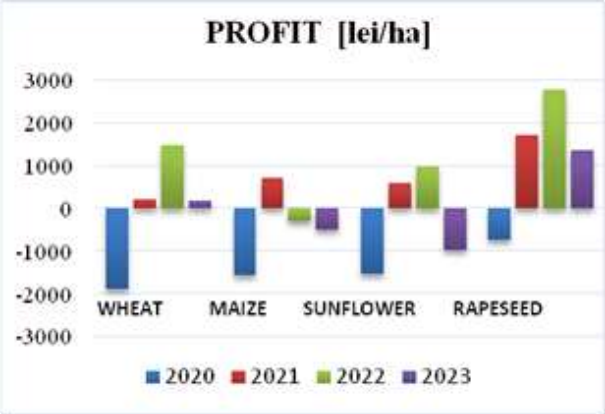

Fig. 1. Changes in profit without subsidies for the main agricultural crops
Source: Own calculations.

In order to measure the influence of subsidies on farmers incomes, three possible scenarios were designed to be followed by farmers, namely:

Scenario 1 - farmers opt for basic income support for sustainability (BISS),

Scenario 2 - Farmers opt for Basic Income Support for Sustainability (BISS) together with Eco-schemes (PD-04 - Beneficial Environmental Practices on Arable Land),

Scenario 3 - farmers opt for the combination of the 2 scenarios presented above plus the measure to maintain organic farming (DR-05 - Maintaining organic certification).

Table 4**.** Typology and amount of direct payments under the CAP (2020-2023)

Year	SAPS **[leiha]**	Greening payment **[lei/ha]**	Measure 11 **[lei/ha]**
2020	491.33	287.71	1,084.77
2021	475.11	288.06	1,084.77
2022	479.09	291.25	1,084.77
Year	**BISS** [lei/ha]	**PD -04** [lei/ha]	**DR - 05** [lei/ha]
2023	480.03	280.05	1,084.77

Source: Agricultural Payments and Intervention Agency (APIA), Annual Reports (2020-2023)

During the period under review, the system of direct payments granted to farmers under the Common Agricultural Policy (CAP) underwent significant changes with the transition to the CAP Strategic Plan 2023-2027. Thus, the name and structure of the main types of payments have changed, while maintaining similarities between the old and new schemes [1, 2, 3, 4].

Until 2022, direct support to farmers included:

-SAPS (Single Area Payment Scheme) - equivalent to BISS (Basic Income Support for Sustainability) from 2023.

-Greening payment - replaced by the CAP Ecoschemes, of which PD-04 - Environmentally beneficial practices applicable on arable land, is to some extent equivalent to the former greening requirements.

-Measure 11 - Maintenance of organic farming - transformed into DR-05 - Maintenance of certification in organic farming.

The new payment system maintains similar objectives in terms of farmers support for sustainability and organic farming. These similarities were taken into account in this analysis, where the three different subsidy scenarios were compared to assess the impact

of financial support on farm income and profitability of agricultural production.

The projected scenarios including economic indicators are presented in Table 5, Table 6 and Table 7.

Analyzing the data in Table 5, it can be seen that the inclusion of basic income support (BISS) contributes to reducing losses, but does not consistently provide a significant increase in farm profitability.

Compared to the situation without subsidies, farmers accessing only BISS manage to slightly improve their average income, but in the difficult agricultural years (2020 and 2023), this support is not sufficient to cover losses. Therefore, for sunflowers, the return remains negative in 2020 and 2023, and for maize and wheat, the increase is modest. This underlines that basic support provides a minimum of financial stability but is not sufficient to ensure sustainable profitability.

Table 6 highlights that the inclusion of eco-scheme PD-04 (environmentally beneficial practices applicable on arable land) leads to an improvement in profitability compared to Scenario 1.

In this case, farmers benefit from a more visible increase in average income, which is reflected in higher values of profit per hectare.

Table 5. Assessing the impact of subsidies on the economic performance of farms - Scenario 1

	WHEAT				MAIZE			
	2020	**2021**	**2022**	**2023**	**2020**	**2021**	**2022**	2023
S_{BV}[1] **[lei/ha]**	491.33	475.11	479.09	480.03	491.33	475.11	479.09	**480.03**
$P_{R\ Final}$[2] **[lei/ha]**	-1,400.53	690.23	1,960.05	655.43	-1,069.77	1,186.91	179.47	**-29.41**
$V_{m\ SBV}$[3] **[lei/ha]**	2,834.47	5,080.23	6,445.05	5,280.43	3,275.23	5,696.91	4,799.47	**4,780.59**
	SUNFLOWER				RAPESEED			
S_{BV} **[lei/ha]**	491.33	475.11	479.09	480.03	491.33	475.11	479.09	**480.03**
$P_{R\ Final}$ **[lei/ha]**	-1,041.67	1,071.81	1,467.85	-490.37	-252.17	2,184.75	3,273.81	**1,836.83**
$V_{m\ SBV}$ **[lei/ha]**	**3,278.33**	**5,509.81**	**6,028.85**	**4,182.63**	**3,952.83**	**6,519.75**	**7,715.81**	**6,394.83**

1 S_{BV} = total subsidies for each scenario. 2 $P_{R\ Final}$ = final profit after including subsidies.
3 $V_{m\ SBV}$= average income with subsidies.
Source: Own calculations.

Table 6. Assessing the impact of subsidies on the economic performance of farms - Scenario 2

	WHEAT				MAIZE			
	2020	**2021**	**2022**	**2023**	**2020**	**2021**	**2022**	2023
S_{BV} **[lei/ha]**	779.04	763.17	770.33	760.08	779.04	763.17	770.33	**760.08**
$P_{R\ Final}$ **[lei/ha]**	-1,112.82	978.29	2,251.29	935.48	-782.06	1,474.97	470.71	**250.64**
$V_{m\ SBV}$ **[lei/ha]**	3,122.18	5,368.29	6,736.29	5,560.48	3,562.94	5,984.97	5,090.71	**5,060.64**
	SUNFLOWER				RAPESEED			
S_{BV} **[lei/ha]**	779.04	763.17	770.33	760.08	779.04	763.17	770.33	**760.08**
$P_{R\ Final}$ **[lei/ha]**	-753.96	1,359.87	1,759.09	-210.32	35.54	2,472.81	3,565.05	**2,116.88**
$V_{m\ SBV}$ **[lei/ha]**	**3,566.04**	**5,797.87**	**6,320.09**	**4,462.68**	**4,240.54**	**6,807.81**	**8,007.05**	**6,674.88**

Source: Own calculations.

Table 7. Assessing the impact of subsidies on the economic performance of farms - Scenario 3

	WHEAT				MAIZE			
	2020	**2021**	**2022**	**2023**	**2020**	**2021**	**2022**	2023
S_{BV} **[lei/ha]**	1,863.81	1,847.94	1,855.10	1,844.85	1,863.81	1,847.94	1,855.10	**1,844.85**
$P_{R\ Final}$ **[lei/ha]**	-28.05	2,063.06	3,336.06	2,020.25	302.71	2,559.74	1,555.48	**1,335.41**
$V_{m\ SBV}$ **[lei/ha]**	4,206.95	6,453.06	7,821.06	6,645.25	4,647.71	7,069.74	6,175.48	**6,145.41**
	SUNFLOWER				RAPESEED			
S_{BV} **[lei/ha]**	1,863.81	1,847.94	1,855.10	1,844.85	1,863.81	1,847.94	1,855.10	**1,844.85**
$P_{R\ Final}$ **[lei/ha]**	330.81	2,444.64	2,843.86	874.45	1,120.31	3,557.58	4,649.82	**3,201.65**
$V_{m\ SBV}$ **[lei/ha]**	**4,650.81**	**6,882.64**	**7,404.86**	**5,547.45**	**5,325.31**	**7,892.58**	**9,091.82**	**7,759.65**

Source: Own calculations.

Fig. 2. Share of subsidies in income for main agricultural crops, by CAP support scenarios
Source: Own calculations.

The analysis of the data in Table 7 shows that Scenario 3 leads to the highest increase in farm profitability compared to the other scenarios analyzed. In this context, the profit per hectare is significantly higher, reflecting higher economic stability for farms benefiting from this support.

In the year 2023, characterized by low profitability under the other scenarios, farmers who accessed all available forms of support maintained a positive level of profitability.

The results of this analysis confirm that the integration of several forms of financial support into the economic structure of farms contributes significantly to increasing their sustainability and reducing the financial risks generated by the volatility of the agricultural market.

Figure 2 also highlights the share of subsidies in farm income for each crop according to the support scenarios analyzed. It shows the following:

-*Scenario 1*, subsidies account for about 10-11% of income, with little impact on economic stability.

-*Scenario 2*, which also includes the eco-scheme, the share of subsidies increases to 16-17%, indicating a more substantial financial support.

-The highest impact is observed in Scenario 3, where subsidies contribute more than 31% of income for most crops, underlining the essential role of this support in ensuring the economic viability of farms.

This confirms the essential role of CAP subsidies in maintaining farm profitability, especially in a volatile agricultural environment.

Applying each scenario to the farm reality regarding performance and average income per hectare, we obtain the following results:
(i)The average yield per hectare is directly influenced by the climatic conditions of the analysis years.
(ii)Selling prices follow the favorable or unfavorable conjuncture on international markets.
(iii)Production costs per hectare are mainly influenced by the sowing and fertilization technological link (Figure 3).
(iv)The average income per hectare in relation to production expenses (direct technical expenses) ranges from 4,429 lei for wheat to 5,665 lei for rape,
(v)The gross margin per hectare varies between 2,252 lei for maize and 3,946 lei for rape.
(vi)Operational expenses per hectare are dominated by depreciation and wages (Figure 4).
(vii)The average gross profit before subsidies is generally between - 415 lei for maize and 1,280 lei for rapeseed.
Scenario 1 applied to the gross margin determines a profit per hectare between -691.8 lei/ha and 2,680.96 lei/ha.
Scenario 2 - applied to the gross margin determines a profit per hectare between -191,8 lei/ha and 3,180.96 lei/ha,
Scenario 3 - generates the highest values, with a profit per hectare between 608.2 lei/ha and 3,980.96 lei/ha.
Figure 3 and Figure 4 present the average distribution of production and operational costs, highlighting the main components that influence farm profitability. These data underline the impact that access to finance and effective cost management have on the economic efficiency of farms, particularly in the context of volatile agricultural markets.
The results obtained substantiate the role and importance of subsidies for agricultural production, we observe that they represent the main source of profit for farms. The results of this paper provide information for decision-maker in the area of agricultural policy and for decision-markers on the farm.

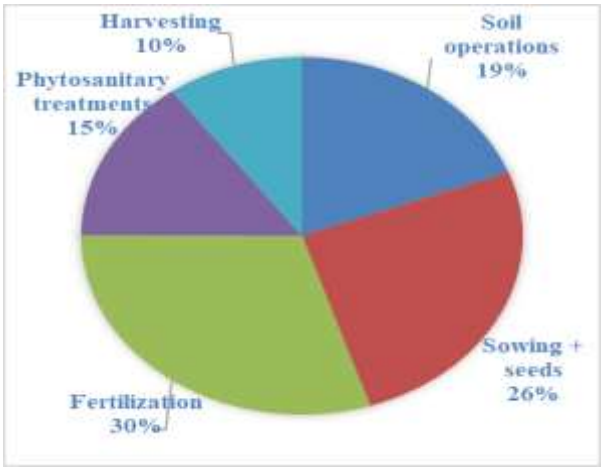

Fig. 3. Production costs [%].
Source: Own calculations.

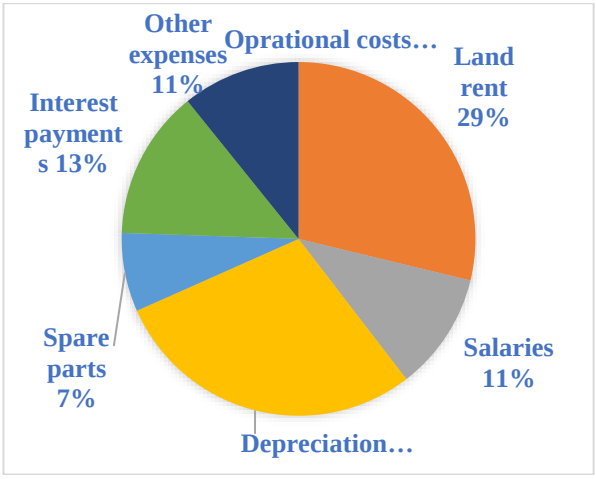

Fig.4. Operational costs [%]
Source: Own calculations.

CONCLUSIONS

"What is the impact of CAP subsidies on farmers' incomes and the profitability of agricultural production?"
This was the central question that the present study aimed to answer through a comparative analysis of different financial support scenarios. The results show that CAP subsidies play a decisive role in maintaining the economic stability of farms, and that in their absence some crops would have been unprofitable in difficult agricultural years.
The application of the economic scenarios revealed significant differences depending on the type and level of financial support accessed. Scenario 1 mitigates losses but is not sufficient to ensure profitability in bad years.
Scenario 2 contributes to increased financial stability and Scenario 3 generates the highest profits, demonstrating that integrating multiple

forms of support is an effective strategy to reduce farmers' economic vulnerability.

Based on the results obtained, the study formulates the following directions for optimizing agricultural policies:

-Improve the implementation mechanisms of ecoschemes, by adapting the eligibility criteria and increasing the flexibility of the techno-economic conditions so that they are more accessible to farmers without compromising sustainability objectives.

-Adapt financial support to agricultural market fluctuations by implementing flexible mechanisms to mitigate the impact of price volatility and unfavorable climatic conditions.

These results underline the need for an adaptable agricultural policy that provides not only financial support, but also measures to make farms more resilient to economic and climatic risks.The answer to the original question confirms that CAP subsidies are a fundamental pillar in maintaining the economic equilibrium of farms and stabilizing the agricultural sector. In this context, optimizing the support mechanisms can contribute to a fairerdistribution of funds and increase the competitiveness of Romanian agriculture.

REFERENCES

[1]Agency for Payments and Intervention for Agriculture (APIA), 2020. 2020 APIA Annual Report. Bucharest: Ministry of Agriculture and Rural Development. https://apia.org.ro, Accessed on November 10, 2024.

[2]Agricultural Payments and Intervention Agency (APIA), 2021, Annual Report APIA 2021. București: Ministry of Agriculture and Rural Development. https://apia.org.ro, Accessed on November 11, 2024.

[3]Agricultural Payments and Intervention Agency (APIA), 2022, APIA Annual Report 2022. Bucharest: Ministry of Agriculture and Rural Development. https://apia.org.ro , Accessed on November 11, 2024.

[4]Agricultural Payments and Intervention Agency (APIA), 2023, APIA Annual Report 2023. București: Ministry of Agriculture and Rural Development. https://apia.org.ro, Accessed on November 11, 2024.

[5]Alexandri, C., Luca, L., 2019, Assessing the impact of direct payments on farm viability by size and specialization. In Activity report of the Institute of Agricultural Economics. București: Institute of Agricultural Economics. https://www.eadr.ro/fisiere/IEAraport2021.pdf. Accessed on November 16, 2024.

[6]Brînaru, A.I., Dona, I., 2016, analysis of the support mechanism of the pillar i and the results in the Romanian agricultural exploitations South-Muntenia region. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 16(2), 43-48.

[7]Chitea, L. 2024, Main measures for small farms after the accession to the European Union through the National Rural Development Program . Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 24(3), 181-190.

[8]Chiurciu, I., Varutoiu, M., 2023, European funding within sub-measure 6.1. Case study applied in Hunedoara county, Romania. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 23(1), 147-152.

[9]European Commission, 2023, Key objectives of the CAP 2023-2027. Brussels: Directorate-General for Agriculture and Rural Development. https://agriculture.ec.europa.eu/common-agricultural-policy/cap-overview/cap-2023-27/key-policy objectives-cap-2023-27_ro Accessed on November 16, 2024.

[10]European Commission, 2023, CAP Strategic Plan 2023-2027 for Romania. Brussels: Directorate-General for Agriculture and Rural Development. https://agriculture.ec.europa.eu. Accessed on November 16, 2024.

[11]Galluzzo, N., 2016, Analysis of subsidies allocated by the common agricultural policy and cropping specialization in Romanian farms using FADN dataset. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 16(1), 157-164.

[12]Lascăr, E. 2014, The role of subsidies in the rural development of South-Muntenia region. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 14(1), 179-182.

[13]Ministry of Agriculture and Rural Development (MADR), 2023, Data on agricultural subsidies and farm structure in Romania. Bucharest: MADR. https://madr.ro Accessed on November 15, 2024.

[14]Ministry of Agriculture and Rural Development (MADR), 2023. Average prices of agricultural products 2020-2023. București: MADR. https://madr.ro. Accessed on November 15, 2024.

[15]National Statistical Institute (NSI), 2023, Database Tempo Online - Agricultural production and cultivated areas in Romania. Bucharest: INS. https://insse.ro. Accessed on November 15, 2024.

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ASSESSING HOUSEHOLD GROUNDWATER CONTAMINATION RISK IN RURAL ROMANIA: A SEMI-QUANTITATIVE REGIONAL MODEL

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Abstract

This paper aims to evaluate groundwater contamination risks affecting household water supplies in rural Romania, where access to centralized infrastructure remains limited. A semi-quantitative risk assessment model was developed and applied to five representative counties—Bihor, Teleorman, Iași, Constanța, and Dolj—based on three dimensions: population exposure, likelihood of contamination, and severity of health impact. Data were collected from national statistics, environmental monitoring institutions, and international health guidelines. Risk scores revealed that Bihor and Teleorman counties face the highest vulnerability due to multiple contaminants (e.g., nitrates, arsenic, coliforms) and widespread reliance on untreated water. The exposed population across these counties is estimated to exceed 670,000 individuals. The study emphasizes the need for improved rural water infrastructure, regular well testing, and targeted policy interventions in agricultural areas. The model provides a useful tool for prioritizing regional investments and supporting water safety strategies under national and EU rural development frameworks.

Key words: *groundwater risk, rural water supply, contamination, Romania, health impact*

INTRODUCTION

Groundwater remains a vital source of drinking water for nearly half of the global population, with reliance especially high in rural and peri-urban areas [12, 33]. This largely invisible resource plays a critical role not only in ensuring household water security, but also in supporting agricultural productivity, maintaining ecosystem stability, and enhancing climate resilience. However, growing pressures from overextraction, contamination, and climate change are threatening its sustainability.

In many regions, aquifers are being depleted faster than they can naturally recharge. This results in falling water tables, land subsidence, reduced water availability, and long-term threats to socio-economic stability [31, 32]. Excessive groundwater exploitation is especially evident in arid and semi-arid regions, where the expansion of intensive agricultural systems and insufficient oversight of irrigation activities contribute significantly to aquifer depletion [7, 26]. At the same time, the overall quality of groundwater resources is declining worldwide. The excessive application of nitrogen-based fertilizers has led to widespread nitrate pollution, while industrial activities continue to introduce heavy metals, solvents, and synthetic chemicals into aquifers[12, 20]. Additionally, emerging contaminants such as pharmaceuticals, endocrine-disrupting compounds, and per- and polyfluoroalkyl substances (PFAS) have been detected across continents - often at concentrations exceeding health thresholds and resistant to conventional treatment technologies [11, 22].

Microbial contamination poses another significant, yet often under-monitored, threat. Pathogens such as *Escherichia coli*, *Salmonella*, and *Cryptosporidium*can enter groundwater through agricultural runoff, malfunctioning septic systems, or inadequately constructed wells. In low- and middle-income countries, over 60% of household water sources - including both protected and unprotected wells - have been found to contain *E. coli* contamination[3, 36]. Borchardt et al. (2021) [4] reported that private wells located near agricultural areas in the United States exhibited a markedly increased risk of microbial contamination, particularly in regions with elevated nitrate concentrations. Similarly, the U.S. Environmental Protection

Agency (2024) [28] highlighted increased risks of groundwater contamination during flooding events, especially in communities where concerns about water quality had already been raised.Compounding the issue, antimicrobial-resistant (AMR) bacteria are increasingly being detected in private groundwater supplies, posing an emerging public health concern [1, 10]. Despite advancements in sensor technologies and digital monitoring platforms, surveillance remains inconsistent - especially in regions with limited institutional capacity or funding [16].

In Romania, many of these global groundwater threats are not only present but often more severe. Approximately seven million people (predominantly in rural areas) depend on private groundwater sources, most commonly shallow and unregulated wells that are particularly vulnerable to chemical and microbial contamination[19]. In Eastern Romania, the Moldavian Plateau faces groundwater stress driven by intensive agricultural extraction and prolonged droughts[14]. In the northwest, groundwater used for domestic purposes has been found to contain elevated levels of arsenic, iron, and manganese, raising serious quality concerns [5, 25]. In the Romanian Plain, including the Târgoviște area, long-term nitrate pollution from fertilizer and livestock operations has been extensively documented, threatening the integrity of local aquifers [13]. Similar patterns of contamination have been documented in Romanian industrial and agricultural contexts, including petroleum hydrocarbons in Caras-Severin County [15] and nitrate leaching in horticultural areas of Constanța [9].

Microbial risks in Romania are equally alarming. Recent studies of karst springs revealed that over 80% of samples exceeded WHO microbial quality standards, with fecal contamination linked to shallow infiltration and surface-level human activities [27]. Rural well surveys conducted in the northeast have reported both microbiological and chemical exceedances, reflecting poor construction practices and minimal regulatory oversight [3]. Seasonal variability and flooding events further exacerbate contamination risks, particularly in vulnerable communities with limited access to water treatment technologies [2].

Given these intersecting challenges, there is an urgent need to strengthen groundwater protection through improved monitoring systems, robust regulatory frameworks, and context-specific risk management strategies. This paper aims to examine global groundwater quality challenges with a focus on household water supplies and associated health risks. It further analyzes the Romanian context through recent scientific studies, legislative instruments, and regional case studies. The goal is to provide evidence-based recommendations and promote community-scale, resilient solutions for sustainable groundwater use.

MATERIALS AND METHODS

Study Area and Scope

This study focuses on groundwater quality risks affecting household water supplies in Romania, particularly in rural areas where centralized water infrastructure is limited or absent. Five counties - Teleorman, Bihor, Iași, Constanța, and Dolj - were selected for regional analysis. These counties represent diverse geographical, hydrological, and land-use profiles and are known for documented groundwater quality concerns[17, 18, 24].

The objective is to assess the degree of exposure to groundwater contamination in these regions and to evaluate the potential public health risks associated with decentralized water sources, such as private wells and boreholes. The analysis integrates both global trends and national case studies, supported by a semi-quantitative risk assessment framework [30, 34].

Data Sources, Databases, and Search Strategy

To ensure a comprehensive and multidisciplinary foundation for the groundwater risk assessment, this study employed a structured search strategy incorporating both international and national data sources. The approach combined peer-reviewed scientific literature, institutional datasets, and regulatory frameworks to inform risk scoring parameters and regional

comparisons. Fig.1 summarizes the data architecture and search process, highlighting the convergence of academic, legal, and environmental inputs that underpin the methodological framework.

Fig.1. Data sources and search strategy for groundwater risk assessment

Source:Authors' drawing based on institutional and scientific data review (WHO, US EPA, INS, ANPM) [34,35, 28, 18, 18].

Risk Assessment Framework

In rural Romania, this study utilized a semi-quantitative risk assessment approach to examine groundwater safety and potential public health risks, based on frameworks developed by the World Health Organization [34, 35] and the U.S. Environmental Protection Agency [30], which are commonly applied in global risk evaluations. The overall Risk Score is calculated as the product of three components: population exposure, contamination likelihood, and severity of health impact. Each component is scored between 0 and 1.

Risk Score = P(Exposure)×P(Contamination)×S(Severity)

where:

- P(Exposure) represents the proportion of the rural population relying on untreated groundwater;
- P(Contamination) estimates the likelihood of contamination, based on documented pollutant exceedances;
- S(Severity) reflects the health impact of the contaminants.

Each model component was defined and scored as follows:

- P(Exposure)

Population exposure was derived using the formula:

$$P(\text{Exposure}) = 1 - \frac{\text{Access to Piped Water } (\%)}{100}$$

Where necessary, values were adjusted to reflect water systems lacking treatment infrastructure.

- P(Contamination) – Likelihood of Contamination

This reflects the probability that groundwater is contaminated with one or more harmful substances. Contamination probability was assessed based on monitoring data from the National Environmental Protection Agency (ANPM), County Public Health Directorates (DSPs), and recent scientific literature (*sources in Romanian*).The scoring criteria used to assign contamination likelihood are detailed in Table 1.

Table 1. Contamination Probability Scoring System

Score	Risk Level	Description
0.2	Low	Rare exceedances; good overall water quality
0.4	Moderate	Occasional exceedances of a single pollutant
0.6	High	Frequent exceedances; presence of one or more contaminants
0.8	Very High	Persistent exceedances; multiple pollutants frequently detected

Source: Authors' scoring scheme based on national monitoring data and WHO/US EPA guidance [34, 35, 28].

- S(Severity) – Health Impact Severity

This component reflects the health consequences of contaminants detected in groundwater. Scoring was informed by the WHO Guidelines for Drinking Water Quality (2022) [35], the EU Drinking Water Directive 2020/2184 [37], and national legislation [38]. The health impact scoring system and examples of associated contaminants are presented in Table 2.

The severity score in each county was derived from specific contaminants detected or reported in institutional monitoring data. The structure and scoring logic are illustrated in Fig. 2, which highlights how the model integrates population exposure, contamination probability, and health impact severity into a single composite risk index.

Table 2. Health Impact Severity Scoring

Score	Severity Level	Examples
0.3	Low	Iron, manganese (aesthetic, low health concern)
0.5	Moderate	Nitrates < 50 mg/L, chlorides (chronic, reversible effects)
0.7	High (vulnerable groups)	Nitrates > 50 mg/L, coliforms (risk to infants, immunocompromised)
0.9	Severe	Arsenic, pesticides, Cryptosporidium (carcinogenic/infectious)

Source: Authors' adaptation using WHO (2022), EU Directive 2020/2184, and Romanian legislation [35, 37].

To support the severity scoring and classification process, a set of priority groundwater contaminants was selected based on their occurrence in national monitoring data and their associated health effects. Table3. summarizes the key contaminants considered in the model, along with their primary sources, health impacts, legal thresholds, and the corresponding regulatory frameworks.

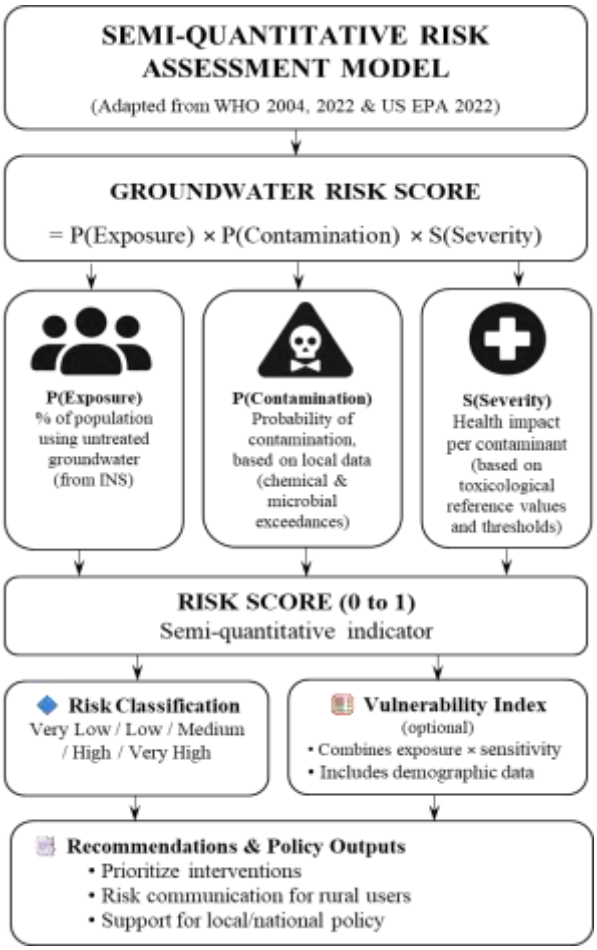

Fig.2. Conceptual structure of the semi-quantitative groundwater risk assessment model
Source: Authors' elaboration adapted from WHO (2004, 2022) and US EPA

Table 3. Key Groundwater Contaminants, Health Impacts, Legal Thresholds, and Regulatory Frameworks

Contaminant	Primary Source	Health Impact	Limit Value	Regulatory Reference
Nitrates (NO_3^-)	Agricultural fertilizers, livestock runoff	Blue baby syndrome (methemoglobinemia), chronic effects	50 mg/L	EU Nitrates Directive 91/676/EEC; WHO (2022)
Coliform Bacteria	Fecal contamination (latrines, septic tanks)	Diarrhea, gastrointestinal infections	0 CFU/100 mL	EU Drinking Water Directive 2020/2184; WHO (2022)
Arsenic (As)	Geogenic (natural bedrock), mining areas	Carcinogenic (skin, lung, bladder cancers)	10 µg/L	WHO (2022); EU Groundwater Directive 2006/118/EC
Ammonium (NH_4^+)	Organic waste, sewage infiltration	Indicator of organic pollution, indirect toxicity	0.5 mg/L	Romanian Law 458/2002; EU Drinking Water Directive
Pesticide Residues	Agricultural runoff, horticulture	Endocrine disruption, chronic toxicity	0.1 µg/L (per substance)	EU Drinking Water Directive 2020/2184
Iron (Fe)	Geogenic, corroded pipes	Aesthetic issues, discoloration, taste	0.2 mg/L	Romanian GO no. 7/2023 (for acceptability)
Manganese (Mn)	Geogenic, old plumbing	Neurological effects at high doses	0.05 mg/L	WHO (2022); Romanian Law 458/2002

Source: Authors' compilation from EU, WHO, and Romanian legal documents [37, 34, 35].

Exposure Estimation

To estimate the number of individuals at risk from contaminated groundwater, the model uses demographic data and piped water access statistics. The exposure indicator, P(Exposure), represents the share of the rural population relying on decentralized or untreated sources, such as shallow wells and boreholes.
The formula applied is:

$$\mathrm{P(Exposure)} = \frac{\text{Rural}}{\text{Population}} \times \left(1 - \frac{\text{Access to Piped Water (\%)}}{100}\right)$$

where:

- Access to piped water (%) is taken from county-level infrastructure data published by the National Institute of Statistics[19].
- Adjustments were made in select cases where piped networks exist but are not equipped with functional water treatment (e.g., lack of disinfection or filtration), based on expert judgment and field reports.

Additionally, the model estimates the absolute number of exposed individuals using the following equation:

$$\frac{\text{Exposed}}{\text{Population}} = \frac{\text{Rural}}{\text{Population}} \times \mathrm{P(Exposure)}$$

This allowed the model to identify regions with both high proportional and high absolute vulnerability, which is crucial for prioritizing public health interventions and infrastructure planning.
For example, while Constanța County had a lower exposure percentage (40%), its total exposed population remained significant due to residual contamination and lack of routine well testing. By contrast, Teleorman County had a near-total reliance on private wells (P = 1.0), contributing heavily to its final risk score.

RESULTS AND DISCUSSIONS

The risk assessment model was applied to five counties in Romania—Bihor, Teleorman, Iași, Constanța, and Dolj—using a composite score derived from population exposure, contamination likelihood, and health impact severity.

The highest risk was recorded in Bihor County, primarily due to the presence of arsenic, nitrates, and coliform bacteria. Arsenic levels in certain areas of Bihor have exceeded WHO limits (10 μg/L), while microbial contamination has been associated with shallow wells and inadequate sanitation infrastructure.
In Teleorman, although fewer types of contaminants were documented, the county exhibits a very high population exposure rate (100%) and widespread nitrate pollution, largely attributed to intensive agricultural practices and livestock farming. Coliform bacteria have also been detected in rural wells.
Dolj and Iași counties show moderate to high contamination likelihood due to persistent nitrate and microbial pollution, particularly in unregulated groundwater sources. In both counties, nitrate concentrations often approach or exceed the 50 mg/L threshold, especially in areas with high fertilizer usage.
Constanța County, though relatively better served by piped water infrastructure, presents regional nitrate contamination in areas with sandy soils and shallow aquifers, along with occasional pesticide residues from horticultural activities.
Each county was evaluated using the composite risk formula based on the three core dimensions. The risk classifications are aligned with thresholds defined in the Integrated Risk Evaluation Matrix (Table 5). While none of the counties exceeded the Critical Risk threshold (> 0.8), Bihor reached the High-Risk range due to the co-occurrence of chemical and microbial pollutants. The other counties displayed Moderate Risk scores, warranting targeted actions related to infrastructure upgrades, enhanced monitoring, and public health planning.
The results of the risk assessment are presented in Table 4, which summarizes the calculated scores and primary contaminants in each county. To support interpretation, Table 5 presents the Integrated Risk Evaluation Matrix used to classify overall groundwater safety levels based on the combined scoring dimensions.

Table 4. Groundwater Risk Scores and Contaminants by County

County	P(Exposure)	P(Contamination)	S(Severity)	Risk Score	Risk Classification	Main Contaminants
Bihor	0.70	0.80	0.90	0.504	High	Arsenic, nitrates, coliforms
Teleorman	1.00	0.60	0.70	0.420	Moderate	Nitrates, coliforms
Dolj	0.65	0.70	0.80	0.364	Moderate	Nitrates, coliforms
Iași	0.60	0.70	0.80	0.336	Moderate	Nitrates, coliforms, ammonium (localized)
Constanța	0.50	0.60	0.70	0.210	Moderate	Nitrates, pesticides, occasional coliforms

Source: Own calculation based on risk model and regional environmental data.

Table 5. Integrated Risk Evaluation Matrix for Groundwater Contamination**

Health Impact Severity → Contamination Probability ↓	High (0.8)	Medium (0.6)	Low (0.4)	Very Low (0.2)
Severe (e.g. arsenic, pesticides)	High–Critical (0.5–0.9)	Moderate–High (0.4–0.6)	Moderate (0.3–0.4)	Low (0.2)
Moderate (e.g. nitrates > 50 mg/L)	Moderate–High (0.4–0.6)	Moderate (0.3–0.5)	Low–Moderate (0.2–0.4)	Low (0.2)
Low (e.g. iron, manganese)	Low–Moderate (0.2–0.4)	Low (0.2–0.3)	Very Low (≤ 0.2)	Very Low (≤ 0.2)

Legend:
High–Critical Risk: Score > 0.5
Moderate Risk: 0.2 – 0.5
Low Risk: 0.2 – 0.3
Very Low Risk: ≤ 0.2
*Note: Risk score calculated using the formula: Risk Score = P(Exposure) × P(Contamination) × S(Severity)
Thresholds adapted from WHO (2004) and US EPA (2012) guidance.
Source:Authors' matrix adapted from WHO (2004) and US EPA (2012) classification systems [34, 28].

Estimation of Rural Exposure to Contaminated Groundwater

To estimate the rural population potentially exposed to untreated or contaminated groundwater, the analysis used national infrastructure data published by the National Institute of Statistics [19].

Exposure levels were calculated by assessing the share of rural residents lacking access to piped water systems in each county.

Fig.3 shows the exposure distribution across the five counties included in the assessment. While Iași and Dolj have the highest number of exposed individuals, all counties show substantial reliance on untreated water sources. This emphasizes the need for targeted health and infrastructure interventions in rural areas.

The results underscore not only spatial inequalities in access to safe water, but also the urgency of incorporating groundwater safety into rural development and public health strategies.

Although classified with moderate risk scores, counties such as Dolj and Iași stand out due to their large rural populations combined with limited water infrastructure—factors that significantly increase the absolute number of households vulnerable to groundwater contamination.

Even in Constanța, where access to piped water is relatively higher, a substantial portion of the rural population remains potentially exposed to nitrates, pesticide residues, and microbial contaminants.

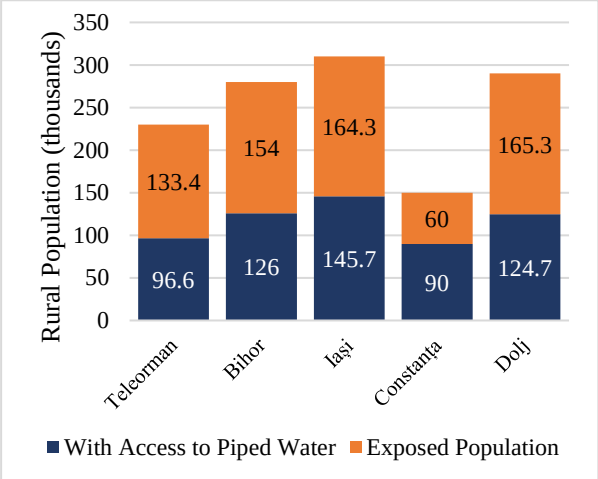

Fig.3. Rural Population Access to Safe Drinking Water in Selected Romanian Counties
Source: Own calculation based on National Institute of Statistics (INSSE), 2022 [19].

Comparative Insights: Romania vs. Western EU Approaches

In contrast to Western EU countries such as the Netherlands, where nearly the entire population is connected to centralized and monitored water supply systems (coverage >99.9%), Romania's rural regions rely heavily on private wells, which are largely unregulated and untested [19, 35].

This disparity is further illustrated in Table 6, which provides an international comparison of groundwater access and safety, highlighting significant differences between countries in terms of infrastructure, regulation, and water quality monitoring.

Table 6. International Comparison of Groundwater Access and Safety

Category	Netherlands	Romania (rural)
Population using private wells	<1%	~70%
Annual testing of private wells	Not applicable	Not mandatory
Access to centralized water	>99.9%	42%
Cost of UV treatment (EUR)	Not required	€100–250 (+ maintenance)
Availability of public subsidies	Yes (via public utilities)	Rare or absent

Source: Authors' comparison using INSSE data, EEA reports, and national policy sources [19].

The lack of legal obligation to test private wells, combined with limited public funding for household treatment systems, places a financial and health burden on vulnerable rural families. By comparison, France and Germany offer subsidies or public investment programs for rural water safety improvements - something Romania currently lacks. While environmental due diligence and risk-based assessments are becoming more common in Western contexts, similar structured assessments are still limited in Romanian practice despite a few emerging examples [9, 15].

Structural Drivers of Rural Vulnerability: Disparities in Access to Safe Water Infrastructure

A major contributor to groundwater-related health risks in Romania is the ongoing gap in safe water access between urban and rural areas. Urban populations are largely served by centralized, treated networks, while many rural communities still rely on unregulated and often untested groundwater sources like shallow wells and boreholes. Data from the National Institute of Statistics [19] indicate that in 2022, more than 98.7% of the urban population had access to piped water, whereas only 42% of the rural population benefited from such access.

This disparity is depicted in Fig. 4, which presents the progression of water infrastructure coverage between 2010 and 2022, highlighting the persistently limited improvement in rural areas despite sustained high levels of urban access.

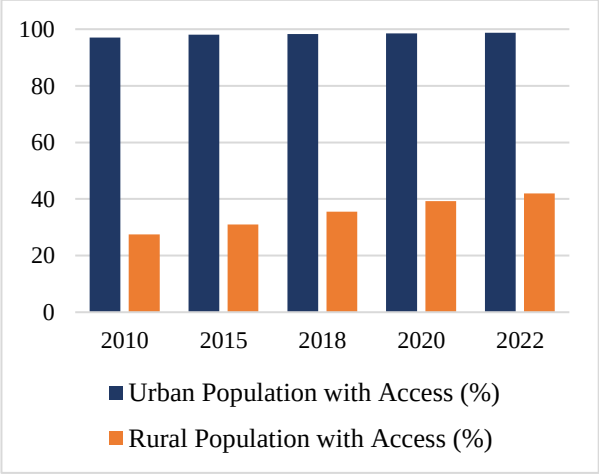

Fig.4.Trends in Access to Piped Water in Urban and Rural Areas of Romania (2010–2022)
Source: Own representation based on Tempo Online Database (INS), 2010–2022 [19].

The widening infrastructure gap continues to exacerbate public health risks, particularly in agricultural regions where nitrate and microbial contamination from fertilizers and livestock waste are common.

Despite gradual improvements over the past decade, rural areas remain substantially underserved. In the absence of regular water testing or treatment mechanisms, households depending on private wells face significantly elevated exposure to microbial and chemical contaminants. This reality reinforces the importance of infrastructure as both a public health determinant and a strategic investment area under national and EU rural development priorities.

Policy Relevance and Strategic Recommendations

The findings of this study underscore the urgent need for targeted policy interventions in rural groundwater governance. Several persistent gaps were identified: inadequate rural water infrastructure coverage [8], lack of legal mandates for testing private wells[38], fragmented environmental–health coordination [23], and low public awareness of nitrate, microbial, and arsenic risks [29, 35].To address these challenges, the following strategic actions are proposed: expanding groundwater monitoring to include private wells [6], introducing mandatory testing protocols supported by subsidies [30], launching educational campaigns [21], and aligning water safety strategies with EU funding mechanisms such as the CAP and Cohesion Policy.

Groundwater contamination risks in rural Romania are further amplified by climate-related stressors, including prolonged droughts, erratic precipitation, and local flooding. These conditions alter aquifer recharge patterns and promote surface contamination through shallow wells. For instance, microbial contamination may surge after heavy rainfall or septic overflow events [29]. In nitrate-vulnerable regions, drought-driven irrigation also accelerates fertilizer leaching into groundwater.

These climate-linked processes function as risk multipliers in areas with limited infrastructure and intensive agriculture. The findings align with recent EU water policy initiatives, including the 2023 revision of the Groundwater Directive and the launch of the Water Resilience Initiative under the European Green Deal. In Romania, the National Recovery and Resilience Plan (PNRR) includes targeted investments for environmental health and rural infrastructure.

Limitations and Future Research Directions

While the applied risk assessment model offers a practical framework for estimating regional groundwater safety, several limitations should be acknowledged. The model relies on aggregated datasets and proxy indicators (e.g., piped water access, reported contamination frequency) rather than high-resolution or real-time monitoring data.

In many rural areas, private wells remain untested, and microbial contamination events (e.g., *Escherichia coli*, *Cryptosporidium*) are likely underreported—especially following extreme weather, which can cause contamination spikes [29]. Moreover, the scoring thresholds for contamination likelihood and severity are based on WHO (2022), EU Directive 2020/2184, and national standards (Gov. Ordinance No. 7/2023), which may overlook local and seasonal variations - such as fluctuating nitrate levels in sandy or clay aquifers. Still, the model offers a conservative and useful tool for identifying at-risk populations and supporting public health actions.

Future research should explore the use of longitudinal data, the integration of sensor-based monitoring, and the engagement of citizen-science networks (European Commission, 2024).These enhancements could improve spatial accuracy and validate exposure estimates across different hydrogeological and land use contexts.

CONCLUSIONS

This study assessed groundwater quality risks affecting household water supplies in five rural counties of Romania using a semi-quantitative risk model incorporating exposure, contamination likelihood, and severity of health impact. The findings reveal that over 670,000 rural residents in the selected counties

may be exposed to untreated or contaminated groundwater, with Bihor County registering the highest composite risk due to arsenic, nitrate, and microbial pollutants.

Despite moderate contamination scores in other counties, the combination of high exposure rates and inadequate infrastructure places significant health burdens on populations in Teleorman, Dolj, Iași, and Constanța. The results highlight not only the uneven spatial distribution of risks but also the structural drivers—such as limited monitoring, unregulated private wells, and low testing frequency—that contribute to groundwater vulnerability in rural settings.

Comparative analysis with Western EU countries highlights Romania's gaps in regulation, household water treatment, and financial support. Climate-related challenges like droughts and floods further increase contamination risks. The study recommends expanding rural monitoring, mandating well testing, promoting water safety education, and aligning with EU policies such as the CAP and Water Resilience Initiative. Despite data gaps, the model serves as a practical tool for targeting interventions and supporting progress toward the EU Water Framework Directive and SDGs.

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REFERENCES

[1]Andrade, L., Kelly, M., Hynds, P., Weatherill, J., Majury, A., O'Dwyer, J., 2020, Groundwater resources as a global reservoir for antimicrobial-resistant bacteria. Water Research. 170, https://doi.org/10.1016/j.watres.2019.115360

[2]Austin, W., Pan, S., Parthum, B.M., 2024, When it Rains, it Pours: Severe Weather Events, Flooding, and Drinking Water Quality. Technical Report 24–12. U.S. Environmental Protection Agency, National Center for Environmental Economics.

[3]Bain, R., Cronk, R., Wright, J., Yang, H., Slaymaker, T., Bartram, J., 2014, Fecal Contamination of Drinking-Water in Low- and Middle-Income Countries: A Systematic Review and Meta-Analysis. PLoS Medicine. 11, 5, https://doi.org/10.1371/journal.pmed.1001644.

[4]Borchardt, M.A., Stokdyk, J.P., Kieke, B.A., Muldoon, M.A., Spencer, S.K., Firnstahl, A.D., Bonness, D.E., Hunt, R.J., Burch, T.R., 2021, Sources and Risk Factors for Nitrate and Microbial Contamination of Private Household Wells in the Fractured Dolomite Aquifer of Northeastern Wisconsin. Environmental Health Perspectives. 129, 6 https://doi.org/10.1289/EHP7813.

[5]Dippong, T., Mihali, C., Avram, A., 2024, Evaluating Groundwater Metal and Arsenic Content in Piatra, North-West of Romania. Water. 16, 4 (Feb. 2024), 539. https://doi.org/10.3390/w16040539.

[6]European Commission, 2024, EU Water Resilience Initiative under the European Green Deal.

[7]Famiglietti, J.S., 2014, The global groundwater crisis. Nature Climate Change. 4, 11, 945–948. https://doi.org/10.1038/nclimate2425.

[8]Government of Romania, 2023, National Recovery and Resilience Plan (PNRR).

[9]Iorga, C.M., Georgescu, P.L., Stancu, M.M., Environment Contamination with Petroleum Hydrocarbons. Land Reclamation Journal, XIII, 706–713.

[10]Kaiser, R.A., Polk, J.S., Datta, T., Parekh, R.R., Agga, G.E., 2022, Occurrence of antibiotic-resistant bacteria in urban karst groundwater systems.Water. 14, 6 (Mar. 2022), 960. https://doi.org/10.3390/w14060960.

[11]Kümmerer, K., Dionysiou, D.D., Olsson, O., Fatta-Kassinos, D., 2018, A path to clean water. Science. 361, 6399 (Jul. 2018), 222–224. https://doi.org/10.1126/science.aau2405.

[12]Lapworth, D., Boving, T., Brauns, B., Dottridge, J., Hynds, P., Kebede, S., Kreamer, D., Misstear, B., Mukherjee, A., Re, V., Sorensen, J., Vargas, C.R., 2023, Groundwater quality: global challenges, emerging threats and novel approaches. Hydrogeology Journal. 31, 1, 15–18. https://doi.org/10.1007/s10040-022-02542-0.

[13]Mihăilă, D., Bălteanu, D., 2022, itrate contamination of groundwater in the Romanian Plain: Causes and implications. Environmental Monitoring and Assessment. 194, 3 (2022), 1–15. https://doi.org/10.1007/s10661-022-09876-4.

[14]Minea, I., Iosub, M., Boicu, D., 2020, Groundwater Resources from Eastern Romania under Human and Climatic Pressure. Sustainability. 12, 24 (Dec. 2020), 10341. https://doi.org/10.3390/su122410341.

[15]Mocanu, L., Mocanu, P., 2016, USA Environmental Due Diligence Practice Case Study on an Industrial Site Located in Caras-Severin County, Romania. V, (2016), 39–48.

[16]Mukherjee, A., Jha, M.K., Kim, K.-W., Pacheco, F.A.L., 2024, Groundwater resources: challenges and

future opportunities. Scientific Reports. 14, 1, 28540, https://doi.org/10.1038/s41598-024-79936-5.
[17]National Administration "Romanian Waters" (ANAR) Report on the State of Waters in Romania, 2022–2023.
[18]National Environmental Protection Agency (ANPM) Annual Environmental Report 2022.
[19]National Institute of Statistics (INSSE) 2022. Population and Housing: Provisional Results of the 2021 Census.
[20]Nhamo, L., Ndlela, B., Nhemachena, C., Mabhaudhi, T., Mpandeli, S., Matchaya, G., 2018, The Water-Energy-Food Nexus: Climate Risks and Opportunities in Southern Africa. Water. 10, 5 (Apr. 2018), 567. https://doi.org/10.3390/w10050567.
[21]OECD, 2021, PFASs and alternatives in food packaging (paper and paperboard): Report on the OECD survey.
[22]Organisation for Economic Co-operation and Development PFAS and alternatives in food packaging (paper and paperboard): Hazard profile, 2022. Organisation for Economic Co-operation and Development.
[23]Organisation for Economic Co-operation and Development (OECD) 2021. Pharmaceutical Residues in Freshwater: Hazards and Policy Responses.
[24]Public Health Directorate of Bihor County (DSP Bihor) Annual Activity Report 2022.
[25]Roba, C., Roșu, C., Pișteа, I., Ozunu, A., Mitrofan, H., 2015, Groundwater quality in a rural area from Buzău County, Romania. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development. 15, 2 (2015), 305–310.
[26]Scanlon, B.R., Ruddell, B.L., Reed, P.M., Hook, R.I., Zheng, C., Tidwell, V.C., Siebert, S., 2018, The food-energy-water nexus: Transforming science for society. Water Resources Research. 53, 5 (2018), 3550–3556. https://doi.org/10.1002/2017WR020889.
[27]Stupar, Z., Levei, E.A., Neag, E., Baricz, A., Szekeres, E., Moldovan, O.T., 2022, Microbial water quality and health risk assessment in karst springs from Apuseni Mountains, Romania. Frontiers in Environmental Science. 10. https://doi.org/10.3389/fenvs.2022.931893.
[28]U.S. Environmental Protection Agency EPA Strategic Plan 2022–2026: FY 2024 Annual Performance Plan and FY 2022 Annual Performance Report. Technical Report EPA-190-R-24-001.
[29]U.S. Environmental Protection Agency 2024. Extreme Weather and Groundwater Contamination: Flood Risk and Private Wells.
[30]U.S. Environmental Protection Agency 2012. Guidelines for Groundwater Risk Assessment. Technical Report EPA/600/R-12/640.
[31]Wada, Y., Bierkens, M.F.P., 2014, Sustainability of global water use: Past reconstruction and future projections. Environmental Research Letters. 9, 10 (2014), https://doi.org/10.1088/1748-9326/9/10/104003.
[32]Wada, Y., Van Beek, L.P.H., Van Kempen, C.M., Reckman, J.W.T.M., Vasak, S., Bierkens, M.F.P. 2010. Global depletion of groundwater resources. Geophysical Research Letters. 37, 20 (Oct. 2010), 2010GL044571. https://doi.org/10.1029/2010GL044571
[33]Water, U.N., 2022, Groundwater: Making the invisible visible. World Water Development Report 2022.
[34]World Health Organization, 2004, Guidelines for Drinking-Water Quality.
[35]World Health Organization, 2022, Guidelines for Drinking-Water Quality.
[36]Wright, J., Gundry, S.W., Conroy, R., 2004, Household drinking water in developing countries: A systematic review of microbiological contamination between source and point-of-use. Tropical Medicine & International Health. 9, 1 (2004), 106–117. https://doi.org/10.1046/j.1365-3156.2003.01160.x.
[37]***Directive (EU) 2020/2184 on the quality of water intended for human consumption.
[38]***Government Ordinance No. 7/2023 on the quality of water intended for human consumption.

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AGRICULTURE PRODUCTION IN TWO SPANISH REGIONS WITH INTENSIVE USE OF FOREIGN LABOUR FORCE: A CASE STUDY OF ALMERIA AND MURCIA

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Abstract

Almeria and Murcia are regions that represent a tiny part of Spain in terms of area and population, but they account for a significant share of the national production and export of vegetables, supplying a large part of the EU Member States. As production and exports have grown, so has the demand for labour, and an increasing proportion of this demand has been met by immigrants. Thus, Murcia and Almería became Spain's major centres of immigrant-based agriculture, where intensive production resembles an industrial process. The aim of this study is to show that the strong raise in production has attracted migrants and their presence in the agricultural sector has increased significantly. Data on production, exports, labour force and migration were collected from different Spanish institutions over a period of thirty-eight years and a multiple linear regression model was applied to test our hypothesis. The results obtained confirm this hypothesis and are consistent with theories explaining labour migration.

Key words**:** *intensive agriculture, immigrants' workforce, labour migration, vegetable exports, production growth*

INTRODUCTION

Migration is a multifaceted, constantly evolving process, and no single theory can fully explain its complexities. As a result, most empirical studies are analytical but fall short in one way or another.

Experts argue that the statistical methods used in these studies are often basic and lack sufficient tests (Massey et al., 1998) [16].

However, correlation-regression models have been successfully used by some authors. Glukhov et al. (2022) developed such a model explaining the migration flow of employed rural population in Saratov region, Russian Federation [8].

Also, regression models were used by White Andreea (2005) to study the influence of economic variables on net migration in Iowa counties [27].

The reasons for initiating migration can be traced to various factors, such as wage disparities between countries, dysfunctions in markets in the countries of origin, the demand for labour in industrialised nations, or the expansion of developed nations into developing country markets (Portes and Böröcz, 1989) [25].

Migratory patterns are primarily driven by economic factors, such as income differences, changing disparities between countries, and the relative economic status and structural characteristics of both origin and destination countries, as affirmed various researchers.

Socio-economic structure and migration at international level and in the situation in Turkey was presented by Akdemir et al.(2024) [2].

Most migrants today originate from nations characterised by limited capital, low job creation, and an oversupply of labour. International migration helps balance labour supply and demographic shifts in both sending and receiving nations, influencing economic growth, trade patterns, income distribution, and political power within and between these countries (Chiswick and Hatton, 2002) [3].

Lee (1966, 1996) [13, 14] explains migration patterns by identifying the factors that compel individuals to leave their home country (push factors) and the factors that draw them to a new destination (pull factors) which is particularly

relevant to this study [13]. The neoclassical theory is also relevant to this research, as it suggests that migration decisions are largely made on an individual basis, with the individual weighing the costs and benefits of migrating.

Although migration decisions can sometimes be family-based (Taylor, 1999) [26], the primary motivation for migration in the case of European countries that have become receivers, including Spain, is wage and employment disparities.

This paper demonstrates that although there is significant demand for immigrant labour in some sectors, workers from low-income countries are often employed in the secondary labour market (Piore, 1979) [24].

According to Lewis (1954) [15], when the labour force increases in receiving countries, output should rise, while demographic and employment pressures in sending countries should decrease.

Furthermore, when there is complementarity between native and immigrant labour rather than substitution, unemployment in destination countries should not rise. This is the case in certain economic sectors in Spain, such as the agriculture.

The South-Eastern Spain is well known for an intensive agriculture and Almeria, a sub region of Andalusia, is a remarkable supplier of vegetables and fruits for the internal and external market (Chiurciu et al, 2021) [4]. This is the reason why in this region it is needed a huge labour force in agricultural production and migrants are welcome to help. Kostova (2008) emphasized the socio-economic effects of migration in Spain [12].

In this context, we focus our study on the Spanish regions Almeria and Murcia, which represent a small portion of Spain in terms of both area and population and provide a relevant share of the production and export of vegetables, supplying a big part of EU Member States.

Along with the strong increase of the production and exports, the demand for labour force raised and increasingly higher part of this demand has been covered progressively by immigrants since 1986 while the production of vegetables has increased by 250% and the export by 700% in the case of Almeria and by 100% and by 400% respectively in the case of Murcia.

We suggest that the strong increase in production and exports generated a *call effect* on migrants and therefore their presence in the agriculture sector in both regions raised so significantly.

MATERIALS AND METHODS

The period analysed in this paper comprises the years 1986-2023. Data refer to national values, as well as regional values (Almería and Murcia). Data on registered foreign population and foreign labour force proceed respectively from the Municipal Register and Labour Force Survey, Spanish National Statistical Institute (INE) [10, 11], as well as from the statistics of the Ministry of Interior [18], National Institute for Social Insurance (from 2013 onwards: Ministry of Inclusion, Social Security and Migration) [23] and the Ministry of Labour and Social Economy (MTES) [19, 20, 21, 22]. Data on regional agriculture production come from the Statistical Yearbook of Andalusia/ Counselling of Agriculture and Fisheries, Provincial Delegation of Almería and Regional Agricultural Statistics, Department of Agriculture and Water, Region of Murcia [5, 6].

Finally, data on agriculture exports were collected from the Spanish National Tax Office and the Ministry of Economy, Trade and Enterprise (DataComex) [1, 7, 17].

The methodology used in this study is a multiple linear regression through which we explain that the strong expansion of the production and exports attracted migrant workers. As a result, their presence in the agricultural sector in both regions have increased substantially.

Among the sixty variables created and analysed for the study (with thirty-eight observations each) collected from Spanish Institutions, we selected several relevant independent variables (mostly calculated shares) and a dependent variable, immigrants in agriculture sector, then we performed an analysis for each region.

Thus, in the function:

$$y_j = b_o + b_1x_{1j} + b_2x_{2j} + \cdots + b_kx_{kj} + u_j \quad \text{.....(1)}$$

where:
y (Immigrants with valid work permission in agriculture) is a variable that can be referred to as dependent and ***x*** are independent (Share Green Houses/Total Vegetable Production (Ha); Vegetable produce (Metric Tonnes (MT)); Share of the exported vegetables (€) and Employed workers in agriculture (annual average values). In the model we notice indication for a direction of the effects from the ***x*** variables to the ***y*** variable, so that the value of the latter seems to be influenced by the values of the former.

RESULTS AND DISCUSSIONS

Immigration in Spain has raised spectacularly during the past thirty years. If we go back in 1986, immigrants accounted for less than 1% of the total population and this remained the case until the early 1990s. In 2000 they represented 2% of the total population, but by the end of 2023 13% of the total population in Spain is foreign. While immigrants represented 2.7% and 1% of the total population of Almería and Murcia at the end of 90ties, according to the recently published data from the INE municipal registry, they now represent 30% and 17%, respectively. The increase of Romanians and Bulgarians has also been huge (Figure 1).

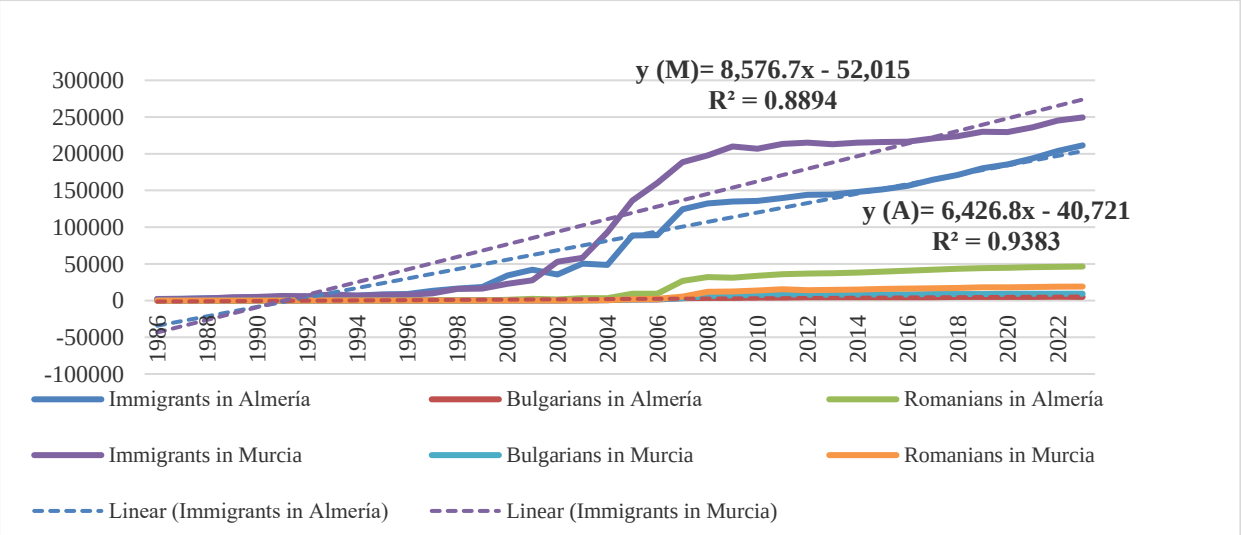

Fig. 1. Evolution of the immigrants in Almería and Murcia
Source: Ministry of Inclusion, Social Security and Migration [23].

The cumulative annual average rate of increase in immigrants' presence is 13% for Almería and 14% for Murcia.
The cumulative annual average rate was calculated using the formula:

n-1 (√(final value ÷ first value) – 1) x 100
.....(2)

Hence, the total growth rate of immigrants for the period is more than 10,000% in both regions.
The intensive agriculture which is so relevant in both regions is similar to an industrial process.
Meanwhile the share of migrants' workers in agriculture sector in each region was insignificant in 1986, much less than 1% of the workers, in 2023 they comprise more than half of those employed in agriculture.
Agriculture itself is a sector that requires labour at a specific moment in time, since harvests cannot be delayed until the arrival of the workers. Therefore, in addition to being labour- intensive, this sector, unlike others, is much less likely to postpone its activity and if it does not have a sufficient number of workers, it is impossible to harvest the production.
Both regions have similar production models: capital- and labour-intensive horticulture that does not allow for much mechanisation, a similar climate and a predominance of salaried

labour, although with a decrease in the number of native workers (Figure 2).
It should be stressed out that this is an extremely important agricultural sector at both, regional and national level.
Its weight in the economies of the two regions is important and is growing more than other economic sectors.
It is also important to underline that intensive agriculture is very prominent in both regions, especially in Almeria, however in Murcia its growth has also been very fast.
The significant rise in production aimed at export is evident, increasing from less than 30% in 1987 to 56% and 70% in 2023 in Almeria and Murcia, respectively. Notably, Almeria and Murcia together account for 60% of the national vegetable exports, with 38% and 22%, respectively.

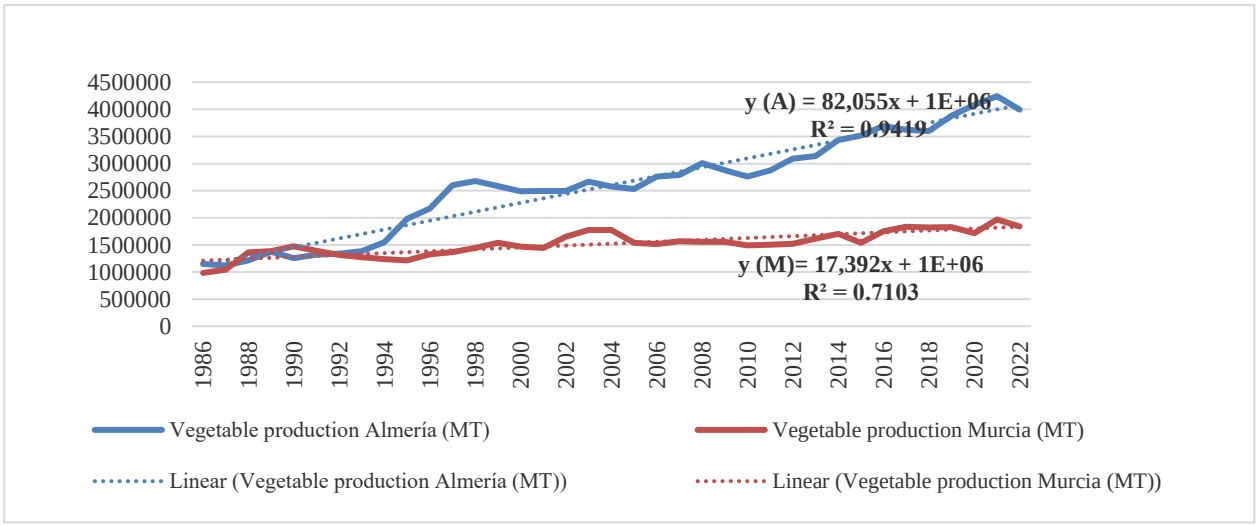

Fig. 2. Vegetable production Almería and Murcia 1986-2023 (Metric Tonnes, MT)
Source: Statistical Yearbook of Andalusia / Counselling of Agriculture and Fisheries, Provincial Delegation of Almería and Regional agricultural statistics, Department of Agriculture and Water, Region of Murcia [11, 5, 6].

This growth is attributed to industrialised agriculture under plastic, which has increasingly incorporated new technologies, it is labour-intensive, and has relatively low mechanisation.
A favourable combination of factors, including climate, access to agricultural credit, sufficient labour supply, and the rising demand for horticultural products from large European markets, has fuelled the sector's expansion.
Additionally, services and industries related to agriculture have also developed alongside the widespread agricultural activity.
In contrast, while intensive agriculture grew and both production and exports expanded, the local population at working age began to shift toward other economic sectors.
The proportion of wage labour also increased. A strong demand for labour in the agricultural sector, which was largely met by migrant workers over time, resulted in a high and positive correlation between the number of migrant workers and the production of key vegetables. In other words, the decrease in the number of native workers employed in agriculture has been clearly compensated by the arrival of workers from abroad.
Definitely the average annual increase in immigrant labour force in agriculture has been spectacular: 1,556 in Murcia and 1,134 in Almería.

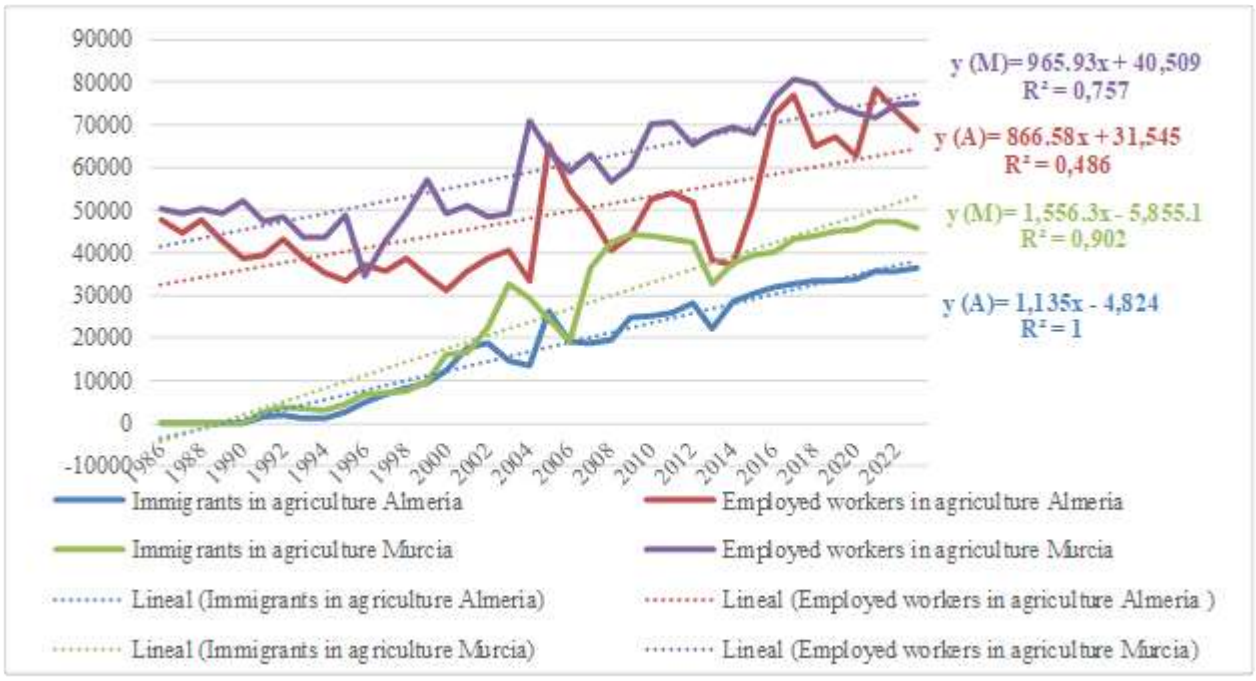

Fig. 3. Evolution of the employed and immigrant workers in agriculture
Source: Labour Force Survey, Spanish National Statistical Institute (INE); National Institute for Social Insurance; Ministry of Inclusion, Social Security and Migration and the Ministry of Labour and Social Economy (MTES) [9, 19, 20, 21, 22, 23].

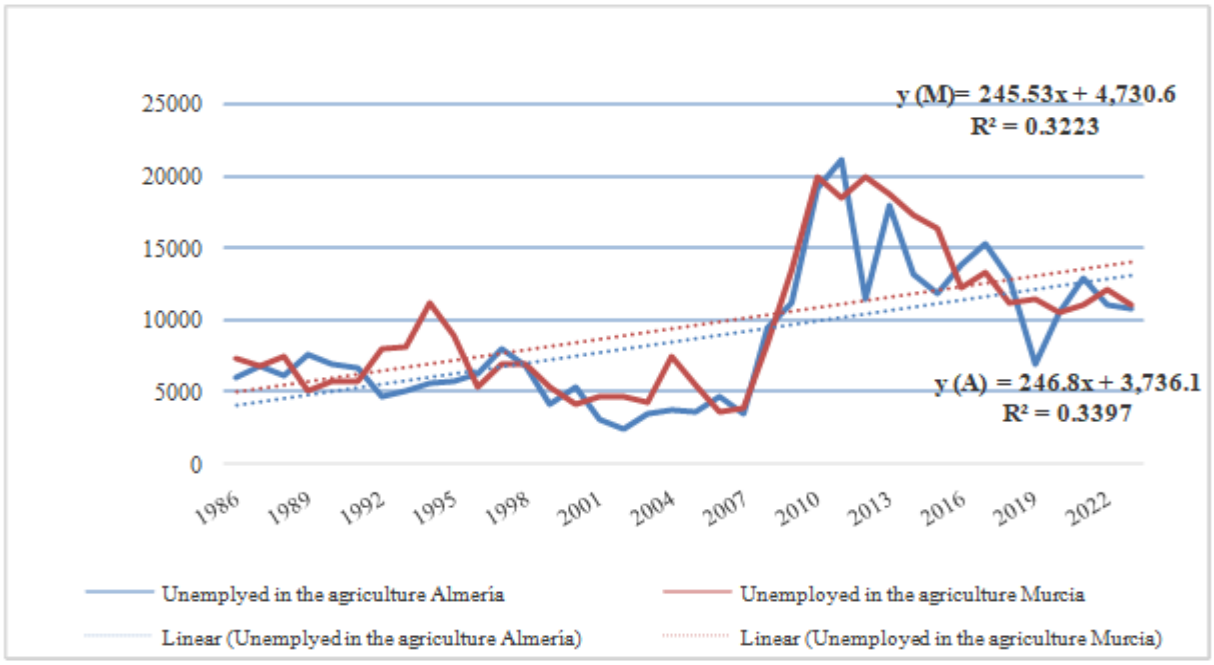

Fig. 4. Unemployed workers in agriculture (Almería and Murcia)
Source: Labour Force Survey, Spanish National Statistical Institute (INE) [9].

This happened to complement and add to the total number of employed in agriculture whose average annual increase was 966 in Murcia and 866 in Almería which suggests that meanwhile native workers have been abandoning the agriculture sector, immigrants have been arriving to support it (Figure 3).

Meanwhile the share of migrants' workers in agriculture sector in each region was insignificant in 1986, much less than 1% of the workers, in 2023 they comprise more than half of those employed in agriculture.

Thus, Murcia and Almería are Spain's larger centers of immigrant-based agriculture.

Meanwhile the number of unemployed in the agriculture in both regions have not experienced a relevant increase only about 240 annually in each region (Figure 4). Out of the sixty variables created and analysed for the study, we selected several key independent variables (primarily calculated shares) and then used the number of immigrants in the agricultural sector as a dependent variable.

The correlations between variables referring to production and exports, on the one hand, and, on the other hand, variables referring to the total and immigrant population show in most cases high positive relationship.

Table 1 shows that the significance is less than 0.05 in both cases (Almería and Murcia), therefore the model is good at explaining the dependent variable, it is statistically significant.

Table 1. ANOVA Almeria and Murcia

ANOVA[a](Almería)

Model		Sum of squares	df	Mean square	F	Sig.
1	Regression	5667091473.400	4	1416772868.350	53.984	<.001[b]
	Residual	892298672.497	34	26244078.603		
	Total	6559390145.897	38			

a.Dependient variable: Immigrants with valid work permission agriculture Almería

b. Predictors: (Constant).Vegetables Exports Almería/Vegetable Exports Spain; Green Houses Ha/Total Vegetable produce Ha (Almería); Employed population agriculture (annual average) Almería; Vegetable produce (MT) Almería

Model Summary[b] (Almería)

Modelo	R	R squared	R squaredadjusted	Standard error of the estimation
1	.929[a]	0.864	0.848	5122.897

a. Predictors: (Constant), Vegetables Exports Almería/Vegetable ExportsSpain; Green Houses Ha/Total Vegetable produce Ha (Almería); Employedpopulationagriculture (annualaverage) Almería; Vegetable produce (MT) Almería

b. Dependient variable: Immigrants with valid work permission agriculture Almería

ANOVA[a] (Murcia)

Model		Sum ofsquares	df	Mean square	F	Sig.
1	Regression	10233016582.826	4	2558254145.706	35.283	<.001[b]
	Residual	2465213490.610	34	72506279.136		
	Total	12698230073.436	38			

a. Dependient variable: Immigrants with valid work permission agriculture Murcia

b. Predictors: (Constante), Green Houses Ha/Total Vegetable Produce Ha (Murcia); Vegetable produce (MT) Murcia; Vegetable Exports Murcia/ Vegetable Exports Spain; Employed population agriculture (annual average) Murcia

Model Summary[b] (Murcia)

Modelo	R	R squared	R squared adjusted	Standard error of the estimation
1	.898[a]	0.806	0.783	8515.062

a. Predictors: (Constant), Green Houses Ha/Total Vegetable Produce Ha (Murcia); Vegetable produce (MT) Murcia; Vegetable Exports Murcia/ Vegetable Exports Spain; Employed population agriculture (annual average) Murcia

b. Dependient variable: Immigrants with valid work permission agriculture Murcia.

Source: Authors' findings.

Then, the R-squared is 0.864 and 0.806 respectively, which indicates that the model explains 86.4% (Almería) and 80.6% (Murcia) of the dependent variable variance.

Significance of the t-test: the variables employed population in agriculture, share of the national exports of vegetables in both regions, vegetable produce in Almería do explain the justification of immigrants' increased presence in agriculture, since as the significance is less than 0.05. The variable on surface Share Green Houses/Total Vegetable Produce is not related to the increased presence of immigrants in agriculture since the significance is greater than 0.05.

Table 2. Coeficients- ALMERIA

Model	**Unstandardised coefficients**		**Standardised coefficients**		
	B	Desv. Error	Beta	**t**	**Sig.**
(Constant)	-39229.664	6713.816		-5.843	0.000
Vegetables Exports Almería/Vegetable Exports Spain	690.511	272.686	0.256	2.532	0.016
Green Houses Ha/Total Vegetable produce Ha (Almería)	49.721	94.516	0.050	0.526	0.602
Employed population agriculture (annual average) Almería	0.226	0.079	0.234	2.872	0.007
Vegetable produce (MT) Almería	0.008	0.002	0.515	4.577	0.000

a. Dependent variable: Immigrants with valid work permission agriculture Almería
Source: Authors' findings.

Table 3. Coeficients- MURCIA

Model	**Unstandardised coefficients**		**Standardised coefficients**		
	B	Desv. Error	Beta	**t**	**Sig.**
(Constant)	-97366.434	15607.376		-6.238	0.000
Green Houses Ha/Total Vegetable Produce Ha (Murcia)	1236.135	842.160	0.075	1.468	0.151
Vegetable produce (MT) Murcia	0.012	0.012	0.145	1.047	0.303
Vegetable Exports Murcia/ Vegetable Exports Spain	1655.772	790.507	0.187	2.095	0.044
Employed population agriculture (annual average) Murcia	0.891	0.170	0.593	5.248	0.000

a. Dependent variable: Immigrants with valid work permission agriculture Murcia
Source: Authors' findings.

Finally, beta coefficients (β): The independent variable that most explains the presence and increase of immigrants with valid work permission in agriculture in both regions is the employed workers in agriculture in both regions: β is 0.6 for Murcia and 0.3 for Almería since in the case of Almería the highest influence has the huge increase in vegetable production (Figure 2).

The next variable that is most explicative is the national share of vegetable exports (β = 0.3 in the case of Almería and 0.2 in the case of Murcia) whose increase in both regions has been immense, too. Furthermore, the greater the Share Green Houses/Total Vegetable Produce (Ha), greater the trend to increase production and in consequence, immigrants' presence in agriculture, although the strength of this relationship is lower, as beta value is closer to 0.

CONCLUSIONS

Our findings indicate that a significant portion of immigrants in both regions is driven by the high demand for labour from abroad. Within the agriculture sector, there has been complementarity between native workers and immigrants.

The obtained results from the F-test, R2, significance of the t-test and β coefficients are adequate to prove our hypothesis. The results go along with theories that explain migration as, among others, the dual labour market theory and the push and pull theory.

The expansion of production and exports has been facilitated by a sufficient labour supply, which has been increasingly met by immigrant workers in labour-intensive roles. Moreover, we suggest that there has been a positive spillover effect, with the growth of ancillary services and the processing industry, leading to the creation of new jobs.

Looking ahead, it is likely that the demand for horticultural products will continue to grow, and production capacities should be able to meet this demand. The increase in immigrant's labour in agriculture will depend on the sector's future needs. However, it is important to highlight that other countries, especially those

in the southern Mediterranean, also produce similar products. Nonetheless, both Spanish regions hold an advantage due to their extensive experience, quality of their produce, well-developed marketing networks, and established markets.

REFERENCES

[1]Agencia Tributaria, 1986-1999, Estadísticas de Comercio Exterior, https://sede.agenciatributaria.gob.es/Sede/estadisticas/estadisticas-comercio-exterior.html, Accessed on October 17, 2024.
[2]Akdemir, S., Gultekin, U., Tuna, K.E., Ismailla, I.S., 2024, International migration and agricultural sustainability in the Çukurova region: detailed analysis of socio-economic structure and migration interactions. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 24(2), 27-38
[3]Chiswick, B. R., Hatton, T. J., 2002, International Migration and the integration of Labor Markets, Discussion Paper Nº 559, Institute for the Study of Labor.
[4]Chiurciu, I.A., Soare, E., Vlad, I.M., Toma, E., 2020, The main trends in the activity of agri-food cooperatives in Almería, Spain. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 20(2), 145-154.
[5]Consejería de agricultura y pesca, Delegación provincial de Almería (1986-2006). Estadística agraria.
[6]Consejería de agricultura y agua, Región de Murcia (1986-2023), Estadística agraria regional.
[7]Consejo Superior de Cámaras, 1999-2004, Base de datos de comercio exterior, https://www.camara.es/comercio-exterior/base-de-datos-de-importaciones-y-exportaciones-en-espana, Accessed on November 3, 2024.
[8]Glukhov, S.G., Kryuchkov, G.G., Providonova, N.V., 2021, Correlation-regression model of migration flows of employed rural population in Saratov region, Russian Federation. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 21(3), 405-410.
[9]Instituto Nacional de Estadística, 1986-2023, Encuesta de la población activa, www.ine.es, Accessed on November 14, 2024
[10]Instituto Nacional de Estadística, 1986-2023, Exploración Estadística del Padrón Municipal, www.ine.es, Accessed on October 18, 2024.
[11]Instituto de Estadística y Cartografía de Andalucía, 1996-2006, Datos estadísticos y geoespaciales, Anuario Estadístico de Andalucía, https://www.juntadeandalucia.es/institutodeestadisticaycartografia/anuario, Accessed on November 10, 2024.
[12]Kostova, M., 2008, Los efectos económicos de la inmigración: el sector de la agricultura en España. Monografías de Temas Laborales. 36, pp. 1 - 332. Andalucía (España): Mergablum. Edición y comunicación, S.L.
[13]Lee, E., 1966, A Theory of Migration. Demography, 3(1), 47-57.
[14]Lee, E., 1996, A theory of migration. In: Robin Cohen (Editor) Theories of Migration, The International Library of studies on migration, An Elgar reference collection, Cheltenham, UK, pp.14-25.
[15]Lewis, W. A., 1954, Economic development with unlimited supplies of labour, Manchester School of Economics and Social Studies, 22, 139-191
[16]Massey, D., Arango, J., Hugo, G., Kouaouci, A., Pellegrino, A., Taylor, J.E., 1998, Worlds in Motion. Understanding International Migration at the End of the Millennium, Clarendon Press, Oxford.
[17]Ministerio de Economía, Comercio y Empresa, DataComex, 1999-2023. Estadísticas de comercio exterior de bienes de España y la UE, https://datacomex.comercio.es/, Accessed on November 12, 2024.
[18]Ministerio del Interior, 1992-2006, Anuario estadístico de extranjería, Secretaría de Estado de Inmigración y Emigración, Madrid.
[19]Ministerio de Trabajo y Asuntos Sociales, 1986-1988, Estadística de permisos de trabajo a extranjeros, Dirección general de informática y estadística.
[20]Ministerio de Trabajo y Asuntos Sociales, 1990-2002, Anuario de migraciones, Madrid.
[21]Ministerio de Trabajo y Asuntos Sociales, 1999-2005, Boletín de Estadísticas Laborales.
[22]Ministerio de Trabajo y Economía Social (MTES), 1986-2023, Estadística de Autorizaciones de Trabajo a Extranjeros, https://www.mites.gob.es/es/estadisticas/Inmigracion_emigracion/PTE/welcome.htm, Accessed on November 4, 2024.
[23]Observatorio Permanente de la Inmigración (OPI), 1996-2023, Ministerio de Inclusión, Seguridad Social y Migración, https://www.inclusion.gob.es/web/opi/estadisticas/catalogo, Accessed on November 6, 2024.
[24]Piore, M., 1979, Birds of Passage: Migrant Labor and Industrial Societies, Cambridge University Press.
[25]Portes, A., Böröcz, J., 1989, Contemporary immigration: theoretical perspectives on its determinants and modes of incorporation, International Migration Review, 23, pp..606-630.
[26]Taylor, E., 1999, The New Economics of Labour Migration and the Role of Remittances in the Migration Process. International Migration, 37, 63–88.
[27]White, A., 2005, Push and pull: Using regression models to study the influence of economic variables on net migration in Iowa counties, University of Northern, Iowa, https://scholarworks.uni.edu/cgi/viewcontent.cgi?article=1153&context=pst, Accessed on April 10, 2025.

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IMPACT OF AGRICULTURE ON THE ENVIRONMENT IN BULGARIA AND ROMANIA

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Abstract

Agriculture has a significant impact on the environment. The implementation of inefficient agricultural practices can have severe consequences, both for natural ecosystems, the environment, soil and water quality, and for all humanity on the planet. Eurostat data for 2007-2023 were used to make a comparison between Bulgaria and Romania regarding the impact of agriculture on environment using specific indicators. The analysis found that in Bulgaria the areas occupied by organic crops continue to increase, and it is expected that by 2027 they will reach 6.98% of the UAA. In Romania, the areas are constantly increasing and reach 5.08% in 2022. The levels of pesticides and mineral fertilizers used in Bulgaria and Romania are relatively slowly decreasing, which will undoubtedly contribute to limiting pollution processes for the benefit of the environment. The recognized need for joint efforts of administrative structures to make adequate decisions regarding achieving a higher degree of sustainability in agriculture. The shift to sustainable models accelerates the transition to agricultural practices aimed at maintaining ecological balance in the system. The protection of the environment and natural resources is of priority importance for achieving a sustainable long-term vision for agricultural development.

Key words**:** *sustainable development, sustainable agricultural practices, analysis, environment*

INTRODUCTION

In recent years, the sustainable development of the agricultural sector has focused on environmental and climate challenges related to a greater contribution to environmental care. Global climate change, limiting harmful emissions into the atmosphere, and preserving and protecting natural ecosystems require a transition to more ecological and sustainable agricultural practices.

The use of excessive amounts of pesticides and fertilizers in agriculture still leads to negative consequences for the environment, climate and biodiversity.

Promoting the implementation of environmentally friendly agricultural practices is key in creating sustainable systems for the production of quality and healthy products in order to maintain the ecological balance of natural resources (Krasteva et al., 2024) [10]. ***This provokes us to formulate the purpose of this study***, namely to analyze various indicators influencing the environment. The main research tasks set by the authors are:

- a theoretical analysis of the sustainable development of agriculture in the context of the Common Agricultural Policy of the European Union is made.
- analysis of the state and monitoring of trends in the impacts of agricultural practices on the environment.
- outlining guidelines for reducing the adverse impact of agriculture on the environment.

In modern conditions, issues related to sustainable development are the subject of attention by a number of researchers worldwide. Characteristic of the national and European agricultural policy is the perception of sustainable agriculture as an important principle for achieving a balanced attitude with optimal use of resources. A number of definitions related to the concept of sustainable agriculture can be indicated.

The term "sustainability" in agriculture is beginning to spread and develop in different aspects - biological, economic, social. The most commonly accepted understanding of

"sustainability" is in relation to ecology, according to which, if an agricultural system has adverse consequences on the environment, it cannot be called sustainable (Hadzhieva, 2007) [7]. Sustainable agriculture outlines the need to function and maintain a balanced interaction between the main components of the agricultural system, providing fairer incomes to farmers. Sustainable development is development that meets the needs of the present generation without limiting the ability of future generations to meet and realize their own needs. The different emphases on the sustainability of agriculture can be combined into a broader definition, namely, sustainable agriculture is economically efficient, environmentally compatible and socially responsible, helping to provide the population with quality food products in the long term and providing an opportunity for a better standard of living in rural areas.

Sustainable development is the subject of attention in a number of European and national documents, as well as in many scientific publications. For example, a study by a team of authors states that sustainable agriculture is considered a complex concept, including environmental, economic and social elements.

Sustainable agriculture is perceived as the most important component of sustainable development for ensuring economic viability and social justice in the functioning of a modern agricultural economy (Ivanov, Radev, Borisov, &Vachevska, 2012) [8].

The issues of sustainability, limited natural resources, and the introduction of environmentally friendly practices are addressed in a publication by Nikolova, which emphasizes the need to create new approaches and sustainable production models to ensure a higher degree of sustainable development of the rural economy (Nikolova, 2024b) [15]. Another author focuses on strategic guidelines for achieving sustainable development of areas with the possibility of preventing environmental pollution (Elitsa, 2024) [4].

In his publication Mitov (Mitov, 2023) [11] tracks the trends of different types of indicators divided into several directions affecting the environment. In this regard, it is increasingly clear that it is necessary to take adequate measures and tools related to the policies implemented in the country to improve the training and training of specialists in the production of high quality products.

In 1992, an Action Plan /"AGENDA 21"/ was adopted which defined the necessary priority tasks related to achieving a balance between the main three segments related to sustainable development at national and international level [22]. The "Agenda for the 21st Century" program continues to clarify the essence of sustainable development for the implementation of the processes of balanced socio-economic and environmental development to meet the growing needs of present and future generations. States must comply with the conditions and adopted basic principles considering all aspects of sustainable development related to environmental protection, biological diversity and rural development.

The 2030 Agenda for Sustainable Development was launched in 2015, which creates a blueprint for a better sustainable future for all peoples of the world. It is based on five components and the included 17 sustainability goals. Each country must take active actions related to the protection of human rights, overcoming hunger and poverty, as well as issues related to providing a favorable environment for living in harmony with the environment and nature. The goals are integrated and indivisible and balance the three dimensions of sustainable development: economic, social and environmental.

The Recovery and Resilience Facility, as part of the Next Generation EU (2021-2024) component of the European Recovery Plan [18] will play a key role. It will support Member States in their efforts to address the economic and social consequences of the COVID-19 pandemic, as well as in their efforts to build more resilient public systems and national economies. To receive support, member states must prepare national recovery and resilience plans setting out their reform and investment programmes until 2026.

Sustainable development issues are also addressed in the National Development Program "Bulgaria 2030", which sets out the vision and general goals and priorities of

development policies in all sectors of government. The document outlines three strategic goals and groups 13 national priorities (National Development Program Bulgaria 2030, 2020) [13]. Special attention in this strategic document is paid to Priority 6 "Sustainable Agriculture". The main emphasis is placed on the processes of restructuring agriculture, establishing structural and sectoral balance between crop production and livestock production, and encouraging more and more young people to engage in agriculture to ensure food security for society.

In this regard, since 2007, the Common Agricultural Policy (CAP) has been implemented in Bulgaria, founded in 1962 with the important task of providing support to farmers and improving the conditions for the development of agriculture in rural areas. The COVID-19 pandemic continues to change the priorities and values of all people. We are increasingly thinking about what food we put on our table and how it affects our health. In modern conditions, the production of agricultural products is faced with a number of economic, social and environmental challenges to ensure the sustainability of farms, meet the need for environmentally friendly food with a reasonable use of natural resources in order to maintain a fair standard of living for farmers. The CAP is a proven mechanism and tool for managing the transition to a sustainable food system and for strengthening the efforts of European farmers to contribute to the EU's climate and environmental objectives [5].

The Farm to Fork strategy is at the heart of the Green Deal and focuses on innovative solutions for sustainable production practices to ensure the future of agriculture. (Draft National Action Programme to contribute to the achievement of the objectives of the Farm to Fork Strategy by 2030, 2023) [3]. The new CAP has been implemented since 1 January 2023, which is an innovative policy and seeks to provide reliable support to farmers and food security with an even higher degree of adaptation to new developments related to economic sustainability in the long term. It will be fairer, greener and more sustainable in terms of agricultural and rural development, contributing to the protection of the environment, climate and biodiversity (Krasteva, 2024) [9].

The CAP is a broad-based strategy and is built on three main objectives for achieving sustainability in agriculture: economic sustainability; environmental sustainability and social sustainability. To achieve them, all EU countries use large-scale actions and measures, each of which draws up a strategic plan. For the period 2023-2027, these strategic plans have an important role to play in supporting the transition of European agriculture towards a new sustainable model. In this sense, joint efforts are needed to support farmers' incomes and to ensure more active actions related to the modernisation of agricultural holdings in order to strengthen the competitiveness of the sector.

Each member state develops a CAP Strategic Plan, which defines various interventions related to increasing investments, promoting sustainable development and modernizing agriculture (Strategic Plan for the Development of Agriculture and Rural Areas for the period 2023-2027, 2023) [20]. The CAP promotes sustainable agricultural practices that are aimed at addressing climate change and protecting the environment [20].

It is also essential to strengthen the socio-economic structure of rural areas with the possibility of increasing jobs and improving the quality of life.

We can summarize that as a result of the studied literary sources and author's opinions on the topic under consideration, the challenges facing the agricultural sector are becoming increasingly significant in achieving sustainability of agricultural production and its impact on the environment. The implementation of sustainable agricultural practices leads to mitigation of the negative effects of climate change, stabilizes agro-ecosystems, protects water, soil, air, biodiversity and increases their resilience in rural areas.

In this context, the purpose of the paper is to analyze the impact of agriculture on environment in Bulgaria and Romania in the period 2007-2023 based on Eurostat data and making a comparison for identifying

similarities and discrepancies of the studied specific indicators.

MATERIALS AND METHODS

The data analyzed in this article are based on public information and official statistical data available by Eurostat. The study is based on an analysis of key indicators and units of measurement - areas with organic farming (hectares and % of the total utilized agricultural area- UAA), pesticide use (tons of active substances), harmonized pesticide risk indicator by categorization of active substances (index, 2011-2013, average =100), amounts of mineral fertilizers used (tons) and ammonia emissions from agriculture (tons).

Romania is a neighboring country of Bulgaria and the EU membership of both countries started on January 1, 2007, which gives us the right to conduct a comparative analysis of some leading indicators for Bulgaria and Romania under equal starting conditions.

General scientific research methods were used: literature research, logical analysis and synthesis, induction, comparative analysis, with part of the data presented in tables and graphs.

RESULTS AND DISCUSSIONS

Analysis of the impact of agricultural practices on the environment

The processes of industrialization have led to many environmental problems related to damage to soil fertility, air and water pollution, gases emitted into the atmosphere, and disruption of biodiversity. The role of the specific indicators considered is of great importance, with an emphasis on accelerating the transition towards achieving sustainable agriculture. In order to limit the negative impact on the environment, various actions and measures will be stimulated, agro-ecological practices related to the application of organic farming methods, precision farming, reducing the use and risk of chemical pesticides and fertilizers will be promoted. (Krasteva et al., 2024) [10]. Animal welfare practices can also be included. In this regard, in order to achieve higher sustainability of agriculture for rural development in Bulgaria, we will outline a more detailed analysis of the environmental impacts of agricultural practices on the environment for the period 2007-2023.

A key priority in the agricultural development policy is organic farming. For example, the National Plan for the Development of Organic Production continues to stimulate actions aimed at sustainable practices and it is indicated that by 2030 at least 25% of agricultural land will be occupied by organically grown crops (National Action Plan for the Development of Organic Production by 2030, 2025) [12]. Such sustainable agricultural practices are the starting point for the development of the food system related to the provision of clean and healthy food. According to Nikolova, in this line of thought, organic production is already applicable in Bulgaria an alternative economic agribusiness model with the possibility of achieving a multiplier effect in the development of modern farms (Nikolova, 2024a) [14].

An indisputable fact and as a good innovative example can be pointed out the choice of farmers who turn to organic beekeeping as another opportunity to start a business in small settlements (Stanev, 2018) [19]. Another author reveals and analyzes specific indicators and significant factors for the development of beekeeping in rural areas (Angelov, 2024) [1].

Therefore, we can emphasize that the transition from traditional to sustainable agricultural production has an important aspect, as it contributes to the preservation of soil fertility, reduces emissions into the atmosphere, minimizes harmful effects on the environment and produces quality products without artificial additives. Nikolova and Pavlov confirm in their publication that it is necessary to take adequate decisions by all stakeholders to reduce the ecological footprint in relation to the consequences of global warming (Nikolova & Pavlov, 2024) [16]. To achieve this goal, we will reveal the state and trends in the development of organic agriculture in Bulgaria and Romania for the period 2007-2023. From the official statistics of Eurostat the areas with organic agriculture in Bulgaria recorded the highest growth in 2016 - 160,620 ha, and the lowest areas were recorded in 2009 - 12,321 ha

(Table 1). If we follow the last completed reference period 2014-2020 for rural development and take 2014 as the base year, we can compare all analyzed years to find the change of each year compared to the base year (2014).

Table 1. Areas under organic farming in Bulgaria and Romania for the period 2007-2023 (ha)

Years	Country			
	Bulgaria	Compared to 2014 change	Romania	Compared to 2014 change
2007	13,646	-34,268	131,456	-157,796
2008	16,663	-31,251	140,132	-149,120
2009	12,321	-35,593	168,288	-120,964
2010	25,648	-22,266	182,706	-106,546
2011	25,022	-22,892	229,946	-59,306
2012	39,138	-8,776	288,261	-991
2013	56,287	+8,373	286,896	-2,356
2014	**47,914**	**St**	**289,252**	**St**
2015	118,552	+70,638	245,924	-43,328
2016	160,620	+112,706	226,309	-62,943
2017	136,618	+88,704	258,471	-30,780
2018	128,839	+80,925	326,260	+37,008
2019	117,779	+69,865	395,228	+105,976
2020	116,253	+68,339	468,887	+179,635
2021	86,310	+38,396	578,727	+289,475
2022	110,441	+62,527	644,520	+355,268
2023	147,798	+99,884	No data	-

Source: based on Eurostat data and author's calculations [6].

The table shows that the largest change in the area of organic farming compared to 2014 was +112,706 ha in 2016.

The total area of organic farming in Bulgaria continues to increase, and in 2023 it covers 147,798 ha of agricultural land, which is 33.83% more than in 2022 and 208.47% more than in 2014.

For comparison, the areas occupied by organic farming in Romania recorded the highest growth in 2022 - 644,520 ha, and the lowest values were recorded in 2007 - 131,456 ha. The largest change compared to the base year was +355,268 ha in 2022 or an 11.37% increase compared to the previous year 2021. The lowest value was reflected in 2012 compared to the base year 2014 -991.

The areas under organic farming in Bulgaria and Romania for the period 2007-2023, as % of the total utilized agricultural area (UAA) are presented in Figure 1. The share of the total organic area in relation to the UAA between 2014 and 2023 in Bulgaria increased from 0.96% to 2.94%. After Bulgaria's accession to the EU, the data show a relatively steady increase, with the highest growth being reported in 2016 – 3.2%. The share of organic farming in terms of UAA in Romania has a continuous increasing trend, rising from 2.09 to 5.08% between 2014 and 2022.

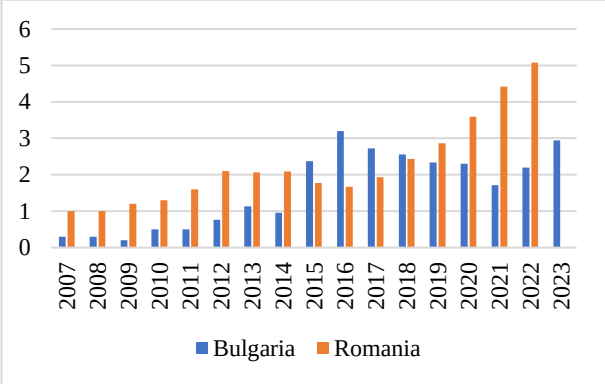

Fig. 1. Areas under organic farming in Bulgaria and Romania for the period 2007-2023 (% of total UAA)
Source: author's figure based on Eurostat data [6].

It can be noted that despite the increased land under organic production, the areas under organic farming reach only 2.94% of the total utilized agricultural area (UAA) in Bulgaria in 2023 and 5.08% in Romania in 2022. The strategic goal of 8% of the UAA being areas cultivated using the organic farming method in Bulgaria has not yet been reached (Nikolova, 2024a) [14]. However, this sector has potential for future development.

It is planned that by 2025 the areas under control system will increase by 5% (252,877 ha), and by 2027 to reach 6.98% (354,279 ha) of the UAA. It is necessary to strengthen the financial support of the measures of the Rural Development Program, which provide a wide range of support instruments to stimulate the development of organic farming in Bulgaria.

For a long time, under the influence of conventional agricultural practices, large doses of chemical pesticides and fertilizers have been applied in agriculture. This leads to disturbances in the ecological balance of nature and has irreversible consequences for human health.

A major source of environmental pollution is the improper use of plant protection products. Therefore, farmers need to make an informed decision on the correct application of pesticide

amount according to the regional level of each farm (Popescu et al., 2021)[17]. Therefore, it is necessary to create a framework to achieve sustainable pesticide use to restore and protect soil fertility and ecosystem services.

The use of pesticides in both countries for the period 2007-2022 is presented in the following figure 2, which is expressed in tonnes. In Bulgaria, for the period 2007-2014, there is a trend of a gradual decrease from 1974.75 tons to 1001 tons of active ingredients.

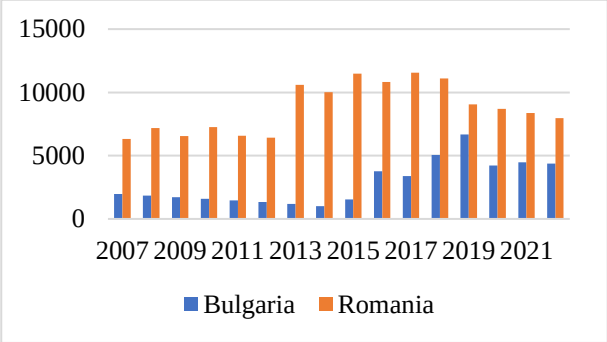

Fig. 2. Pesticide use in Bulgaria and Romania for the period 2007-2022 (tonnes of active ingredient)
Source: author's figure based on Eurostat data [6].

The published data for Bulgaria shows that for the period 2007-2014 there was a smooth and sustainable decrease in the use of pesticides - from 1,974.75 tons of active ingredients to 1,001 tons of active ingredients.

From the following year 2015, an increasing trend is observed, which continues until 2021 (from 1,541.9 tons to 4,484 tons). In the last year 2022, a slight decrease of 4,384.65 tons or -2.22% compared to the previous year 2021 was observed. In Romania, for the period 2007-2012, the data are relatively constant, varying from 6,314 tons to 6,418.7 tons. A drastic increase was observed in the following years for the period 2013-2018 (from 10,585.65 tons to 11,107.63 tons). From 2019-2022, a steady trend of decrease from 9,046.66 tons to 7,957.02 tons or -4.93% compared to 2021 was observed.

The harmonized pesticide risk indicator by active substance categorization in Bulgaria and Romania for the period 2011-2022 is presented in Figure 3. These indicators were created to measure the progress made in achieving the objectives of Directive 2009/128/EC on the sustainable use of pesticides. The indicator is presented as indices against a baseline of 100. The harmonised risk indicator is based on statistical data on the quantity of active substances in plant protection products placed on the market under Regulation (EC) No 1107/2009.

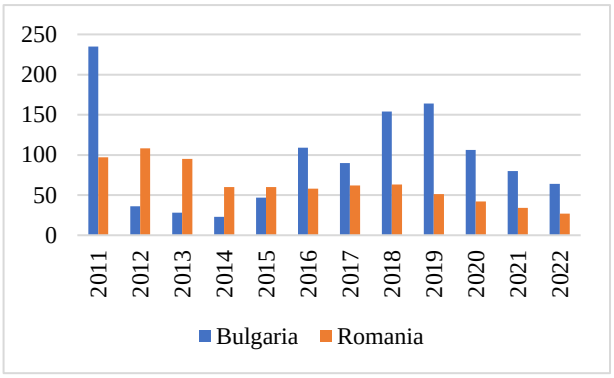

Fig. 3. Harmonized pesticide risk indicator by categorization of active substances in Bulgaria and Romania for the period 2011-2022
(index, 2011-2013, average =100)
Source: author's figure based on Eurostat data [6].

In Bulgaria, according to the published statistical data for the period 2011-2022, the highest risk from pesticides by categorization of active substances was observed in 2011 - 235, and the lowest risk was established in 2014 - 23. For the period 2016-2019, an increase was observed with values from 109 to 164.

From 2020-2022, the total risk from pesticides is reduced, reaching a value of 64 in 2022, but compared to the base year 2014, an increase of +178% was observed. For comparison, Romania has lower values of the harmonized pesticide risk indicator compared to Bulgaria. The highest value was measured in 2012 – 108, and the lowest value in 2022 – 27. In 2022, a decrease of -55% was observed compared to the baseline year 2014.

The correct use of pesticides and fertilizers plays an important role in modern agriculture. Fertilization with mineral fertilizers increases the reserves of nutrients in the soil and improves its physicochemical properties. The preservation of soil microorganisms enhances growth, increases yields and helps capture carbon dioxide. The frequent and excessive use of mineral fertilizers in agriculture leads to changes in soil acidity and structure, which disrupt the balance in ecosystems and have a negative impact on the environment. This is

confirmed in another scientific publication, in which uncontrolled application causes imbalance in the natural environment and is a risk factor for human health (Dinu et al., 2022)[2].

The following Table 2 presents current statistical information based on Eurostat data on the amounts of mineral fertilizers used in Bulgaria and Romania for the period 2007-2023. The table contains data on the total consumption of nitrogen (N) and phosphorus (P), measured in absolute volumes - tons. The highest amounts of nitrogen fertilizers used in Bulgaria were observed in 2016 - 365,913 tons, and the lowest were registered in 2008 - 173,917 tons. In 2023, 340,801 tons of nitrogen fertilizers were imported, which is 91.53% more than in 2007, 5.88% more than in the base year 2014, but 0.71% less than in the previous year 2022. With regard to phosphorus fertilizers, it is noted that in 2016 the highest quantities used were 36,050 tons, and in 2013 the lowest values were 11,656 tons. In 2023, 34,844 tons were used, which is 170% more than in 2007, 23.8% more than in the base year 2014 and an 8.75% increase compared to the previous year 2022.

After Bulgaria's entry into the EU, there was a gradual increase in the amount of mineral fertilizers used until 2016, when they reached their highest levels of 401,963 tons. After this period, a decrease was observed, reaching 375,645 tons in 2023. The relative share of the used quantities of mineral fertilizers for Bulgaria is calculated and presented in the table. The relative share in 2007 decreased compared to the base year 2014 by -45.50%, and in 2023 there was a slight increase by 7.28%.

Table 2. Amounts of mineral fertilizers used in Bulgaria and Romania for the period 2007-2023, tons

Years	Nitrogen (N)		Phosphorus (P205)		Allfertilizers		Relativeshare %
	Bulgaria	Romania	Bulgaria	Romania	Bulgaria	Romania	Bulgaria
2007	177,936	265,487	12,927	45,113	190,863	310,600	-45,50
2008	173,917	279,886	13,342	44,718	187,259	324,604	-46,52
2009	177,553	296,055	13,387	43,900	190,940	339,955	-45,47
2010	199,083	305,757	17,043	53,849	199,083	359,606	-43,14
2011	192,357	313,333	12,902	55,123	205,259	368,456	-41,38
2012	235,386	289,963	20,798	49,353	256,184	339,316	-26,84
2013	258,856	344,468	11,656	49,697	270,512	394,165	-22,74
2014	322,004	303,562	28,144	51,772	350,148	355,334	**St**
2015	341,608	357,352	27,573	57,921	369,181	415,273	5,44
2016	365,913	344,311	36,050	55,097	401,963	399,408	14,80
2017	351,120	381,342	29,562	63,253	380,682	444,595	8,72
2018	339,329	468,639	33,280	82,264	372,609	550,903	6,41
2019	352,486	455,964	33,501	87,904	385,987	543,868	10,24
2020	364,335	468,891	34,441	81,900	398,776	550,791	13,89
2021	342,890	510,802	31,836	103,728	374,726	614,530	7,10
2022	343,254	459,017	32,040	86,724	375,294	545,741	7,18
2023	340,801	463,657	34,844	91,649	375,645	555,306	7,28

Source: based on Eurostat data and author's calculations [6].

For comparison, in Romania, the highest levels of nitrogen fertilizer use were recorded in 2021 - 510,802 tons, and the lowest amounts were recorded in 2007 - 265,487 tons. Regarding phosphorus fertilizers, the highest use was recorded in 2021 - 103,728 tons, and the lowest value was recorded in 2009 - 43,900 tons.

The total amount of mineral fertilizers used is increasing, reaching its peak in 2021 - 614,530 tons, compared to the base year 2014, the increase is 73%.

From the data analysis thus considered, we can summarize that in Bulgaria for the last 3 analyzed years (2021-2023) a relatively stable decrease in the use of mineral fertilizers has been observed. This will immediately contribute to the retention of nutrients in the soil, limiting pollution processes for the benefit of the environment and the climate, which will undoubtedly accelerate the transition to more sustainable agricultural practices. The optimal use of mineral fertilizers is an important part of measures to reduce harmful emissions from agriculture.

The following Figure 4 shows the dynamics of ammonia emissions from agriculture in Bulgaria and Romania for the period 2007-2022.

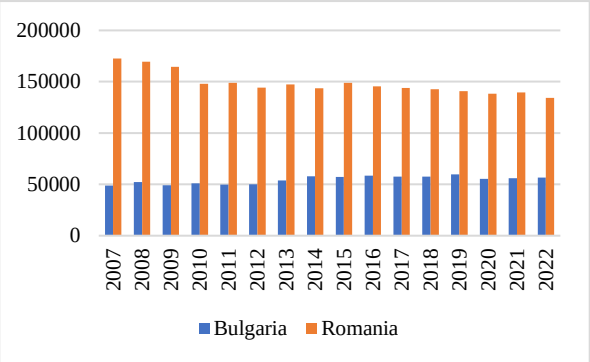

Fig. 4. Ammonia emissions from agriculture in Bulgaria and Romania for the period 2007-2022, tons
Source: author's figure based on Eurostat data [6].

This indicator measures ammonia (NH3) emissions resulting from agricultural production and is a result of manure management, application of inorganic nitrogen fertilizers and animal manure applied to the soil, as well as urine and manure deposited by grazing animals.

Ammonia emissions from agriculture in Bulgaria for the period 2007-2022 range from 48,775 tons to 58,435 tons in 2016, where the highest share of emissions was observed. In 2022, ammonia emissions amounted to 56,671 tons, which is an increase of 1.37% compared to the previous year 2021, and a decrease of -1.85% compared to the base year 2014. In Romania, for the period 2007-2009, the highest values (172,669 tons – for 2007; 169,555 tons – for 2008 and 164,386 tons – for 2009) of ammonia emissions from agriculture were observed. After this year, we must note its decrease, which continues until 2022 and reaches 134,286 tons. In 2022, the decrease is -3.86% compared to the previous year 2021 and -6.56% compared to the base year 2014.

It can be noted that agriculture is a leading source of ammonia emissions. Ammonia can have negative consequences, not only for natural ecosystems, but also harm human health. Therefore, it is necessary for all state and local institutions to have a responsible attitude and to invest joint efforts in carrying out a number of activities related to the achievement of a common goal, namely reducing the risk of using inefficient agricultural practices on the environment.

CONCLUSIONS

The analysis conducted provides grounds for drawing some specific generalizations and conclusions:

- The results of the research conducted in recent years show that the attention of the new challenges facing agriculture is increasingly directed towards the transition to a sustainable food system. The new CAP lays the foundation for fairer and more sustainable agricultural models of farming.

-In Bulgaria, in recent years, organic farming has been developing at a rapid pace and with great dynamics, with more and more agricultural land switching to organic production methods. The areas with organic farming recorded the highest growth in 2016 - 160,620 ha, and in 2009 the lowest areas were recorded - 12,321 ha. The total area for organic farming continues to increase, and in 2023 it will cover 147,798 ha of agricultural land, which is 33.83% more than in the previous year 2022. It is planned that by 2025 the areas in the control system will increase by 5% (252,877 ha), and by 2027 they will reach 6.98% (354,279 ha) of the UAA.

- The total use of pesticides in Bulgaria in 2022 was found to have a slight decrease of 4384.65 tons or -2.22% compared to the previous year 2021. For the last 3 analyzed years (2021-2023), a relatively stable decrease in the use of mineral fertilizers was found. In 2022, ammonia emissions amounted to 56,671 tons, which is an increase of 1.37% compared to the previous year 2021.

- It is necessary to initiate effective policies and measures to reduce the high risk of the impact of agricultural activity on the environment and climate. Undoubtedly, the implementation of sustainable agricultural practices is a priority opportunity to achieve long-term sustainability of agriculture and the development of the rural economy at regional and national levels.

REFERENCES

[1]Angelov, G., 2024, Status and trends in the development of the beekeeping sector in Bulgaria. Innovative development of agricultural business and rural areas. Fourth International Scientific Conference IDARA – 2024 Conference proceedings 3 – 4.10.2024, pp. 282-290, Sofia.

[2]Dinu, T.A., Popescu, A., Chirciu, I.A., Soare, E., Stoicea, P., Iorga, A.M., 2022, Study on the use and marketing of pesticides in Romania in the context of applying the farm to fork strategy. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Vol. 22 (2), 279-292.

[3]Draft National Action Programme to contribute to the achievement of the objectives of the Farm to Fork Strategy by 2030, 2023., https://www.mzh.government.bg/media/filer_public/2023/08/28/reforma_s6r1_programa_mzkh_-_proekt.pdf., Accessed on 25.01.2025.

[4]Elitsa, L., 2024, Strategic Guidelines for Sustainable Development of the North Central Region. Theory and Practice for Sustainable Management and Development of Rural Territories in Bulgaria, Publishing House: AI Tsenov, Svishtov, 31.05.2024 г., pp. 198-207.

[5]European Commission, Agriculture and Rural Development, Sustainable agricultural practices and methods,https://agriculture.ec.europa.eu/sustainability/environmental-sustainability/sustainable-agricultural-practices-and-methods_en, Accessed on 17.02.2025.

[6]Eurostat Database, https://ec.europa.eu/eurostat/data/database, Accessed on 17.02.2025.

[7]Hadzhieva, V., 2007, Sustainable development of agriculture in Bulgaria. // EconomicAlternatives, Issue 5., pp. 28-38.

[8]Ivanov, B., Radev, T., Borisov, P.,Vachevska, D, 2012, A methodological approach to assessing sustainability in agriculture. Agricultural Economics and Management, 57, 4, pp. 48-59.

[9]Krasteva, I., 2024, Promoting sustainable agricultural practices in agriculture. Innovative development of agricultural business and rural areas. Fourth International Scientific Conference IDARA – 2024 Conference proceedings 3 – 4.10.2024, pp. 230-238, Sofia.

[10]Krasteva, I., Nikolova, M., Yordanova, E., Angelov, G., Markov, T., 2024, Analysis and assessment of the use of pesticides and fertilizers in the rural territories of Republic of Bulgaria. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development., Vol. 24(2), 565-576.

[11]Mitov, A., 2023, Sustainable agricultural development in Bulgaria and the European Union. Economics and management of agriculture, 68, *2*, pp. 65-83.

[12]National Action Plan for the Development of Organic Production by 2030 , 2025., https://www.mzh.government.bg/bg/politiki-i-programi/politiki-i-strategii/nacionalen-plan_za_razvitie_na_bioproizvodstvoto/., Accessed on 03.03.2025.

[13]National Development Program Bulgaria 2030, 2020,file:///D:/Users/Windows/Downloads/bulgaria%202030%20(2).pdf., Accessed on 15.02.2025.

[14]Nikolova, M., 2024, Comparative Analysis of the State and Potential for the Development of Organic Farms in the North-West and North-Central Planning Regions in Bulgaria. Journal of Mountain Agriculture on the Balkans, 27 (4), 572-604.

[15]Nikolova, M., 2024, Sustainable development of rural areas - theoretical aspects, trends and challenges. Theory and Practice for Sustainable Management and Development of Rural Territories in Bulgaria, Publishing House: AI Tsenov, Svishtov, 31.05.2024 , pp. 9-24.

[16]Nikolova, M., Pavlov, P., 2024, Regional differences of greenhouse gases from agricultural activities in Bulgaria. Conference Proceedings "Innovative development of agricultural business and rural areas", 3 – 4.10.2024., pp. 35-46, Sofia: DOI: https://doi.org/10.37075/idara.2024.03.

[17]Popescu, A., Tindeche, C., Mărcuță, A., Mărcuță, L., Honțuș, A, 2021, Pesticides - a problem in Romania's agriculture? Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development. Vol. 21(4), 477-486.

[18]Recovery and Resilience mechanism, as part of the Next Generation EU (2021-2024) component of the European Recovery Plan https://nextgeneration.bg/1#two, Accessed on 20.01.2025.

[19]Stanev, Y., 2018, Entrepreneurship as a possibility for employment (self-employment) and development of small localities in Bulgaria. E-Journal "Dialogue" 4., pp. 36-48.

[20]Strategic Plan for the Development of Agriculture and Rural Areas of the Republic of Bulgaria for the period 2023-2027 (2023)., https://sp2023.bg/index.php/bg/. (n.d.)., Accessed on 12.02.2025.

[21]UN UN Transforming our world: The 2030 Agenda for Sustainable Development, https://sdgs.un.org/2030agenda. (n.d.).., Accessed on 21.02.2025.

[22]UN Transforming our world: The 2030 Agenda for Sustainable Development, https://sdgs.un.org/2030agenda. (n.d.).., Accessed on 21.02.2025.

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ESTIMATING EUROPEAN UNION FIELD CROPS FARM SUSTAINABILITY THROUGH MEASURING POLICY IMPLEMENTATION EFFICIENCY BY DATA ENVELOPMENT ANALYSIS

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Abstract

European Union`s Common Agricultural Policy (CAP) supports farm sustainability as a definition by its measures and tools, but the issue of its implementation efficiency differs despite of the common sense that European Commission (EC) stimulates the cohesion and coherence principles to all of the Member States (MS). This paper aims to reveal the efficiency of CAP implementation on field crop farms separated by economic sizes (6 classes) and compared to non-specialized average farm`s sustainability levels. The technical efficiency (TE) scores are received by applying Data Envelopment Analysis (DEA) using Benefit of Doubt (BoD) modelling modification on 15 indicators representing equal number of variables of the three main sustainability dimensions – economic, social and ecological. The received results clarify a huge difference of CAP implementation between the most advanced, largest holdings and the other five smaller economic size classes. Furthermore, it is exposed that payments per unit area benefit the most efficient farms that apply the best return of scale (and scale efficiency) at the expense of all others.

Key words**:** *agricultural holdings, Common Agricultural Policy, European Union, field crop farms, sustainability*

INTRODUCTION

In the recent years Europe depends more and more on responding to the main challenges: adaptation to climate changes, depopulation of rural communities, limitation of natural resources. This is the reason why enormous expectations are placed on sustainable management to balance between nature, society and the economy. Nowadays, the question of the optimal ratio between the number of agricultural holdings and their productivity and efficiency is becoming increasingly relevant. This issue is a subject of the Common Agricultural Policy as a definition and execution (subsidizing).

CAP is a widespread object of analysis in the academic community. One of the most important scientist`s goals was highlighted at the Conference in Rio de Janeiro – monitoring system on decision making units in the context of sustainability development to be established (United Nations, 1992) [16]. Furthermore, this monitoring process from a scientific point of view has its fundamental prerequisites – multidisciplinary indicators supported by significant weights in a long term time period to be available.

In order statistical error to be minimized, it is obligatory the used set of indicators to be extracted by a single data set that is able to provide sufficient financial information on the socio-economic relations and fund raising. Both sides of its distribution are in a sharp conflicts of interests. On the other hand, scientists` and policy makers` needs to diverse quantitative values to assess the qualitative effects of the agriculture`s environmental impact.

Hopefully, various databases are created, improved and provided by the European Commission. Even EC has already announced the conversion of Farm Accountancy Data Network by replacing accounting with sustainability – FSDN aiming to enrich and support the policy monitoring (European Commission, 2024)[10].

However, some of desired indicators were collected for the second inspected time period only which is a barrier in front of the priority of constructing a long-term investigation and aiming not to affect data homogeneity.

Organization for Economic Co-operation and Development (OECD) warns when quantitative data is scarce, like in the current case, proxy indicators might be used (Nardo et al., 2008) [14]. Their extraction involves using data taken from the DMU`s expenditures made on the main production factors (e.g. purchases of the detrimental (synthetic) inputs, energy usage).

The last necessary and mandatory condition to build this study is the task specific measuring tool to be chosen, adopted and implemented – the Data Envelopment Analysis maintaining a specific modelling approach – the "Benefit of the Doubt" which is famous by allowing more than several (up to 5-6) indicators to be enforced in the DMUs` technological performance without distorting the received composite indicators or the so called indexes.

Articles dedicated to sustainability assessment in a long-term period are very few. Most papers put an attention on a different sustainability issues, e.g. competitiveness, social prosperity or female management, good agricultural practices, agro-ecology. Other popular part of the studies that are fully committed to agricultural sustainability are focused on so called situational picture of a current moment (Bachev, 2016; Ivanov et al., 2009, Bachev and Terziev, 2017) [2, 12, 4], and other that can be directly applicable to the assessment of governance efficiency (Bachev et al., 2017, Bachev, 2017) [3, 5].

Nevertheless, such an assessment can compare a measurement to an earlier point in time, where details frequently presented – once per couple of years (Bachev, 2022)[1]. Hypothetically, such an approach might skip some fluctuation in the agricultural management`s behaviour where several successful years might be followed by a catastrophic circumstances reflecting on yields and respectfully economic results. This is a process that could be significantly alleviated by a governmental support.

One of the exceptions (regardless its mid-term observation period 2011-2018) is an article which covers all the sustainability pillars. Despite the shortcomings of using different databases, that paper is based on a sufficient quantitative indicators including the Eurostat and Faostat, FADN and Statistics Poland data (Kalinowska et al., 2022) [13]. That research is based on a set of variables very similar to those used in the current article in terms of their number and structure.

This observation gives an assessment which is a mixture between decision making units' management and the efficiency of governmental policy implementation where the weight is put on the governance sustainability ranking and its impact on administratively separated different production scale agricultural holdings.

MATERIALS AND METHODS

DEA's popularity stems from its relative lack of assumptions, ability to benchmark multi-dimensional inputs and outputs as well as computational ease owing to it being expressible as a linear program, despite aiming to calculate efficiency ratios (Cooper, William, Seiford et al., 2011) [9]. DEA is a nonparametric tool in operations research and economics for estimating the production frontiers (Charnes, Cooper & Rhodes, 1978) [6]. DEA creates virtual producer on the production border combining the most efficient decision making units (DMUs) in the sample. The other scores computed by the program is presented as a coefficient according to the distance from the best indicators combination between 0 - 1.

In 2008 the Organization of Economic Co-operation and Development issued the Handbook on Constructing Composite Indicators (or indices) where the "Benefit of Doubt" approach (modification of Data Envelopment Analysis) was presented as an instrument for benchmarking countries` performance (Nardo et al., 2008) [14] especially appropriate for the needs of measuring sustainable development (Cherchye and Kuosmanen, 2006) [7]. The authors proposed an approval of method usage that estimates the achieved technological production level in a competitive economic conjuncture that is applicable as a policy application efficiency concerning all other conditions being equal (e.g. soil quality or climate and weather impact – not kept into

consideration). This instrument has already been used as a composite index assessment tool in the context of policy effectiveness assessment (Cherchye et al., 2007) [8].

However, area payments affect very significant the field crop production and in this paper the perception that the CAP focus is concentrated on the sustainability of this type of agricultural holdings considering the following conception: the bigger is their production scale, the greater is their sustainability level.

The current research, which this paper is a part of, also aims to determine the production specialization where CAP should be improved in terms of economic, social and ecological aspects. The results of this article are going to be used as a benchmarking fundament to calculate the lack of sustainability of the other types of farming (e.g. horticulture, wine, milk, etc. which FADN dataset could support). Keeping in mind the consequences of area payments support on farms` large scale production technology, the following policy focus should target which might be the most appropriate production scale for each production specialization.

That research is focused especially on micro-economic level and includes 15 indicators, 5 per each pillar which are focused on pointing out the DMUs` production scale and figuring out the efficiency of some main production, social and detrimental factors.

Data Envelopment analysis is applied using a classical input oriented model confirming constant return to scale.

Sustainability indicators and measuring units

Economic variables – agricultural area (ha), labour (annual working units – AWU), capital (€), gross production (€), intensity of land usage (€/ha).

Social variables – income per family member, paid wages, own production factors, gross farm income, cash flow and services to the rural society – sum of provided services and rent payments (all in €).

Ecological variables: fertilizers, plant protection, energy (expressed by costs in €), environment payments as a share of the total area payment and nitro-fixing (protein) crops as a part of the crop rotation strategy (both coefficients).

As a benchmark in this study is used the average values of a common synthetic farm that combines all of the specializations and economic sizes from the FADN dataset (2007 - 2022).

Results are separated in two inspected periods and covers 8 years in a row respectfully when the different policies were applied (2007-2014 and 2015-2022).

RESULTS AND DISCUSSIONS

This policy efficiency measurement is quite specific concerning the diversity of scores which present the three sustainability pillars as summarized results into a cumulative function received by applying a 15 indicator DEA-BoD optimization model. This means that in the most cases policy implementation effects are "summed" in the final score which might be equal to the highest pillar or might be higher than each single pillar assessment. This circumstance presents a significantly different estimation then the usual and common agricultural sustainability estimation approaches are made where the compound sustainability scores are found as an average mean between the different sustainability pillars.

This "sum" is logically justified by the multidisciplinary function of the agricultural sustainability by adding social and environmental features to the main economic goals which causes extra effects on the main policy implementation checkpoints while at the same time these three pillars exclude each other or there is conflict of interests between them. First sustainable fundament is the economic pillar which creates the funding of other activities, second is the social pillar where the labour and social interests are collateralized, and the last production priority in the sustainability concept is defined as environmental pillar. However, nowadays the last production priority became the most important thing in human attitude and subsistence.

First Economic Size Class (ESC1) Farms (2, 000 – 8,000 €Standard Output)

This farm group was left by Italy and Spain after 2014 when Estonia achieved such representatives which were not performing during the first CAP period (Table 1). This is the reason why they are not included (last column on Table 1) and respectfully their smallest agricultural organizations are not presented on the Figure 1 where the summarized technical efficiency results are illustrated.

Table 1. ESC 1 holdings` total utilized agricultural area, economic output (earliest available accounting year) and data availability.

Member State	Total UAA (ha/farm)	Gross output (€/farm)	Data 2007-2014	Data 2015-2022	Incl./ Not
Bulgaria	**6.5**	6,637	8/8	8/8	Yes
Greece	**6.3**	9,419	8/8	7/8	Yes
Spain	***22.0***	*16,548*	*8/8*	*0/8*	-
Italy	***7.4***	*22,433*	*7/8*	*0/8*	-
Latvia	**23.6**	9,876	3/8	2/8	Yes
Lithuania	**25.3**	10,054	7/8	8/8	Yes
Hungary	**10.9**	8,702	8/8	8/8	Yes
Poland	**12.4**	14,677	8/8	8/8	Yes
Portugal	**10.3**	5,605	8/8	6/8	Yes
Romania	**6.7**	6,819	8/8	8/8	Yes
Cyprus	**7.4**	5,767	7/8	8/8	Yes
Slovenia	**5.4**	9,124	3/8	7/8	Yes
Malta	**2.2**	4,744	1/8	7/8	Yes
Estonia	***13.9***	*5,852*	*0/8*	*4/8*	-

Source: FADN [8].

That tiny farm group is characterized by relatively larger farms in the Baltic countries and smaller ones on the Balkans.

There are three types of behaviour among the smallest farm representatives:

The Greek farms gain a spectacular score which is presented as more intensive and sustainable than the reference EU values in both investigated CAP schedules and furthermore, their trend follows the increasing common EU farms` sustainability tendency.

The second CAP benchmark is only passed by Portugal farmers who strengthened all the estimated sustainability pillars but most intensively the ecological performance. In those cases, the change is covered by a raise in the economic and ecological (the pillar which is above EU farm average) sustainability aspects.

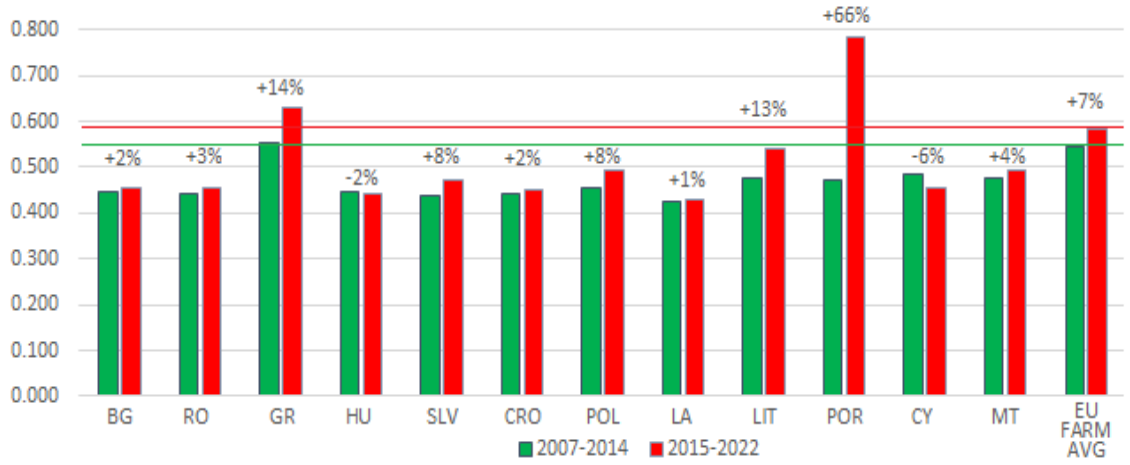

Fig. 1. Sustainable Policy Implementation Efficiency ESC1
Source: Own calculations based on the data from FADN [8].

In a smaller scale this is common also for Poland and Lithuania, but their performance is not that essential and below the reference.

From another side, the smallest farms in Cyprus and Hungary lose a small part of their tiny environmental dignities which reflects on the sustainability levels. The rest of the

participants share mutual trend of development which is expressed by inflation related but inconsiderably positive fluctuation in the social pillar.

The smallest farms size group is losing a 20% of its members and is also the poorest sustainable economic size class of the field crops farms.

Second Economic Size Class Farms (8,000 - 25,000 €SO)

Second farm group was left by Slovakia as confirming not interested in boutique farming and being famous with their large farm cooperatives (Table 2).

The largest farms according to their physical size in that class belong to Scandinavian MS with higher than the average rate of sustainability due to the high social levels (Figure 2).

Table 2. ESC2 holdings` total utilized agricultural area, economic output and data availability

Member State	Total UAA (ha/farm)	Gross output (€/farm)	Data 2007-2014	Data 2015-2022	Incl./ Not
Bulgaria	**40.8**	14,535	8/8	8/8	Yes
Czechia	**26.9**	27,620	8/8	3/8	Yes
Denmark	**28.5**	67,775	8/8	5/8	Yes
Estonia	**59.6**	26,142	8/8	3/8	Yes
Greece	**12.0**	19,693	8/8	7/8	Yes
Spain	**40.8**	27,240	8/8	7/8	Yes
Italy	**13.3**	27,926	8/8	8/8	Yes
Cyprus	**8.3**	25,762	8/8	8/8	Yes
Latvia	**62.9**	20,555	8/8	8/8	Yes
Lithuania	**47.8**	21,867	8/8	8/8	Yes
Hungary	**29.7**	25,226	8/8	8/8	Yes
Malta	**3.3**	18,133	8/8	7/8	Yes
Austria	**29.9**	33,743	8/8	8/8	Yes
Poland	**26.4**	30,214	8/8	8/8	Yes
Portugal	**21.1**	16,963	8/8	8/8	Yes
Romania	**15.4**	24,788	8/8	8/8	Yes
Slovenia	**14.7**	22,472	8/8	7/8	Yes
Slovakia	***37.7***	*23,178*	*2/8*	*0/8*	-
Finland	**43.7**	27,674	8/8	8/8	Yes
Sweden	**47.2**	70,123	8/8	1/8*	*Yes
France	**6.7**	27,473	3/8	8/8	Yes
Croatia	**12.7**	16,027	2/8	7/8	Yes

Source: FADN [8].

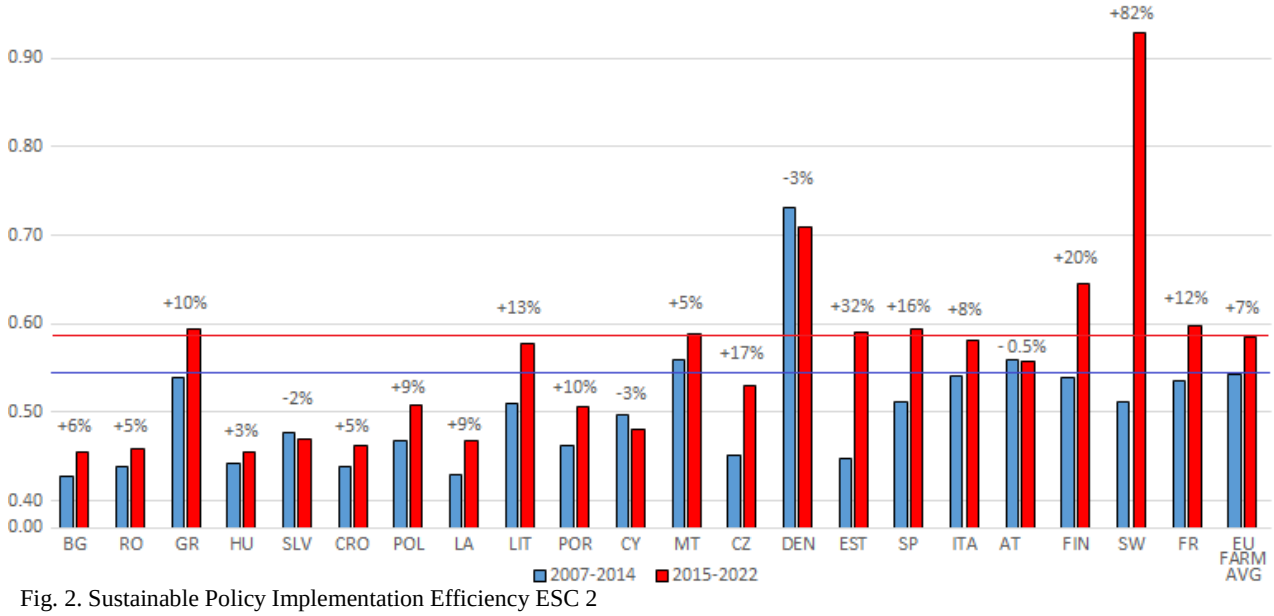

Fig. 2. Sustainable Policy Implementation Efficiency ESC 2
Source: Own calculations based on the data from [8].

Same applies to the Baltic countries and Spain, but Latvia could not reach the needed ecological policy applications and is outside that definition. Those farms have above 40 ha farms land (Denmark only 28.5 ha). This is

similar to Bulgaria where is detected the smallest output in this size class. A size contrast appears in a comparison with Cyprus - below 10 ha farms which present one of the most disappointing results.

Malta and France also possess very small units of this class but they gain an increasing and above average sustainability scores after an economic performance improvement.

Most of the Balkan member states– Romania, Bulgaria, Croatia, Hungary and Slovenia, also Latvia, share common trend – slowly increasing social level below the benchmark. While Romania, Bulgaria and Latvia slightly rise the ecological rates, Hungary could not, similar to Slovenia and Croatia which have greater economic levels than Czechia and Poland regardless their better composite sustainability achievement.

Greece achieves environmental growth, which concerns also Italy where the economic drop is compensated by a social progress which go hand by hand in Austria at account of a low ecological reduction to form the last farms that have high sustainability indexations.

Third Economic Size Class Farms (25,000 – 50,000 €SO)

The most impressive results in the lower-medium economic size class are presented again by the production units of the Scandinavian member states (Figure 3). Denmark and Finland get optimized their energy usage which reflects on the agri-ecological performance. Sweden gain an increase by maximizing the economic efficiency by consistently improving inflation related productivity of labour and capital. Exactly the opposite is the behaviour of Italy Germany and France, forming a half of the European Union founding countries, demonstrate composite sustainability indicators above at least the first reference level. Nevertheless, decades after the establishment of the so called "green revolution" in particular European chemical factories converting one of the most polluting human activities into producers of agricultural factors of production (Pingali, 2012) [15] are loudly announced to be replaced by a massive new wave of ecological priorities taking a solid part of the currently adapted EU policies, despite being below the EU separator. The same irregularities were applied also in Romania Bulgaria, the Czech Republic and Estonia, Greece and Cyprus.

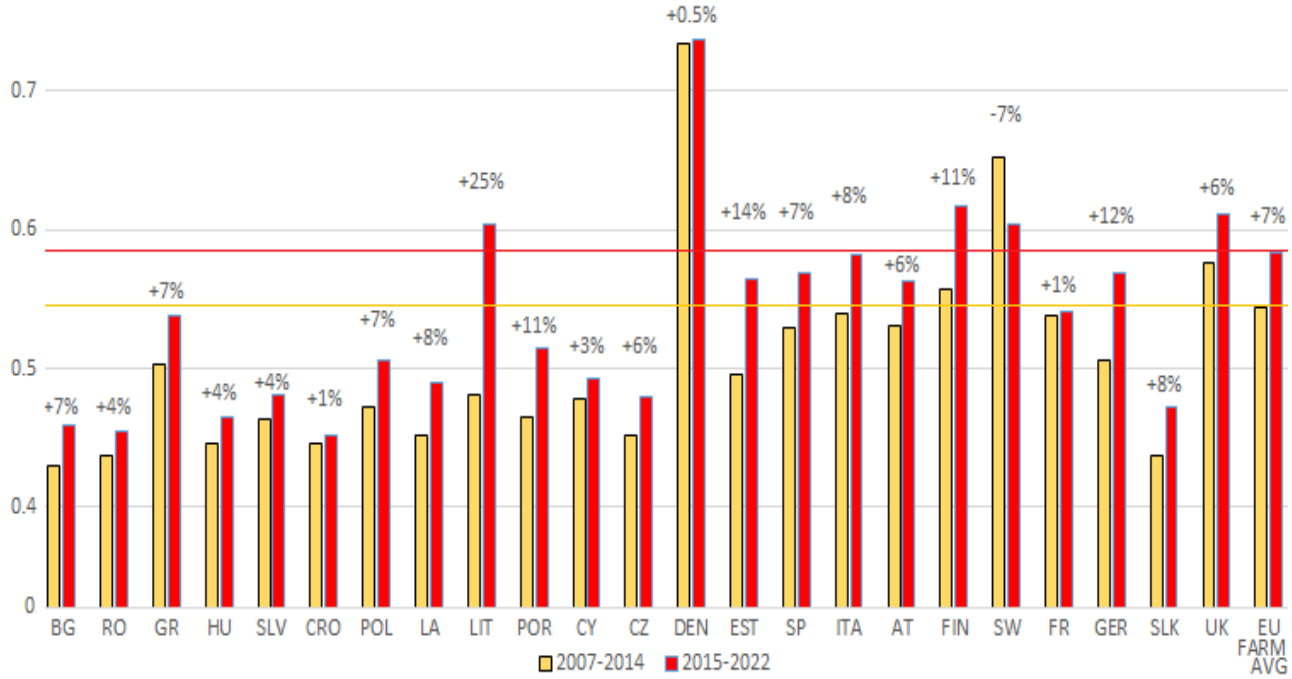

Fig. 3. Sustainable Policy Implementation Efficiency ESC 3
Source: Own calculations based on the data from [8].

Table 3. ESC3 holdings` total utilized agricultural area, economic output and data availability

Member State	Total UAA (ha/farm)	Gross output (€/farm)	Data 2007-2014	Data 2015-2022	Incl./ Not
Bulgaria	**109.2**	38,029	8/8	8/8	Yes
Czechia	**61.0**	56,466	8/8	8/8	Yes
Denmark	**51.5**	101,827	8/8	8/8	Yes
Germany	**36.9**	63,024	8/8	7/8	Yes
Estonia	**132.9**	62,369	8/8	8/8	Yes
Greece	**22.9**	44,969	8/8	7/8	Yes
Spain	**81.6**	56,599	8/8	7/8	Yes
France	**56.8**	65,677	8/8	8/8	Yes
Italy	**24.9**	60,864	8/8	8/8	Yes
Cyprus	**18.8**	36,512	8/8	8/8	Yes
Latvia	**117.5**	60,910	8/8	8/8	Yes
Lithuania	**108.0**	59,195	8/8	8/8	Yes
Hungary	**72.5**	53,770	8/8	8/8	Yes
Malta	***5.7***	*41,805*	*8/8*	*1/8*	-
Netherlands	**20.6**	88,039	2/8	5/8	Yes
Austria	**50.5**	58,882	8/8	8/8	Yes
Poland	**61.1**	64,336	8/8	8/8	Yes
Portugal	**63.5**	38,457	8/8	8/8	Yes
Romania	**87.7**	42,082	8/8	8/8	Yes
Slovakia	**71.8**	51,047	8/8	8/8	Yes
Finland	**89.7**	67,578	8/8	8/8	Yes
Sweden	**73.2**	68,492	8/8	8/8	Yes
UK	**59.2**	67,313	8/8	6/8	Yes
Ireland	***52.9***	*51,567*	*2/8*	*0/8*	-
Slovenia	**23.6**	45,259	3/8	6/8	Yes
Croatia	**31.1**	33,339	2/8	7/8	Yes

Source: FADN [8].

That staging is not negative in Poland, Latvia and Finland and even slightly but non-essentially increasing as well as in Croatia, Slovenia and Hungary, Slovakia and Lithuania, Spain.

Portugal and Austria are the only members that improve their economic outcome more significantly even not achieving the separating line which is succeeded by United Kingdom (after a triple growth in all the sustainability dimensions) and Sweden the economic resilience is improved at the expense of both ecological and social challenges which are therefore ignored.

In addition to their unsatisfactory results, Romania, Bulgaria and the Baltic countries have built the largest production facilities in this group by economic size (Table 3), which further worsens the achieved results, although this fact is not taken into account by the applied method.

Fourth Economic Size Class Farms (50,000 – 100,000 €SO)

The upper medium economic size class presents a surprizing output – not because Cyprus but United Kingdom is one of the only two presented island countries that maintain a decrease leading to a drop down the benchmark in the second inspected program period (Figure 4).

While this trend is accompanied by a decline only in the economic index of the resource larger country, the other one (that cultivate significantly limited agricultural area on macro level) realize a decline spread through all of the sustainability dimensions, and furthermore the economic pillar`s decline is severely drastic.

The last available Cyprus data score is 2016 which affects the economic sustainability crash by 88.5 % compared to 2007. This policy implementation is explaining the lack of farmers participating in the ESC 5 (Table 5).

Despite the overall sustainability increase, the economic sustainability drops are observed through the holdings of the Baltic member states, Bulgaria and Romania, whose farms cultivate the biggest agricultural areas according to most of the others in that size class (Table 4).

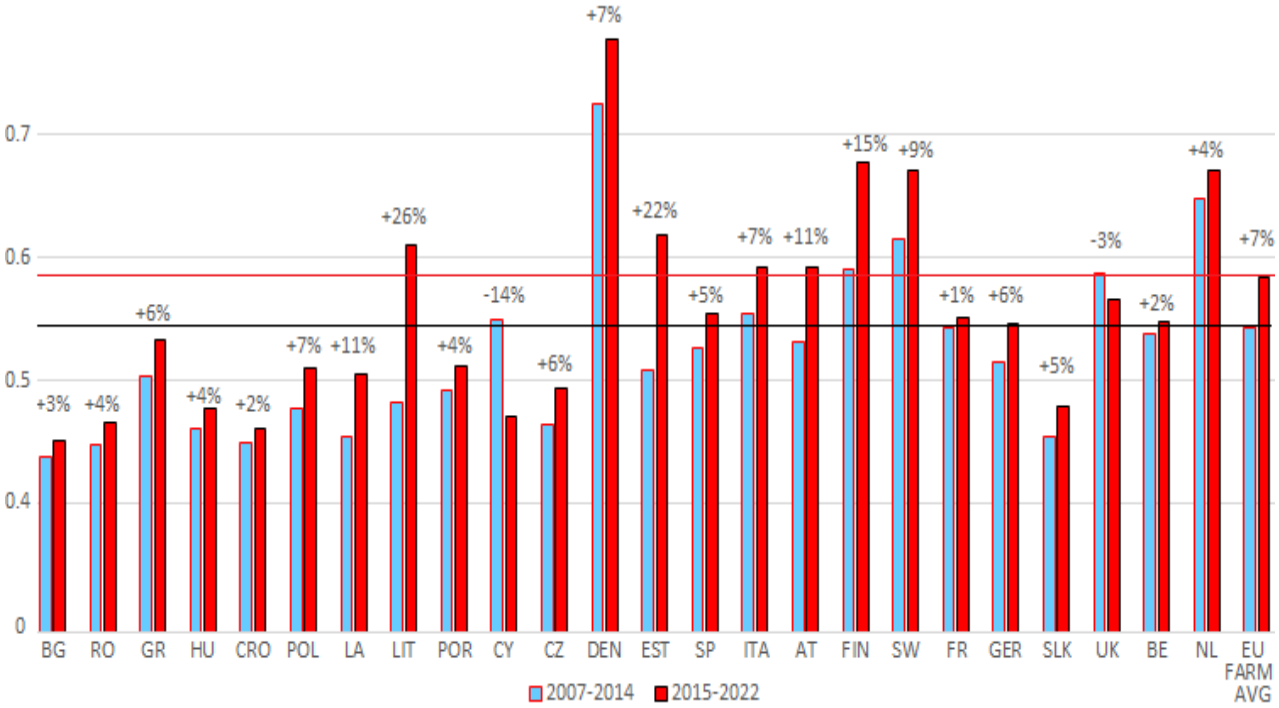

Fig. 4. Sustainable Policy Implementation Efficiency ESC 4
Source: Own calculations based on the data from [8].

Table 4. ESC 4 holdings` total utilized agricultural area, economic output and data availability

Member State	Total UAA (ha/farm)	Gross output (€/farm)	Data 2007-2014	Data 2015-2022	Incl./ Not
Belgium	**44.5**	73,559	8/8	8/8	Yes
Bulgaria	**227.2**	75,877	8/8	8/8	Yes
Czechia	**120.4**	108,756	8/8	8/8	Yes
Denmark	**83.0**	226,246	8/8	8/8	Yes
Germany	**62.1**	103,887	8/8	7/8	Yes
Estonia	**253.5**	145,535	8/8	8/8	Yes
Greece	**33.6**	63,475	8/8	7/8	Yes
Spain	**120.7**	95,195	8/8	7/8	Yes
France	**99.1**	119,336	8/8	8/8	Yes
Italy	**43.5**	80,886	8/8	8/8	Yes
Cyprus	**17.2**	113,368	8/8	2/8	Yes
Latvia	**254.2**	127,135	8/8	8/8	Yes
Lithuania	**200.4**	124,759	8/8	8/8	Yes
Hungary	**147.9**	111,819	8/8	8/8	Yes
Netherlands	**30.3**	189,077	8/8	8/8	Yes
Austria	**72.1**	95,839	8/8	8/8	Yes
Poland	**120.6**	120,218	8/8	8/8	Yes
Portugal	**119.2**	91,055	8/8	8/8	Yes
Romania	**165.6**	64,078	8/8	8/8	Yes
Slovakia	**158.2**	116,721	8/8	8/8	Yes
Finland	**131.6**	112,749	8/8	8/8	Yes
Sweden	**112.4**	130,887	8/8	8/8	Yes
UK	**103.2**	121,599	8/8	6/8	Yes
Ireland	***69.2***	*72,573*	*5/8*	*1/8*	-
Slovenia	***23.0***	*58,015*	*3/8*	*0/8*	-
Croatia	**57.1**	67,932	2/8	7/8	Yes

Source: FADN [8].

Most of the new MS farms` performances are struggling economically together with France, Portugal and Spain. Such a finding is still quite sharp away than expected by a new ideological prism declared in European Community policy.

In the other hand are situated definitely smaller production scale units – Netherlands, Italy and Greece (below 50 ha) which are increasing the ecological narrative while holding stable the other sustainability components.

The overall sustainability is increasing most sensitively in the Scandinavian MS and

furthermore Sweden, Poland, Austria and Belgium gain success in all the sustainability pillars after the policy switch.

Fifth Economic Size Class Farms (100,000 – 500,000 €SO)

The Baltic states and Bulgaria (the only depressed compound index on Figure 5) and Romania are again struggling the emerging negativity in the economic sustainable development (-20% to -32%) mostly in favor of ecological goals of the contemporary agricultural policy.

This concerns also the Czech Republic, Hungary and Slovakia (they all share common trends on Figure 5).

Even Italy and Portugal joined the eco group after the policy change in 2014 and applied that by 2015 supporting schemes. This phenomenon is even more spread among the largest agricultural producers.

Among the new member states (ESC 5), representatives below 300 ha agricultural land are available only in small Slovenia and Croatia (Table 5).

While the farms next to Alps increase the sustainability level due to socio-economic improvements (like the Baltic MS but not due to environmental practices), so the newest Mediterranean MS reveal the lowest sustainability score in the first of the largest farm size groups.

Again CAP impact on Scandinavian agricultural units is in accordance with the highest sustainability performances among all the three dimensions.

This is not applicable to Sweden`s environmental score, which is applied also by the Netherlands, Belgium and most of the Balkan countries.

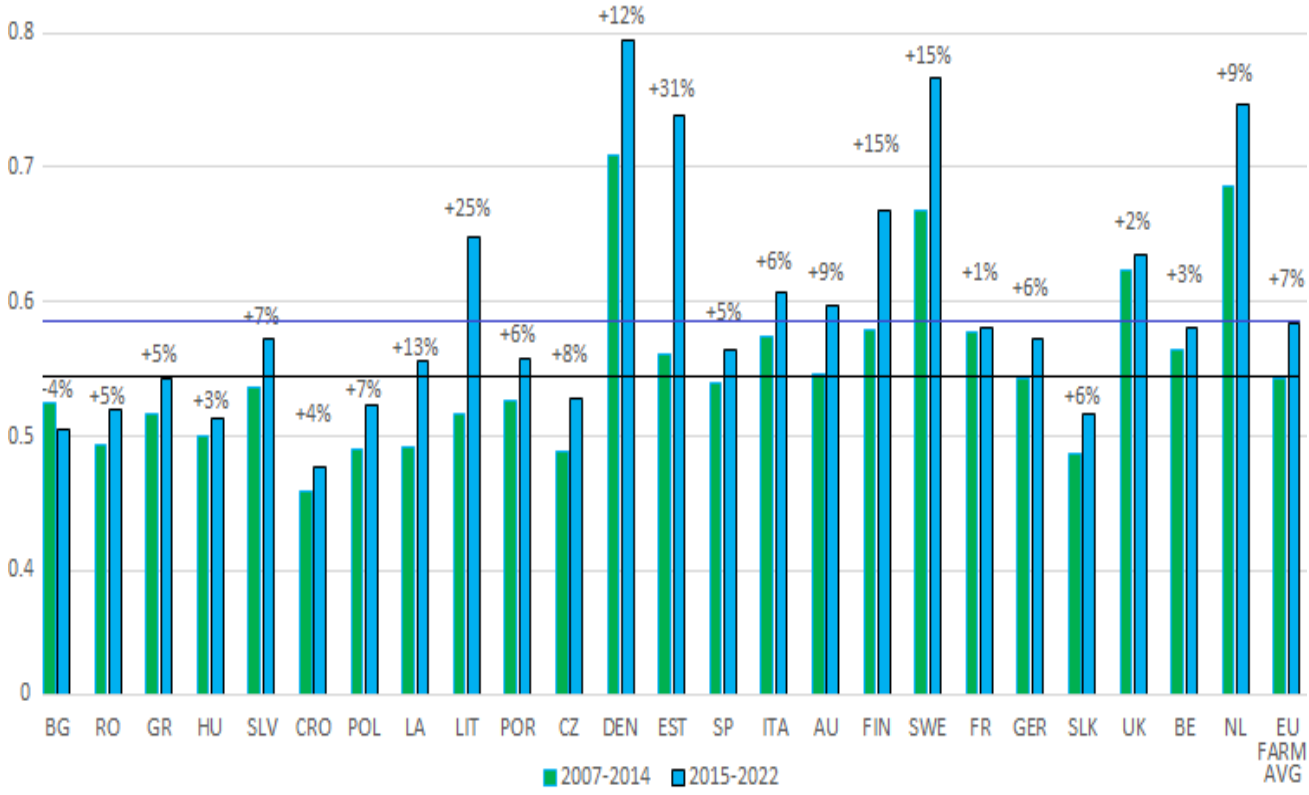

Fig. 5. Sustainable Policy Implementation Efficiency ESC 5
Source: Own calculations based on the data from [8].

Table 5. ESC5 holdings` total utilized agricultural area, economic output and data availability

Member State	Total UAA (ha/farm)	Gross output (€/farm)	Data 2007-2014	Data 2015-2022	Incl./ Not
Belgium	**91.1**	217,254	8/8	8/8	Yes
Bulgaria	**747.8**	264,878	8/8	8/8	Yes
Czechia	**339.2**	321,235	8/8	8/8	Yes
Denmark	**215.6**	404,187	8/8	8/8	Yes
Germany	**141.9**	240,109	8/8	7/8	Yes
Estonia	**706.1**	393,000	8/8	8/8	Yes
Greece	**39.4**	92,302	8/8	7/8	Yes
Spain	**292.8**	217,950	8/8	7/8	Yes
France	**165.7**	244,203	8/8	8/8	Yes
Italy	**101.4**	216,209	8/8	8/8	Yes
Cyprus	***61.5***	*101,868*	*5/8*	*0/8*	-
Latvia	**639.1**	447,352	8/8	8/8	Yes
Lithuania	**477.2**	356,251	8/8	8/8	Yes
Hungary	**392.1**	316,635	8/8	8/8	Yes
Netherlands	**74.7**	323,527	8/8	8/8	Yes
Austria	**85.4**	186,308	8/8	8/8	Yes
Poland	**340.8**	339,961	8/8	8/8	Yes
Portugal	**140.9**	219,585	8/8	8/8	Yes
Romania	**536.0**	234,311	8/8	8/8	Yes
Slovakia	**525.6**	426,255	8/8	8/8	Yes
Sweden	**257.2**	359,623	8/8	8/8	Yes
UK	**227.1**	323,323	8/8	8/6	Yes

Source: FADN [8].

There is not a single example of a decrease in the social aspects of that size class.

Sixth Economic Size Class Farms (more than 500 000 €SO)

The highest levels of policy efficiency (touching the ceiling) are presented in the largest farms class (Figure 6). However, the agricultural holdings are separated in two rapidly different performance directions. Positive trends are seen in the cases of Lithuania and Slovakia (new MS), Belgium, the Netherlands and Germany (Founding MS), Denmark and United Kingdom.

Declining group is consisted mostly of the New MS (highest production scale - above 1,300 ha, Table 6) which lose some of the reached sustainability level gained during the first inspected program period. France and Italy (smallest scale in the class) also cannot succeed to earn some points after 2014. All the presented new MS lose economic performance while only Lithuania gains an ecological acquisition. Only Belgian farms succeed to realize a potential in all sustainability pillars.

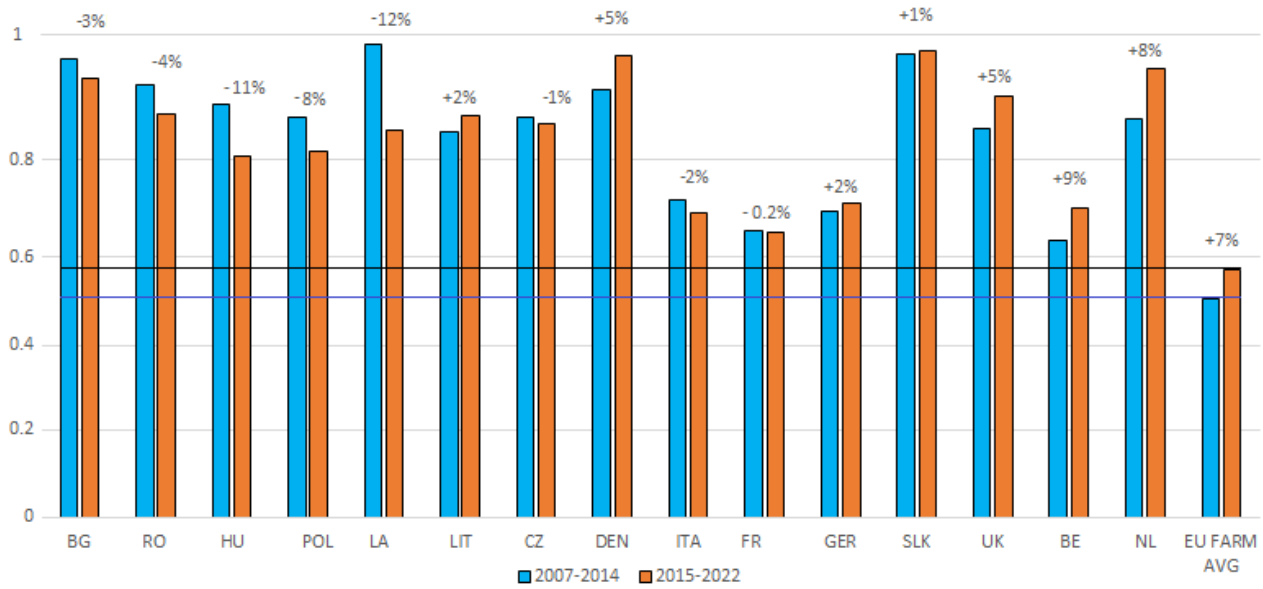

Fig. 6. Sustainable Policy Implementation Efficiency ESC 6
Source: Own calculations based on the data from [8].

Table 6. ESC6 holdings` total utilized agricultural area, economic output and data availability

Member State	Gross UAA (ha/farm)	Total output (€/farm)	Data 2007-2014	Data 2015-2022	Incl./ Not
Bulgaria	**1,954.2**	883,167	8/8	8/8	Yes
Czechia	**1,317.4**	1,636,743	8/8	8/8	Yes
Denmark	**656.1**	1,198,765	8/8	8/8	Yes
Germany	**674.3**	1,028,185	8/8	7/8	Yes
France	**219.8**	691,158	8/8	8/8	Yes
Italy	**359.0**	946,569	8/8	8/8	Yes
Hungary	**1,816.5**	1,749,451	8/8	7/8	Yes
Netherlands	**182.1**	1,005,782	8/8	8/8	Yes
Poland	**1,295.0**	1,424,812	8/8	8/8	Yes
Romania	**2,313.1**	859,165	8/8	8/8	Yes
Slovakia	**1,902.7**	1,699,860	8/8	8/8	Yes
UK	**626.0**	1,217,940	8/8	6/8	Yes
Lithuania	**1,509.7**	1,193,655	5/8	8/8	Yes
Belgium	**102.6**	485,859	3/8	2/8	Yes
Latvia	**1,575.1**	1,739,646	3/8	8/8	Yes
Estonia	***1,403.7***	*1,145,011*	*0/8*	*8/8*	-
Spain	***359.2***	*1,029,257*	*0/8*	*8/8*	-
Sweden	***719.8***	*1,521,419*	*0/8*	*3/8*	-

Source: FADN [8].

Summary of the Empirical Results

In terms of the "virtual producer" who perform on the highest production frontier in the sample, the peer-designers constituting the 15-indicator best production function of that efficiency estimation on sustainability policy implementation are as following:

-ESC 1 – Portugal 2018 (leading ecological pillar).

-ESC 2 – France 2016 (economic pillar).

-ESC 3 – Denmark 2021 (social pillar).

-ESC 6, economic oriented: Romania, Slovakia, Denmark (2008) and the Netherlands (2022).

-ESC 6, social oriented: Bulgaria, Romania and Denmark (2022) Slovakia (2016) and again Romania (2008).

-ESC 6, eco oriented: the Baltic MS, the Czech Republic and Hungary (all 2022).

CONCLUSIONS

The EU`s Common Agricultural Policy has its specifics as far as it is concerned to the so called new member states.

We can see how the physical farms size and sustainability levels changes in different classes being in relation to Bulgaria and Romania, Baltic countries and the others.

Out of the most, it is obvious that there are some exceptions to Poland, the Czech Republic and to some extent the scale efficient Slovakian cooperatives.

Most of the increase in ecological terms lay down on a single CAP tool – the area payments for nitro-fixing crop rotation (EU farm average +112%). Especially bright is the case in Bulgarian **average** field crops farms (+621%), which was a CAP scheme abused by farmers by sowing Alfalfa (Lucerne) as a permanent grassland which in reality pauses the crop rotation for at least 5-year (which was the actual CAP engagement time period).

In several cases the increase started at very low stage – Bulgaria, Croatia (+44%) and Slovenia (+307%), comparable with the Netherlands where the level stays stable in terms of limited and very intensive farm area.

Baltic MS started at higher initial level of that indicator and additionally coefficients raise between 260-400%.

Change in cash-flow volumes of the observed crop rotation vary: up to a hundred percent - Ireland, Italy, Spain, Greece and Germany; to up to 200% in Romania, Poland, Luxemburg, while also massive increase was observed in Denmark +371%, Portugal +488%. Czechia +211%, Finland +197%.

On the other hand, France, UK, Sweden, Austria, Cyprus and Hungary have no structural changes covered by traditional to an extend level.

This paper clearly shows how CAP average efficiency is boosted by the highest economic farm size class of that farm type.

In terms of the scale efficiency, all Balkan holdings smaller than the largest seems to be

inefficient in the policy application, which additionally causes lack of value added per unit area represented in the production functions of the current study, especially Bulgaria and Romania. On the other hand, Scandinavian MS are performing very well concerning the smaller economic classes.

Keeping in mind the constantly decreasing number of small farmers (Eurostat, 2022), the average farm area is permanently increasing and concentrating the CAP subsidies in smaller and smaller amount of decision making units.

This puts out the question – is CAP funding distribution designed to fail? Is the concentration of land, subsidies (power) and production in a small amount of entrepreneurs just a policy design? Is CAP modifying farms` structure in the last programme periods in order to eliminate a huge amount of small farmers or to increase their economic size and production scale (function of the area payments) which might lead to less employment and depopulation of the rural areas pushing the people concentration in the urban areas as indirect policy consequences?

Questions for author`s further research.

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REFERENCES

[1]Bachev, H., 2022, A Framework for Assessing the Governance Efficiency of Agricultural Farms, Available at SSRN: https://ssrn.com/abstract=4155798 or http://dx.doi.org/10.2139/ssrn.4155798 .

[2]Bachev, H., 2016, Устойчивост на земеделските стопанства в България (Sustainability of Agricultural Farms in Bulgaria), SSRN: https://ssrn.com/abstract=3568113, http://dx.doi.org/10.2139/ssrn.3568113, Accessed on 27 February 2025.

[3]Bachev, H., Ivanov, B., Toteva, D., Sokolova, E., 2017, Agrarian Sustainability in Bulgaria – Economic, Social and Ecological Aspects, Bulgarian Journal of Agricultural Science, 23 (No 4), 519–525, Agricultural Academy.

[4]Bachev, H., Terziev, D., 2017, Environmental Sustainability of Agricultural Farms in Bulgaria, ASERS Publishing, Vol.8(5), JEMT Vol. VIII, Issue 5(21), Fall 2017. https://doi.org/10.14505//jemt.v8.5(21).02 .

[5]Bachev, H., 2017, Socio-economic and environmental sustainability of Bulgarian farms, Agricultural and Resource Economics: International Scientific E-Journal, Agricultural and Resource Economics: International Scientific E-Journal, Vol. 3(2), June.

[6]Charnes A., Cooper W. W. and Rhodes E. (1978). "Measuring the Efficiency of Decision Making Units." EJOR 2: 429-444.

[7]Cherchye, L., Kuosmanen, T., 2006, Benchmarking Sustainable Development: A Synthetic Meta-Index Approach, Chapter 7. In M. McGillivray and M. Clarke (eds), Perspectives on Human Development (United Nations University Press).

[8]Cherchye, L., Moesen, W., Rogge, N., Puyenbroeck, T., 2007, An Introduction to ‘Benefit of the Doubt’ Composite Indicator. Social Indicators Research. 82. 111-145. 10.1007/s11205-006-9029-7.

[9]Cooper, W. W.; Seiford, L. M.; Zhu, J., eds. (2011). Handbook on Data Envelopment Analysis. International Series in Operations Research & Management Science (2 ed.). Springer US. ISBN 978-1-4419-6150-1;

[10]European Commission`s Farm Accountancy Data Network, 2024, https://agridata.ec.europa.eu/extensions/FADNPublicDatabase/FADNPublicDatabase.html, Accessed on 25 September 2024.

[11]Eurostat, 2022, Farms and farmland in the European Union – statistics: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Farms_and_farmland_in_the_European_Union_-_statistics, Accessed 13 May 2025

[12]Ivanov, B., Radev, T., Vachevska, D., Borisov, P., 2009, Устойчивост в земеделието (Sustainability in Agriculture), Avangard Prima Publishing House.

[13]Kalinowska, B., Bórawski, P., Bełdycka-Bórawska, A., Klepacki, B., Perkowska, A., Rokicki, T., 2022, Sustainable Development of Agriculture in Member States of the European Union, Sustainability. 10.3390/su14074184.

[14]Nardo, M., Saisana, M., Saltelli, A., Tarantola, S., Hoffman, A., Giovannini, E., 2008, Handbook on Constructing Composite Indicators and User Guide, Organization of Economic Co-operation and Development, 10.1787/533411815016, OECD Statistics Working Paper.

[15]Pingali, P., 2012, Green revolution: impacts, limits, and the path ahead. Proc Natl Acad Sci USA;109(31):12302-8. doi: 10.1073/pnas.0912953109. Epub 2012 Jul 23. PMID: 22826253; PMCID: PMC3411969.

[16]United Nations, 1992, The Rio Declaration on Environment and Development, https://www.un.org/en/development/desa/population/migration/generalassembly/docs/globalcompact/A_CONF.151_26_Vol.I_Declaration.pdf, Accessed on 05 February 2025.

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EVOLUTION OF THE PRE-EMPTION RIGHT IN THE PURCHASE OF AGRICULTURAL LAND IN ROMANIA: IMPLICATIONS AND REGULATIONS

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Abstract

In the context of the dynamics of the agricultural land market in Romania, the right of pre-emption is a crucial instrument for protecting both the state's economic and social interests and those of the local communities. This article analyses the evolution of this right in national regulations, from the first post-1989 regulations to the recent amendments to the European and national laws. Materials, data sources, and research methods used encompassed legislative texts, government and institutional reports, statistical databases on real estate transactions, and official publications from national and European institutions. First of all, it discusses the purpose of the pre-emption right in preventing speculative acquisitions and in protecting agricultural resources,which are vital for national food security. The article also addresses the economic and social implications of these regulations, including the impact on potential investors, but also the possible effects on rural area development. Finally, it presents the current legislative challenges to ensure a balance between protecting agricultural resources and stimulating investments in the agricultural sector. Main results and conclusions show that the development of the pre-emption right in Romania has been gradual, with significant legislative changes. Despite this, land fragmentation remains high, transaction volumes and land prices continue to rise, and challenges such as incomplete cadastral registration, ageing rural populations, and limited access to financing persist.

Key words**:** *pre-emption right, agricultural land, regulations, rural area development*

INTRODUCTION

The land fund as a resource is defined by FAO (Food and Agriculture Organisation) as the physical element of the environment, a socio-economic component of a natural terrestrial unit [8].

Agricultural land constitutes fundamental capital because it is intended for the production of food for people through growing plants and raising animals [19].

The land fund represents one of the most important resources of the country, as part of the country's economy, but also as a social aspect. After 1989, following the restoration of property rights, a significant portion of agricultural land was returned by the Romanian state to its rightful owners or their heirs [5]. As a result, the pre-emption right, defined as the priority right to purchase an asset, in this case, agricultural land, was established as an important principle considered in land market transactions. Any legislative change to this rule can accelerate or slow down the dynamics of agricultural land purchases in Romania.

The purpose of the study is to trace the evolution of the pre-emption right in Romania from its inception until today, highlighting key legislative changes related to agricultural land transactions. The study aims to analyze the impact of these laws on the trading volume of agricultural land during the period 2017–2024. It also seeks to understand how the pre-emption right influences the dynamics of the land market, land fragmentation, and rural development in Romania.

MATERIALS AND METHODS

The first part of this article aims to trace the evolution of the pre-emption right from its inception to the present day, highlighting the changes introduced through land legislation

over time. For this purpose, the relevant legislation from the year 1989 to the present was studied.

In the second part of the article, we analysed the impact of applying the legislation to trading agricultural land in Romania, depending on the volume of such trading during the period 2017-2024, based on statistical data from professional institutions in Romania.

Data sources include official Romanian legislation from 1989 to the present, statistical data on agricultural land transactions collected from 2017 to 2024 by the specialized agency responsible for registering property rights and transfer deeds. Additional sources are reports and strategic documents from the Ministry of Agriculture and Rural Development, EU official documents, and cadastral registration data related to agricultural land.

Data processing and other methods used involved qualitative legal analysis to review changes in land legislation over time and comparative analysis of the evolution of the pre-emption right. Statistical methods were applied to analyze trends in land transaction volumes. The study also incorporated a review of strategic policy documents and cadastral records to assess their influence on market transparency and the exercise of pre-emption rights.

RESULTS AND DISCUSSIONS

In Romanian legislation, which follows the events of 1989, the right of pre-emption was established in 1991, upon the issuance of the law by which the land fund began its transformation and in the first phase, it was transferred from the property of the Romanian state to private property. Thus, article 48 of Law 18/1991, which was previously referred to, stated the following [11]: the alienation of agricultural land through sale-purchase is done by complying with the priority of purchase in the case of co-owners and then of neighbouring owners. This procedure was carried out through a specialized institution called the Agency for Rural Development and Planning. Thus, the owner of the land that was to be alienated was obliged to notify this institution of his intention, and the Agency transmitted to the people information about the transaction that was to take place within 15 days. Holders of the pre-emption right were required to declare their intention to purchase the land within 30 days. If, upon expiry of this period, neither the Agency for Rural Development and Planning nor any co-owners or neighbouring landholders expressed interest, the land could be legally transferred to a third party. Moreover, the legal provision stated that non-compliance with the pre-emption right could result in the annulment of the transaction.

The problem of pre-emption rights in Romania was also approached from a historical point of view, in the view of the French doctrine and legislation, in the view of the new civil code in various domains by Foltis (2010) [9].

In 1998, the legislation governing the legal circulation of land was amended [12]. One of the newly introduced provisions established that the pre-emption right was extended to include tenants, ranked after co-owners and neighbouring landowners in the order of priority. The term in which pre-emptors could express their interest in purchasing the land was increased by another 15 days, and the document containing the details of the sale was registered within the town hall of the locality where the property was located.

In 2009, Law no. 287/2009 on the Civil Code [13] introduced the notion of the *pre-emptor*, referring to the holder of the pre-emption right, who may acquire an asset with priority, provided that the legal or contractual conditions are met. The law also established specific provisions regarding lease agreements. The Civil Code of July 17, 2009 (republished) [6], retained the same legal framework governing the right of pre-emption.

In the context of Romania's accession to the European Union and the implementation of the Common Agricultural Policy, foreign citizens were granted the right to purchase agricultural land in Romania. This development contributed to a reduction in land fragmentation but simultaneously led to an increase in land concentration, particularly in the southern regions of the country. The monopolization of agricultural areas and their excessive fragmentation are considered

sensitive points that could hurt the food security of our country [24].

The Ministry of Agriculture and Rural Development published in 2015 a proposal for the action plan for the period 2020-2030. The document was developed following prior consultations with a large number of people working in the field. The document lists the three highest priorities considered: land merging, increasing the capitalisation of agricultural potential and reducing poverty in rural areas (rural areas development). The limitations in the economic progress of rural areas are also mentioned here. These are: restricted access to financing, land fragmentation, an ageing population and lack of professional training [16].

In this context, Law no. 17/2014 [14] was adopted, establishing a separate legal framework from the Civil Code. As a special law, it plays a key role in clarifying and regulating the procedures for exercising the right of pre-emption. This is a key factor in the agricultural land market in Romania. Article 1 of Law 17/2014 states the purposes of this law:

a) ensuring food security, safeguarding state interests, and managing natural resources in alignment with national priorities in these areas;

b) establishing a dedicated legal framework for the sale and purchase of agricultural land located outside the built-up areas of localities;

c) facilitating the consolidation of agricultural land through merging processes.

This law establishes the ranks of pre-emptors as follows:

1. co-owners;
2. tenants:
3. natural and legal persons who own land with a common side;
4. The State Domains Agency, as a representative of the Romanian State.

This law, along with its implementing regulations, establishes the procedure for obtaining the principal approval (endorsement) for the sale of agricultural land located outside the built-up areas. The approval is issued by the competent authority—either the Ministry of Agriculture and Rural Development or the County Directorates for Agriculture, depending on the size and location of the land. The process involves ensuring full transparency by publishing the sale offer on the official website of the respective institution: at the national level for plots exceeding 30 hectares, and at the county level for those under 30 hectares. Additionally, the issuance of this approval is conditional upon verifying compliance with the legal provisions governing the exercise of the pre-emption right. It should also be stated that for the alienation of agricultural land, under certain legal conditions, specific endorsements issued by the Ministry of National Defence or the Ministry of Culture are required.

In 2017, the Official Journal of the European Union published the Commission's point of view on agricultural land transactions [7]. This document is issued in response to the European Parliament's request to publish guidelines on the regulation of agricultural land markets under European Union law. This document also notes that some European countries, including Romania, have adopted land laws after 2013 to counteract undesirable effects on their land markets (e.g. pressure on agricultural land due to the need to use it for non-agricultural purposes).

These guidelines have been incorporated into Romanian legislation through the substantial amendment of Law no. 17/2014, introduced by Law no. 175/2020 [15]. The new provisions include prior approval for transactions involving agricultural land, requirements for professional training in agriculture, and residency conditions for natural or legal persons intending to acquire agricultural land. Seven categories of pre-emptors are established:

a) first-rank pre-emptors: co-owners, first-degree relatives, spouses, relatives and persons with legal affinity up to the third degree inclusive;

b) the next pre-emption rank (II): natural or legal persons who own agricultural investments such as orchards, vineyards, hop plantations, private irrigation and/or tenants. Among the two categories of pre-emptors included in the second rank, priority is granted to the first category in the purchasing process.

c) Third-rank pre-emptors include: owners of land sharing a common boundary with the land offered for sale, and natural or legal persons

who are tenants of extra-urban areas adjacent to the land in question.
d) fourth rank: made up of young farmers;
e) fifth-rank pre-emptors: specialised research and development institutions operating in the area where the agricultural land subject to sale is located;
f) sixth-rank pre-emptors: individuals residing or having their domicile in the locality where the land is situated or in neighbouring localities.
g) seventh rank of pre-emption: State Domains Agency, as representative of the Romanian State.
Law no. 175/2020 introduces the concept of the 'potential buyer', defined as a natural or legal person eligible to purchase agricultural land if the pre-emption right is not exercised, provided that specific legal conditions are met. As a result of the legislative amendments, the legal framework governing the exercise of the pre-emption right has become significantly more restrictive. The timeframe for exercising this right has been extended to 45 working days. Furthermore, a specialized buyer may express interest in acquiring the land within 30 calendar days following the conclusion of the pre-emption phase.
The procedure for selling agricultural land is characterized by a high degree of transparency, ensured by the institutions involved. Specifically, the sale offer is published online, thereby making the landowner's intention to alienate the property publicly accessible to any interested party. The exercise of the pre-emption right and the endorsement obtained under the law are also made transparent in the same way.
Although clear rules for trading agricultural land (outside urban areas) have been implemented in Romanian legislation over the last 10 years, the number of transactions is still high.
To better understand the effect of implementing the pre-emption right in agricultural land transactions, we have made a synthesis of the evolution of their volume during the period 2017-2024, data collected from the official website of the specialized agency whose purpose is to register real estate transfer deeds and register property rights [4]. Two reasons led to the choice of the above-mentioned period: since 2017 to the present, the data are centralized monthly and a symmetry can be established in terms of periods, having as reference the year 2021, when Law 175/2020 became fully functional (4 years before and 4 years after implementing Law 175/2020).
Below is the summary table with the above-mentioned data:

Table 1. Number of agricultural land transactions

Year	Number of transactions
2017	127,724
2018	117,293
2019	100,925
2020	107,610
2021	109,647
2022	142,891
2023	135,261
2024	125,632

Source: www.ancpi.ro [4].

The increasing trend in the annual number of agricultural land transactions indicates that the existing agricultural area in Romania is still quite fragmented.
Although the legislation regulating the right of pre-emption in the agricultural land market has been implemented, significant challenges remain in the development of rural areas in Romania.
While the number of agricultural land transactions continues to grow, a similar upward trend is observed in land prices [2], [23].
Fig. 1 shows the slightly increasing trend in the number of agricultural land transactions, a trend that began after 2021.
An additional indicator of the fragmented structure of agricultural land is the existence of a draft law currently under debate in the Romanian Parliament, which aims to facilitate land consolidation.

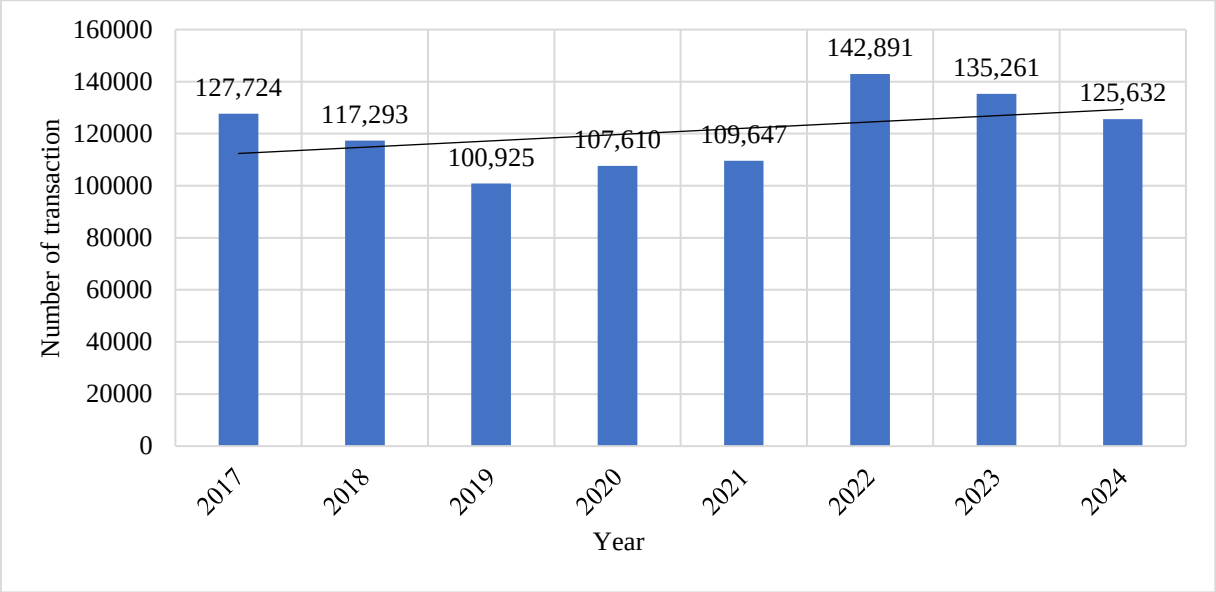

Fig. 1 Evolution of the volume of agricultural land transactions between 2017 - 2024
Source: www.ancpi.ro [4].

This process is intended to be applied only where necessary—namely, in regions with a high degree of land fragmentation—and is designed to support the development of the agricultural sector and, consequently, the advancement of rural areas [1]. Through this normative act, still in the draft stage, the merging of lands would imply an exchange of areas between two or more owners [18], therefore not a sale-purchase transaction.

Nevertheless, land consolidation can already occur in practice when, during the sale of agricultural land located outside urban boundaries, the neighbouring owner or tenant exercises their right of pre-emption.

The legal procedure for the transfer of ownership through the sale of such land includes several mandatory steps. Specifically, the town hall in whose administrative jurisdiction the land is located, along with the county directorate for agriculture, are required to publicly display the sale offer as submitted by the landowner. Thus, the person interested in purchasing agricultural land is informed in real time about the offers that have appeared, to exercise their pre-emption right within the legal term (45 working days from the date of initiating the sale procedure). It is the farmer's choice whether he exercises his right of priority in purchasing agricultural land or not.

In turn, farmers, those who contribute essentially to the development of rural areas, may face various difficulties in this process: the number of small farms is still high, there is insufficient technological equipment in agricultural holdings, the increasingly aging rural population, aspect highlighted in the document published by the relevant ministry, in the analysis of the National Strategic Plan 2021-2027 [17].

Another aspect worth mentioning is that less than 20% of farms need other financial resources to survive, as shown by a recent analysis of the situation in agriculture carried out by the National Council for SMEs. This study highlights the need to allocate financial resources for the purchase of agricultural machinery, farm management, digitalization process, research and development, and human resources. Moreover, the analysis emphasizes that self-financing remains the primary method of supporting agricultural activities in Romania [20].

Another significant factor influencing the effective exercise of the pre-emption right is the cadastral registration process of agricultural land, which is still incomplete. A criticism of this process emerges from the document drawn up following the consultations and opinions expressed during the second meeting on the merging of agricultural areas [10].

However, the national cadastre and land registry program is currently being

implemented, which aims to register properties in Romania free of charge. The measure was established by the Government through Emergency Ordinance 31/2018 [21], [22].
At this moment, out of an area of 9.54 million ha of agricultural land benefiting from subsidies from the Agency for Payments and Interventions in Agriculture, 8.17 million ha have been registered, i.e. a percentage of 86% [3].

CONCLUSIONS

The evolution of the pre-emption right in Romania was a slow process, without initially benefiting from special legislation, even after 2007. Indeed, an acceleration of the change in the rules for the acquisition of agricultural land occurred in 2014, and a major change in the land legislation was implemented 6 years later. The conditions for agricultural land transactions have become stricter to better respond to the 3 purposes of the law.
The current legal framework governing the pre-emption right in Romania provides investors with a genuine opportunity to gain priority access to the acquisition of agricultural land. At the same time, the fact that legislation on land acquisition is substantially revised every few years can have a stabilizing effect by establishing clearer and more predictable rules for the Romanian land market over longer periods.
An additional function of the pre-emption right is its potential to contribute to rural development—particularly through facilitating the consolidation of agricultural land—provided it is consistently exercised by eligible farmers who can fully benefit from this legal mechanism.

REFERENCES

[1]Agrointel.ro, Agricultural land consolidation Law Project, https://agrointel.ro/260230/legea-comasarii-terenurilor-agricole-proiect, Accessed on 11.03.2025.
[2]Agro-TV.ro, How much costs one hectare of arable land and pastures in Romania, https://agro-tv.ro/cat-mai-costa-ha-de-teren-arabil-si-pasuni-in-romania, Accessed on 12.02.2025.
[3]ANCPI, National Agency of Cadastre and Real Estate Advertising, Implementation status of ANCPI specific activities as of 29.02.2025, https://www.ancpi.ro/pnccf/documente/NOTA%20privind%20activitatea%20ANCPI%20la%20data%20de%2028.02.2025.pdf, Accessed on 25.03.2025
[4]ANCPI, Statistics, https://www.ancpi.ro/statistici/, Accessed on 16.03.2025.
[5]Burcea, M., Vlad, I.M., Oltenacu, N., 2023, Romania's agricultural land fund and the dynamics of the land ownership during the period 1990 – 2020. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 23(3), 77-84.
[6]Civil Code of July 17, 2009 (**republished**) https://legislatie.just.ro/Public/DetaliiDocument/109883, Accessed on 12.03.2025
[7]Commission Interpretative Communication on the acquisition of agricultural land and European Union law 2017/C 35/05, Official Journal of the European Union.
[8]Deteix, L., Salou, T., Drogué, S., Loiseau, E., 2023, The importance of land in resource criticality assessment methods: A first step towards characterizing supply risk, Science of The Total Environment, Vol. 880, pp. 163248.
[9]Foltis, A.I., 2010, The judicial regime of the pre-emption right, Doctoral Thesis, University " Lucian Blaga" from Sibiu, Faculty of Law " Simion Barnutiu".
[10]Istudor, N., Popescu, G., 2017, Problems of Agrarian Policy, Consolidation of agricultural lands, ASE publishing House, pp.21, https://www.rndr.ro/documente/brosuri/Comasarea-terenurilor-din-agricultura.pdf, Accessed on 13.03.2025.
[11]Land Fund Law No. 18 of February 19, 1991 https://legislatie.just.ro/Public/DetaliiDocumentAfis/1459, Accessed on 12.03.2025.
[12]Law No. 54 of March 2, 1998, on the legal circulation of land, https://legislatie.just.ro/Public/DetaliiDocument/14220 Accessed on 12.03.2025.
[13]Law 287/2009 on the Civil Code, https://legislatie.just.ro/Public/DetaliiDocumentAfis/109883, Accessed on 12.03.2025
[14]Law no. 17 of March 7, 2014 on some measures regulating the sale-purchase of agricultural land located outside the urban area and amending Law no. 268/2001 on the privatization of trading companies that manage public and private state-owned land for agricultural purposes and the establishment of the State Domains Agency, (https://legislatie.just.ro/Public/DetaliiDocument/156290?isFormaDeBaza=True&rep=Tru), Accessed on 18.03.2025.
[15]Law no. 175 of 14 August 2020 amending and completing Law no. 17/2014 on some measures regulating the sale-purchase of agricultural land located outside urban areas and amending Law no. 268/2001 on the privatization of trading companies that manage public and private state-owned land for agricultural purposes and the establishment of the State Domains Agency https://legislatie.just.ro/Public/DetaliiDocument/229148), Accessed on 17.02.2025.
[16]Ministry of Agriculture and Rural Development, Strategy for the development of the agri-food sector on

medium and long term 2020-2030, https://www.madr.ro/docs/agricultura/strategia-agroalimentara-2020-2030.pdf, Accessed on 17.03.2025.
[17]Ministry of Agriculture and Rural Development, National Strategic Plan 2021-2027, https://www.madr.ro/docs/dezvoltare-rurala/PAC_dupa_2020/2020/Analiza-nevoi-PNS-2021-2027.pdf, Accessed on 17.03.2025.
[18]Notari.pro, Land consolidation, https://notari.pro/dictionar-juridic-dex/comasare-terenuri, Accessed on 19.03.2025.
[19]Popescu, A., Dinu, T.A., Stoian, E., 2019, Efficiency of the agricultural land use in the European Union, "Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development", Vol.19(3), 475-486.
[20]Revista-ferma.ro, 16 farms need financing to survive, https://revista-ferma.ro/16-din-ferme-au-nevoie-de-finantare-ca-sa-survivietuiasca/, Accessed on 15.03.2025.
[21]Romania's Government, Measures for free registration of agricultural lands, https://gov.ro/ro/print?modul=stiri&link=masuri-pentru-intabularea-gratuita-a-terenurilor-agricole, Accessed on 22.03.2025.
[22]Romania's Government, Emergency Ordinance of 31 April 2018 on the amendment and completion of the Law on the Cadastre and Real Estate Advertising no.7/1996, https://legislatie.just.ro/Public/DetaliiDocumentAfis/199890, Accessed on 24.03.2025.
[23]Stoica, D.G., Dumitru, E.A., 2021, Aspects that contributed to changes in the price of agricultural land in Romania and other countries in the European Union. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 21(4), 565-570.
[24]Urșanu (Popovici), E.-A., Grigorescu, I., Roznovițchi (Mocanu), I., 2024, Land reform catalysts of capitalism and communism: 150 years of agricultural change in Romania, Journal of Historical Geography, Vol. 86, pp. 326-340.

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AGRICULTURAL LAND ADMINISTRATION IN ALBANIA POST-PRIVATIZATION: CHALLENGES AND ISSUES FOR SUSTAINABLE DEVELOPMENT

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Abstract

The purpose of this paper is to analyze the major challenges associated with the administration and use of agricultural land in Albania from the pre-1950 period to 2023. Before 1950, 91.4% of Albania's agricultural land was privately owned. From 1946 to 1968, nationalization policies created 420 agricultural cooperatives managing 75.7% of arable land, with 77 state enterprises controlling 21.4%. This resulted in significant land fragmentation and distribution across small plots. While decentralization aimed to empower farmers, it increased production costs, degraded land, and reduced soil fertility on nearly 30% of the land. Key issues include inefficient administrative changes, fewer than 50% of farmers with land ownership certificates, and informal urban expansion reducing agricultural land. Furthermore, land fragmentation—where 50% of farms are smaller than 1 hectare—has hindered the adoption of modern agricultural technologies and increased operational costs. Additionally, the country's irrigation capacity has fallen by 50-60% compared to 1990 levels. Statistical data on land use, farm size, sectoral reports, policy documents, and national agricultural data are used. While a national land administration system and database have been established, the study highlights the need for better coordination among institutions and increased efforts to advance scientific research on soil protection, in alignment with EU directives. Addressing these challenges is crucial and more efficient and sustainable agricultural sector that can support Albanian long-term economic and environmental goals.

Key words**:** *land administration, governance, privatization, land health, fragmentation*

INTRODUCTION

Agriculture is a key economic activity in Albania, contributing 18-20% to the GDP and providing income for rural areas, where about 47% of the population lives (INSTAT, 2022) [21]. Agriculture is vital for Albania's economy, supporting food needs, agro-processing, and exports. Alexandratos and Bruinsma (2012) [1] project global population growth to 9.15 billion by 2050, which could impact food security in many countries. Albania's agricultural land covers 686,355 hectares, or 23.87% of its total area. The average farm size is 1.2 hectares, with land often divided into more than four plots. This is lower than in many European countries, where agricultural land occupied 30-37% of territory (FAO, 2017) [16]. The purpose of this study is to analyse and reflect on the main issues and findings regarding the administration of agricultural land at all levels of government in Albania, including the roles and responsibilities of institutions and law enforcement agencies, as well as the challenges that have arisen following the privatization reform about ownership, land management, sustainable development, and land use. Since the privatization of land in 1991, the transition years have been marked by a series of challenges in agricultural land administration, highlighting the need for a sustainable administration system that addresses legal aspects, land use, administrative structures, property rights, and land protection technologies and practices. Land administration involves applying rules of land tenure, including registration, use planning, consolidation, management, and taxation (FAO, 2007) [12]. It has evolved due to

political and economic changes at various levels. Agricultural land administration has evolved from centralized planning to market-driven reforms, impacting legislation, property rights, and governance. UNECE [47] defines it as the process of recording and sharing information on land ownership, value, and use to support land markets (Hulls et al., 2005) [19]. Land administration in Albania, like other Eastern European countries, evolved through three major reforms between 1946-1990, starting with land confiscation and redistribution to landless families post-WWII. It has since expanded to include sustainable development and technological advances. Between 1946 and 1968, agricultural collectivization was initiated and completed, resulting in a new land distribution model in which 21% of agricultural land was allocated to state farms, while 79% was managed by agricultural cooperatives. In 1991, with the political system changed in Albania, the agricultural land privatization reform was implemented, leading to the establishment of family farms. Land administration supports sustainable development through efficient land-use planning, GIS, and technology, but it remains a complex legal, social, and political challenge (Williamson et al., 2010) [49]. An effective land administration system promotes resilience, inclusive planning, sustainable resource management, and climate protection (Expert Group on Land Administration and Management, 2019) [10].

Post-privatization of agricultural land, challenges in property rights, land reforms, fragmentation, land use, and management practices have emerged.

In this context, this research examines the functioning of agricultural land administration structures, land use, urban informality, severe land fragmentation, degradation phenomena, fertility decline, and other land management challenges.

MATERIALS AND METHODS

To identify the sources of agricultural land and analyse its dynamics over different periods, statistical data from INSTAT [20, 21, 22, 23], the Ministry of Agriculture and Rural Development [31, 32, 33, 34] — the central institution responsible for agricultural land— and statistical yearbooks published across various periods have been utilized. Additionally, data from the State Cadastre Agency regarding land ownership certification have been considered. This information covers the period from 1950 to 2023.

Land privatization is based on data from the land division reform, implemented under Law No. 7501 “On Land”, which was initiated in 1991 and has shaped the evolution of land ownership (Republic of Albania, 1991).

The study of agricultural land administration issues post-privatization relies on collected information, as well as the authors' contributions to research conducted in municipalities and national institutions.

The main indicators considered in this study include the total area of agricultural land over time, land use categories (such as arable land, pastures, orchards, and vineyards), and the structure of land ownership (state-owned, private, or communal). A fragmentation index measures land fragmentation; the count of issued ownership titles provides knowledge on property formalization. Changes in land cover and land use (LCLU), legal and institutional developments, and socioeconomic variables—such as the number of farm households and average landholding size—were also examined.

Several research methods were employed to support a comprehensive understanding of the topic. Documentary and archival research let one examine legal papers, cadastral records, and historical data sets to track policy changes. Using time-series analysis, land use and ownership pattern trends from 1950 to 2023 were assessed. Geographic information systems (GIS) driven spatial analysis let one see land distribution and use changes across time. Key stakeholders, including landowners and municipal officials, were included in field surveys and semi-structured interviews, which provided qualitative depth to the study. A comparative study was also done to see how land reforms and government models have changed throughout time and area. This mix of indicators and research techniques offers a strong basis for comprehending the

evolution, issues, and present condition of agricultural land management in Albania.

RESULTS AND DISCUSSIONS

1. An overview of agricultural land resources in Albania

The continuous expansion of agricultural land has been a key component of national policies aimed at developing agriculture as a major economic activity, both in rural areas and at the national level. Before 1990, state policies followed the principle of "relying on our own strength," which emphasized self-sufficiency in agricultural production to meet the needs of the population. However, this approach often led to the misallocation of land resources, such as converting forested areas into farmland or draining wetlands in coastal regions.

As a result, approximately 35% of agricultural land was created through wetland reclamation in coastal areas, as well as deforestation and pasture conversion in hilly and mountainous regions.

Land expansion boosted agricultural production but caused environmental issues like biodiversity loss, soil erosion, and degradation. From 1950 to 1985, agricultural land nearly doubled to 713,000 hectares.

The establishment of the domestic chemical fertilizer industry, the expansion of irrigation capacity, and the intensification of agricultural practices further contributed to progress, positioning agriculture as a priority sector.

Table 1. Agricultural land area 1950-2022

Crt. No.	Year	Category of land agriculture (ha)				
		Land agriculture	Arable land	Fruit trees	Olives	Vineyards
1	1950	391,000	374,000	3,000	11,000	4,800
2	1960	457,000	417,000	15,000	17,000	8,000
3	1970	599,000	321,000	30,000	36,000	12,000
4	1980	702,000	585,000	56,000	43,000	18,000
5	1990	703,698	581,600	59,800	45,060	19,757
6	2000	699,000	577,854	12,167	46,000	5,824
7	2010	695,520	570,954	16,300	48,000	9,712
9	2022	686,355	566,372	20,658	53,802	12,002

Source: State Planning Commission 1950-1990, Statistical yearbook,
INSTAT and Ministry of Agriculture 2000-2023 [43, 44, 45, 20, 21, 22, 23, 31, 32, 33, 34].

The highest rate of increase in agricultural land area in Albania was observed between 1950 and 1985, with an expansion of 321,000 hectares—an increase of approximately 98.6%. However, after this period, the potential for further expansion of agricultural land became very limited. Studies conducted by the Ministry of Agriculture and the Soil Science Institute of Albania in the early 1990s indicated that the potential for increasing agricultural land was insufficient to significantly impact agricultural production (Ministry of Agriculture, 1988) [31]. Therefore, given the limited land area per capita, policies have been oriented towards programs and financial support for the full utilization of agricultural land, land conservation, protection against degradation, and rehabilitation through strategic measures at the central, regional, and local government levels. These policies also emphasize the development of essential infrastructure for irrigation and drainage, increased investment, and improved agricultural yield per unit of land. As noted by FAO, "The overall availability of food is also affected by changes in agricultural yields, productivity, as well as changes in the availability of arable land" (FAO, 2011) [13]. Before 1990, cultivation was practiced twice a year on irrigated lands. However, the population's needs for agricultural and livestock products were not fully met according to standard requirements. Based on relief characteristics, Albania's agricultural lands are classified into three main types: plain, hilly, and mountainous lands (Ministry of Agriculture, 1990) [32].

Plain lands, located in the low coastal zone along the Adriatic and Ionian Seas, comprise 43.3% of the total agricultural land area. These

areas are characterized by highly productive soils, slopes of 0–5%, and are equipped with irrigation and drainage systems, making them essential for primary agricultural production. Within this zone, coastal agricultural areas cover approximately 250,000 hectares and are classified as high-quality farmland (Soil Science Institute of Albania, 1995) [42].

Hilly lands, which extend up to 400–600 meters above sea level, account for 34% of the total agricultural area. These lands are characterized by soils with good productive capacity, making them suitable for both field crops and fruit trees. However, they present challenges related to irrigation due to their 5–25% slopes and susceptibility to erosion. While some of these lands are partially supported by irrigation and drainage systems, water management remains a critical issue (FAO, 2006) [11].

Mountainous lands, extending over 600 meters above sea level, account for 22.7% of Albania's agricultural land. These areas have steep slopes and are suitable only for specific agricultural and horticultural crops that can tolerate erosion and landslides. Irrigation capacity in these areas is very low. A significant portion of abandoned and unused land is located in these regions due to population migration. Currently, institutions and experts are engaged in discussions regarding legal initiatives for the protection, utilization, and ownership rights of land in this category (Ministry of Agriculture and Rural Development, 2018) [33]. Land administration in these regions faces challenges related to implementing modern agricultural technologies, requiring stronger agricultural mechanization to address labor shortages and shifts in the agricultural structure. Based on international soil classification, approximately 80% of Albanian soils fall into the Cambisols, Luvisols, Regosols, and Phaeozems categories (Lushaj & Zdruli, 2007) [9]. After 1990, the total area of agricultural land declined, not only due to the exhaustion of new land resources but also due to the conversion of farmland for non-agricultural purposes. Land privatization led to informal urbanization and urban sprawl, particularly in peri-urban areas near major cities, where population migration from rural areas and the establishment of businesses encroached on highly productive farmland (Toto et al., 2019) [46]. Urban expansion gradually shifted the population balance, with the urban population increasing from 35% in 1990 to approximately 53–55% today (INSTAT, 2022) [22]. Around major cities and urban centers, approximately 180 km² of agricultural land has been converted into urban land. To address this issue, the government established the National Legalization Agency to review and legalize unauthorized constructions since 1991, formally converting urbanized agricultural land into urban zones (ALUIZNI, 2015) [2]. The second phenomenon observed during and after land privatization is that approximately 16% of agricultural land, primarily low-fertility land (sandy, stony, saline, and acidic), which was previously maintained through state investments and programs, was refused by farmers and remained state-owned and uncultivated. Land must be preserved and restored where losses occur, or negative environmental impacts should be mitigated (Kucaj, 2024) [24]. The third phenomenon that emerged after privatization, due to demographic shifts from rural to urban areas or migration abroad, was the informal urbanization of agricultural lands, particularly in the coastal region—the most productive agricultural areas of the country. This led to the rapid transformation of peri-urban zones surrounding major cities, shifting land use from predominantly agricultural to urban purposes. Simultaneously, agricultural land in previously inhabited areas was abandoned, leading to degradation and loss of productivity. The loss of agricultural land due to urbanization is also linked to inconsistencies between urban and agricultural land legislation. During the transition years, until 2009, urban planning did not incorporate agricultural land protection. Many local government units with agricultural functions were reclassified into urban areas. Additionally, legal frameworks intended to balance urban and agricultural land development, such as those introduced under Law No. 10119, dated 23.04.2009 [26], On Territorial Planning, focused primarily on

urban development without adequately addressing agricultural land and natural ecosystems (Shutina et al., 2014) [41]. Despite the significant loss of agricultural land due to informal urbanization since 1990, it remains essential to establish a comprehensive and accurate land administration and protection framework. Institutions such as the State Agency for Cadaster, municipalities, and the Ministry of Agriculture and Rural Development must collaborate to verify and update cadastral records at national, local (municipal), and regional (county) levels to reflect actual land use changes.

2. Ownership and privatization reforms of agricultural land

2.1. Changes in Ownership

Land ownership, as a fundamental issue within any social system, and particularly for agricultural land, has undergone dynamic changes in Albania, reflecting shifts in the political and economic system, land reforms, governance, agricultural sector organization, land use patterns, the development of the land market, implemented economic models, the level of national independence, professional human capacity, and the overall development of the country. According to Article 17 of the UN Declaration on the Rights of Peasants and Other People Working in Rural Areas, “Peasants and other people living in rural areas have the right to land, individually and/or collectively, including the right to have access to, sustainably use, and manage land” (European Coordination Via Campesina, 2023) [8]. Before 1912, during the Ottoman period, land was included in the land fund and registered by the Turkish state. After 1912, the land was privately and partly owned. Following World War II, in 1945-1946, Albania implemented its first massive agrarian land reform, expropriating large and foreign landowners, benefitting over 300,000 families who previously owned little or no land. However, the private ownership gained from this reform was short-lived. From 1946 onwards, the state organized cooperatives and state-owned agricultural farms, progressively transitioning land ownership from private to state hands. By 1950, about 91.4% of agricultural land was privately owned, with only 8.6% under state or cooperative ownership. By 1960, this had shifted to 13.5% private ownership and 86.5% state-owned (Statistical Yearbook, 1976) [43]. In 1968, with the completion of the collectivization of agriculture, Albania saw the establishment of 414 agricultural cooperatives by 1983, with an average size from 300 to 5,000 hectares. These cooperatives administered 75.7% of the agricultural land, while 77 state-owned farms, with average size from 300 to 12,000 hectares, managed 21.4% of the land. In 1974, the Albanian Constitution declared land as state property, with 95% of the land being utilized by agricultural cooperatives and farms, while 5% was reserved for state and social institutions. Nationalization of land and top-down planning fostered an environment conducive to investment, with 85% of the land organized into plots averaging 12 hectares in the plains, irrigation systems covering 62.8% of the area, and flood protection measures in place, ensuring 100% cultivation of agricultural land. These measures significantly improved the national economy and land quality. However, policies aimed at meeting the agricultural needs of the country did not adequately ensure the welfare of the rural population. As noted, "Information on land tenure, land use, land value, and land development are known to enable economic opportunities, reduce land-related disputes, and support food security" (Expert Group on Land Administration and Land Management, 2019) [10]. With the implementation of the land division reform in 1991, the agricultural land surface of 686,355 hectares in 2023 is now divided as follows: 80% in private ownership and 20% in state ownership for use by institutions. Romania's Civil Code defines property as "the right to enjoy and dispose of exclusively, within legal limits" (Zaharia, 2003) [53].

3. Privatization of Agricultural Land and the level of administration

3.1. Land privatization

With the implementation of Law No. 7501, dated 19.07.1991 [27], "On Land," the privatization of agricultural land owned by former agricultural cooperatives was carried out over approximately 570,000 hectares.

Additionally, with the approval of Council of Ministers' Decision No. 452, dated 17.10.1992 [4], "On the Restructuring of State-Owned Agricultural Enterprises," land from state-owned agricultural farms (152,000 hectares) was also divided. This reform is considered the largest land reform in the country after collectivization, creating approximately 394,849 small family farms with an average size of 1.26 hectares per farm (2003 Statistical Yearbook). While the land division reform was accepted by all political factors, it failed to achieve effective governance of agricultural land during the transition phase, and many problems related to land fragmentation remain. The division process, which was based on the number of people per family and criteria such as proximity to plains and hills, arable land and orchards, and access to irrigation, resulted in significant fragmentation of land ownership. Family farms were divided into 4.4 plots, with some cases reaching up to 12 plots, with an average size of 1.26 hectares per farm.

According to size, about 53% of farms are up to 1 ha, 36.4% have 1-2 ha, and only 11.2% have a size of over 2 ha. The average size of plots within a property is 0.30 ha, ranging between 0.17-0.48 ha across the 12 regions of the country.

Table 2. Classification of Farms by size in hectares of land

	Farm size ha	% of farms to total
1	0.1-0.5	25
2	0.6-1	27.4
3	1.1-2.0	36.4
4	> 2.1	11.2

Source: INSTAT, 2015 [22].

After privatization, the designed plots, which previously averaged 12 ha and cultivated the same crops using uniform technology, were divided among 15-25 owners on average. Due to fragmentation, land cultivation fell to 70-75% of the total agricultural surface, compared to 100% in 1990 (Statistical Yearbook, 1990; INSTAT, 2015) [45, 20]

Studies on Albanian agricultural land confirm a high degree of fragmentation based on the Simos index, which complicates land management, mechanization, irrigation, and drainage system maintenance. Fragmentation reduces irrigation efficiency by 35%, lowers agricultural production, increases land loss by 3-5%, and raises fuel consumption for fieldwork on fragmented plots by 25-30% compared to a similarly sized unfragmented area (Lushaj, 2003; Lushaj, 2018) [28, 29].

Additionally, farmers tend to abandon agricultural plots located far from their homes. In certain agricultural regions, farmers may travel up to 10-20 km daily to access all their plots, further reducing land use efficiency (Fig 1).

Fig 1. Land Fragmentation in Librazhd District, Albania
Source: Original photo taken by authors.

Land consolidation initiatives, which aim to unify farm property in one place or in as few locations as possible, are still in their initial stages. In 2016, the National Land Consolidation Strategy was developed; however, there is still no specific law on agricultural land consolidation. The existing legal framework, including the Civil Code of the Republic of Albania, allows for further fragmentation of land ownership. Based on land typology and characteristics, land consolidation methods could be applied to approximately 60-65% of the agricultural surface. These methods range from simple approaches, such as plot exchange and coordinated planting of base plots with the same crop, to more structured agreements, cooperative work, agricultural associations, land market promotion, land ri- parcelling, and the implementation of favourable policies to encourage farmers to consolidate land and

expand their farms (Lushaj & Kucaj, 2021) [30].

The problems related to land division, accumulated over the years, remain a limiting factor for land registration, which serves as an indicator of administrative efficiency and the provision of ownership certificates to farmers. Currently, only 55-60% of property titles have been issued, which does not fully guarantee ownership, hindering long-term investments, the development of the land market, and the expansion of agricultural farms. Land registration is essential for promoting land consolidation, facilitating the taxation system, and enabling credit and investment. Commenting on the importance of land markets and regulations, it has been noted that "well-functioning land markets are of utmost importance for economic development, particularly in rural areas" (Deininger & Feder, 2001; European Commission, 2021) [5, 7].

The territory of Albania is divided into more than 3,000 cadastral zones, of which rural cadastral zones account for over 90% of the total (Musta, 2006) [35].

The registration of agricultural land has not progressed as expected, both in terms of quantity and in terms of strategic planning for potential areas. In the first phase, registration efforts focused on peripheral mountainous areas where the land market was nearly nonexistent, whereas priority should have been given to regions with intensive agricultural development, where a functioning land market could emerge. The low level of ownership certification has kept agricultural land transactions (sales and leases) at low levels, limiting farm expansion, land administration, and consolidation while fostering an informal leasing market. In the absence of proper certification, land use has significantly decreased. The initial phases of land division were also accompanied by legal violations and weak governance. During the transition years, the government and responsible institutions failed to regulate population movement from rural to urban areas, which could have prevented the unauthorized conversion of approximately 30,000 hectares of agricultural land into informal urban settlements. This process resulted in about 300,000 informal constructions on agricultural lands between 1991 and 2004 (Musta, 2006) [35].

During and after the division of land from former agricultural cooperatives and state farms, numerous issues arose. Analysis identified border conflicts in 174 villages, mainly in coastal areas, as well as approximately 20,000 hectares of land occupied by individuals without legal documentation, which were not granted ownership titles. Additionally, 5,200 cases involved the issuance of use titles beyond legal deadlines, and illegal land acquisitions occurred through ownership transfers in areas designated as tourism priority zones under VKM No. 88, dated 01.03.1998. In violation of the law, land division commissions engaged in illegal actions by allocating forest land, pasture, and fallow land to residents, despite these categories being excluded under Law No. 7501 [27]. In 80 villages, land distribution exceeded legal limits. Furthermore, during the land reform process, approximately 114,000 hectares of agricultural land were rejected by owners due to poor agricultural productivity (acidic, saline, and sandy soils) and degradation in hilly and mountainous areas (Government Land Commission, 2007) [18].

Many irregularities occurred in land distribution, including multiple allocations to different farmers, mapping errors, discrepancies between maps and actual terrain, and prolonged judicial conflicts stemming from flawed decisions by property title-issuing authorities. The literature emphasizes that "Land administration and management (LAM) systems are a fundamental infrastructure for the proper functioning of land markets. Land markets enable land to flow to those who are willing and able to use land well, thereby facilitating investments and growth, improving land allocation, and developing financial markets. For land markets to work efficiently, they must be underpinned by land administration systems that define property rights, guarantee security of tenure, establish a mechanism for registering these rights within a reasonable time and cost, and generate

information to support property valuation and taxation" (World Bank Group, 2017) [51].

Until 1997, no cadastral zone was registered in the registration offices. In some areas in the north of the country, although land was distributed according to Law No. 7501 and ownership documents were issued, many farmers continued agricultural activities on their pre-agrarian reform properties, which they held illegally. These shortcomings have prolonged the process of issuing ownership certificates, impacting property security and land administration.

In 1994, the system *For the Registration of Immovable Properties* was established, leading to the gradual organization of central and local offices, which are now digitized and equipped with the necessary infrastructure. In 2001, with support from USAID and the Albanian government, the *Initial Project Management Unit for the Registration of Immovable Properties* was launched, introducing a new model for documenting agricultural land ownership. This process included field verification, public posting of ownership data for 90 days to allow for corrections, and submission to registration offices for final processing (USAID, 2001) [48].

Significant progress has been made in Albania's land administration, protection, and use through the adoption of legal and sub-legal acts. To further promote agricultural land certification, the Albanian Parliament passed Law No. 20/2020, which defined final registration procedures (Parliament of Albania, 2020) [37]. This law has led to notable progress in land registration, with annual registrations expected to reach approximately 25,000 family's year. The State Cadastre Agency (ASHK) [2], established in 2019, is the primary public authority responsible for implementing this law, coordinating land registration efforts with central institutions and local government units to streamline the process and complete land documentation (ASHK, 2021) [2].

3.2. Land Administration

The principles of land administration focus on land registration, management, land taxation and valuation, privatization, land use planning, project design, and implementation. "Public land administration includes initial registration, transfers, surveying, and property valuation" (FAO, 2016) [15]. Until 2014, Albania's territory was organized into 60 municipalities (large cities) and 309 communes (rural areas), which operated separately in the process of land administration and use.

With the implementation of Law No. 115/2014 [39], "*On the Administrative-Territorial Division of Local Government Units in the Republic of Albania"*, the country's territory was restructured into 61 municipalities starting in 2015 (Parliament of Albania, 2014) [37]. Previously, municipalities had a strictly urban character, but after the reform, they incorporated rural areas, creating a mix of urban and rural governance. For example, the municipality of Korça expanded from 21.4 km² before 2015 to 793.2 km², a 37-fold increase. The municipality is now organized into eight administrative units, of which seven have a rural character, while one represents the city of Korça (INSTAT, 2015) [22].

At the national level, this administrative restructuring has significantly altered rural-urban relationships within municipalities, leading to shifts in land use and governance due to the expansion of rural areas under municipal administration.

Urban and rural land uses are no longer mutually exclusive or separate in the planning process but coexist in a continuum of interconnected communities. Urban-rural linkages now shape new relationships between areas, influencing territorial policies, land administration, natural resource governance, and control over agricultural land. The territorial division reform under Law No. 115/2014 [39] positively impacted governance and agricultural land administration. Based on this law, municipalities drafted General Local Plans (15-year detailed plans) that integrate planning, administration, and protection of agricultural land from urbanization, aligning stakeholders toward better land and territory management. As a result, the urbanization of agricultural lands has declined to negligible levels (Parliament of Albania, 2014) [39].

In the context of land ownership and administration, strong connections exist between land governance and effective land use. The concept of land governance is not

new; it broadly encompasses ownership rules, reforms, institutions, legislation, administration, and land policies. As highlighted by the FAO (2007) [12], "good governance principles in land administration include land registration, management of state-owned land, property taxation, privatization and restitution, land use planning, professional services, the management of customary land, and the development of projects." While these elements require context-specific solutions, they share common approaches to enhancing governance and land administration.

It is often mentioned in the literature that good governance in land administration does not occur in isolation from other levels of development. As Burns and Dalrymple (2008) [3] state, "Weak governance in land administration is a key contributor to issues of: informal models of service provision, corruption, illiquidity of assets, limited land markets, tenure insecurity, inaccurate and unreliable records, informal settlements, unrealized investment potential in property, land speculation and encroachment, idle and unproductive use of land, inequitable land distribution, social unrest, and inadequate provisions of infrastructure." In this context, agricultural land administration structures in Albania should prioritize governance issues in development policies at all levels of government. The agricultural land administration system in Albania remains an objective to be improved at all levels. Over the last 35 years, agricultural land governance structures have undergone continuous changes and are still not fully consolidated.

The administration of agricultural land in Albania is the responsibility of institutions at national, regional, and local levels. At the national level, the Ministry of Agriculture and Rural Development is the highest state authority responsible for the technical direction of land administration structures, drafting and implementing policies and legislation on agricultural land, and determining the rules for land protection and the creation of a database. The State Inspectorate of Land Protection is responsible for ensuring the enforcement of legal measures in this field. However, land governance institutions have undergone frequent organizational changes since 1990. From 1960 to 1992, the ministry was called the "Ministry of Agriculture," but its name, structure, and competencies have changed four times since then. These frequent institutional changes, especially in a country in transition, have often led to instability and a lack of coordination. As Palmer et al. (2007) [36] highlight, "Reforming the organizations and practices responsible for land administration is one of the most difficult governance challenges in the land sector. Legal or policy reforms... must be operationalized through the system of land administration. Land administration includes the systems for land registration, land use planning, land management and property taxation. Each of these topics has clear governance dimensions."

The Ministry of Justice develops policies on property rights through the institutions responsible for registration, property restitution, and property compensation, in cooperation with other relevant institutions. The State Agency for Cadastre operates under the authority of this ministry and is responsible for real estate registration, legalization, and property transactions. This agency was formed through the merger and restructuring of three key institutions: (i) the real estate registration offices, (ii) the agency for the legalization of unauthorized constructions and urbanized land, and (iii) the property restitution and compensation committee (Republic of Albania, Law No. 111/2018) [40].

At the regional (county) level, Law No. 8752, dated 26.03.2001 [38], "On the Establishment and Functioning of Structures for Land Administration and Protection," established the Directorates of Land Administration and Protection in Albania's 12 regions as a delegated function of the Council of Ministers. In the municipalities, Land Administration and Protection Offices were created with responsibilities related to land administration at the municipality level, the development of geographical and cadastral information, and aspects of land valuation (Republic of Albania, Law No. 8752/2001) [38]. The Land Protection Inspectorate also operates at the regional level. Since 2015, the responsibility for the administration of agricultural land at the local

level has been transferred to municipalities through the Land Management and Protection Office.

This office plays a crucial role in territorial administration, land protection, database management, soil fertility conservation, and land taxation (Republic of Albania, Law No. 115/2014) [39].

3.3 The establishment of the Land information and database in Albania

The United Nations Economic Commission for Europe (UNECE) in 1993 [47] issued the guideline *"On the Establishment of a Land Administration System in the Countries of Eastern and South-Eastern Europe"*, which outlined the necessity for each country to establish a land administration system (UNECE, 1993) [47].

A key component of land administration is the Geographic Information System (GIS), which enables efficient land management and decision-making. In Albania, during 2002-2003, "the *Land Use Policy* project" [6] was implemented, financed by the European Commission and carried out by Agrotec Company of Italy in collaboration with the Soil Science Institute of Albania and the Ministry of Agriculture.

The project utilized GIS to develop a model and methodology for land use planning, sustainable land resource management, and the creation of a land information database to support land administration and management (European Commission, 2003) [6].

The database established within the study area included an inventory of land resources, climate data, geology, land cover, soil characteristics (horizons, type, depth, texture, chemical and physical properties, land assessment and suitability indicators), land use data (current use, types of use, production systems), socio-economic data, ownership records, land use change analysis, agro-ecological and socio-economic studies, and land use planning.

The GIS-based system supported land use planning and administration by facilitating decision-making on land use, guaranteeing ownership rights, enabling land taxation, and promoting the land market.

During the project, the model was implemented in selected municipalities and communes across Albania.

After its completion, Albanian institutions, under the Ministry of Agriculture, continued expanding the system. As of today, GIS-based land management has been implemented across approximately 460,000 hectares, covering 70% of the country's agricultural land.

The database has been digitized and mapped to include land use and land change maps (Fig. 2), soil classification, slope analysis, ecological zoning, agricultural production capacity, and suitability assessments for various crops. Additionally, hazard maps have been developed for risks such as flooding, erosion, irrigation constraints, and soil fertility issues (Ministry of Agriculture and Rural Development of Albania, 2020) [33].

The data used in this system were collected from various sources, including field observations, satellite imagery, orthophotos, cadastral records (land and parcel books, Form 6, ownership documents from registration offices, and land ownership certificates), information from the Soil Science Institute of Albania, regional land administration and protection directorates, and former communes and municipalities.

The fieldwork involved soil profile analysis and land classification, which have been vital for land administration post-privatization, aiding in land management, planning, and productivity.

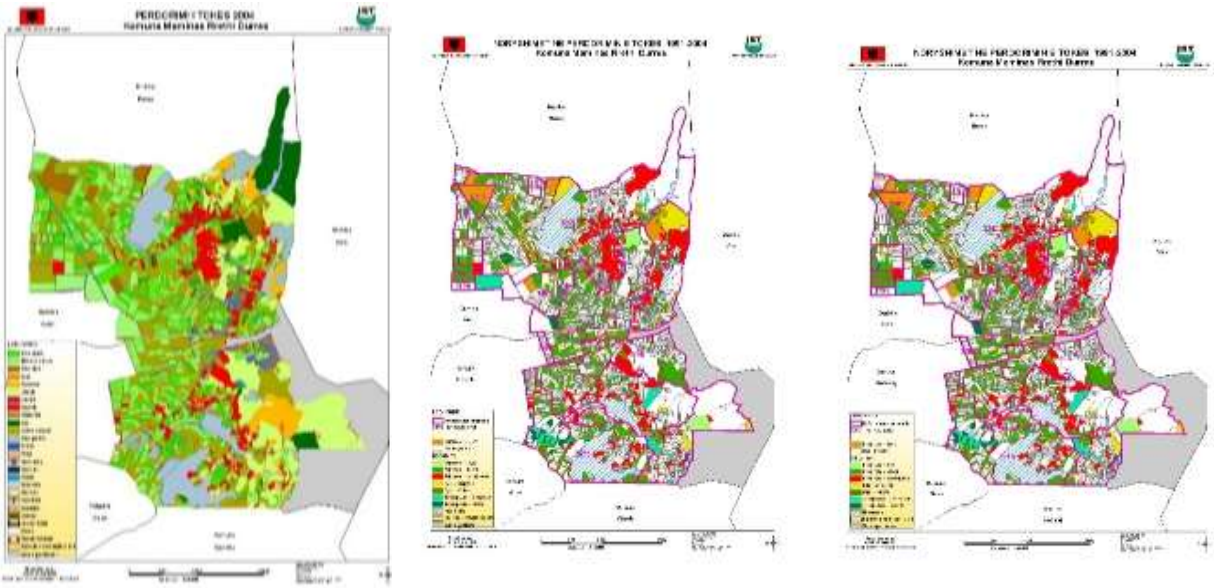

Fig. 2. Change of land use 1991-2004, Maminas
Source: Soil Science Institute [42].

3.4 Land tax

Land tax is a financial instrument that collection from landowners, as outlined in Law 139/2015, as amended. Land tax serves not only as a financial resource but also as an instrument for land protection and management (FAO, 2007). Agricultural lands equipped with ownership documents are subject to taxation. In Albania, land taxation is based on land categories evaluated from class 1 to class 10, where class 1 represents land with the highest production capacity. The tax is calculated in lek per hectare.

The level of land tax is determined and differentiated in four groupings at the territorial level and for each zone in seven levels according to the classes (Law 139/2015) [25] (Fig. 3).

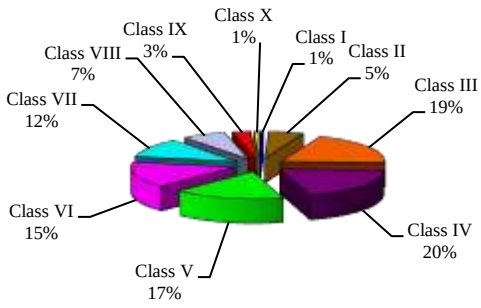

Fig. 3. Distribution of agricultural lands in 10 classes (according to the national classification)
Source: Ministry of Agriculture and Rural Development, 2007 [34].

Land tax collection has not been successful. Local authorities have collected about 30-35% of the annual amount. "In previous centuries, taxes on property formed the most important source of tax revenue for both national and local taxes. More recently, as tax bases have expanded, property taxes have seen a long-term decline in relative importance" (FAO, 2007) [12]. According to the World Bank, "Taxes on land and real property constitute one of the most stable sources of revenues for local government units (Government Land Commission, 2007) [18]. Revenues derived from real property taxes are fully devolved, which should encourage LGUs to make good in the performance of this vital function" (World Bank, 2010) [50]. Although Albanian legislation stipulates that no less than 40% of the annual financial fund created by agricultural land taxes should be used to implement protective measures for agricultural land, this has not yet been implemented by most municipalities in the country. The agricultural land tax should serve as an incentive instrument for bringing land under cultivation. In the assessment of the land tax, improvements need to be made, such as: areas that are grouped together, representing a large area but not reflecting significant land changes within the area, making the value unrealistic. The distribution according to the area and the class categories is more like a social

distribution than based on the characteristics and potential of the land. In each area, there are lands of all categories, but they are simplified to a value, even though there are significant differences. In this context, the division of the zones would be fairer if it were based on grouping lands according to classes in territories with limited surfaces, rather than by geographical boundaries. Additionally, the taxation of the land should be gradually established based on production potential, as is applied in some countries of the region (FAO, 2016) [14].

In the transition period, the irrigation and drainage infrastructure suffered serious damage. The actual irrigation after 1990 is several times lower. In 2023, actual irrigation is 2.2 times lower than in 1990, or 46%.

Table 3. Potential irrigation capacity and irrigated areas (ha)

Potential irrigation capacity in ha	**1960**	**1980**	**1990**	**2000**	**2010**	**2020**	**2023**
Potential irrigation capacity Ha	240,000	435,000	480,000	319,736	331,452	359,542	358,135
Actual potential capacity Ha	135,300	370,800	440,000	203,530	204,544	242,653	242,699
Actually, irrigated area ha	**125,300**	**350,800**	**410,000**	**168,880**	**125,664**	**181,704**	**189,734**

Source: INSTAT, 2023 [23].

The expansion of irrigation with advanced technologies, such as s irrigation in the form of rain, micro-irrigation, and underground systems, is projected to increase to enhance water efficiency and protect the land from drought and climate change (FAO, 2021; World Bank, 2018) [17, 52].

CONCLUSIONS

1.Albania is a mountainous country, with three-quarters of its surface covered by mountains, and it has less than 0.17 ha of agricultural land per inhabitant. Additionally, the country faces several challenges stemming from the privatization of land. The opportunities for expanding agricultural land are limited, making the improvement of the land administration system a key challenge for institutions, landowners, and society. This is essential for the sustainable development of the country, encompassing economic growth, environmental sustainability, and social stability.

2.The municipalities of Albania have developed General Local Plans, in which are included land-related issues into their analysis, strategy, planning, and project development. These plans focus on land protection, irrigation, flood control, drought mitigation, and other vital areas for the country's sustainable development.

3.Albania has made notable progress in establishing a land information system, covering 70% of its agricultural land. This includes the processing and mapping of geospatial data, the creation of a land database, the development of land legislation, and the digitization of registered properties. However, challenges remain in land administration that need to be addressed, including completing the registration process, certifying agricultural land, resolving ownership disputes, managing data effectively, improving land use planning, enhancing land tax collection, upgrading administration technologies, and building management capacities.

4.Land administration, in all its regulatory, legal, technical, social, and implementation aspects, requires the coordination of various stakeholders. This includes central, regional, and local institutions, society, landowners, and the academic and scientific sectors. Their collective efforts are crucial in improving agricultural land administration practices, expanding the use of new administration technologies, and monitoring progress through a coordinated inter-institutional plan at both the regional and national levels.

5.The consolidation of land ownership, which is currently fragmented into an average of 4.4 parcels with an average farm size of 1.26 ha at the national level, remains a significant challenge in land administration. This high

level of fragmentation has led to serious difficulties in implementing agricultural technologies, land loss, decrease production and increase labour costs, reduced production, and other disadvantages. To address these issues, it is crucial to draft a law on land consolidation, as recognized globally, establish consolidation structures at all levels of government, and strengthen land management capacities.

6.After the 1990s, demographic movements saw a shift from rural areas to cities, leading to the abandonment of agricultural land. The rapid transformation of peri-urban agricultural areas into urban zones has heightened the need for decisions regarding uncultivated land, particularly land rejected by owners during the land division reform due to low fertility.

7.Land ownership, especially for agricultural land, is a fundamental issue in any social system. In Albania, it has undergone continuous changes influenced by political shifts, territorial reforms, land reforms (1945-1991), forms of government, the organization of the agricultural sector, the economic model, and the country's overall development. The most recent reform (1991) was developed through broad political consensus but lacked a solid foundation in models that ensure good governance of agricultural land, effective administration, conflict avoidance, and property guarantees. This led to the high fragmentation of agricultural land and a reduction in its effective use. During the land allocation reform, approximately 114 thousand hectares of agricultural land were rejected by owners due to poor agricultural quality, resulting in land degradation and loss of production capacity. While 30 thousand hectares were converted for construction purposes.

Recommendations

The structures and institutions responsible for the governance and administration of agricultural land at the national, regional and local levels should analyze in detail the current state of land administration. This assessment should encourage experts and decision-makers to develop programs and plans for progress in all components of agricultural land administration and unresolved issues from land reform.

REFERENCES

[1]Alexandratos, N., Bruinsma, J., 2012, World agriculture towards 2030/2050: The 2012 revision. FAO.

[2]ALUIZNI, 2015. Property Management Agency (Agjencia e Trajtimit të Pronave.) https://atp.gov.al/vkm-aluizni/ Accessed on February 5, 2025.

[2]ASHK. (2021). State Cadastre Agency Annual Report. Tirana: ASHK.

[3]Burns, T., Dalrymple, K., 2008, Concepts, themes, and emerging directions in land administration for sustainable development. Land Use Policy, 25(2), 195-206.

[4]Council of Ministers' Decision No. 452 dated 17.10.1992. On the restructuring of state-owned agricultural enterprises.

[5]Deininger, K., Feder, G., 2001, Land institutions and land markets. In B. L. Gardner & G. C. Rausser (Eds.), Handbook of Agricultural Economics (Vol. 1, pp. 288-331). Elsevier.

[6]European Commission, 2003, Final Report on the Land Use Policy Project in Albania. Brussels: European Commission.

[7]European Commission, 2021, Study on the Functioning of Land Markets in the EU. Brussels: European Commission.

[8]European Coordination Via Campesina, 2023, UN Declaration on the Rights of Peasants and Other People Working in Rural Areas.

[9]European Commission, 2007, Status and prospect of Soil information in South-eastern Europe: edited by Hengl, T., Panagos, P., Jones, A., Toth, G., pages 11-23, Lushaj Sh, Zdruli P, "Land and Soil resources of Albania: current problems and future trends"

[10]Expert Group on Land Administration and Management, 2019, Framework for Effective Land Administration (FELA). United Nations.

[11]FAO, 2006, World Reference Base for Soil Resources. Food and Agriculture Organization of the United Nations.

[12]FAO, 2007, Good governance in land tenure and administration. Food and Agriculture Organization of the United Nations.

[13]FAO, 2011, The State of the World's Land and Water Resources for Food and Agriculture (SOLAW). Food and Agriculture Organization of the United Nations.

[14]FAO, 2016, Land Use Planning and Development for Sustainable Agriculture. Rome: Food and Agriculture Organization.

[15]FAO, 2016, Land Tenure and Administration.

[16]FAO, 2017, Land Tenure and Rural Development in Albania. Food and Agriculture Organization of the United Nations.

[17]FAO, 2021, Irrigation and Water Management in Agriculture. Rome: Food and Agriculture Organization.
[18]Government Land Commission, 2007, Report on Land Distribution and Legal Issues in Albania. Tirana: Government of Albania.
[19]Hulls, S., et al., 2005, Land Administration Guidelines: With Special Reference to Countries in Transition. United Nations Economic Commission for Europe (UNECE).
[20]INSTAT, 2015, Statistical Yearbook 2015. Institute of Statistics, Albania.
[21]INSTAT, 2022, Agriculture Statistics in Albania 2022. Institute of Statistics of Albania.
[22]INSTAT, 2015, Albania's Territorial and Demographic Changes Report. Tirana: Institute of Statistics.
[23INSTAT, 2023.
[24]Kucaj, E., 2024, The effects of climate change on the agricultural sector in Albania. E3S Web of Conferences 02008 (2024). ICED2024. https://doi.org/10.1051/e3sconf/202458502008
[25]Law 139/2015, 2015, Law on the Taxation of Agricultural Land in Albania. Republic of Albania.
[26]Law No. 10119, dated 23.04.2009. On Territorial Planning.
[27]Law No. 7501, dated 19.07.1991. On Land.
[28]Lushaj, Sh., 2003, Agricultural Land Fragmentation in Albania. Tirana: Agricultural University of Tirana.
[29]Lushaj, Sh., 2018, Challenges of Land Management and Fragmentation in Albania. Tirana: Agricultural University of Tirana.
[30]Lushaj, Sh., Kucaj, E., 2021, Challenges and Opportunities for Land Consolidation in Albania. Tirana: Agricultural University of Tirana.
[31]Ministry of Agriculture, 1988, Agricultural Land and Soil Resource Studies in Albania. Ministry of Agriculture of Albania.
[32]Ministry of Agriculture, 1990, Agricultural Land Classification and Productivity Assessment in Albania. Ministry of Agriculture of Albania.
[33]Ministry of Agriculture and Rural Development of Albania, 2020, Annual Report on Agricultural Land Administration and GIS Implementation in Albania. Tirana: Ministry of Agriculture.
[34]Ministry of Agriculture and Rural Development, 2007. National Classification of Agricultural Lands in Albania. Report of the Ministry of Agriculture and Rural Development. Tirana: Ministry of Agriculture and Rural Development.
[35]Musta, B., 2006, Land Registration and Property Rights in Albania: Challenges and Progress. Tirana: Academy of Sciences of Albania.
[36]Palmer, D., Fricska, S., Wehrmann, B., 2009, Towards Improved Land Governance. Food and Agriculture Organization of the United Nations (FAO).
[37]Parliament of Albania, 2020, Law No. 20/2020 on Final Registration of Agricultural Land. Tirana: Official Gazette.
[38]Republic of Albania, 2001, Law No. 8752, dated 26.03.2001, "On the Establishment and Functioning of Structures for Land Administration and Protection". Official Gazette of Albania.
[39]Republic of Albania, 2014, Law No. 115/2014, "On the Administrative-Territorial Division of Local Government Units in the Republic of Albania". Official Gazette of Albania.
[40]Republic of Albania, 2018, Law No. 111/2018, "On Cadastre". Official Gazette of Albania.
[41]Shutina, D., Dhrami, K., 2014, Urban development in Albania and the effect on agricultural land (Habitat magazine, Sustainable Development &Environmental Issues no.4, 2014, pages 64-87)
[42]Soil Science Institute.
[43]Statistical Yearbook, 1976, Agricultural Land Ownership in Albania.
[44]Statistical Yearbook, 2003, Albanian Statistical Office.
[45]Statistical Yearbook, 1990, Albanian Statistical Office.
[46]Toto, R., Allkja, L., 2019, Land Development in Albania – Challenges and Innovations. In R. Toto (Ed.), Annual Review of Territorial Governance in Albania, 1, 55–68. https://doi.org/10.32034/CP-TGAR-I01-04
[47]United Nations Economic Commission for Europe (UNECE), 1993, Guidelines on the Establishment of a Land Administration System in Eastern and South-Eastern Europe. Geneva: UNECE.
[48]USAID, 2001, Initial Project Management Unit for the Registration of Immovable Properties in Albania. United States Agency for International Development.
[49]Williamson, I. P., Enemark, S., Wallace, J., Rajabifard, A., 2010, Land Administration for Sustainable Development. ESRI Press.
[50]World Bank, 2010, Real Property Taxation for Local Governments. Washington, D.C.: The World Bank.
[51]World Bank, 2017, Land Administration and Management: Unlocking Land Markets for Economic Growth. Washington, D.C.: World Bank.
[52]World Bank, 2018, Water Use Efficiency and Climate Change Adaptation in Agriculture. Washington, D.C.: The World Bank.
[53]Zaharia, A., 2003, Romania's Civil Code and Property Rights.

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BIBLIOMETRIC ANALYSIS OF QUALITY IN EDUCATION: GLOBAL TRENDS AND RESEARCH GAPS

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Abstract

The aim of the bibliometric analysis of quality in education was to provide a clear and quantifiable overview of the evolution, trends and impact of research in this field, helping to identify authors, institutions and works with major influence. By analyzing metrics such as the number of publications, frequency of citations and international collaborations, research can contribute to highlighting centers of excellence and main research directions, as well as outlining emerging themes and gaps in the specialized literature. The integration of the bibliometric analysis in the current study enabled us to objectively evaluate the conceptual and methodological advancements in the field of education quality, making it easier to identify the most useful approaches and underlying theories. This gave us a strong foundation on which to guide future research and for the foundation of educational policies. The obtained results highlighted the main research directions, such as teaching evaluation and the impact of technology, also showing the evolution of interest in these topics. Influential authors and institutions, networks of scholarly collaboration, and seminal articles that formed the basis of the research were identified. It was also possible to identify gaps in the literature, insufficiently explored areas and future research directions, reflecting the impact of educational policies on academic priorities, which provided us with a complex picture necessary for the development of educational strategies and training programs.

Key words: *education, quality, bibliometric analysis, global trends, gaps*

INTRODUCTION

Quality in education is a complex and dynamic concept, often defined and interpreted in various ways depending on the cultural, political and economic context [6]. According to academic research, the quality of education refers to the processes, the environment and the results within the educational system, aiming to ensure an optimal preparation for pupils and students so that they can contribute actively and effectively in society. Quality assurance in education depends on meeting the needs of the beneficiaries, compliance with established standards and continuous adaptation to the demands of modern society [1, 3, 14]. Thus, Cristea S. believes that education involves meeting the expectations of beneficiaries and complying with educational standards [4]. Taraza et al. emphasizes the fact that quality assessment must be based on social and community values [24]. Zorina Ghileț chi supports the need for a unified evaluation system, adapted to the needs of the beneficiaries [25]. Șerban Iosifescu shows that quality education must meet the expectations of "customers" through standards adapted to society's requirements. On an international level, Michael Fullan shows that a quality education involves continuous innovation and adaptation to changes in society and requires the support of the entire community [5, 11]. Harvey and Green distinguish between several forms of quality, such as quality as excellence, fit for purpose, transformation and added value, emphasizing the complexity of the concept in education [8]. J. P. Keeves and R. J. Watanabe show that quality assessment must

be contextualized and adapted to the cultural specificity of each region, highlighting the importance of a global frame of reference [9]. These papers outline the idea that ensuring educational quality depends on adapting to the needs of beneficiaries and integrating flexible and dynamic standards. Among the essential components of quality in education are: accessibility, content relevance, teaching effectiveness, and learning outcomes.

The quality of teaching activity directly influences students' learning outcomes and contributes to improving school performance. In essence, the quality of teaching is defined by the competences and abilities of teachers, by teaching methods and strategies, but also by their ability to create a stimulating and inclusive learning environment [13, 16, 22].

One of the main components of the quality of teaching activity is the professional training of teachers. Studies show that teachers who are well trained, both in their subject area and in pedagogy, have a greater ability to explain concepts clearly, answer students' questions, and motivate them in the learning process. Continuous training and constant updating of knowledge are essential for teachers to adapt to new requirements and educational technologies [2]. The quality of the teaching activity also depends on the teaching methods used. Research shows that interactive and student-centered methods, such as project-based learning, case studies, open and collaborative discussions, are more effective than traditional lecture-based teaching. These methods promote active learning and support the development of critical thinking, creativity and problem-solving skills.

Another important element is the teacher-student relationship, which influences the quality of the learning process. Studies show that teachers who build respectful and supportive relationships with their students create a more open and encouraging learning environment. This positive relationship can increase students' motivation and help them develop self-confidence, which helps improve their school performance.

Assessment is another significant factor in determining the quality of teaching. Formative assessments, which provide feedback throughout the learning process, are more effective in supporting student progress than summative assessments. They enable teachers to quickly identify areas where students are struggling and adapt teaching materials and methods to meet individual needs.

Technology is also playing an increasingly important role in teaching. Utilizing contemporary educational technologies, such tablets, interactive apps, and e-learning platforms, can improve students' educational experiences and assist teachers in modifying their instruction to accommodate different learning preferences. Research indicates that integrating technology into the classroom improves learning by making a variety of resources and current knowledge more accessible [2, 21].

Classroom atmosphere and climate also contribute to the quality of teaching. A safe learning environment that promotes collaboration and encourages the expression of ideas helps students to be more engaged and learn more effectively. A positive climate also reduces learning anxiety and fosters openness to new knowledge and skills.

Therefore, the quality of teaching depends on a number of factors that interact with each other, from teacher training and teaching methods to the use of technology and the creation of a positive learning environment. The quality of teaching not only influences academic results, but plays an essential role in the formation of individuals who are motivated, capable and ready to adapt to the demands of a constantly changing society [21]. In this context, the use of bibliometric analysis of quality in education has the role of providing an in-depth understanding of the evolution, trends and main research directions in this field, by quantifying and analyzing data related to scientific publications.

MATERIALS AND METHODS

By using bibliometric analysis as our research approach, we were able to identify authors, institutions, and nations that made major contributions to the issue of quality in education and gather useful information about how this concept has changed over time.

Temporal trends, such as the frequency of publications published on the subject of educational quality, can be highlighted using bibliometric analysis, which identifies the times when this subject attracted more attention.

This reflected contextual changes such as educational reforms or international initiatives that influenced research and implementation of quality in education.

Another essential role is to identify the main areas and sub-areas of research related to the quality of education. Bibliometric analysis allows highlighting emerging themes and understanding topics that dominate current research, such as teacher quality assessment, curriculum effectiveness or the impact of educational technologies on teaching quality.

Through the bibliometric analysis, the collaboration network between authors and institutions can be identified, highlighting the centers of excellence in educational research. These allow the understanding of international collaboration dynamics and the recognition of higher education and research institutions that have a major impact in this field.

The study offers comprehensive data on the influence and citations of publications, highlighting the most significant works and writers in the area of educational quality. This makes it possible to emphasize basic theories and methods and to describe the theoretical and conceptual underpinnings upon which further study is based.

Another role of the bibliometric analysis is the evaluation of existing gaps in the literature, i.e. of insufficiently studied aspects. This information directs future research towards less addressed but essential topics for a complete and practical understanding of quality in education.

Additionally, bibliometric analysis makes it easier to create a cognitive map of the area, providing a nuanced understanding of the structure, connections, and development of the topic of educational quality. This approach allows highlighting not only the evolution, but also the connections and influences between the various theories, concepts and methodologies in the field.

The consulted databases were WOS and Scopus. The consultation took place between November 8-11, 2024, the keywords used being: "educational technology", "educational innovation", "quality in education" and "global trends". The search was made starting from the term "educational technology" resulting in a number of 118,967 articles. Next, the refinement was carried out according to the second keyword, resulting in a number of 10,559 articles. The third key word, "quality in education," was later searched for, yielding 1,501 articles that were evaluated using Voswiever software, which enabled us to both generate and analyze conceptual maps. After applying the fourth refinement, the term "global trend" is used, a number of 28 articles resulted that were analyzed with the aim of identifying the purpose, objectives and results obtained, as well as research gaps.

RESULTS AND DISCUSSIONS

The bibliometric analysis followed several aspects related to scientific research. Thus, the relationship between co-occurrence and keywords highlights a complex research that explores the relationship between education, technology, as well as the impact on human development. Areas of interest include innovation in education, technological methods used in instruction, and the link between education and public health. The 3 interconnected clusters show that the themes of education, innovation, methodology and social impact are addressed together to explore the benefits and challenges of integrating technology into modern education.

The blue cluster, focused on methodology and technology, underlines the growing importance of technology in education, this trend demonstrating that research in the field supports the development of computer-assisted teaching methods and digitized curriculum, facilitating a more accessible education adapted to modern needs . The link between the green and red clusters shows that education has a significant impact on human development, with research demonstrating that investment in education contributes to the overall well-being of communities and

improves quality of life. The red cluster highlights the role of innovative education and higher education in the formation of new generations, this because research on educational innovation is essential for adapting learning processes to contemporary challenges, including rapid technological changes.

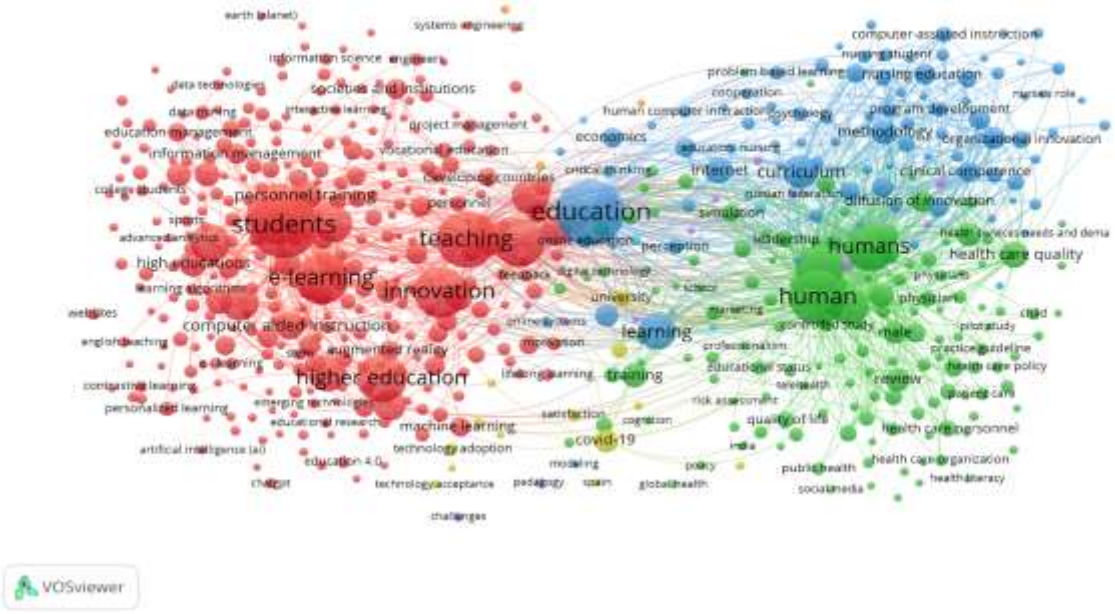

Fig. 1. The relationship between co-occurrence and keywords
Source: own processing Voswiever [25].

The interconnection between education, technology and health demonstrates that modern education can contribute to balancing social and economic differences.

Thus, research in this field supports educational policies that not only modernize education systems, but also contribute to a sustainable development of society.

Figure 2 shows the collaborative relationship between co-authors from various countries, highlighting international research networks. The analysis shows that the United States emerges as the main connecting node, having strong ties with multiple countries, which indicates its central role in the global scientific collaboration network.

Distinct regional clusters also appear, such as Russia and European countries, China and Asian countries, which demonstrate strong collaborations within geographic regions, and less inter-regional collaborations.

African and South American countries are relatively under-represented, due to unequal access to international collaborations, which limits scientific progress in the respective regions.

The relationship between co-citations and keywords is organized into several clusters that reflect the main areas of research interest. The minimum number of citations was 10. The blue and green cluster focuses on topics related to education, digital learning, curricula, and educational technology.

This cluster confirms an approach to new educational methods and their impact on students, with an emphasis on the integration of technology in education. The red cluster includes terms such as "humans", "health care delivery", "nursing education" and "health quality" because there is a field of study that focuses on health education and how it affects the caliber of medical services. This is because more people are using technology in the classroom, which has sparked interest in incorporating digital into the learning process.

As a result, subfields like e-learning and education have emerged. 4.0. The creation of strong research networks between subfields

such as e-learning, educational technology and health education shows research synergy and a multidisciplinary approach. There is a continuing need for interdisciplinary collaboration to improve learning and vocational training methods that can have a significant impact in various social fields.

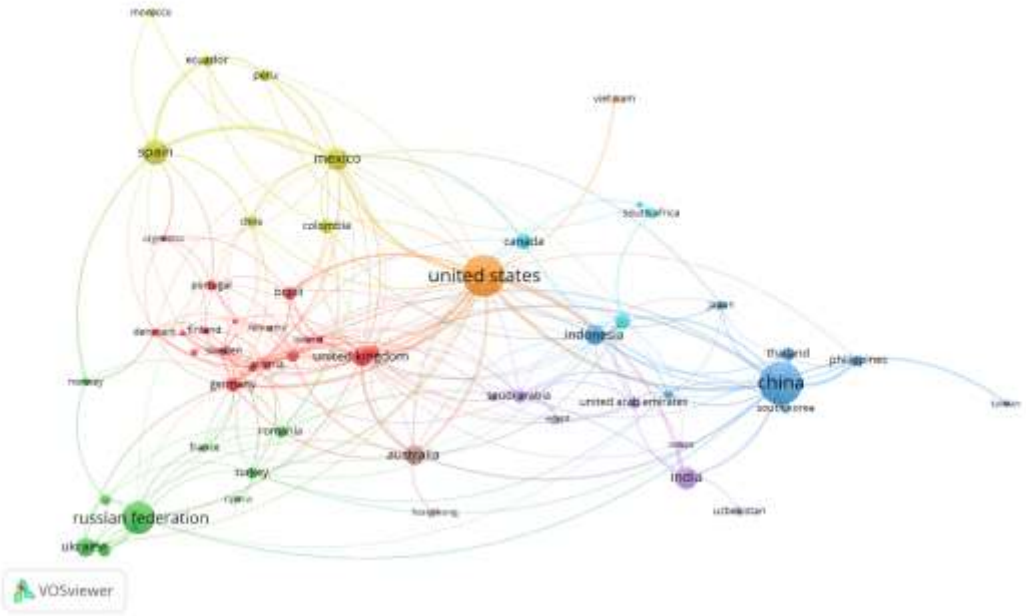

Fig. 2. The relationship between co-authors and countries
Source: own processing Voswiever [25].

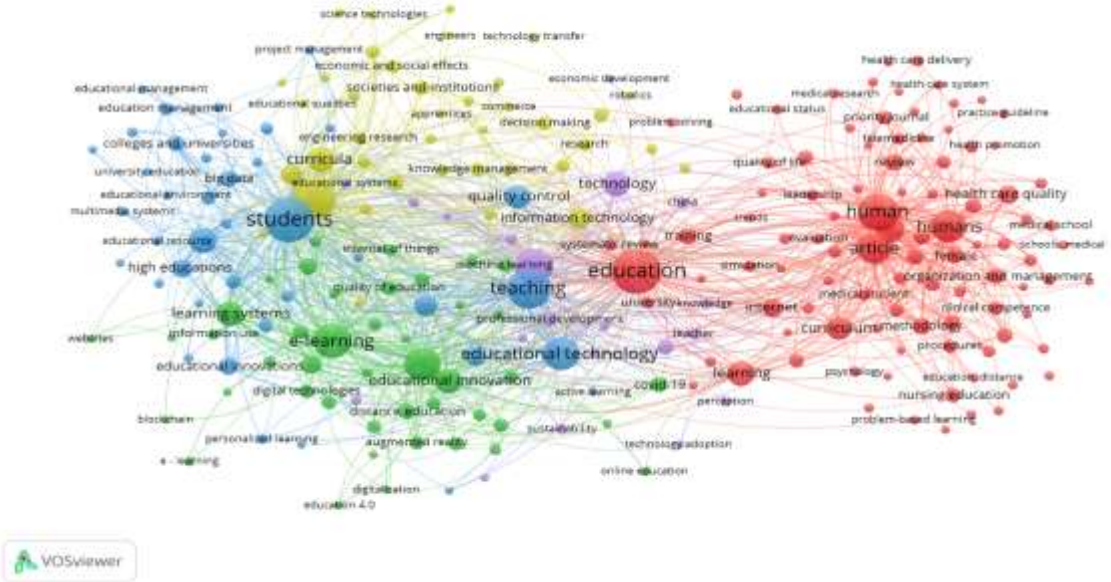

Fig. 3. The relationship between co-citations and all keywords
Source: own processing Voswiever [25].

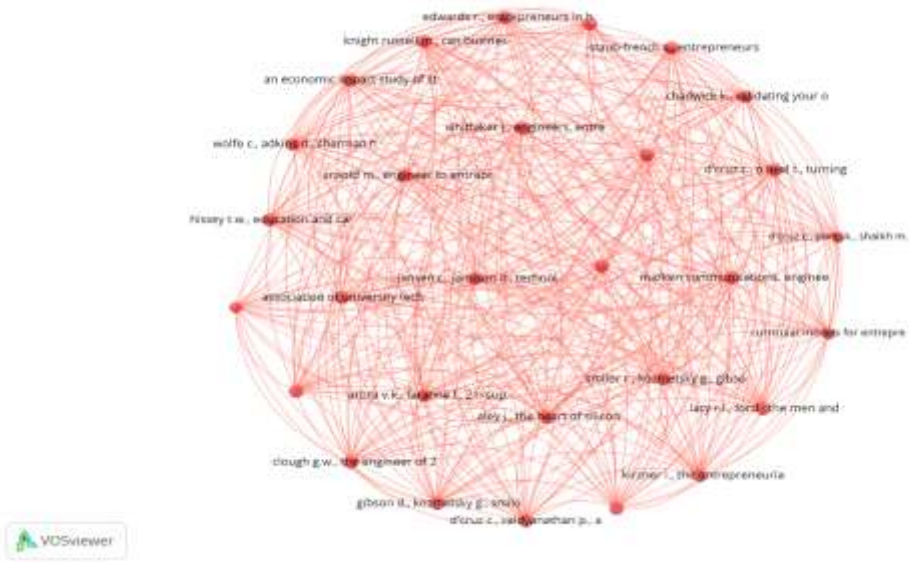

Fig. 4. The relationship between co-citations and cited references
Source: own processing Voswiever [25].

Figure 4 shows the relationship between co-citations and cited references, showing the interconnection between different papers through shared citations, illustrating a complex network of sources and authors contributing to a common research topic. The complexity and density of the network indicate a multidisciplinary approach or an interdependence of research themes. References are used repeatedly to support different aspects of the studies, thus showing that there is a common theoretical basis around which these works are built. The structure highlights the essential role of co-citation in forming a common knowledge base and in facilitating collaboration and integration of ideas between different research papers.

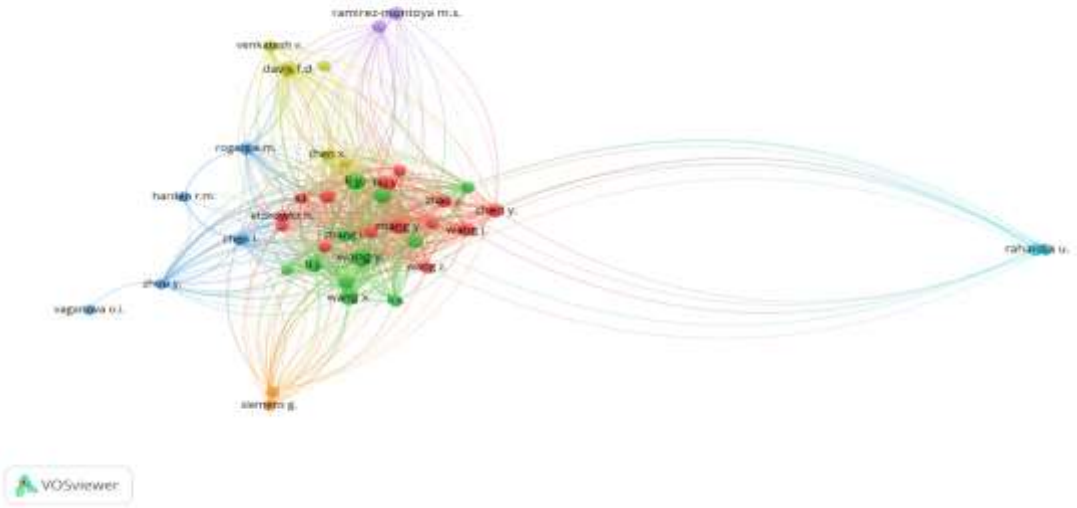

Fig. 5. Relationship between co-citations and authors
Source: own processing Voswiever [25].

The relationship between co-citations and authors, highlights close links between certain groups of researchers. The condition that was set when analyzing these relationships was the

minimum number of 30 citations/author. Center nodes, densely connected, represent authors frequently cited together, indicating common influence on the field. These core groups indicate the existence of specific research subfields or themes that have been developed through collaboration or common references. There are certain authors such as Siemens G., who is known for his contributions in the field of connectivist learning and educational technologies, Rogers E.M. who supports the theory of diffusion of innovation, with a direct influence in the adoption of new technologies, Venkatesh V. who analyzes the acceptance and use of technologies, including the UTAUT model or Davis F.D. known for the Technology Acceptance Model (TAM), frequently used in technology adoption studies. Certain authors, such as Rahimipoor U., are connected to the rest, but more peripherally, indicating a relatively independent specialization or influence, possibly with distinct contributions from the central group.

Next, we analyzed the first 11 of the 28 articles identified in the bibliometric analysis, starting from the addition of the last keyword "global trend" and taking into account the year of publication. Thus, the articles published in the period 2019-2024 were analyzed, taking into account the major changes in education that occurred after the outbreak of the Covid-19 pandemic and the progress recorded in this field.

Table 1. Findings from educational research, educational quality, and worldwide trends

Author(s)	Title	Year of publication	Category Scopus	Main findings
Lopes, G. C. D., de Farias, W. S., Lopes, P. C. P., da Silva, R. T., Catapan, A	The importance of cross-border education in contexts of collaboration between countries according to the SDGS	2024	Journal of Lifestyle and SDG'S Review	To build an inclusive and sustainable global society, in accordance with the Sustainable Development Goals, effective policies and international collaboration are needed, but also investments in new technologies are essential to expand access and improve quality in cross-border education [10]
Muskhir, M., Luthfi, A., Watrianthos, R., Usmeldi, U., Fortuna, A., Samala, A. D.	Emerging Research on Virtual Reality Applications in Vocational Education: A Bibliometric Analysis	2024	Journal of Information Technology Education: Innovations in Practice	VR brings a significant transformation in vocational education, especially in training for technical skills. The study recommends that VR program designers align relevant technologies with trends in the literature to improve the quality of learning. For society, the increased interest and investment in VR in vocational education underlines the potential of this tool for global training. The study highlights the need for future research focused on the integration of VR into vocational curricula to address current gaps and support the development of interventions tailored to students' specific needs [17]
Zorrilla Noriega, A. M., Sánchez Arias, M.,	Challenges for skills creation in legal education: an analysis of the Mexican context in line with global trends	2023	Higher Education, Skills and Work-Based Learning	The study aims to improve the training of law students, preparing them with the necessary skills to face the current challenges of the profession, connecting the learning process with the skills required in the labor market. The methodology includes two main components: an analysis of the norms governing the educational system and professional practice in Mexico, together with an extensive literature review on global trends in legal education [26].
Melnychenko, S., Vedmid, N., Okhrimenko, A., Romanchuk, L. D.	Transformations of educational technologies	2021	IEEE International Conference on Modern Electrical and Energy Systems	The purpose of the article is to justify the directions for the formation of an innovative educational space according to the "Education 5.0" model, in order to guarantee the caliber of the curriculum, particularly for the instruction of electrical and energy system specialists. The results of the study include the generalization of

				major challenges and directions for their implementation in the educational process; presentation of a quality assurance system model in a higher education institution, based on nine essential components; and substantiating the main directions of strategic changes in the design and implementation of educational programs, particularly for the education of experts in the fields of energy and electricity. The suggested strategy seeks to make educational programs more competitive as a foundational element for professional training in line with societal norms and demands [15].
Shukshina, L. V., Gegel, L. A., Erofeeva, M. A., Levina, I. D., Chugaeva, U. Y., Nikitin, O. D.	STEM and STEAM education in Russian Education: Conceptual framework	2021	Eurasia Journal of Mathematic, Science and Technology Education	The quality of professional training in the digital domain may be enhanced by the real-world application of STEM and STEAM technologies. Digital literacy, computational thinking, creativity, and interpersonal skills are among the fundamental competences in STEM and STEAM professions. Through the development of abilities in exact sciences, linguistics, engineering, art, and other disciplines, STEAM education in Russian higher education seeks to change the way that scientific knowledge is perceived and create a process of innovative development [23].
Guàrdia, L., Clougher, D., Anderson, T., Maina, M.	IDEAS for transforming higher education: an overview of ongoing trends and challenges	2021	International Review of Research in Open and Distributed Learning	Using a three-stage exploratory methodology, the study investigates organizational, educational, and technical trends and problems. A literature review in the first phase found 14 noteworthy trends, which were then discussed with higher education experts. The second stage inventoried 108 initiatives representing these trends, of which 30 were selected for detailed analysis in the third stage. Through the thematic analysis of the 30 cases, 12 innovative themes were identified that contributed to the development of the IDEAS framework, a guide for next-generation pedagogy in the transformation of higher education. The IDEAS framework is detailed in the discussion, with examples and methods of application in the context of higher education [7].
Makhynia, N., Kichuk, Y., Ptashchenko, O., Kyrylenko, K., Horchynska, K., Riznyk, V.	Innovations in the educational process and pedagogical technologies under the influence of crisis phenomena and global digitalization	2021	Estudios de Economia Aplicada	Innovations in the educational process are essential because the future well-being of a country depends on the education level of the youth. Pedagogical technologies are improved to provide modern and quality education. In this study, the authors analyzed innovations in education, the impact of the crisis and global digitalization, as well as international trends, finding that the processes of knowledge acquisition and transfer are increasingly organized in networks and proposed an algorithm for the formation of a pedagogical cluster. The authors created a sophisticated system of indicators to determine this cluster's efficiency. The study's recommendations will assist academic institutions in comprehending the clustering process, appreciating its significance, and defining

				their part in this change in the educational process [11].
Ovsienko, L. V., Zimina, I. V.	Model of university's career guidance activities within the context of lifelong learning,	2020	Higher Education in Russia	The authors believe that a reevaluation of the function of universities is necessary, beginning with the reality that the population's formal educational potential in Russia is not being properly utilized, which become engines of economic growth and regional centers of innovation. In addition to education and science, universities assume a third social mission, influencing regional processes through their intellectual potential. The authors believe that the unique mission of higher education is the continuous development of each child and the creation of conditions for self-development, career paths and supporting talents, ensuring continuity and identifying individual potential [18]
Romanenko, E. S., Khokhlova, E. V., Ivashova, V. A., Mironova, E. A., Chvalun, R. V.	Fermentation specialist competency profile: current trends	2020	IOP Conference Series: Earth and Environmental Science	The study presents the results of a survey conducted in southern Russia among fermentation specialists, who provided opinions on the competencies required in an educational program to ensure the competitiveness of graduates in this field. According to the survey, the less trained skills are: the use of information technologies to solve technological problems; applying the principles of the quality management system and the legal and organizational bases in the managerial and entrepreneurial activity; and the ability to search, store, process and analyze information from various sources, presenting it in the required format with the help of computer and network technologies [20].
Makarigakis, A. K., Jimenez-Cisneros, B. E.	UNESCO's contribution to face global water challenges	2019	Water	Education is fundamental to addressing the challenges of water security and resource management in light of climate change and population expansion. Through the International Hydrological Program (IHP), UNESCO plays a crucial role in enhancing knowledge by promoting education and capacity building , innovation and the science-policy interface. This reflects an integrated educational approach that not only trains future hydrologists, but also sensitizes decision makers and the general public, promoting a deeper understanding of the importance of sustainable water management [12].
Qamar, S. Z., Pervez, T., Al-Kindi, M.	Engineering education: Challenges, opportunities, and future trends	2019	Proceedings of the 16th IEOM Global Engineering Education: First GCC International Conference on Industrial Engineering and Operations Management	This article, based on the authors' experience as professional engineers and academics, examines the challenges, opportunities, and future trends in engineering education. The main challenges relate to the curriculum, teaching methods and educational environment. A balance is required between overall excellence and specific areas of performance. In pedagogy, the focus should be on improving problem-solving skills, continuous learning and developing social skills (leadership, teamwork, communication, understanding of economics, business, management and entrepreneurship). Support must be

				provided through qualified technical staff and well-equipped facilities. Emerging trends include hands-on labs, industry-oriented curriculum, enhancing the active learning environment, and using interactive technologies such as adaptive software, e-learning, and distance learning [19].

Source: Own processing.

Although many of these studies focus on recent trends and innovations, such as STEM/STEAM education, interactive technologies, and hands-on methods, there is a lack of long-term evaluation of the impact of these innovations on graduate performance and adaptability. Therefore, we believe that longitudinal studies are needed to assess the lasting effects on skills and careers.

Although modern teaching methods such as hands-on laboratories and industry-oriented curriculum are discussed, few studies critically address the quality of their implementation. We therefore consider it necessary to put more emphasis on how differences in infrastructure, teacher training and resources affect the effectiveness of these methods.

Also, many educational trends emphasize the importance of social and cognitive skills (problem-solving skills, critical thinking, communication), but clearer and more objective methodologies are needed for their assessment. Future research could develop specific instruments to effectively measure these competencies.

At the same time, the use of modern technologies in education, although promising, can accentuate inequalities between students with limited access to technology and those who benefit from advanced resources. We believe that future research should look at how technological solutions can be implemented to support equity in education and reduce disparities.

On the other hand, given the rapid pace of technological and labor market changes, constant research into how education can become flexible enough to continuously adapt to new demands is essential. Thus, studies are needed on educational strategies that allow the rapid adaptation of curricula and teaching methods to new global challenges.

Exploring these aspects can contribute to a better understanding of how quality education can be ensured and improved in the long term to meet the complex and dynamic needs of contemporary society.

CONCLUSIONS

The consolidation of knowledge in this area is greatly aided by bibliometric analysis of educational quality, which offers distinct and well-supported viewpoints for upcoming studies, educational initiatives, and governmental regulations.

By highlighting the crucial role of well-known writers who have made substantial contributions to our understanding of and integration of technology and innovation in educational processes, the analysis highlights the significance of quality in education. Their contributions, which are frequently co-cited and recognized as fundamental, support the development of models and theories that promote effective educational practices and the acceptance of technology in learning. The interdisciplinary collaboration and the diverse contribution of the authors in the network reflect a common concern for improving the quality of education, showing that a quality education requires the integration of validated theoretical approaches adapted to modern technological and pedagogical needs.

The study also highlights the central role of influential authors such as Siemens, Rogers, Venkatesh and Davis, whose seminal works are heavily co-cited and form the theoretical core of the field, while interdisciplinary collaborations and contributions by peripheral authors extend and diversifies understanding by emphasizing the importance of both central influences and niche contributions in the development of knowledge.

Global trends in education emphasize the importance of developing practical, technological and social skills that support both economic growth and social sustainability

and environmental protection. Education is no longer just a process of transmitting knowledge, but becomes an integrated platform that promotes critical thinking, international collaboration and the application of technology in the formation of innovative solutions to global challenges. This orientation towards skills-based education reflects an increasingly pressing need to prepare individuals capable of continuous learning, adaptability and active engagement in sustainable development, preparing them for an interconnected and rapidly changing world.

REFERENCES

[1]Alecu, I. N., Marcuta, L., Marcuta, A., Angelescu, C., 2011, The role of an E-learning platform in the sustainable development of the online learning at the University of Agricultural Sciences and Veterinary Medicine, Distance Learning Department, Bucharest, Scientific Papers Series–Management, Economic Engineering in Agriculture and Rural Development, 11(2), 5-8.

[2]Anghel, R. E., Marcuta, A., Tindeche, C., Rosu, M., Traistaru, C., Marcuta, L., 2022, Study on the perception of students of the faculty of management and rural development regarding the teaching-learning-assessment activity carried out online during the COVID-19 period, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Vol. 22(4).

[3]Centino Jr, L. S., Panulin, E., 2023, Beneficiaries' Perception on the Education Extension Programs of De La Salle University-Dasmariñas.Academia Lasalliana Journal of Education and Humanities 5(1):17-29

[4]Cristea, S., 2008, Calitatea în educaţie/educaţia de calitate (Quality in education/ education of quality), Revista Didactica Pro, revistă de teorie şi practică educaţională, 51(4-5), 107-112.

[5]Fullan, M., 2015, The new meaning of educational change, Teachers College Press.

[6]Ghileţchi, Z., 2017, Calitatea în educaţie: definire şi abordare conceptuală (Quality in Education: definition and conceptual approach), Univers Pedagogic, 55(3), 19-22.

[7]Guàrdia, L., Clougher, D., Anderson, T., Maina, M., 2021, IDEAS for transforming higher education: an overview of ongoing trends and challenges, International Review of Research in Open and Distributed Learning, 22(2), 166-184.

[8]Harvey, L., Green, D., 1993, Defining quality. Assessment & evaluation in higher education, 18(1), 9-34.

[9]Keeves, R. Watanabe, (Eds.), 2003, International handbook of educational research in the AsiaPacific region, pp. 1095–1106. Dordrecht: Kluwer Academic Publishers.

[10]Lopes, G. C. D., de Farias, W. S., Lopes, P. C. P., da Silva, R. T., Catapan, A., 2024, The Importance of Cross-Border Education in Contexts of Collaboration Between Countries According to the SDGS. Journal of Lifestyle and SDGs Review, 4(2), e02054-e02054.

[11]Makhynia, N., Kichuk, Y., Ptashchenko, O., Kyrylenko, K., Horchynska, K., Riznyk, V., 2021, Innovations in the educational process and pedagogical technologies under the influence of crisis phenomena and global digitalization, Estudios de Economia Aplicada, vol. 39, pp. 1-10.

[12]Makarigakis, A. K., Jimenez-Cisneros, B. E., 2019, UNESCO's contribution to face global water challenges, Water, 11(2), 388.

[13]Malika, G. D., 2024, Understanding the Significance of An Inclusive Education System: Strategies for Developing Qualitative Education. Multidisciplinary Subjects, 82.

[14]McCambly, H., Mulroy, Q., 2024, Constructing an educational "quality" crisis: (E) quality politics and racialization beyond target beneficiaries, Educational Evaluation and Policy Analysis, 46(2), 192-221.

[15]Melnychenko, S., Vedmid, N., Okhrimenko, A., Romanchuk, L. D., 2021, Transformations of educational technologies. IEEE International Conference on Modern Electrical and Energy Systems (MEES), pp. 1-4.

[16]Mohzana, M., Arifin, M., Pranawukir, I., Mahardhani, A. J., Hariyadi, A., 2024, Quality Assurance System in Improving the Quality of Education in Schools. Mudir: Jurnal Manajemen Pendidikan, 6(1).

[17]Muskhir, M., Luthfi, A., Watrianthos, R., Usmeldi, U., Fortuna, A., Samala, A. D., 2024, Emerging Research on Virtual Reality Applications in Vocational Education: A Bibliometric Analysis. Journal of Information Technology Education: Innovations in Practice, 23, 005.

[18]Ovsienko, L. V., Zimina, I. V., 2020, Model of university's career guidance activities within the context of lifelong learning, Higher Education in Russia, 29(12), 134-143.

[19]Qamar, S. Z., Pervez, T., Al-Kindi, M., 2019, Engineering education: Challenges, opportunities, and future trends, Proceedings of the 16th IEOM Global Engineering Education: First GCC International Conference on Industrial Engineering and Operations Management (IEOM-2019), Riyadh, Saudi Arabia (pp. 26-28).

[20]Romanenko, E. S., Khokhlova, E. V., Ivashova, V. A., Mironova, E. A., Chvalun, R. V., 2020, Fermentation specialist competency profile: current trends. IOP Conference Series: Earth and Environmental Science, Vol. 422(1), p. 012092). IOP Publishing.

[21]Rosu, M., Marcuta, A., Tindeche, C., Anghel, R. E., Traistaru, C., Marcuta, L., 2022, Study on the perception of students of the faculty of management and rural development regarding the role of digitalization in the training of competences necessary for the integration of graduates in the labor market, Scientific Papers Series

Management, Economic Engineering in Agriculture and Rural Development Vol. 22(4).
[22]Sok, S., Heng, K., 2024, Research on teacher education and implications for improving the quality of teacher education in Cambodia, International Journal of Professional Development, Learners and Learning, 6(1), 1-9.
[23]Shukshina, L. V., Gegel, L. A., Erofeeva, M. A., Levina, I. D., Chugaeva, U. Y., Nikitin, O. D., 2021, STEM and STEAM education in Russian Education: Conceptual framework. Eurasia Journal of Mathematics, Science and Technology Education, 17(10).
[24]Taraza, E., Anastasiadou, S., Papademetriou, C., Masouras, A., 2024, Evaluation of Quality and Equality in Education Using the European Foundation for Quality Management Excellence Model—A Literature Review, Sustainability, 16(3), 960.
[25]Vosviewer visualizing scientific landscapes, https://www.vosviewer.com/, Accessed on March 5, 2025.
[26]Zorrilla Noriega, A. M., Sánchez Arias, M., 2023, Challenges for skills creation in legal education: an analysis of the Mexican context in line with global trends. Higher Education, Skills and Work-Based Learning, 13(6), 1305-1317.

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ADAPTATION OF PASTURE COMPOSITION TO CLIMATE CHANGE CONDITIONS – A FACTOR FOR INCREASING ANIMAL FODDER QUALITY AND IMPLIEDLY MILK PRODUCTION

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Abstract

Natural grasslands with spontaneous vegetation have been gradually replaced by new categories, where human intervention is considerable. Research has shown that their valorization is done through the application of modern technologies. Feed production and its cost are influenced and limited by climatic challenges, multiplying through the mirror effect, in human food. The aim of the work is to demonstrate, with the help of statistical indicators, the influence of temperatures and precipitation on feed and milk production. According to the calculations made, it emerged that extreme temperatures negatively influence the amount of feed obtained, with rapid evaporation taking place. The lack of precipitation increases the risk of severe drought, having a domino effect. This phenomenon leads to a reduction in the water level in rivers, the groundwater area, slows down crop growth, leads to increased pest attacks and favors the occurrence of fires. Adaptation to climate change is essential for mitigating potential damage and identifying opportunities for farmers to respond.

Key words**:** *climate change, pasture, fodder, temperature, precipitation*

INTRODUCTION

As agriculture developed, natural (primary) grasslands with spontaneous vegetation were replaced by new categories: permanent or secondary grasslands, temporary grasslands and intensive forage crops where human intervention is considerable. In most cases, grassland vegetation is made up of perennial plants, associated in complex groups that give them specific features, both in terms of the relationship between species and related to the environment (water regime and soil nutrients, temperature, grazing/mowing frequency).

However, the land area destined for animal feed is limited and even declining in Romania [8] and this a reason as farmers to look for alternatives on forage resources under the actual climate conditions [1].

Grassland plants belong to different botanical families with a wide spectrum of economic value. For example, there are valuable forage species with a good chemical composition and high yields, but also many less valuable species, consumed very little by animals because they can be toxic or harmful.

It follows that it is necessary to direct the process of vegetation formation on grasslands, in order to obtain plants with the best biological and economic characteristics.

Climate change has brought intense heat waves and heavy rainfall. Changing weather patterns require an adaptation of all livestock systems including the adaptation of pastures regarding the quality and quantity of fodder. Their effects vary depending on the region and the production systems [2].

Due to rising temperatures, the season may be extended, contributing to the growth of pastures especially in areas dependent on rainfall, and their instability may annihilate the benefits of a longer season [4].

Globally, climate change threatens the sustainability of ecosystem functioning. Generally, pastures in warmer areas are affected and can have a crucial impact on the production and nutritional traits (protein content, essential fatty acids, amino acids) of forage, but also from an economic point of view [6].

The adaptation of pastures to climatic conditions depends on the management of the

implementation of agricultural practices of grazing, which allows farmers to adapt to new challenges by including forage species that are favorable to climate change and can maintain their quality. Some studies have shown that the response of plants affects the quality and ruminal fermentation of forages, that is, the process by which plants are broken down in the rumen of animals to make them digestible [3].

A quantification of climate change on the livestock sector indicates that the impact is evident in the supply chain (production-consumption) with severe consequences in regions with warmer climates and socially and economically vulnerable [5].

According to the Report "Impact of Climate Change and Adaptation in the European Agricultural Sector", published in November 2024 by the European Environment Agency, a negative impact on agriculture is expected in many areas of Europe, especially in the south. According to the press release issued by the Copernicus Climate Change Service (C3S), 2024 became the first year in which an annual temperature anomaly exceeding the threshold of 1.5 degrees Celsius above pre-industrial levels was recorded [10]. However, the environmental and climatic conditions in our country are still favorable for obtaining high yields of fodder crops [9].

The factors that determine their success are climatic, edaphic and the assortment of plants that make up the meadows. Meadows are successive forage crops and require a sum of temperature degrees of 1,200-2,000^{O}C during the vegetation period. This amount, from harvest to the first frost, determines the choice of varieties and hybrids. High temperatures negatively influence the amount of fodder obtained, due to the high evapo-transpiration of plants and pedological drought. The orientation towards obtaining quantitative and qualitative fodder, with constant production over time, is essential to maintain the price of finished products at an optimal level, without increases that would negatively affect the possibility of purchasing and consumption [11].

In extreme temperatures, rapid evaporation occurs, and if there is no precipitation, the risk of severe drought increases. Climate uncertainties make it difficult to predict the impacts of climate change, making the adaptation of livestock systems more complex [7].

The purpose of the paper is to study the influence of temperatures and precipitation on feed and milk production using regression equations, correlations and coefficient of determination.

MATERIALS AND METHODS

In this paper, the Pearson correlation coefficient was used to analyze the correlation between average annual temperatures and perennial forage production.

The second correlation analyzed was that between average annual precipitation and perennial forage production.

Based on statistical data from the INS, the correlations between average temperatures and average milk production, respectively between precipitation and average milk production, were analyzed during the period 2014-2023, at the national level.

The correlation and linear regression were calculated using the functions available in Excel.

RESULTS AND DISCUSSIONS

Analyzing the correlation between annual temperatures and perennial fodder production, we observe that up to a certain thermal threshold, this is favorable for the growth of fodder plants.

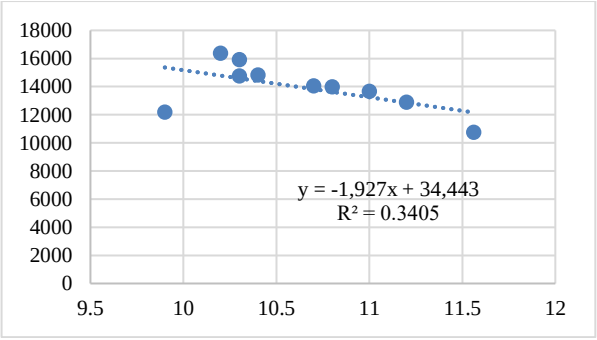

Fig. 1. Correlation between temperature and average perennial forage production, 2014-2023

Source: authors' calculations authors' calculations based on data from the National Institute of Statistics of Romania (NIS)

The increase in temperature above this threshold leads to a decrease in production yield.

The correlation coefficient of 0.58 indicates a good association between the two variables, and the coefficient of determination R^2 shows that 34.05% of the production value can be explained by the linear relationship with the recorded temperatures (Figure 1).

The correlation coefficient is positive and has a small value r = 0.583 indicating a moderate connection between the temperatures and forage production in the analyzed period. The coefficient of determination R^2 shows 34% of the variation in forage production is determined by the changes in the temperature regime.

Under these conditions, farmers can consider preventive measures and adaptation to the new conditions by irrigating fodder crops (Figure 1).

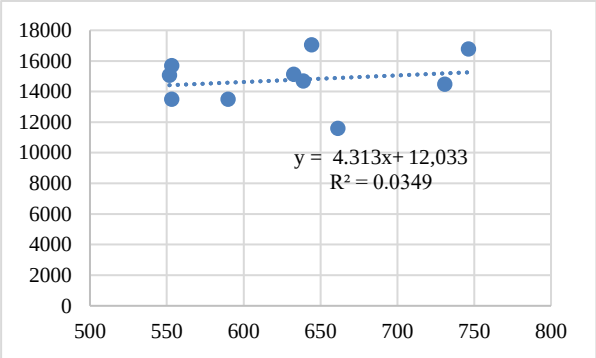

Fig. 2. Correlation between precipitations and average perennial forage production, 2014-2023

Source: authors' calculations based on data from the National Institute of Statistics of Romania (NIS)

Water also falls into the category of climatic factors. The minimum amount of precipitation required in a year is 125 mm annually.

The distribution over time intervals determines the minimum degree of soil moisture necessary for plant germination. Analyzing the correlation between annual precipitation and perennial forage production, we observe that up to a certain threshold they are favorable for the development of forage plants. An increase in precipitation above this threshold leads to a decrease in production yield.

The correlation coefficient of + 0.25 indicates an acceptable association between the two variables, and the coefficient of determination R^2 shows that 3.49% of the production value can be explained by the linear relationship with recorded precipitation (Figure 2).

The edaphic factors are the soil with its physical, chemical and biological properties. Good production is obtained on fertile, well-structured soils with a high capacity to retain water from precipitation.

Regarding the assortment of plants, successive crops are established according to the vegetation period and the requirements of the climate and soil. The first crop must leave the field as early as possible, and the second must be as drought-resistant as possible.

Since 2017, Nicolae Dragomir has been drawing attention to the fact that many of the organoleptic characteristics of animal products are directly influenced by the characteristics and quality of the feed consumed. A product of animal origin intensely influenced by the characteristics of the feed is milk, appreciated by consumers for its color, aroma, texture and flavor. The aroma, for example, is due to volatile substances present in the composition of dicotyledonous plants from the floristic structure of natural meadows (dandelion, yarrow, pennyroyal, wild carrot, plantain, mint). The flavor of this product is given by the sugar content, and the texture by the fat content. In other words, the diversity and abundance of meadows is felt in milk [2].

In practice, there are clear differences between milk from animals raised on natural grasslands and sown grasslands.

Milk from animals grazing on grasslands consisting only of grasses (sedge, ryegrass, fescue, etc.) is less fragrant, not having a specific aroma. This is due to the hexane present in these plants, which causes the oxidation of the milk.

Milk from animals grazing on grasslands with a high proportion of toxic floristic species has a “repulsive” aroma due to “plastic”, “metallic” or “pharmaceutical” odoriferous substances.

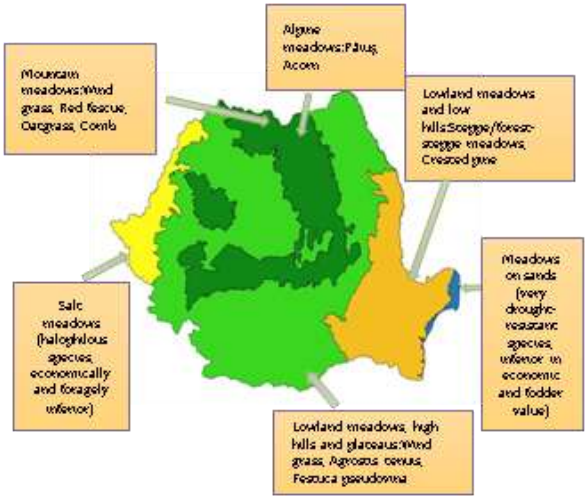

Fig. 3. Distribution of grasslands by geographical region
Source: authors' interpretation.

In contrast, milk from animals grazing on meadows in hilly and mountainous areas, made up of aromatic plants (thyme, rosemary, cumin, chicory, etc.), has a pleasant aroma due to "floral" type odoriferous substances. In the case of meadows made up of leguminous plants (white clover, red clover, alfalfa, vetch, etc.), the aroma of the milk is "grass", "hay" or "fruits", which gives it a special flavor [2].
Aromatic nuances are generally imperceptible in milk, being noticeable and making the difference between derivatives such as butter and cheese, as a result of the share of fatty acids that depend on the animal's diet.
The correlation coefficient determined between temperature and milk production is negative (-0.30%), indicating an acceptable association between the two variables. The correlation is negative and shows that, as temperatures increase, production tends to decrease, the relationship between the two variables being weakly consistent (Fig. 4).
The trend is negative and is given by the equation:

$$y = -1,043.6x + 58,076$$

where the coefficient 1,043.6 shows that for every degree Celsius increase milk production decreases, and the intercept point 58,076 indicates the estimated production when the temperature is zero. The R^2 value represents the trend line of the data variations suggesting that only 9% of the variation in milk production can be explained by the variation in the average annual temperature. The remaining 91% is influenced by other factors, such as animal nutrition, health conditions, farm technologies, etc.

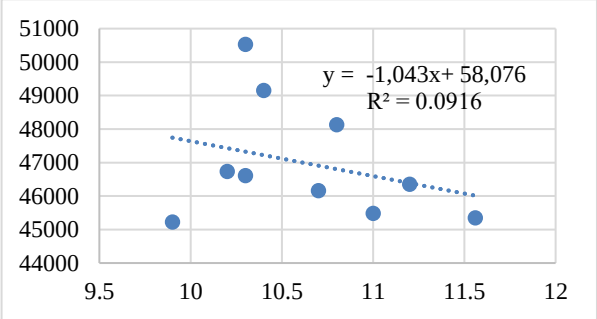

Fig. 4. Correlation between temperature and milk production, 2014-2023
Source: authors' calculations authors' calculations based on data from the National Institute of Statistics of Romania (NIS)

In the graphic representation it can be seen that in years with high temperatures the production is lower (e.g. 2023 with an average annual temperature of 11.56^0C, respectively 45,354 thousand hl of milk) and in years with moderate temperatures the production is higher (e.g. 2014 byh 10.3^0C and a production of 50,535 thousand hl) (Figure 4).

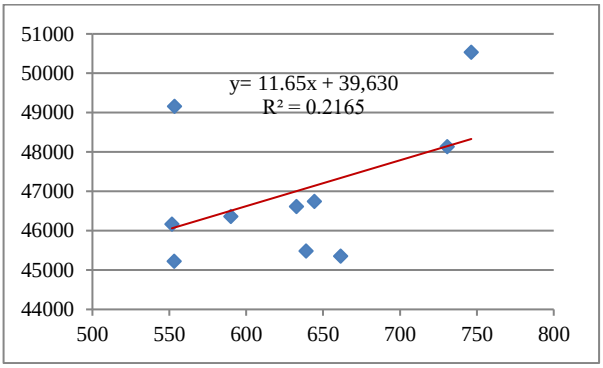

Fig. 5. Correlation between precipitation and milk production, 2014-2023
Source: authors' calculations based on data from the National Institute of Statistics of Romania (NIS)

A moderate positive relationship is given by the positive correlation coefficient r = 0.46 between milk production and precipitation in the analyzed period 2014-2023, which can be observed the significant influence of limiting climatic factors (Figure 5).
The quality of feed (nutritional value) is an essential factor in increasing milk production, depending on annual precipitation. So it can be

said that the relationship between the two variables is deterministic in the trend of increasing milk production.

Dairy products from large and small ruminants are rich in saturated fatty acids. Excessive consumption of such products increases the risk of cardiovascular diseases in humans. To prevent these risks, people intervene in the diet of animals by giving them green fodder, rich in Omega-3 (ryegrass, white clover, etc.) harvested in spring or early autumn. The content of fatty acids, Omega-3 in particular, is higher in hilly and mountain meadows than in plains.

Correct and balanced nutrition of animals determines the production of quality milk and derivatives, directly influencing human health. The increase in the content of Omega-3 and Omega-6 in feed is correlated with the increase in animal production. The quality of feed is assessed by the Omega-6/Omega-3 ratio which must be 4-5/1 (Table 1).

Table 1. Feed quality depending on the ratio of saturated fatty acids

Feed	Omega-3	Omega-6	Omega-6/ 0mega-3 ratio
Seeding pasture	1.60	0.30	0.19
White clover	1.52	0.53	0.35
Ryegrass	1.48	0.28	0.19
Natural pasture	1.36	0.42	0.31
Red clover	0.94	0.46	0.48
Dactylis glomerata	0.82	0.24	0.29
Lucerne	0.73	0.38	0.52

Source: taken from Dragomir N., Ferma Ferma Magazine no. 2 (185) from February 1-15, 2017 [2].

The lower content of Omega-6 than Omega-3 is beneficial for animal health. Excess Omega-6 can lead to severe inflammation in animals that consume poor quality feed. The optimal balance of fatty acids with a significant ratio is represented by sown meadow and ryegrass (0.9; 0.29), and the highest ratios may be less beneficial (high Omega-6 content) is represented by alfalfa and red clover (0.52; 0.48).

CONCLUSIONS

It is necessary to identify the moment of occurrence of extreme phenomena, based on early warning systems regarding the occurrence of heat waves or cold waves, the occurrence of floods or the occurrence of drought, as well as knowledge of the effects they have on crops.

Knowledge of meteorological phenomena must be based on technological practices applied in relation to the current evolution of climatic conditions and predictable scenarios.

Adaptation to the effects of climate change is a complex process based on optimizing the duration of the vegetation period of agricultural crops, on the resistance of genotypes to extreme temperatures, to deficits/excesses of water in the soil and to the increased risk of the appearance of phytopathogenic agents, on ecological plasticity, on tolerance to the effects of extreme weather phenomena.

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REFERENCES

[1]Chetroiu, R., Ilie, D.M, 2024, Challenges and alternatives on the forages resources providing under current environmental and climate conditions, Scientific Papers Series "Management, Economic Engineering in Agriculture and Rural Development, Vol.24(2), 267-272.

[2]Dragomir, N., 2017, The quality of green fodder and human health, Ferma Magazine no.2 (185), https://revista-ferma.ro/calitatea-furajelor-verzi-si-sanatatea-omului/, Accessed on January 15, 2025

[3]Hart, H.E., Christofides, S.R., Davies, T.E., Steven, P.R., Creevey, J.C., Müller, T.C., Rogers, J. H., Kingston-Smith, A., 2022, Forage grass growth under future climate change scenarios affects fermentation and ruminant efficiency, October 2022, Scientific Reports. 12(1), 4454. doi: 10.1038/s41598-022-08309-7.

[4]Izaurralde, R., Thomson, A., Morgan, J., Fay, P., Polley, H., Hatfield, J., 2011, Climate Impacts on Agriculture: Implications for Forage and Rangeland Production. Agronomy Journal, 103 (2), 371-381.

[5]Joyce, L., Briske, D., Brown, J., Polley, H., McCarl, B., Bailey, D., 2013, Climate Change and North American Rangelands: Assessment of Mitigation and

Adaptation Strategies. Rangeland Ecology & Management**,** 66 (5), 512-528.
[6]Martins-Noguerol, R., Moreno-Pérez, A.J., Pedroche, J., Gallego-Tévar, B., Cambrollé, J., Matías, L., Fernández-Rebollo, P., Martínez-Force, E., Pérez-Ramos, I.M., Climate change alters pasture productivity and quality: Impact on fatty acids and amino acids in Mediterranean silvopastoral ecosystems, Agriculture, Ecosystems & Environment, Vol. 358, 1 December 2023, 108703.
[7]Plesa, A., Pacurar, F., Rotar, I., Ghete, I., 2024, Fodder crops and climate change, Romanian Journal of Grassland and Forage Crops (2024) 30, 37-42.
[8]Popescu, A., Tindeche, C., Marcuta, A., Marcuta, L., Hontus, A., Stanciu, M., 2024, Land use for animal feed in Romania in the period 2013-2022. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 24(2), 799-808.
[9]Puia, I., Pavel, C., Bărbulescu, C., Oprin, C., 1980, Production and storage of fodder, Didactic and Pedagogical Publishing House.
[10]Tarnavsky, E., Rossi, M., Bussay, A., Morel, J., Biavetti, I., Bratu, M., Cerrani, I., Claverie, M., De Palma, P., Fumagalli, D., Manfron, G., Niemeyer, S., Nisini Scacchiafichi, L., Panarello, L., Seguini, L., Van Den Berg, M. and Zucchini, A., 2024. JRC MARS Bulletin - Crop monitoring in Europe - January 2024 Vol. 32 No 1, Van Den Berg, M. editor(s), Publications Office of the European Union, Luxembourg, 2024, doi:10.2760/03283, JRC136584.
[11]Tulu, D., Gadissa, S., Hundessa, F., Kebede, E., 2023, Contribution of Climate-Smart Forage and Fodder Production for Sustainable Livestock Production and Environment: Lessons and Challenges from Ethiopia, Hindawi, Advances in Agriculture, Vol. 2023, Article ID 8067776, pp. 1-11., https://doi.org/10.1155/2023/8067776

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THE ROLE OF SMALL FARMS WITHIN THEIR NATIONAL CONTEXTS IN CENTRAL AND EASTERN EUROPE

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Abstract

Small farms play a crucial role in shaping the agricultural landscapes and economies of many nations, serving as both cultural staples and significant contributors to food security and rural livelihoods. This study applies K-Means clustering to examine the dynamics of small agricultural holdings across European regions, using key indicators such as the number of holdings, utilized agricultural area (UAA), economic output (Euro), and agricultural labor input (AWU). The analysis identified four distinct clusters that reveal the diverse roles small farms play in national agricultures. The findings illustrate the multifaceted roles small farms perform—from sustaining rural economies and preserving traditions to confronting productivity challenges and resource constraints. The study underscores the necessity for region-specific policies that enhance the sustainability and competitiveness of small farms. By framing the role of small farms within their national contexts, this research provides a strategic foundation for strengthening their contributions to agricultural sustainability and resilience.

Key words**:** *small farms, region, Central and Eastern Europe. Cluster analysis*

INTRODUCTION

Small farms are integral to global agriculture, contributing significantly to food security, biodiversity preservation, and rural economies. Despite the trend towards large-scale industrial farming, smallholder farms—those typically smaller than 2 hectares—remain common, making up more than 80% of all farms globally and providing a significant amount of the global food supply [23]. Small-scale farms are central to promoting regional development and sustainable agricultural practices, as they challenge the industrial agrifood complex by fostering local food systems and agroecological alternatives [1]. The importance of small farms extends beyond mere food production. They play a vital role in maintaining agrobiodiversity, as diverse cropping systems are more prevalent in smallholder settings, enhancing resilience against pests, diseases, and climate variability [2]. Moreover, small farms often employ sustainable practices that contribute to environmental conservation, such as reduced chemical use and integrated crop-livestock systems [27]. Small farms have a crucial role in maintaining rural life on an economic level. They are vital to the socioeconomic fabric of rural communities and offer job possibilities. In many developing countries, smallholder agriculture is a primary source of income and plays a crucial role in poverty alleviation [17]. Furthermore, small farms contribute to local economies by supporting local markets and preserving traditional food systems [19]. However, small farms face numerous challenges, including limited access to markets, credit, and technology, which can impede their productivity and sustainability. This study aims to analyze the role of small farms in national agricultures by examining their contributions to sector. Through a comprehensive review of existing literature and empirical data, the research seeks to highlight the multifaceted importance of smallholder farms and observe their current state to inform policy decisions that support their integration into broader agricultural development strategies.

MATERIALS AND METHODS

The K-means clustering algorithm was chosen for this study due to its efficiency in handling large datasets and its ability to identify underlying patterns within multidimensional agricultural data. K-means is a widely used unsupervised learning technique that partitions data into distinct groups based on feature similarity [24]. The method has been extensively applied in agricultural research, particularly for farm typology classification, land-use pattern analysis, and productivity assessment [5, 30]. K-means clustering operates by minimizing intra-cluster variance through an iterative reassignment process [16]. Unlike hierarchical clustering methods, which can become computationally expensive as dataset size increases, K-means efficiently handles large-scale agricultural datasets, making it particularly suitable for studies involving spatial and economic data [32]. Prior to applying the K-means algorithm, data preprocessing was conducted to ensure consistency and comparability across different variables. Given the multidimensional nature of the dataset—including economic indicators (e.g., farm income, subsidies), structural characteristics (e.g., land size, labor input), and productivity measures—normalization was applied using min-max scaling to bring all variables into a comparable range between 0 and 1 [15]. This step is crucial, as K-means clustering relies on Euclidean distance, which can be disproportionately influenced by variables with larger magnitudes [20]. Outliers were identified and addressed using the interquartile range (IQR) method to prevent their undue influence on clustering results [21]. Missing values were handled through multiple imputation, ensuring that incomplete records did not introduce bias into the clustering process [35].

Choosing the optimal number of clusters (K) is one of the main challenges in K-means clustering. To address this, two main methods are used: Silhouette Score Analysis [29] and the Elbow Method [34]. In the Elbow Method, a graph is created showing how the within-cluster sum of squares (WCSS) changes with respect to the number of clusters, K. The best number of clusters is the one where the graph shows the so-called "elbow" — the point where the reduction in WCSS begins to slow down, and the improvements become less significant. The Silhouette Score, on the other hand, evaluates the cohesion and separation of clusters by measuring how similar an observation is to its assigned cluster compared to others. Both methods were computed, and results were cross-validated to ensure the robustness of cluster selection. The final K-value was determined based on the convergence of both techniques and domain-specific knowledge of agricultural classifications.

Once the optimal number of clusters was established, the K-means algorithm was applied as follows:

•Random Initialization – K initial centroids were randomly selected from the dataset to serve as the starting points.

•Assignment Step – Each data point was assigned to the nearest centroid based on Euclidean distance.

•Centroid Update – New centroids were computed as the mean of all data points in each cluster.

•Convergence Check – Steps 2 and 3 were repeated iteratively until centroid positions stabilized or the maximum number of iterations was reached [22].

•To mitigate the sensitivity of K-means to centroid initialization, the K-means++ initialization technique was implemented, ensuring that initial centroids were spread out to improve clustering performance [3].

To assess the quality of the clustering results, multiple validation techniques were applied:

•Dunn Index [12] to evaluate the compactness and separation of clusters.

•Calinski-Harabasz Index [6] for measuring cluster dispersion.

•Silhouette Analysis for internal validation of clustering quality. Following validation, clusters were interpreted based on agricultural characteristics, economic performance, and structural factors. Statistical comparisons (e.g., ANOVA, post-hoc Tukey tests) were conducted to identify significant differences between clusters [18].

RESULTS AND DISCUSSIONS

The analysis of small agricultural holdings (0–2 ha) in selected EU countries between 2010 and 2020 reveals a pronounced decline in their numbers, particularly in Romania, Poland, and Hungary. Over the period from 2010 to 2020, significant structural changes have occurred in the agricultural sector of this EU countries, particularly in the segment of small farms (0-2 ha). The comparative analysis of the data from Figures 1 and 2 highlights a general decline in the number of small holdings, accompanied by an increase in economic output (measured in Euro), a reduction in the agricultural workforce (AWU), and relatively stable levels of utilized agricultural area (UAA). The observed transformations suggest that the remaining small farms have either intensified production, diversified their activities, or become more commercially integrated. This shift away from small agricultural holdings can be further analyzed through the lens of labor input and economic performance. The limited investment in fixed assets indicates a low level of capital allocation, which considerably restricts the growth potential and financial viability of small farms. These trends are particularly pronounced in Romania and Poland, where the most substantial declines in small farm numbers have been recorded. At the same time, the economic productivity of small farms has increased, suggesting improved efficiency and farm consolidation. In contrast, countries such as Czechia, Slovenia, and Slovakia have exhibited minimal structural changes, maintaining relatively stable farm numbers and economic performance. The observed trends can be attributed to multiple factors, with the most influential being agricultural policy reforms under the European Union's Common Agricultural Policy (CAP), population and economic changes. The CAP is one of the main forces behind this trend and has been widely criticized for disproportionately favoring large agricultural enterprises. In Romania, the sharp decline in small farm numbers can be linked to ongoing land consolidation processes, the outmigration of rural labor, and a shift towards commercialized agriculture. Despite the reduction in farm numbers, the economic output of the remaining farms has increased, suggesting efficiency gains and improved access to CAP subsidies. Poland exhibits a similar trajectory, where small farms are disappearing due to consolidation and integration into larger agricultural structures. Increased mechanization and access to EU markets have facilitated higher productivity, reflected in the rise in economic output. Greece stands out as an exception, where economic productivity has surged, possibly due to diversification into high-value crops and agritourism rather than extensive farm consolidation. In Hungary and Bulgaria, the decline in small farm numbers is also apparent but at a more moderate scale.

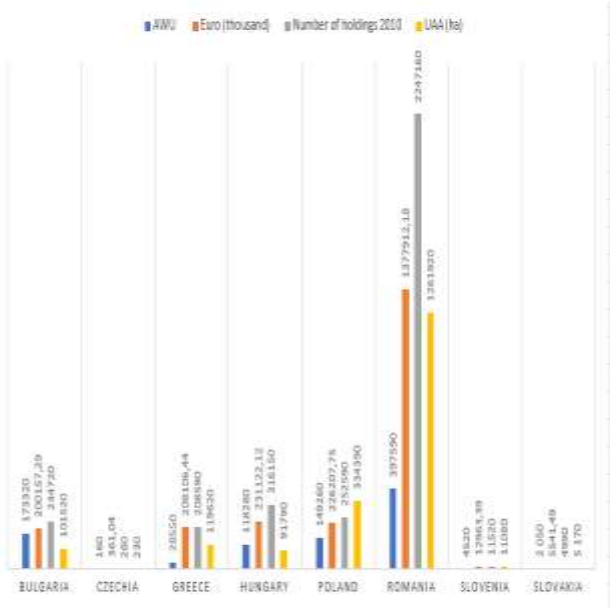

Fig. 1. Small farms/holdings 0-2 ha 2010
Source: Eurostat - Statistics | Eurostat [13].

These countries have experienced a gradual transition towards commercial farming, supported by CAP payments and foreign investments. However, the workforce reduction suggests a declining interest in small-scale farming as younger generations migrate to urban areas. Meanwhile, in Czechia, Slovenia, and Slovakia, the structure of small farms has remained largely unchanged, which can be attributed to the historically lower prevalence of fragmented land holdings and a focus on larger, corporate-style farming. Overall, the transformation of small farms in the EU is driven by economic pressures, policy incentives favoring larger commercial farms, and demographic changes that reduce labor availability in rural areas. The trend suggests a

continuing transition towards a more capital-intensive and technologically advanced agricultural sector, where fewer but more efficient farms dominate production. This shift has implications for rural development, food security, and land ownership patterns, requiring adaptive policy measures to balance economic viability with social sustainability in the agricultural sector.

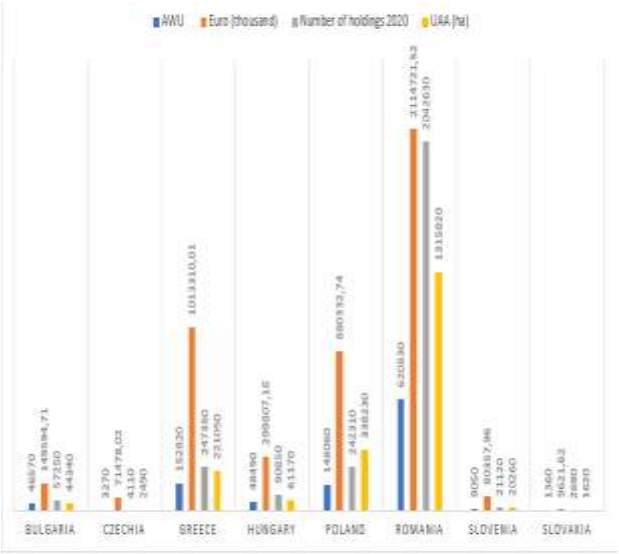

Fig. 2. Small farms/holdings 0-2 ha 2020
Source: Eurostat - Statistics | Eurostat [13].

Clusters

Identifying (k) the effective number of clusters is to provide meaningful dataset segmentation. The within-cluster sum of squares (WCSS) was plotted against various values of k to use the Elbow Method. The results reveal a distinct inflection point at k = 4, indicating that beyond this point, adding more clusters results in marginal improvements in intra-cluster compactness while increasing complexity. This suggests that a four-cluster solution provides a balanced trade-off between cluster cohesion and separation (Figure 3). To further validate the clustering structure, Silhouette Analysis was conducted. The silhouette score measures how well each data point fits within its assigned cluster while maintaining distinct separation from others. The analysis demonstrates a peak silhouette score at k = 3, followed by a gradual decline as k increases. The drop in silhouette scores beyond k = 4 suggests that higher cluster numbers lead to overlapping and less-defined groupings. Given these results, k = 4 was selected as the optimal clustering solution, ensuring both meaningful segmentation and distinct cluster differentiation (Figure 4).

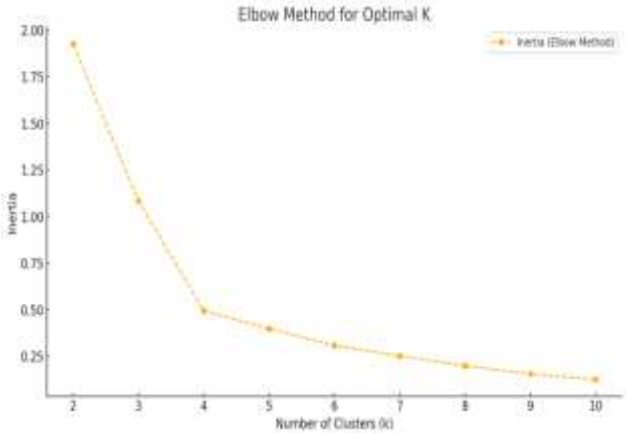

Fig. 3. Elbow Method optimal K
Source: Eurostat and calculation by the authors [13].

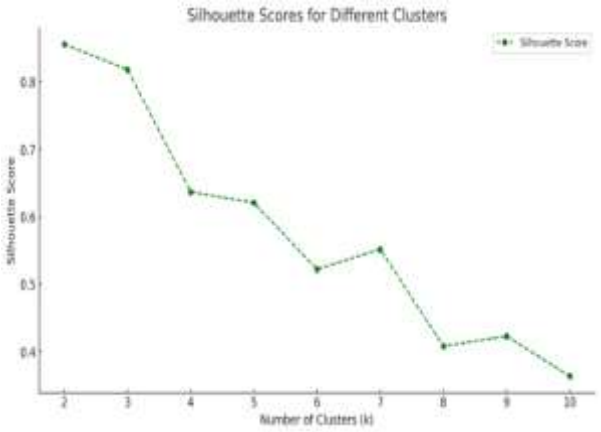

Fig. 4. Silhouette scores
Source: Eurostat [13] and calculation by the authors.

This distribution suggests a clear differentiation between high-performance agricultural regions and those struggling with structural inefficiencies. The findings reinforce the argument that small farm efficiency is not solely dependent on land area or number of holdings but also on infrastructural investments, technological adoption, and market accessibility (Figure 5).

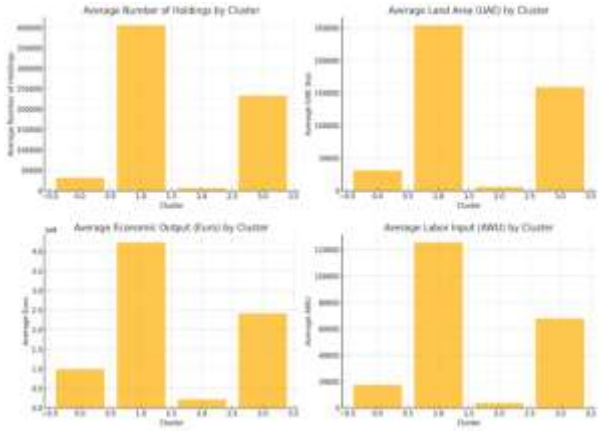

Fig. 5. Farm specifics for the clusters
Source: Eurostat [13] and calculation by the authors.

Structural Patterns in Cluster Frequency and Land Utilization

Further insights were derived from analyzing cluster frequency distributions and utilized agricultural area (UAA). The results show that certain clusters are overrepresented in particular regions, indicating strong spatial patterns in agricultural organization. For instance, regions with a predominance of smallholder farms demonstrate high cluster frequencies but exhibit disparities in productivity, emphasizing the need for policy interventions targeted at increasing efficiency.

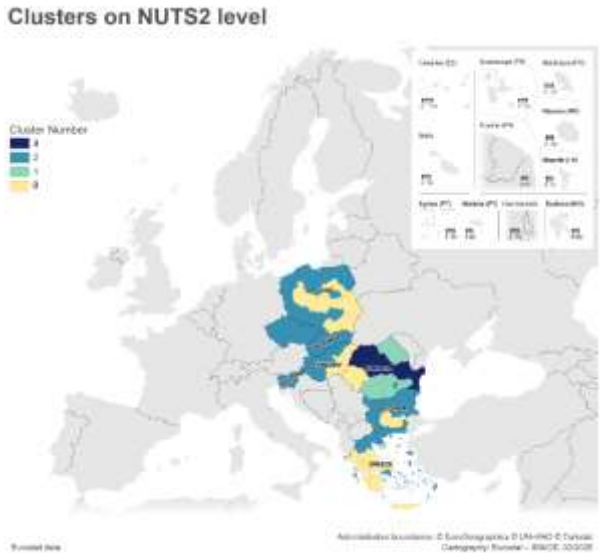

Fig. 6. Clusters on NUTS2 level
Source: Eurostat [13].

Clusters with lower economic output yet high land utilization (as seen in Cluster 3) underscore the presence of inefficient extensive farming, reinforcing the need for modernization efforts. On the other hand, high-output clusters align with regions that have successfully integrated modern farming techniques, value chain participation, and targeted governmental support (Figure 6).

•Cluster 0: High Economic Activity and Productivity

Characterized by high economic output per holding and per hectare.

Includes regions such as Kriti (Greece), Thessalia (Greece), Mazowiecki Regionalny (Poland), and Sud-Vest Oltenia (Romania).

These regions likely benefit from mechanized farming, efficient input use, and market-oriented production.

Policy Implications: Investment in modern agricultural technologies, irrigation, and sustainability-oriented subsidies.

•Cluster 1: Extensive Agriculture with Low Productivity

Includes regions such as Nord-Est and Sud-Muntenia in Romania, with high farm counts but low output per unit of land.

Agriculture is dominated by subsistence farming, labor-intensive practices, and fragmented land ownership.

Policy Implications: Urgent need for mechanization, cooperative farming models, and infrastructure investments.

•Cluster 2: Medium-Scale Agricultural Activity

Comprising regions from Bulgaria, Hungary, Czechia, and Poland, exhibiting a balanced mix of traditional and modern agriculture.

These regions benefit from CAP funding but require further modernization to remain competitive.

Policy Implications: Targeted subsidies for mechanization, training programs for farmers, and expansion of value-added agricultural production.

•Cluster 3: Low Activity and Small Holdings

Predominantly urbanized or industrialized regions where agriculture plays a marginal role.

Includes regions such as Prague, Bratislava, Budapest, and Bucuresti-Ilfov.

Policy Implications: Diversification strategies such as agro-tourism, organic farming, and non-agricultural rural employment.

Comparative Analysis of Agricultural Structures Across Countries

A comparative assessment of the clustered countries highlights key differences and similarities in agricultural structures, economic output, and trade performance.

•Bulgaria vs. Greece:

Greece, particularly in regions like Kriti and Thessalia, has successfully developed high-value export crops such as olives and citrus fruits, leveraging CAP funding for modernization. In contrast, Bulgaria remains highly dependent on cereal and sunflower production, with lower value-added exports.

•Bulgaria vs. Poland:

Poland's agricultural sector benefits from larger average farm sizes, better mechanization, and stronger integration into European markets. While Bulgaria struggles with land fragmentation, Poland has successfully consolidated small farms into cooperatives, enhancing trade competitiveness.

•Bulgaria vs. Romania:

Romania, similar to Bulgaria, has a high number of fragmented farms, particularly in regions like Nord-Est and Sud-Muntenia. However, Romania's total agricultural land is significantly larger, and its domestic market absorption capacity is higher, providing it with slightly better resilience in times of trade disruptions.

•Bulgaria vs. Hungary:

Hungary has a more diversified agricultural portfolio, with a significant emphasis on horticulture and specialty crops, while Bulgaria relies more on extensive farming of staple grains. Hungary's investment in agri-tech and climate resilience strategies provides a useful model for Bulgaria's adaptation to climate change.

Trade Implications and Policy Considerations

Bulgaria should leverage its climate conditions and agricultural potential to develop export-oriented sectors, such as organic farming, wine production, and processed agricultural goods. The dominance of small and fragmented farms hinders scalability and productivity, limiting Bulgaria's competitiveness in international markets. Greece, Poland, and Hungary exhibit successful agricultural trade models, emphasizing farm consolidation, mechanization, and integration into high-value markets.

Discussion

The dynamics of the EU's CAP, which often favours larger farms over smaller ones, are the main factor influencing the loss of small agricultural holdings in a few EU countries. The small farms have significantly decreased due to this policy-driven imbalance, with recorded decreases of 45,000 in Slovakia, 50,000 in Latvia, 88,000 in Lithuania, and 79,000 in Germany. Conversely, Czechia and Slovakia, which already had low numbers of small farms in 2010, appear to have undergone early consolidation following economic transitions in the 1990s. The most pronounced decline is observed in Poland, where more than 1 million small farms disappeared over the study period. Overall, this shift has resulted in a 41% reduction in the total number of farms across the region.

Another key factor influencing this trend is the liberalization of land markets in post-socialist EU member states. Research by Swinnen and Mathijs [33] highlights that, following accession to the EU, Eastern European countries experienced a surge in land acquisitions by agribusinesses and foreign investors. This has particularly affected small farmers in Poland and Romania and Bulgaria where land consolidation has been more pronounced. The shift toward commercial agriculture has also contributed to these developments, as small farms face difficulties in integrating into modern supply chains dominated by larger agribusinesses [26].

Demographic factors also play a crucial role in the decline of small farms. Studies by Davidova & Thomson (2014) [11] indicate that a significant proportion of smallholders in Eastern European countries are of advanced age, with limited generational succession in farming. This demographic trend is further exacerbated by rural depopulation, as younger generations increasingly migrate to urban centers or Western European countries in search of better economic opportunities. Research by Davidova and collective [10] highlights that youth outmigration reduces

labor availability and intergenerational land transfer. Romania and Poland report the highest Agricultural Work Unit (AWU) values, reflecting the labor-intensive nature of small holdings. However, this is juxtaposed with low economic returns per AWU, indicating inefficiency. Studies [28] suggest that mechanization remains limited in these holdings due to high upfront costs and fragmented land ownership. Despite the overall decline in small agricultural holdings, some countries exhibit distinct trends. Greece, for instance, shows an increase in economic output despite a reduction in the number of small farms, suggesting that the remaining farms have adapted through diversification or specialization in high-value agricultural products. This aligns with findings by Mattas and collective [25], who emphasize the role of product differentiation in enhancing smallholder profitability. The data reveals a marked decline in the number of small holdings across all countries studied, with Romania showing the steepest drop. For instance, Romania's small holdings decreased by nearly 20% between 2010 and 2020. Similar trends are observed in Bulgaria and Hungary, where rural depopulation, particularly in Eastern Europe, has led to the abandonment of small farms. Romania dominates in UAE for small holdings, followed by Poland. This suggests that while the number of holdings declines, the total land area cultivated remains significant. However, studies [9] argue that land fragmentation continues to impede efficiency and sustainability.

CAP's Pillar II measures, aimed at rural development, provide crucial support to smallholders. For example, subsidies for organic farming and agri-tourism encourage diversification. While Pillar I subsidies (area-based payments) disproportionately benefit larger farms, marginalizing smallholders. This is corroborated by studies [31] that critique CAP for exacerbating inequality in subsidy allocation. Previous research [7, 8] has demonstrated that CAP direct payments contribute to increased land prices, making it more challenging for small farms to remain viable. Consequently, many smallholders have been forced out of the sector, either due to economic pressures or through land acquisitions by larger agricultural entities. The decline in small holdings signals the erosion of a critical economic safety net for rural households. Without targeted interventions, rural poverty and inequality may rise, particularly in countries like Romania and Bulgaria. Small holdings often employ traditional, low-intensity farming practices, which are more environmentally sustainable than industrial agriculture. Their disappearance could lead to increased land degradation and biodiversity loss, as highlighted by Baldock and collective [4]. Small holdings provide cultural and social value, sustaining rural traditions and communities. Their decline undermines social cohesion in rural areas, as noted in studies by Halfacree [14]. If these trends persist, the EU's small-scale farming faces an increasingly uncertain future, underscoring the need for legislative initiatives and measures that support their resilience and sustainability.

CONCLUSIONS

The ever-reduction in small-scale farming in the EU is a multifaceted process driven by CAP policies, demographic shifts, technological advancements, and land market dynamics. The observed trends indicate a structural transformation toward larger, capital-intensive farming enterprises, posing significant challenges for the sustainability of smallholder agriculture. If these developments persist, targeted policy interventions may be necessary to support small farms, given their important role in rural livelihoods, biodiversity conservation, and local food security. Bulgaria's agricultural trade competitiveness is significantly influenced by structural disparities, climate risks, and land ownership patterns. The clustering analysis highlights key policy directions that can enhance regional resilience, productivity, and external market integration. By implementing targeted interventions in climate adaptation, land consolidation, and high-value export diversification, Bulgaria can strengthen its agricultural sector and improve its positioning in global trade networks. Small agricultural

holdings in Eastern Europe are at a crossroads, caught between traditional practices and modern pressures. While their decline is driven by economic and demographic forces, policy adjustments and innovative practices can revitalize their role in sustainable agriculture and rural development. A balanced approach, integrating economic viability with environmental and social goals, is essential to ensure their continued relevance.

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REFERENCES

[1]Ambros, P., Granvik, M., 2020, Trends in Agricultural Land in EU Countries of the Baltic Sea Region from the Perspective of Resilience and Food Security. Sustainability, 12(14), 5851. https://doi.org/10.3390/su12145851

[2]Altieri, M.A., 2004, Linking ecologists and traditional farmers in the Search for Sustainable Agriculture. Frontiers in Ecology and the Environment, 2, 35-42.

[3]Arthur, D., Vassilvitskii, S., 2007, k-means++: The advantages of careful seeding. Proceedings of the 18th Annual ACM-SIAM Symposium on Discrete Algorithms, 1027-1035.

[4]Baldock, D., Beaufoy, G., Bennett, G., Clark, J., 1993, Nature conservation and new directions in the EC Common Agricultural Policy: The potential role of EC policies in maintaining farming and management systems of high nature value in the community. Institute for European Environmental Policy.

[5]Bezdek, J. C., Hathaway, R. J., Sabin, M. J., Tucker, W. T., 1999, Convergence theory for fuzzy c-means: Counterexamples and repairs. IEEE Transactions on Systems, Man, and Cybernetics, 29(3), 826-835.

[6]Calinski, T., Harabasz, J., 1974, A dendrite method for cluster analysis. Communications in Statistics, 3(1), 1-27.

[7]Ciaian, P., Swinnen, J., 2014, Land market developments in the EU: A survey of research. European Review of Agricultural Economics, 41(1), 135-161.

[8]Ciaian, P., Kancs, D., Swinnen, J. F. M., 2010, EU land markets and the Common Agricultural Policy. European Review of Agricultural Economics, 37(4), 553–577. https://doi.org/10.1093/erae/jbq013

[9]Csaki, C., Jambor, A., 2019, Convergence or divergence-Transition in agriculture of Central and Eastern Europe and Commonwealth of Independent States revisited. Agricultural Economics/Zemědělská Ekonomika, 65(4), 160–174.

[10] Davidova, S., Bailey, A., Dwyer, J., Erjavec, E., Gorton, M., Thomson, K., 2013, Semi-Subsistence Farming – Value and Directions of Development, study prepared for the European Parliament Committee on Agriculture and Rural Development. http://www.europarl.europa.eu/committees/en/AGRI/studiesdownload.html?languageDocument=EN&file=93390 Accessed on 28.02.2025

[11]Davidova, S., Thomson, K. J., 2014, Family farming in Europe: Challenges and prospects. European Review of Agricultural Economics, 41(4), 659–683. https://doi.org/10.1093/erae/jbu039

[12]Dunn, J. C., 1974, Well-separated clusters and optimal fuzzy partitions. Journal of Cybernetics, 4(1), 95-104.

[13]Eurostat, https://ec.europa.eu/eurostat/data/database, Accessed on 28.02.2025

[14]Halfacree, K., 2007, Back-to-the-land in the twenty-first century–making connections with rurality. Tijdschrift voor Economische en Sociale Geografie Journal of Economic & Social Geography, 98(1), 3-8.

[15]Han, J., Kamber, M., Pei, J., 2011, Data mining: Concepts and techniques. Morgan Kaufmann.

[16]Hartigan, J. A., Wong, M. A., 1979, Algorithm AS 136: A k-means clustering algorithm. Journal of the Royal Statistical Society: Series C (Applied Statistics), 28(1), 100-108.

[17]Hazell, P., Poulton, C., Wiggins, S., Dorward. A., 2007, The future of small farms for poverty reduction and growth. In Discussion Paper. https://doi.org/10.2499/97808962976472020vp42

[18]Huberty, C. J., Olejnik, S., 2007, Applied MANOVA and discriminant analysis. John Wiley & Sons.

[19]IFAD, 2013, Annual report https://www.ifad.org/en/w/publications/ifad-annual-report-2013 Accessed on 28.02.2025

[20]Jain, A. K., 2010, Data clustering: 50 years beyond k-means. Pattern Recognition Letters, 31(8), 651-666.

[21]Leys, C., Ley, C., Klein, O., Bernard, P., Licata, L., 2013, Detecting outliers: Do not use standard deviation around the mean, use absolute deviation around the median. Journal of Experimental Social Psychology, 49(4), 764-766.

[22]Lloyd, S., 1982, Least squares quantization in PCM. IEEE Transactions on Information Theory, 28(2), 129-137.

[23]Lowder, S. K., Skoet, J., Raney, T., 2016, The number, size, and distribution of farms, smallholder farms, and family farms worldwide. World Development, 87, 16–29. https://doi.org/10.1016/j.worlddev.2015.10.041

[24]MacQueen, J., 1967, Some methods for classification and analysis of multivariate observations. Proceedings of the Fifth Berkeley Symposium on Mathematical Statistics and Probability, 1, 281-298.

[25]Mattas, K., Tsakiridou, E., Karelakis, C., Lazaridou, D., Gorton, M., Filipović, J., ..., Veneziani, M, 2022, Strengthening the sustainability of European food chains through quality and procurement policies. Trends in Food Science & Technology, 120, 248-253.
[26]Matthews, A., 2018, Structural changes in EU agriculture and rural development policies. European Review of Agricultural Economics, 45(4), 657-682.
[27]Pretty, J., Benton, T. G., Bharucha, Z. P., Dicks, L. V., Flora, C. B., Godfray, H. C. J., Goulson, D., Hartley, S., Lampkin, N., Morris, C., Pierzynski, G., Prasad, P. V. V., Reganold, J., Rockström, J., Smith, P., Thorne, P., Wratten, S., 2018, Global assessment of agricultural system redesign for sustainable intensification. Nature Sustainability, 1(8), 441–446. https://doi.org/10.1038/s41893-018-0114-0
[28]Rizov, M., Pokrivcak, J., Ciaian, P., 2013, CAP subsidies and productivity of the EU farms. Journal of Agricultural Economics, 64(3), 537–557. https://doi.org/10.1111/1477-9552.12030
[29]Rousseeuw, P. J., 1987, Silhouettes: A graphical aid to the interpretation and validation of cluster analysis. Journal of Computational and Applied Mathematics, 20, 53-65.
[30]Ruß, G., Brenning, A., 2010, Data mining in precision agriculture: Management of spatial information. Computers and Electronics in Agriculture, 70(1), 7-20.
[31]Pe'er, G., Zinngrebe, Y., Moreira, F., Sirami, C., Schindler, S., Müller, R., ..., Lakner, S., 2019, A greener path for the EU Common Agricultural Policy. Science, 365(6452), 449-451.
[32]Steinley, D., 2006, K-means clustering: A half-century synthesis. British Journal of Mathematical and Statistical Psychology, 59(1), 1-34.
[33]Swinnen, J. F., Mathijs, E., 2018, Agricultural privatisation, land reform and farm restructuring in Central and Eastern Europe: A comparative analysis. In Agricultural privatization, land reform and farm restructuring in Central and Eastern Europe, Routledge, 333-371.
[34]Thorndike, R. L., 1953, Who belongs in the family? Psychometrika, 18, 267-276.
[35]Van Buuren, S., Groothuis-Oudshoorn, K., 2011, mice: Multivariate imputation by chained equations in R. Journal of Statistical Software, 45(3), 1-67.

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SMALL AND FAMILY FARMS - A PILLAR IN RURAL DEVELOPMENT IN BULGARIA

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Abstract

The role of small and family farms in rural development has been a cornerstone of agricultural policy and socio-economic studies in Bulgaria provoced by the constant change in social, economical and enviormental factors. This paper aims to explore the challenges and contributions of small-scale and family farming in the context of Bulgaria`s post-1991 land reforms and integration of acquis communautaire. PESTEL analysis is combined with desk research and literature review to highlight the processes that reflect on small and family farms. Small and family farms play a critical role in sustaining rural livelihoods, preserving traditions, and fostering socio-cultural cohesion. The lack of consensus for the definition of `small farms` complicates the process of policy alignment, as definitions varies based on physical size, economic value, labor input etc. These farms often struggle under market pressures but remain essential for agro-ecology and resilience of rural areas. They are vulnerable economic units the existence of which is caused mostly by social rather than market motives. The study emphasizes the need for targeted support to boost the sustainability and socio-economic impact of small and family farms in Bulgaria.

Key words**:** *small and family farms, rural development, PESTLE*

INTRODUCTION

Small and family farms have historically been the backbone of rural economies, providing numerous social, economic, and environmental benefits, they are integral to the country's rural development, serving as a cornerstone for economic stability and cultural heritage. Despite their vital role, they often face significant challenges that threaten their viability. This research aims to explore the multifaceted contributions of small and family farms, emphasizing their importance in promoting social and economic development, reducing inequality, and fostering environmental sustainability in rural areas. Some authors (Doitchinova, 2022) [17] have found that the rate of decline in farms continues to be very high, most often this is happening to small family farms. They are high-risk because they lack significant financial resources and find it more challenging to implement risk management mechanisms. Other authors note the importance of small and family farms that are the producer of quality and authentic food, but in small quantities, and which are seasonally dependent (Branzova, 2018) [11]. In terms of Bulgarian farms' contribution to food and social security in rural areas, smallholders are crucial to subsistence farming and provide a crucial safety net for low-income households, which is an extension of the nation's meagre social security system. Today, they provide essential livelihoods for rural populations while preserving traditional agricultural practices, making them vital to local economies and food security (Bulgaria relocation, 2024) [12]. The concentration of agricultural land in large farms, utilizing mainly someone else's land for the short-term tenement, has a negative impact on the sustainability of agricultural production structures, which in turn leads to unsustainable development and destabilization of the sector as a whole (Yanakieva, 2007) [69] which further highlights the importance of small and family farming. The significance of small and family farms extends beyond mere economic contributions; they embody resilience and adaptability in the face of modern challenges

such as market competition, climate change, and demographic shifts. These farms are characterized by their small size and focus on subsistence, often prioritizing household needs over commercial production. The authors point out that policy ought to consider the socioeconomic elements that support the continuation of subsistence farming in addition to commercial considerations, which are essential for household livelihood (Fredriksson et al., 2021) [26]. At the European level, there has never been a common understanding of "small farms". When talking about the small farming sector, different terms such as "family farming", "agroecological farming", "subsistence farming", and "peasant farming", "small holdings" "small farms" are used. Each of them puts emphasis on different aspects of the farming system, being alternately the physical or economical size of the exploitation when having in mind the case of small farming, the main source of labour for family farming, the degree of involvement in the market or, lastly, the farmer himself with his/her rights and connection to the land - as in peasant farming (Gioia, 2017) [28]. A unified definition of farming in Europe is made more difficult by the fact that the number of small farms in the EU increased by two folds as a result of the agricultural countries of Eastern Europe joining the EU between 2004 and 2007.The most commonly used parameters to define small farms are physical size, economic size, and labour input (Gioia, 2017) [28]. Historically, small farms have been the earliest and most resilient representatives of family and small-scale businesses worldwide. In recent years, numerous studies have focused on the entry of a new generation into farm management, bringing diverse perspectives, education, attitudes, and motivations that ultimately foster the introduction of innovations in agricultural practices (Van der Ploeg, 2018; Milone and Ventura, 2019; Conway et al., 2019) [68, 45, 14]. This aligns with contemporary trends advocating for the support of small and family farms, thereby promoting the sustainable development of economic activities in rural areas. Researchers increasingly highlight the importance of integrated and sustainable practices, including agroecology, examining gender roles in farming and rural development approaches. According to them, this change indicates a rising awareness of how family farming supports environmentally friendly farming practices, tackling global issues, and creating a food-secure environment for future generations (Suman et al., 2025) [63]. In Bulgarian rural areas, around 45% of the population covers 85% of the territory but the main decline in population is seen exactly as in this areas which hinders the development and sustainability of small farms (Marinov, 2019) [41]. Over the coming decades, rural areas are poised to emerge as increasingly attractive destinations for settlement, driven by a confluence of natural, ecological, and socio-economic factors. Beyond their traditional roles in agriculture and forestry, these regions hold significant potential for diversifying economic activities, particularly through the expansion of non-agricultural enterprises that foster employment opportunities for the working-age and reproductive-age population. A particularly distinctive feature of rural economies is the small agricultural holding, which embodies a unique organizational structure. It functions not merely as a site of production but as an integrated economic unit that simultaneously serves as a workplace, a territorial asset, and a mechanism for securing household sustenance. Moreover, it represents a nexus where economic imperatives intersect with cultural traditions, social continuity, and the broader dynamics of rural development. As such, the evolution of these agrarian structures is crucial for shaping the future trajectory of rural economies, influencing both livelihoods and broader socio-economic stability.

The widely used definition in Bulgaria for a small farm is related to the size of the farm expressed in hectares or the number of animals, which cannot be applied as independent criteria. The production capacity of a small farm varies significantly due to differences in the quality of arable land, access to resources, market, technological development and opportunity costs of capital and labor in the economy. In the categorization of small farms, a combination of the criteria of utilized agricultural area (UAA) and labour input on

the farm can be applied. These indicators are highly dependent on the specialization of the farm. Additionally, as a generalizing criterion, information about the farm's financial status may be utilized. The most often used method of classification is based on the farm's economic size, which is determined by the standard output in euros. While some definitions are based on several requirements, others just include one. There is therefore no agreed definition, on the international stage or among academics. As Nagayates (2005) [50] correctly points out, the primary consensus on small farms may be the lack of a single definition. According to some Bulgarian authors (Harizanova-Bartos & Terziyska, 2020) [32], the criteria for determining farms as small are as follows: UAA; annual work units invested in the farm; market participation; economic size or a combination of criteria. The authors share that the size of the standard output is applicable to all types of farms and allows for their comparison. When it comes to family farms the United Nations' Food and Agriculture Organisation (FAO) defines a family farm as '… an agricultural holding which is managed and operated by a household and where farm labour is largely supplied by that household'. Agricultural family holdings range from small, semi-subsistence farms with only family workers and farms that must rely on other gainful activities for a diversified source of income to much larger, more productive farms that are still primarily managed by family members. Family farms are by far the most common type of farm in the European Union (EU).By Eurostat data and research the average size of family farm in Bulgaria is around 0-7 ha.

MATERIALS AND METHODS

The research begins with detailed theoretical overview of the problem. The idea is based on literature review to understand the process that is the focus of this article and highlight the state of small and family farms. The study uses both qualitative and quantitative approaches as well as graphic method of representation. The classification used in the study is the administrative division of the territory of Bulgaria according to the NUTS classification from Regulation 2023/674, the

P	E	S	T	E	L
Government policy Political stability Corruption Foreign trade policy Tax policy Labor law Trade restrictions	Economic growth Exchange rate Interest rates Inflation rates Disposable income Unemployment rate	Population growth rate Age distribution Career attitudes Safety emphasis Health consciousness Lifestyle attitudes Cultural barriers	Technology incentives Level of innovation Automation R&D activity Technological change Technological awareness	Discrimination laws Antitrust laws Employment laws Consumer protection laws Copyright and patent laws Health and safety laws	Weather Climate Environmental policies Climate change Pressures from NGO's

Fig. 1. Schematic of the components of the PESTEL analysis
Source: Author's adaptation by Marmol, T., Feys, B., Probert, C. (2015) [43].

Commission upgraded the NUTS classification from 1 January 2024. Based on the literature review and statements that are part of our introduction to the topic the scope of the small farms is farms with UAA of 0-2 ha for small farms, since a big portion of family farms are included in this scope with medium size of 0-6.5 ha (Eurostat, 2020) [71], they are as well object of our research. The chosen PESTEL analysis is used to highlight the role of the small and family farms and their state and development in the Bulgarian rural areas. This PESTEL is based on research that is specifically of small farms in Bulgaria and official statistical reports. This research firstly conducts a research based on literature review on other Bulgarian authors and then based on this conduct a desk Research, logical, expert method, to reveal the state and problems of small and family farms in rural areas. PEST analysis is an analysis of the influence of political, economic, socio-cultural, and technological indirect environments (Aguilar, 1967) [1], with indirect effects on the object of study. At the beginning of the new millennium, there are authors who, in perfecting management theory (Carr & Nanni, 2009) [13] that define PESTEL and its various variations in relation to the environment. In strategic management, this type of analysis is used to identify, track and assess the changes that will occur in these environments and the underlying factors and the severity with which they affect it. This is done because these changes can

change the whole competitive situation in the industry.

Figure 1 presents the components of PESTEL analysis.

Political factors (P) include analysis of: government regulation of business, commercial law, labor legislation, tax legislation, legislation in the field of import and export regulation, competition protection, consumer protection, environmental protection law, etc.

Economic factors (E) include an analysis of the general state of the country's economy (inflation, gross domestic product, interest rates, exchange rate, unemployment, etc.) and the ratio between small, medium and large businesses, between private and state property, the intensity and the type of competition, etc.

Socio-cultural factors (S) cover the study of demographic trends (age, sex, number, natural increase, birth rate, mortality, population migration), level of education and social groups among the population, cultural beliefs and values (traditions, customs, beliefs, religion, culture), the individual needs of people (career aspiration, way of spending free time, etc.)

Technological factors (T) analysis covers innovation and innovation, technology transfer, the availability and access to patents, the attitude towards copyright of researchers, the availability and access to the services of research institutes.

Environmental factors (E) environmental factors related to the applied technological solutions and policies in order to preserve the potential of the ecological resource in agriculture. This is a condition for the sustainability of economic systems.

Legislative framework (L) European, national, sectorial legislation forming an institutional framework that develops into business environment and operates in the primary sector of agriculture.

PESTLE as an analytical method has its advantages as well as certain disadvantages, which we will discuss briefly.

Advantages of PESTLE analysis are: • Easy to do, the costs are only time spend on the analysis; • Provides insight into the broader business environment; • Promotes the growth of strategic thinking; • Increase awareness of project threats; • Can assist the organization in anticipating future challenges and taking steps to mitigate or lessen their effects; • Can assist the organization in identifying and seizing opportunities.

Disadvantages of PESTLE analysis: • Usually provides a simple list without critical presentation; • The rapid pace of change in society makes it increasingly difficult to predict events that may affect the organization in the future; • Gathering a large amount of information can make it difficult for us to see the "forest behind the trees" and lead to "analysis paralysis"; • The analysis may be based on assumptions that may be unfounded. Given the objectification of the analysis and the achievement of reliable results, the presence of high expertise by those applying the PESTLE analysis is an imperative require.

RESULTS AND DISCUSSIONS

The empirical data reveal a profound structural transformation in Bulgarian agriculture, characterized by a sharp decline in the number of small farms across all size categories. Between 2010 and 2020, holdings with 0 ha declined from 13,148 to 5,564, reflecting a significant contraction in non-market-oriented agricultural activities. A more pronounced decline is observed in farms between 0 and 1 ha, which decreased from 248,015 to 37,452, marking a six-fold reduction. Similarly, holdings within the 1 to 2-hectare range contracted from 46,944 to 19,276, further underscoring a process of consolidation favoring larger-scale agricultural enterprises (Figure 2). These findings align with broader trends of land concentration observed across the EU that is especially pronounced in Eastern Europe, suggesting that Common Agricultural Policy (CAP) instruments have contributed to an uneven distribution of benefits, disproportionately favoring larger landholders over small-scale farms. The structural decline of small farms can be understood through the lens of CAP-induced market distortions and institutional incentives. The CAP’s direct payment system, which allocates subsidies based on the Single Area Payment Scheme

(SAPS), inherently favors farms with larger landholdings. Given that direct payments are predominantly area-based, farms below a critical threshold of land ownership receive minimal financial support, undermining their long-term viability and with that hindering, further the sustainability goals of the EU.

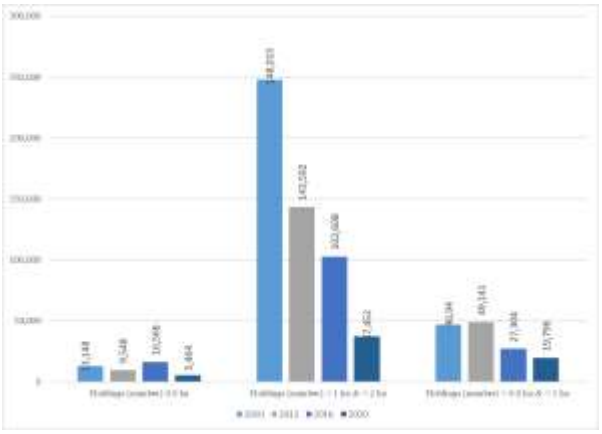

Fig. 2. Number of farms by physical size classes in Bulgaria (2020)
Source: Ministry of Agricultural (2020) [46]. Agricultural Census 2020.

This process is further exacerbated by land market dynamics, where access to CAP funding facilitates the expansion of large agricultural enterprises at the expense of smaller farms. The incentivization of land consolidation, coupled with the declining competitiveness of smallholders in CAP-subsidized markets, has led to accelerated land absorption by more capital-intensive actors. This is particularly evident in Bulgaria, where the absence of strong counterbalancing mechanisms - such as targeted small-farm support or redistributive CAP policies—has reinforced patterns of agricultural concentration. The existing threshold for small farms participation in market activities in Bulgaria is very high, combined with EU CAP policy makes the existence of small and family farms highly unsustainable, as they face structural disadvantages in accessing subsidies, markets, and investment opportunities, leading to their gradual marginalization and eventual exit from the agricultural sector. Beyond direct subsidies, CAP's investment programs have further constrained smallholder resilience. Many small farms struggle to access modernization grants due to administrative complexities, high co-financing requirements, and bureaucratic barriers, disproportionately favoring well-organized, large-scale farm enterprises. While CAP's rural development programs theoretically provide a corrective mechanism, the empirical evidence suggests that a significant proportion of funds have been allocated to larger farms with greater institutional capacity to navigate the funding process. A corresponding decline in the UAA of small farms is evident. Farms in the 0–1 ha category experienced a sharp reduction in UAA, from 81,628 ha in 2010 to 16,212 ha in 2020. A similar trend is observed for farms between 1 and 2 ha, where UAA declined from 62,550 ha in 2010 to 28,124 ha in 2020 (Figure 3).

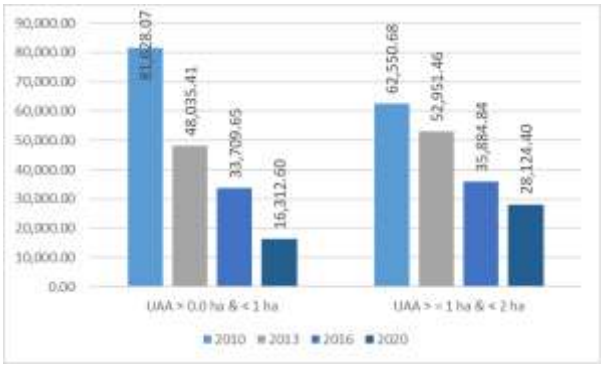

Fig. 3. Number of farms by UAA classes in Bulgaria (2020)
Source: Ministry of Agricultural (2020) [46]. Agricultural Census 2020.

This reduction in cultivated land by small farms is indicative of land abandonment, economic pressures, or transfer of land to larger agricultural holdings.
The consolidation of farmland has encouraged large-scale, export-oriented agribusinesses, favoring intensive cereal and oilseed production over diversified, locally oriented farming. In the Bulgarian case, rural labor displacement has not been accompanied by a proportional expansion of alternative employment opportunities in the rural areas. Small farms contribute to local economic diversification, particularly in agro-processing, niche organic production, and short food supply chains. Their decline reduces the multiplier effects of rural entrepreneurship, leading to a more homogenized and externally dependent rural economy and rural areas. With

land increasingly concentrated in fewer hands, rural governance structures have shifted toward oligopolistic patterns, where large-scale landowners exert disproportionate influence over local economic and political decision-making. This power asymmetry risks exacerbating social inequalities and reducing participatory governance.

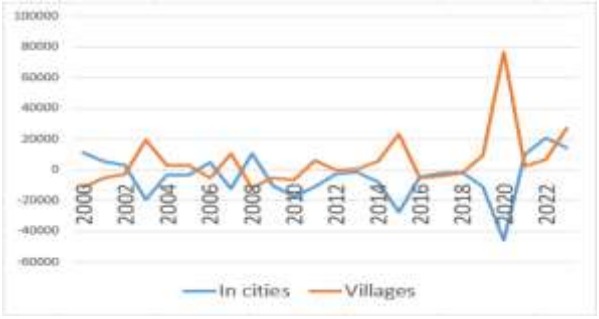

Fig. 4. Mechanical movement of population by location
Source: National Statistics Institute Bulgaria [72].

The interplay between agricultural restructuring and demographic trends has influenced, rather than uniformly exacerbated, rural depopulation and labor market imbalances. While the declining viability of smallholder farming has traditionally accelerated the migration of younger cohorts to urban centers or abroad, this process has not been linear. Fluctuations in migration patterns, particularly in 2020, likely due to external reasons such as the COVID-19 pandemic (Figure 4). While rural depopulation remains a structural issue, short-term economic and social movements can temporarily alter migration flows. As noted in the Harris-Todaro (1970) [33] migration model, rural to urban migration is driven by income differences, even if urban employment opportunities remain uncertain. However, recent patterns indicate that external factors such as health crises, housing affordability, and remote work opportunities had significant influences on these trends, with potential policy implications for rural development.

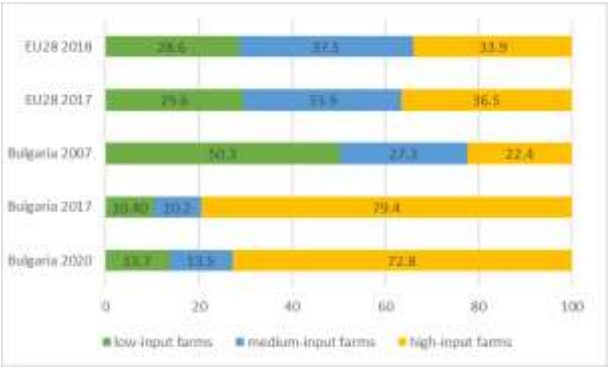

Fig. 5. Farming intensity by input type (%)
Source: EC Europe [19].

The decline of small farms has significant environmental implications (Figure 5), as land-use patterns shift in response to policy frameworks. Small farms traditionally maintain heterogeneous landscapes, incorporating diverse crops, agroforestry, and mixed livestock systems and are the last stronghold for diverse specialization. The rapid decline of low-input, farms corresponds to the loss of agrobiodiversity and landscape diversity. This has critical ecological consequences, as their replacement by large monocultural operations reduces genetic diversity, disrupts pollinator ecosystems, and increases vulnerability to climatic shocks. The transformation of Bulgarian agriculture from a predominantly small, low-input model to an industrialized, high-input system represents a shift in land use, resource allocation, and rural socio-economic structures. The empirical data presented indicate a pronounced departure from the traditional, diversified agricultural landscape toward a capital-intensive, monocultural paradigm, with profound consequences for rural sustainability. Bulgaria's shift has been rapid, policy-driven, and disproportionately shaped by external economic incentives.

Regional differences in Bulgaria

The restructuring of Bulgaria's agricultural sector has followed a highly uneven regional trajectory, with smallholder decline and land concentration manifesting differently across the country's planning regions. The empirical data provided illustrate significant regional disparities in farm structure, land use, and farm size distribution, reinforcing the argument that the decline of small farms is not only a function

of market incentives and CAP policies but also of deeply embedded spatial inequalities. This section explores the regionalized impact of land consolidation, farm structure transformation, and rural economic marginalization, contextualizing these trends within broader theoretical frameworks of agricultural transition. The contrast between capital-intensive, mechanized commodity farming in the north and labor-intensive, diversified production in the south explains the regional divide in land consolidation.

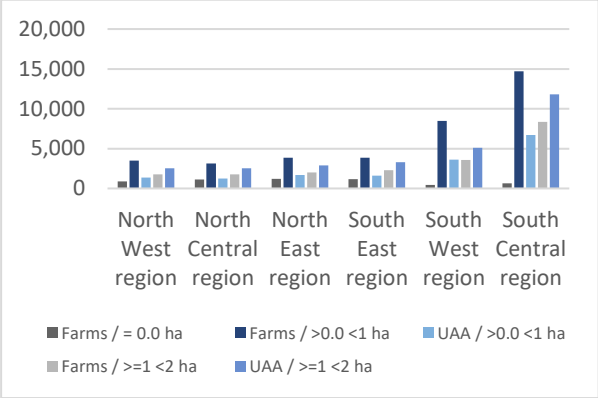

Fig. 6. Regional distribution of small farms by utilized agricultural area classes (2020)
Source: Ministry of Agricultural (2020) [46]. Agricultural Census 2020

The main trends and changes throughout this period are related to the decline in the number of small and family farms, which has hindered substantially over the course of the period in all the regions of Bulgaria (Figure 6). Farms of less than 2 ha are declining due to migration to larger farms or economic reasons such as many small farmers' incapacity to compete with larger and more advanced farms. Some small farmers sell their land or merge with others to benefit from economies of scale and better access to financing, subsidies, and technologies. In addition, small farms benefit greatly from increased mechanization and modernization. However, small and family farms frequently fail to meet the qualifying requirements or struggle to participate in European funding. A significant issue for small and family farms is migration and demographic shifts. As the population in Bulgaria's rural areas continues to decline many small farms face challenges despite efforts to boost agriculture. The agricultural workforce is weakened, and the will to expand small farms is diminished due to many young people moving to cities or overseas.

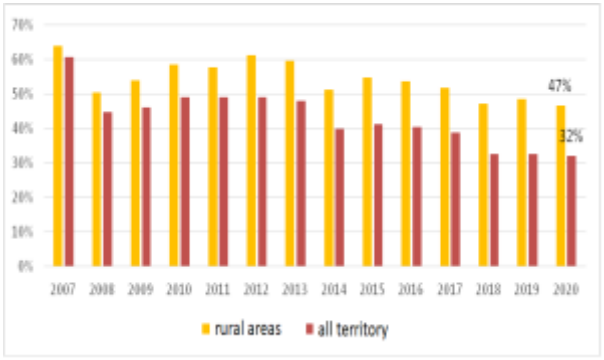

Fig. 7. Family farms in Bulgaria
Source: Eurostat [71].

Family farms makeup significant portion of farms in all territories of the country but are predominant in rural areas they are essential to the survival of family holdings and rural areas (Figure 7). Many small farms in Bulgaria continue to operate as family farms, founded on traditional production practices and frequently maintaining close relationships with the local community despite the pressure from huge agribusinesses. Nevertheless, they still have few prospects for growth and deal with economic and demographic issues.

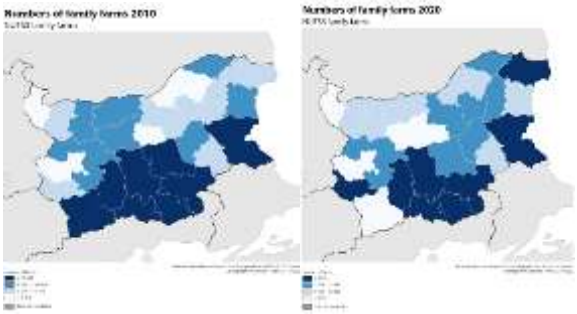

Fig. 8. Number of family farms in Bulgaria by region (2010-2020)
Source: Eurostat data [71].

The changes in these farms are related to several economic, social, and political factors that we have mentioned previously. The regional analysis reveals that the decline in family farms is not uniform across Bulgaria similarly to those of family farms. The number of family farms has decreased in all regions, with northern Bulgaria experiencing a more pronounced reduction. The maps illustrate that areas with traditionally high densities of family

farms, such as the central and western regions, have also undergone substantial contraction (Figure 8). The decline in UAA for family farms follows a similar pattern, further reinforcing the trend of increasing land consolidation (Figure 9).

The PESTEL Analysis

This analysis is done based in the literature review and is presented in Table 1.

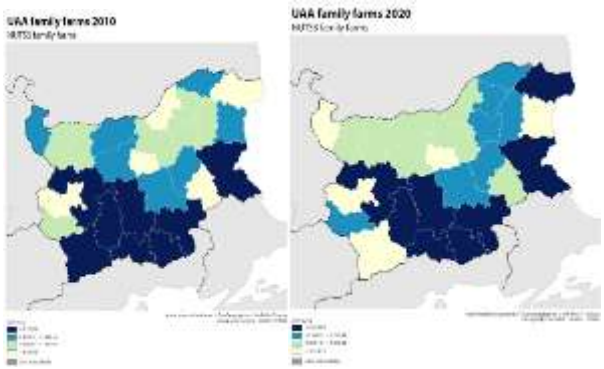

Fig. 9. UAA of family farms in Bulgaria by region (2010-2020)
Source: Eurostat data [71].

Table 1. PESTEL analysis of small and family farms based on literature review

Factors	**Analysis of Small and Family farms in Bulgarian rural areas by FACTOR**
Political factor	Small farms in Bulgaria are heavily influenced by government policies, particularly those linked to the European Union's Common Agricultural Policy (CAP). The CAP aims to provide financial support to farmers, but it has historically favored larger farms due to economies of scale and bureaucratic requirements (European Commission, 2021) [19]. the new CAP 2023–2027 mandates a redistributive payment (at least 10% of direct subsidies) targeted at small and medium farms (The Greens/EFA, 2018) [65]. The new EU plan is capping large farm subsidies to allocate more resources to small farms (European Parliamentary Research Service, 2022) [22]. Financial aid to small farms has often been ineffective or unequal, with larger farms (Beluhova-Uzunova et al., 2019) [9]. Administrative obstacles pose challenges for small farmers seeking CAP subsidies, as complex application processes and lack of support services hinder their ability to secure funding (Harizanova-Bartos & Stoyanova, 2023) [30]. Frequent political shifts in Bulgaria lead to policy instability, affecting the predictability of agricultural regulations and subsidy programs (Doitchinova, 2022) [17]. Post-1991 land reforms in Bulgaria led to significant land fragmentation, making it difficult for small farms to consolidate and remain competitive (Yanakieva, 2007) [69].. Bulgaria's agricultural regulations and compliance are challenging for small farms (Fredriksson et al., 2021) [26]. CAP second pillar for rural development includes measures like the Small Farmers Scheme but has complex application procedures (European Parliamentary Research Service, 2022) [22]. Insufficient tailored support for small-scale farmers affects rural communities and biodiversity, targeted financial programs for small farms enhance sustainability and competitiveness (Koteva, 2020) [37]. Promoting cooperation among small farms improve market access and resource-sharing opportunities (Bachev et.al, 2024) [5].
Economic factor	Bulgaria's agriculture is highly polarized, with small farms controlling a minor share of agricultural land, while large farms dominate the sector (Nikolov et al., 2015) [54]. Small farms struggle to enter large retail chains, making them reliant on local markets for sales (Nikolova, 2020) [55]. Economic pressures, including market competition from large agribusinesses and imported agricultural products, limit smallholders' market share and profit margins (Branzova, 2018) [11]. In times of economic crisis, such as during the COVID-19 pandemic and the war in Ukraine, small farms have played a vital role in ensuring food security by supplying local markets with fresh produce (Kabadzhova et al., 2024) [34]. Small farms have a crucial societal function in providing jobs and a means of subsistence for their owners' households, but they have little opportunity of improving their market positions in regional marketplaces (Todorova, 2023) [66]. Access to financing remains a critical issue for small farms. Due to their limited assets, small farmers struggle to secure loans, leading to underinvestment in modern technology and infrastructure (Fredriksson et al., 2021) [26]. Small farms struggle to accumulate capital for reinvestment, due to low profitability (Koteva & Fidanska, 2018) [38]. Lack of financial resources prevents investment in modernization and innovation, restricting competitiveness (Ahmedova, 2015) [2]. Economic challenges represent a significant weakness for small farms by limiting their ability to compete with large farms. Lack of financial resources, restricted market access, and difficulties in obtaining funding contribute to instability (Nikolova, 2020) [55] due to limited collateral and high perceived risk from banks (Dirimanova & Ivanova, 2014) [16]. They have limited market integration due to weak competitiveness and difficulty accessing value chains dominated by large agribusinesses (Fredriksson et al., 2021) [26]. Small farms in Bulgaria operate with low market output and profit margins, as they produce primarily for family consumption and sell only small surpluses (Fredriksson et al., 2021) [26]. Public support is crucial for the economic sustainability of small farms, as there is a strong correlation between subsidies and small-farm incomes (Kirechev, 2024) [35]. Small farms develop new production in unconventional agricultural activity by introducing and establishing new production, which depends on nonagricultural activity to increase profits (Nikolova & Linkova, 2011) [56]. NAAS provides free advisory support in crop production, livestock farming, agrarian economics, and access to rural development programs (National Agricultural Advisory Service, 2024) [51]. NAAS organizes training sessions and seminars to improve farmers' skills and helps small farms prepare project applications for rural development funding (European Commission, 2024) [19].
Social factor	Demographic shifts present a significant challenge for small farms. Bulgaria's rural areas have experienced severe depopulation, with younger generations migrating to urban centers or abroad (Aleksandrova & Kabadzhova, 2020) [3]. The labor shortage in agriculture are exacerbated by rural depopulation, making it difficult for small farms to operate efficiently (Marinov, 2019) [41]. Aging farmer demographic combined with the decline in workforce threaten the sustainability of small farms and rural development (Bachev at. al., 2024) [5].

	Youth migration to bigger cities and foreign countries reduces rural workforce and weakens social support for small farms. Economic downshifts and change in family structures affect small farms' ability to sustain long-term operations (Touch et al., 2024) [67]. Small farms maintain traditional farming techniques, local crop varieties, and livestock breeds, contributing to agricultural and biodiversity conservation (FAO, 2022) [23]. Small farms strengthen rural communities by helping local cooperation, maintaining traditions, and fostering a sense of belonging among residents. They contribute to rural economic stability and reduce dependence on external markets by providing employment and producing local goods (Bachev at. al, 2024) [5]. Greater adoption of innovation in small-scale farming are facilitated by increasing access to training programs and technological subsidies could facilitate (Barducz & Jitea, 2024) [8]. The increase in demand for organic and locally produced food by fostering change in consumer preference, provides opportunity for small farmers to engage in short supply chains and direct-to-consumer sales (Korpelainen, 2023) [36]. A great contribution to regional economic development is seen thanks to rural tourism initiatives, where small farms serve as eco-tourism destinations, (Harizanova-Bartos et al., 2020) [31].
Technological factor	Small farms in Bulgaria face challenges in adopting new agricultural technologies. Investments in modern irrigation systems, automation, and precision farming technologies are hindered by limited financial resources (Sun et al., 2024) [64]. Small farms in Bulgaria lag in technology adoption and mechanization, as many use outdated machinery and techniques (Fredriksson et al., 2021) [26]. Automated systems optimize resource use, improve yield quality, and reduce environmental impact. Bulgarian companies like Ondo offer automated irrigation and climate control solutions (Para Expert, 2025) [57]. Drones assist in monitoring crop health, assessing soil conditions, and improving pesticide application, as ProDrone Sys provides aerial surveying services for Bulgarian farmers (Para Expert, 2025) [57]. Additionally, digitalization in the agricultural sector is lagging, with few small farmers utilizing e-commerce platforms to sell their products (Madureira et al., 2024) [40]. That leads to fewer opportunities to adopt cost-saving technology or expand, as instead, farmers try to cope by diversifying production to spread risk (Mihailova, 2020) [44]. The intergenerational knowledge transfer related to farming practices is hindered by depopulation trend results in an aging agricultural workforce and a decline (Zobena, 2023) [70]. The development of pest-resistant and climate-adapted crop varieties enhances sustainability in small farms (Regional Development Union, 2022) [59]. Agricultural apps provide farmers with weather forecasts, market information, and farming best practices, aiding decision-making. Modern technologies help reduce costs and labor input (Doitchinova & Stoyanova, 2024) [18]. Technological advancements enhance the quality of agricultural output, making products more competitive in the market (NIK Agriculture, 2024) [53]. Many small farms struggle to afford advanced agricultural technologies (Aleksiev, 2023) [4] and have limited training opportunities hinder effective adoption of modern farming techniques (Branzova & Dimitrova, 2023) [10]. Technological advancements in organic farming, such as low-input and sustainable agricultural techniques, present an opportunity for smallholders to align with EU environmental policies while improving productivity (Dimitrova, 2024) [15]. The digital revolution in agriculture marginally touched Bulgaria's small farms, reason is limited internet connectivity and digital skills in many rural areas (Dirimanova & Ivanova, 2014) [16].
Ecological/ Environmental factor	In Bulgaria, the Ministry of Agriculture and Food provides training initiatives for improving farmers' knowledge of sustainable practices, soil health, and climate adaptation (Ministry of Agriculture and Food, 2025) [47]. Farmers are showing cautious but growing interest in precision agriculture technologies, recognizing benefits for efficiency and sustainability, despite concerns over cost and complexity (Sarov et al., 2024) [61]. Small farms often utilize diverse cropping systems and traditional farming practices that promote biodiversity and ecosystem resilience (National Agricultural Advisory Service, 2025) [52]. Climate change represents a significant threat to small farms in Bulgaria, with increasing droughts, extreme weather events, and soil degradation reducing agricultural yields (Stoyanova, 2022) [62]. They are more exposed to climate change effects, such as droughts and extreme weather, making sustainable farming harder to maintain (FAO, 2024) [25]. Local farmers play a key role in maintaining environmental knowledge and sustainability within their communities (FAO, 2024) [25]. Small farms, however, often employ traditional and ecologically friendly farming methods that support the EU's Green Deal objectives, such as crop rotation, permaculture, organic farming, and low pesticide use (Suman et al., 2025) [63]. Limited financial resources restrict the adoption of sustainable farming technologies, leading to reliance on conventional methods (Bailly, & Muro, 2024) [6]. Maynard, H., & Nault, J. (2005) [42] think that the ability of life support systems to maintain the quality of the environment while contributing to other sustainability objectives. Enhancing financial incentives for agroecological practices could help mitigate the negative impact of climate change on small farms (Ricciardi et al., 2018) [60]. Bulgarian small farms being eligible for subsidies to adopt or maintain sustainable practices allocated by EU funding to encourage organic farming (European Court of Auditors, 2024) [21]. Implementation measures to minimize greenhouse gas emissions primarily impacted small farmers and farms that were unable to adapt to climate change (Petkov et al., 2017) [58]. The emphasis on sustainable farming presents both a challenge and an opportunity. While EU environmental policies promote biodiversity and low-carbon farming, compliance costs may be prohibitive for smallholders. Bulgaria's National Strategy for Biodiversity Conservation acknowledges the role of small farms in preserving biodiversity and promotes incentives for conservation-oriented agriculture (European commision, 2023) [20]. Compared to large-scale industrial farms, small farms generally have a reduced environmental impact, producing fewer emissions and maintaining ecological balance in rural areas (Lin et al., 2011) [39].
Legal factor	The post-socialist land restitution policies resulted in highly fragmented land ownership, complicating efforts to consolidate plots into economically viable farm sizes (Food and Agricultural Organization of the United Nations, 2002) [24]. Restitution for the reinstatement of private property and its subsequent acquisition by the former owners and their heirs have been fraught with issues and had lasting effect on small farms and their decline (Georgiev, 2024) [27]. Strict food safety and organic certification requirements place a disproportionate regulatory burden on small farms compared to large agribusinesses (Guarín et al., 2020) [29]. The implementation of CAP measures favors large farms, as smaller farmers often lack the administrative capacity to comply with funding requirements (Harizanova-Bartos & Terziyska, 2020) [32]. Simplifying bureaucratic procedures and offering tailored legal support to small farmers could improve their competitiveness within the agricultural sector (Băluță et al., 2024) [7]. Small farms have access to CAP funding, but complex application processes limit participation

	(European Commission, 2024) [19]. The "National Strategy for Small and Medium Enterprises 2021–2027" outlines measures to improve small farms' competitiveness (Ministry of Economy, 2020) [48]. The "National Program for Action" focuses on combating land degradation and promoting sustainable land use (Ministry of Environment and Water, 2015) [49]. The "Farm to Fork" strategy under the European Green Deal promotes fair, sustainable, and eco-friendly food systems, emphasizing support for small-scale farmers (European Commission, 2020) [19]. Local and regional markets supply a large part of the agricultural sector, which most private farms in Bulgaria are small (Todorova, 2023) [66]. The "Thematic Sub-programme for the Development of Small Farms" (Rural Development Program 2014–2020) provides financial aid and starting, development and investment support to small farms (Ministry of Agriculture and Food, 2017) [46]. Strengthening agro-environmental measures in rural development programs to enhance sustainability and resilience in small farms (European Commission, 2020) [19].

Source: Summarized based on literature review.

CONCLUSIONS

Small and family farms in Bulgaria play an essential role in food security, rural employment, and biodiversity conservation. However, they face significant challenges in accessing financing, overcoming regulatory barriers, and adapting to technological and environmental changes. Targeted policy reforms, financial support, and digitalization initiatives are necessary to ensure the long-term sustainability of smallholder agriculture in Bulgaria. This raises critical questions regarding the long-term implications of CAP on rural socio-economic diversity, land ownership concentration, and food system resilience. Future policy reforms must consider redistributive mechanisms, such as progressive area-based payments and targeted support for small farms, to mitigate the unintended consequences of CAP-induced land consolidation. The structural decline of small farms in Bulgaria is not merely an agricultural transition but a broader rural transformation with far-reaching socio-economic and environmental consequences. The evidence suggests that CAP's existing policy framework has disproportionately favored land concentration, reinforcing economic polarization, rural depopulation, and environmental degradation. If left unaddressed, these trends will irreversibly reshape Bulgaria's rural landscape, leading to a long-term loss of rural economic diversity, environmental sustainability, and social cohesion. Future policy adjustments must therefore prioritize inclusivity, resilience, and sustainability, ensuring that rural development is not merely a byproduct of agricultural modernization but a central objective in its own right. Future research should explore longitudinal econometric analyses of CAP's impact on rural income distribution and land tenure dynamics, providing a data-driven foundation for evidence-based policy reform.

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REFERENCES

[1]Aguilar, F., 1967, Scanning the business environment, New York, Macmillan, USA.
[2]Ahmedova, S., 2015, Factors for increasing the competitiveness of small and medium-sized enterprises (SMEs) in Bulgaria. Procedia-Social and Behavioral Sciences, 195, 1104-1112.
[3]Aleksandrova, S., Kabadzhova M., 2020, Diversification of the economic activities – a better future for Bulgarian rural areas, International Conference "European agriculture and the new CAP 2021-2027: Challenges and opportunities", Institute of Agricultural Economics, Sofia, 20(1), 51-62.
[4]Aleksiev, G., 2023, Social networks - A tool for cooperation of Bulgarian agricultural produce. Conference Proceedings „Innovative development of agricultural business and rural areas", 28 – 29.09.2023, Sofia, 220-227.
[5]Bachev, H., Mihailova, M., Terziev, D., Geogiev, M., Dimova, N., Marinov P., Mikova, R., Blagoeva, S., 2024, Vuvedenie v ikonomikata na agrarnite dogovori (Introduction to the economic of agricultural contracts), Institute of agricultural economics.
[6]Bailly, S., Muro, M., 2024, The costs and benefits of transitioning to sustainable agriculture in the EU https://ieep.eu/wp-content/uploads/2024/07/The-costs-and-benefits-of-transitioning-to-sustainable-agriculture-IEEP-2024.pdf , Accessed on 05.02.2025.
[7]Băluță, A.D., Ivan, V.D.I., Iagăru, R., 2024, Strategic management of sustainable rural economy development in Vaideeni community, Valcea county, Romania.

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development. 24(4), 67-81.
[8]Barducz, E.A., Jitea I.M., 2024, Risk management at the level of Romanian small and medium-sized agricultural business - a systematic literature review. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 24(4), 83-94.
[9]Beluhova-Uzunova, R., Hristov, K., Shishkova, M., 2019, Small farms in Bulgaria – trends and perspectives. Agricultural Sciences, 11(25), 39-45.
[10]Branzova, P., Dimitrova, A., 2023, Agricultural irrigation - Innovative solutions. Conference Proceedings „Innovative development of agricultural business and rural areas“, 28-29.09.2023, Sofia, 126-133.
[11]Branzova, P., 2018, Development of the farmers' markets in Bulgaria. Proceedings of the International scientific and practical conference “Bulgaria of regions”, 1, 223-230.
[12]Bulgaria relocation, 2024 (August 13), Agriculture and village life in Bulgaria. https://bulgariarelocation.org/articles/agriculture-and-village-life-in-bulgaria Accessed on 05.02.2025.
[13]Carr, L. P., Nanni, A. J., 2009, Delivering results: Managing what matters. New York: Springer, 44-45.
[14]Conway, S. F., McDonagh, J. O. H. N., Farrell, M., Kinsella, A., 2019, Human dynamics and the intergenerational farm transfer process in later life: A roadmap for future generational renewal in agriculture policy. International Journal of Agricultural Management. Institute of Agricultural Management, vol. 8(01), August.
[15]Dimitrova, A., 2024, Risk Management in Production Structures–Realities, Challenges and Opportunities. Economic Thought journal, Bulgarian Academy of Sciences, Economic Research Institute, Issue 3, pp.353-366.
[16]Dirimanova, V., Ivanova, B., 2014, The effectiveness of advisory services to respond to demands of diverse types of small-scale farmers: The role of advisory services for the new established and semisubsistence farmers in Bulgaria. Report for AKIS on the ground: focusing knowledge flow systems of the PRO AKIS project. www.proakis.eu/publicationsandevents/pubs, Accessed on 05.02.2025.
[17]Doitchinova, J., 2022, Bulgarian agriculture in search of innovative approaches, solutions and structures, Conference proceedings: Innovative development of agricultural business and rural areas, 13-22.
[18]Doitchinova, J., Stoyanova, Z., 2024, Regional Aspects of Transformations in Agriculture: The Case of the Republic of Bulgaria. Sustainability, 16(23), 10711.
[19]European commission, 2020-2024, https://agriculture.ec.europa.eu/common-agricultural-policy/income-support/additional-schemes/payments-small-farmers_en Accessed on 05.02.2025.
[20]European commission, 2023, Biodiversity strategy for 2030 https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030_en, Accessed on 05.02.2025.
[21]European court of auditors, 2024, Special report 19/2024: Organic farming in the EU – Gaps and inconsistencies hamper the success of the policy 23/09/2024, https://www.eca.europa.eu/en/publications?ref=sr-2024-19 Accessed on 05.02.2025.
[22]European Parliamentary Research Service, 2022, https://www.europarl.europa.eu/RegData/etudes/BRIE/2022/733630/EPRS_BRI(2022)733630_EN.pdf, Accessed on 05.02.2025.
[23]Food and Agricultural Organization of the United Nations, 2022, Biodiversity for food and agriculture frequently asked questions /https://openknowledge.fao.org/server/api/core/bitstreams/f8a81c95-88b1-4a5e-bbbb-cb4ded5434fb/content Accessed on 05.02.2025.
[24]Food and Agricultural Organization of the United Nations, 2002, Land fragmentation and land consolidation in the agricultural sector. A case study from Bulgaria. 1-91.
[25]Food and Agricultural Organization of the United Nations, 2024, Sustainable Food and Agriculture
[26]Fredriksson, L., Rizov, M., Davidova, S., Bailey, A., 2021, Smallholder farms in Bulgaria and their contributions to food and social security. Sustainability, 13(14), 7635.
[27]Georgiev, M., 2024, Legal issues in the property, use, preservation, and management of agricultural lands in Bulgaria. Journal of Agricultural and Environmental Law, 19(37), 135-170.
[28]Gioia, A., 2017, Small Farms in Europe: Time for a Re-Definition Eco Ruralis. 17, 71-88.
[29]Guarín, A., Rivera, M., Pinto-Correia, T., Guiomar, N., Šūmane, S., Moreno-Pérez, O. M., 2020, A new typology of small farms in Europe. Global food security, 26, Artículo 100389.
[30]Harizanova-Bartos, H., Stoyanova, Z., 2023, Risk Management in Agriculture: Lesson from Bulgaria, Eurasian Studies in Business and Economics. In: Eurasian Business and Economics Perspectives, Proceeding of the 38th Eurasia business and Economics Society Conference, Springer, 167-178.
[31]Harizanova-Bartos, H., Stoyanova, Z., Harizanova-Metodieva, T., 2020, Rural development in Bulgaria: some factors and conditions for success. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development. 20(1), 237-244.
[32]Harizanova-Bartos, H., Terziyska, R., 2020, Opportunites for the development of small farms in Bulgaria. Agricultural University – Plovdiv, Scientific Works, LXII(2), 53-60.
[33]Harris, J.R., Todaro, M.P., 1970, Migration, Unemployment and Development: A Two-Sector Analysis, American Economic Review, 60 (1): 126–142, JSTOR 1807860
[34]Kabadzhova, M., Mihaylova, M., Tsvyatkova, D., 2024, Farmers' attitudes to implementation of CAP

greening practices in both the Blagoevgrad and Kyustendil regions in Bulgaria. Economic Studies, 33(1), 128-149.
[35]Kirechev, D., 2024, A study of the net income–subsidy relationship on small farms in Bulgaria. In Proceedings of the Department of Agricultural Economics – Varna, 1, 146-181.
[36]Korpelainen, H., 2023, The role of home gardens in promoting biodiversity and food security. Plants, 12(13), 2473.
[37]Koteva, N., 2020, Razvitie na zemedelskite stopansta I selskite domakinstva v usloviata na OSP (Development of agricultural holdings and rural households under the CAP) Publisher: Institute of Agricultural Economics, 21-26
[38]Koteva, N., Fidanska, B., 2018, evelopment and Support of Small Farms in Bulgaria, Bulgarian Journal of Agricultural Economics and Management, 1(63), 3-18.
[39]Lin, B. B., Chappell, M. J., Vandermeer, J., Smith, G., Quintero, E., Bezner-Kerr, R., ... & Perfecto, I., 2011, Effects of industrial agriculture on climate change and the mitigation potential of small-scale agro-ecological farms. Cabi Reviews, (2011), 1-18.
[40]Madureira, T., Nunes, F., Mata, F., Vaz-Velho, M., 2024, A SWOT analysis of organizations in the agri-food chain sector from the Northern region of Portugal using the PESTEL and MEETHS frameworks. Agriculture, 14(9), 1554.
[41]Marinov, P., 2019, Index of localization of agricultural holdings and employees in the rural areas of the South Central Region for Bulgaria. Bulgarian Journal of Agricultural Science, 25(3), 464–467.
[42] Maynard, H., & Nault, J. (2005). Big Farms, Small Farms. Ottawa (Canada): Agricultural Institute of Canada. 1-44
[43]Marmol, T., Feys, B., Probert, C., 2015, PESTLE analysis, Publisher: 50Minutes.
[44]Mihailova, M., 2020, The state of agriculture in Bulgaria – PESTLE analysis. Bulg. J. Agric. Sci., 26 (5), 935–943.
[45]Milone, R., Ventura, F., 2019, New generation farmers: Rediscovering the peasantry. Journal of Rural studies, 65, 43-52.
[46]Ministry of Agriculture and Food, 2017, Annual report. https://www.mzh.government.bg Accessed on 05.02.2025.
[47]Ministry of Agriculture and Food, 2025, Annual report. https://www.mzh.government.bg Accessed on 05.02.2025.
[48]Ministry of Economy, 2020, National Strategy for Small and Medium Enterprises 2021–2027, https://www.fmfib.bg/en/knowledgehub/document/125/overview, Accessed on 05.02.2025.
[49]Ministry of Environment and Water, 2015, The "National Program for Action" https://www.moew.government.bg/en/water/, Accessed on 05.02.2025.
[50]Nagayets, O., 2005, Small farms: current status and key trends. The future of small farms, 355, 26-29.
[51]National Agricultural Advisory Service, 2024, https://www.naas.government.bg/en/, Accessed on 05.02.2025.
[52]National Agricultural Advisory Service, 2025, https://www.naas.government.bg/en/ Accessed on 05.02.2025.
[53]Nik.bg, 2025, Agricultural Drones, https://nik.bg/en/precision-farming/autonomy/agricultural-drones-en/, Accessed on 05.02.2025.
[54]Nikolov, D., Chopeva, M., Radev, T., Borisov, P., 2015, Sustoyanie i perspektivi za razvitie na malkite zemedelski stopanstva. (Status and prospects of development of small agricultural holdings) Avangard prima. Sofia.
[55]Nikolova, M., 2020, Opportunities and challenges in the sale of agricultural products from small and family farms in Bulgaria. Trakia Journal of Sciences, 18(Suppl 1), 549-559.
[56]Nikolova, M., Linkova, M., 2011, Risk diversification in the agricultural sector in Bulgaria. Amfiteatru Economic Journal, 13(29), 305-320.
[57]PARA expert, 2025 (January 10), Професионална асоциация по роботика, автоматизация и иновации.(Professional Association for Robotics, Automation and Innovation, https://para.expert/, Accessed on 05.02.2025.
[58]Petkov, P., Dandov, K., Teneva, N., 2017, Restoration and Sustainable Management of Irrigation and Drainage Systems and their use as a Tool for Adapting of Bulgarian Agriculture to Climate Change in the Region. Ikonomika i upravlenie na selskoto stopanstvo, 62(3), 3-16.
[59]Regional Development Union, 2022, https://www.upu.int/UPU/media/upu/files/postalSolutions/developmentCooperation/RDP2022-Europe-Central-Asia-EN.pdf https://www.mrrb.bg/en/ Accessed on 05.02.2025.
[60]Ricciardi, V., Ramankutty, N., Mehrabi, Z., Jarvis, L., Chookolingo, B., 2018, How much of the world's food do smallholders produce? Global Food Security, 17, 64–72. https://doi.org/10.1016/j.gfs.2018.05.002
[61]Sarov, A., Ivanov, B., Mihailova, M., Bozhinov, B., Vasileva, S., 2024, Statistical grouping in studying farmers' attitudes for adopting practices of precise agriculture. Bulgarian Journal of Agricultural Economics and Management, 69(1), 27–37.
[62]Stoyanova, N., 2022, The effect of climate change on agricultural production in Bulgaria. The Journal of Global Climate Change, 1(1), 33-38.
[63]Suman, S., Prusty, A. K., Deb, A., Kumari, A., 2025, Global Research Trends in Family Farming: A Bibliometric Insight. Indian Journal of Extension Education, 61(1), 25-31.
[64]Sun, Z., Tavakoli, S., Khalilpour, K., Voinov, A., Marshall, J. P., 2024, Barriers to Peer-to-Peer Energy Trading Networks: A Multi-Dimensional PESTLE Analysis. Sustainability, 16(4), 1517. https://doi.org/10.3390/su16041517
[65]The Greens/EFA, 2018, https://www.greens-efa.eu/en/ Accessed on 05.02.2025.

[66]Todorova, S., 2023, Legal aspects of cooperation in agriculture in Bulgaria. Trakia Journal of Sciences, 21(1), 186-190.
[67]Touch, V., Tan, D. K., Cook, B. R., Li Liu, D., Cross, R., Tran, T. A., ... & Cowie, A., 2024, Smallholder farmers' challenges and opportunities: Implications for agricultural production, environment and food security. Journal of Environmental Management, 370, 122536.
[68]Van der Ploeg, J. D., 2018, The New Peasantries: Rural Development in Times of Globalization (2nd ed.). Routledge. https://doi.org/10.4324/9781315114712
[69]Yanakieva, I., 2007, The agricultural land problems in Bulgaria and implementation of the Common Agricultural Policy. AgriECON, Czech, 53(4), 189–193.
[70]Zobena, A., 2023, Small farms: the potential of social farming for social inclusion in Latvia. Rural Areas and Development, 18, 107–114.5
[71]***Eurostat, https://ec.europa.eu/eurostat/data/database, Accessed on 05.02.2025.
[72]*** National Statistical Institute of Bulgaria, https://www.nsi.bg/en, Accessed on 05.02.2025.

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THE IMPACT OF AGRICULTURAL INPUTS ON CROP PRODUCTION EFFICIENCY ACROSS ROMANIAN DEVELOPMENT REGIONS: A MULTI-CROP ANALYSIS (2007-2023)

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Abstract

The paper aims to investigate the link between agricultural inputs and crop production in Romania's eight development regions over the period of 2007-2023 for the selected crops wheat, corn, barley and sunflower. The study uses data from the Romanian National Institute of Statistics to check how chemical fertilizers (nitrogen, phosphorus and potassium), mechanical equipment and other agricultural inputs influence crop production. Through correlation and regression analysis, strong and significant links between the use of chemical fertilizers and crop production with different levels of effectiveness in the regions and crops have been established. The result of the analysis revealed that phosphorus fertilizer had the highest correlation coefficient with wheat and barley production, while potassium had the highest correlation with sunflower production. It was also found that variation in the effectiveness of inputs was a crucial factor; the South-East and South-Muntenia regions were more effective in converting fertilizer inputs into output. The results show that wheat and barley are the most consistent in their response to fertilizer application (R^2 values are 0.21-0.29 and 0.24-0.25 respectively) while corn and sunflower have a relatively weaker response (R^2 values of 0.13-0.14 and 0.14-0.15, respectively). These results imply that fertilizer application should be done on a region and crop basis in order to enhance production in Romania

Key words**:** *agricultural inputs, crop production, regional development, fertilizer efficiency, Romanian agriculture*

INTRODUCTION

Agriculture represents the foundation of th eeconomical framework of Romania, by contributing to its national gross added value with aproximately 3.9% in 2023 [29], much more above the average score UE27 of 1.3% [31]. Taking into consideration that aproximately 45.7% of the Romanian population leaves in the countryside – in contrast with the EU27 avarage of 24% [32] – the importance of the field extends beyond the economical indicators including the social and teritorial development [17].

The regional agricultural development has been of main concern since Romania's entry in EU, especially regarding the process of turning into practice of the collective agricultural policy [1]. The regional variations concerning the agricultural productivity and the use of resources have become essential factors in understanding the agricultural development of Romania [4]. The differences regarding the use of farms inputs among regions especially fertilizers and pesticides [21, 22] led to variations of yields besides the influence of climate change. Each of the eight development regions in Romania presents distinctive agricultural features modeled by geographical, climatic factors and the Ministry of Agriculture and Rural Development [15] has established frames for aproaching regional agricultural challenges promoting at the same time a durable growth. Analyzing the data from the National Institute of Statistic from 2007-2023 the current research examines the connections between the agricultural inputs and the productivity in the regions in order to

offer recommendations based on evidence for optimizing the agricultural production at a regional level.

One of this important aspects of agriculture is the one referring to fertilization, which represents a fundametal pillar of modern agricultural production being essential to maintaining the fertility of the soil and maximizing the crops productivity [18]. In the last decades the fertility paradigma has been through a major transformation going through a significant transformation from the generalized application of chemical fertilizers to a sustainable, integrated approach based on data known as precise nutritional management [8, 12, 19].

The correct fertilizing ensures not only the macro and micro necessary nutrients in the physiological processes of plants, such as photosynthesis breathing or protein synthesis but also the balance between productivity and the impact of the environment. Recent studies emphasises that the traditional fertilizers NPK, although efficient, can lead to substantial losses leeching and gas emissions leading to the waters contamination and the lowering of soil quality if they are not properly managed [9].

A notable change in this field is the adoption of precision fertilization, which entails the local and synchronized appliance of nutrients according to the pants necessities, to the vegetation phase and the characteristics of the soil [16, 23, 25].

Moreover, the specific management of nutrients at plot level proved itself efficient in raising the production yield, the reducing of the greenhouse gasses emissions and the raising of farmers incomes [10, 24, 26].

This technological transformation reflects current trends in European agriculture, which is increasingly aligned with sustainability and efficiency goals [3]. By using modern technologies – sensors, satellite imagery and soil analysis – Romanian farmers are starting to adopt a data-driven farming model, where decisions are scientifically based. This step is essential to increase the competitiveness of the agricultural sector in the context of the European single market.

National and European agricultural policies also encourage the transition to sustainable practices through financial allocations and direct incentives, which contributes to the widespread adoption of modern methods of fertilization and soil management [2]. In this sense, the role of agriculture is no longer limited to food production, but extends to essential ecological and social functions [13, 20]. In combination with practices of conservative agriculture such as direct seeding and the keeping of the vegetal waste fertilization becomes not only an agricultural technique but an instrument to protect the environment and to fight climatic changes [14].

Modern fertilization is no longer regarded as a simple appliance of nutritive substances but as a complex process integrated part of the intelligent agriculture which contributes to the global food safety conserving the natural resources and to the agroecosystems towards the climatic stress. Thus, the integrated strategies of fertilizing based on the combination of organic and mineral fertilizers, the rotation of crops and the continuous analysis of the soil are fundamental for a durable agriculture in the long term [7].

Another important aspect is the economical one. Therefore, the technological modernization of fertility is not only an answer to the environmental changes but also a strategic economical process which offers opportunities for the development of new products and the raise of competitiveness in the global agricultural industry [11].

The importance of studying the efficiency of fertilizers in the Romanian agriculture is emphasised by the country's position as a major producer of corn in the EU, having approximately 2.6 million cultivated hectares in 2015 (Tudor et al., 2017) [27]. Despite this and although Romania has the biggest cultivated area, the yields are significantly behind other EU countries, emphasizing the critical necessity to optimize the use of inputs.

Recent research has shown that the use of nitrogen fertilizers has a significant impact on the wheat production in Romania, the studies having shown that 78.76% from the variation of the production can be due to the levels of applying the nitrogen fertilizers [28].

The same study has shown that fertilizer consumption rates in Romania are significantly lower than in other countries in EU, having an average of only 38.65 kg N/ha, in contrast with higher rates in countries such as Poland (96.24 kg N/ha) and France (110,80 kg N/ha), emphasizing the potential to optimize the efficiency of using fertilizers.

In this context, the purpose of the paper is to investigate the link between agricultural inputs and crop production in the eight development regions of Romania, during the period 2007–2023, for wheat, corn, barley and sunflower crops.

MATERIALS AND METHODS

This research uses quantitive data from the National Institute of Statistics (NIS) of Romania for the years 2007, 2014, 2019, 2020, 2021, 2022 și 2023.

The set of data comprizes four major essential crops from the agricultural production in Romania: wheat, corn, barley and sunflower. For every crop we have collected data regarding the production volumes, the cultivated areas and the agricultural inputs from eight development regions of Romania, established by the law no. 315/2004 North-West, Center, North-East, South-East, South-Muntenia, Bucuresti-Ilfov, South-West Oltenia and West [4].

The study analyzes three different categories of agricultural inputs: chemical fertilizers (nitrogen, phosphorus and potassium), mechanical equipment (tractors, combines and seeders) and other factors of production including natural fertilizers and pesticides. We use the analysis of the correlations to examine the relation between these inputs and the vegetal production with levels of significance established at $p<0.01$ and $p<0.05$ because this statistic approach allows us to quantify the power and the direction of the relations between the agricultural inputs and the results of the productivity.

The statistic analysis was done using IBM SPSS Statistics Version 25.0, while the organizing of the data and preliminary calculations were done using Microsoft Excel 2019.

This methodological aproach is in agreement with the recent studies concerning the agricultural regional efficiency in Romania. As Chivu et al. (2020) [6] shows, the analysis of the agricultural productivity using the function Cobb-Douglas in classical form.

For the entries that present significant correlations we do regression analysis using the model:

$MP = \beta_0 + \beta_1 F + \varepsilon$

- MP represents the average productions
- β_0 is the constant term
- β_1 is the regression coeficient
- F represents the intake of fertilizers
- ε is the error term

The validity of the model is evaluated through the values R square, F statistics, Durbin-Watson statistics and the beta standardized coefficients.

This methodological frame is in agreement with current standards in the agricultural economical research [11] integrating at the same time the regional specificities of the Romanian agriculture.

The methodology followed the approach of systematic revision described by Dumitru et al. (2023) [9], where the data were collected through extensive searches in the databases, focusing on the publications revised by colleagues referring to the vegetable production and the impact of climatic changes. The systematic revision was combined with the bibliometric analysis to identify the main tendencies and models of research in the field.

RESULTS AND DISCUSSIONS

The regional distribution of the agricultural production

The analysis of the agricultural productions in the development regions of Romania shows distinctive models regarding the crops distribution and the varieties of the yield.

During the evaluated period of time (2007-2023), there have been significant differences between regions in volume as well as in the efficiency of the agricultural production.

Table 1. The regional distribution of the agricultural production (the average on the selected years 2007-2023)

Region	Wheat (kg/ha)	Corn (kg/ha)	Barley (kg/ha)	Sunflower (kg/ha)
North-West	3,746	4,869	3,530	2,084
Centre	3,862	5,337	3,763	2,379
North-East	3,319	4,001	3,212	1,812
South-East	3,291	3,652	3,549	1,815
South-Muntenia	3,820	4,221	3,958	2,010
Bucharest-Ilfov	3,850	3,941	3,808	1,848
South-West Oltenia	3,556	3,882	3,653	2,021
West	4,502	4,981	4,278	2,405

Source: Processed data NIS [30]

Table 1 presents the distribution of the agricultural production in the eight development regions of Romania for the main evaluated crops (wheat, corn, barley and sunflower). The data indicates substantial regional variations regarding the volume of the production reflecting the differences regarding the cultivated areas, the agricultural practices and the use of resources.

South-Muntenia and South-East regions have constantly shown bigger volumes of production for all the crops that have been studied, especially for the wheat and corn crops.

This model is probably due to more factors, including favorable climatic conditions, larger agricultural areas and to the agricultural practices historically established in these regions.

On the other hand, Bucurest-Ilfov and Centre regions have recorded lower production volumes, mainly because of smaller agricultural areas and because of their more urban features.

Still, these regions have often shown a bigger efficiency in what the hectare yield is concerned, especially when it comes to crops such as wheat and corn.

The temporal analysis from 2007 until 2023 shows a general tendency of growth in the efficiency of production in all the regions, although there have been significant variations from one year to the other.

These variations reflect the impact of change in the meteorologic patterns of the rates concerning the adoption of technologies and of the evolution of agricultural practices in each of the regions.

The analysis of the wheat production

The analysis of the wheat production in connection with the agricultural inputs emphasized significant correlations with more key factors especially with chemical fertilizers.

Table 2 shows coefficients of correlation between different agricultural inputs and the wheat production.

Chemical fertilizers showed the strongest associations with the results of the wheat production.

Phosphorus fertilizers showed the biggest correlation ($r=0.541$, $p<0.01$), followed by nitrogen ($r=0.523$, $p<0.01$) and potassium ($r=0.456$, $p<0.01$).

However, the mechanical equipment and other intakes presented weaker correlations, insignificant to the levels of production.

The regression analysis of the three significant relations concerning the fertilizers have shown distinctive models.

Table 2. The analysis of the correlation: the production of wheat and the agricultural intakes

Input Variable	Pearson Correlation	Significance Level
Nitrogen fertilizer	0.523	**
Phosphorus fertilizer	0.541	**
Potassium fertilizer	0.456	**
Tractors	0.239	ns
Agricultural combines	0.150	ns
Mechanical seeders	0.115	ns
Natural fertilizers	0.052	ns
Fungicide	0.194	ns
Herbicide	-0.079	ns

Source: personal processing of NIS data [30].
Note: ** significant for $p<0.01$; ns= insignificant

The model of the fertilizer based on phosphorus gave a regression coefficient of 56.545 ($p<0.01$) with a standard error of

11.253, explaining 29.2% of the variation of the production (R^2= 0.292) and showing an adequate independence of the waste (Durbin-Watson=2.320). The analysis of the nitrogen fertilizers showed a regression coefficient of 43.210 ($p<0.01$) with a standard error of 10.792, explaining 20.8% of the variant (R^2= 0.208) and maintaining an adequate waste independence (Durbin-Watson = 2.384).

These findings point to the fact that, although all the three studied fertilizers significantly influence the wheat production, the phosphorus fertilizers prove to have the strongest effect, explaining approximately 29.2% of the production variation.

The positive coefficients for all the three studied fertilizers suggest that high usage rates are associated with higher production values, although the yield drops at higher usage rates.

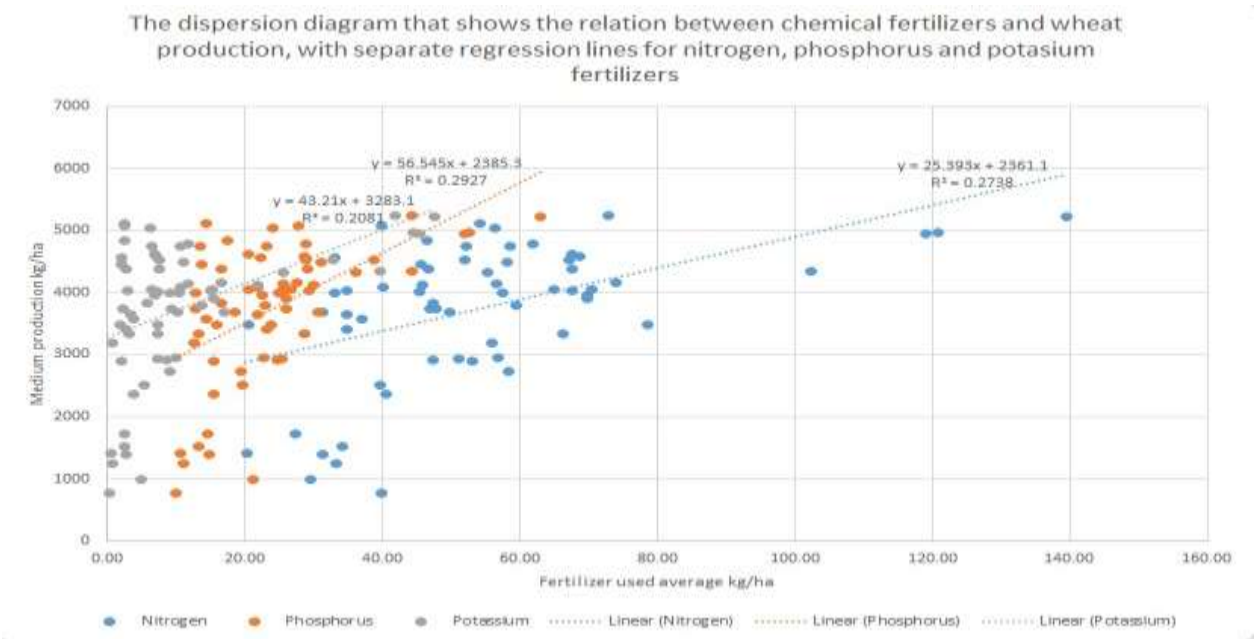

Fig. 1. The dispersion diagram that shows the relation between chemical fertilizers and wheat production, with separate regression lines for nitrogen, phosphorus and potasium fertilizers
Source: personal processing of NSI data [30].

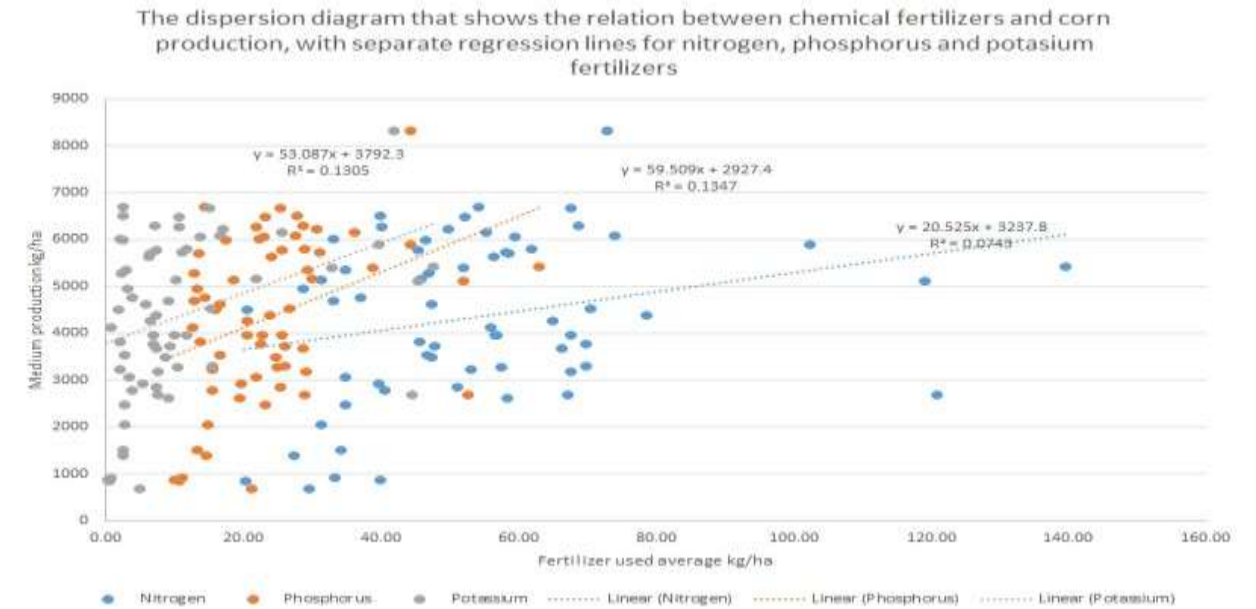

Fig. 2. The dispersion diagram that shows the relation between chemical fertilizers and corn production, with separate regression lines for nitrogen, phosphorus and potasium fertilizers
Source: personal processing of NSI data [30].

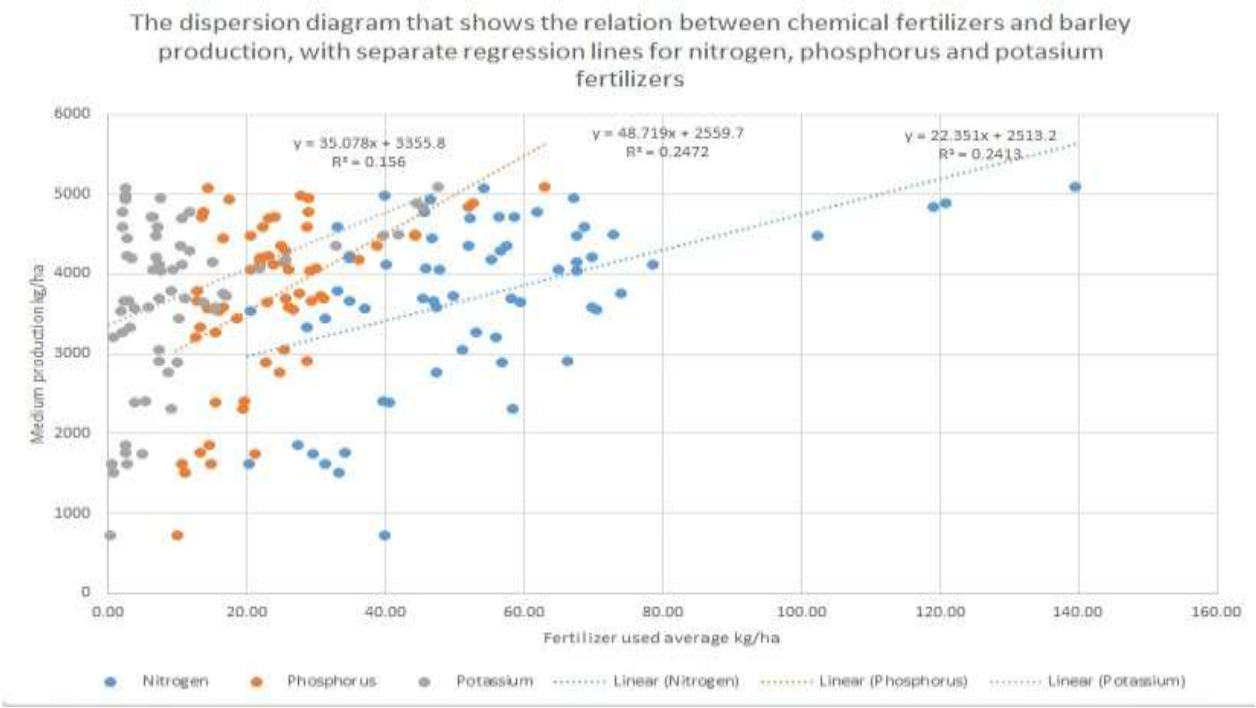

Fig. 3. The dispersion diagram that shows the relation between chemical fertilizers and barley production, with separate regression lines for nitrogen, phosphorus and potasium fertilizers
Source: personal processing of NSI data [30].

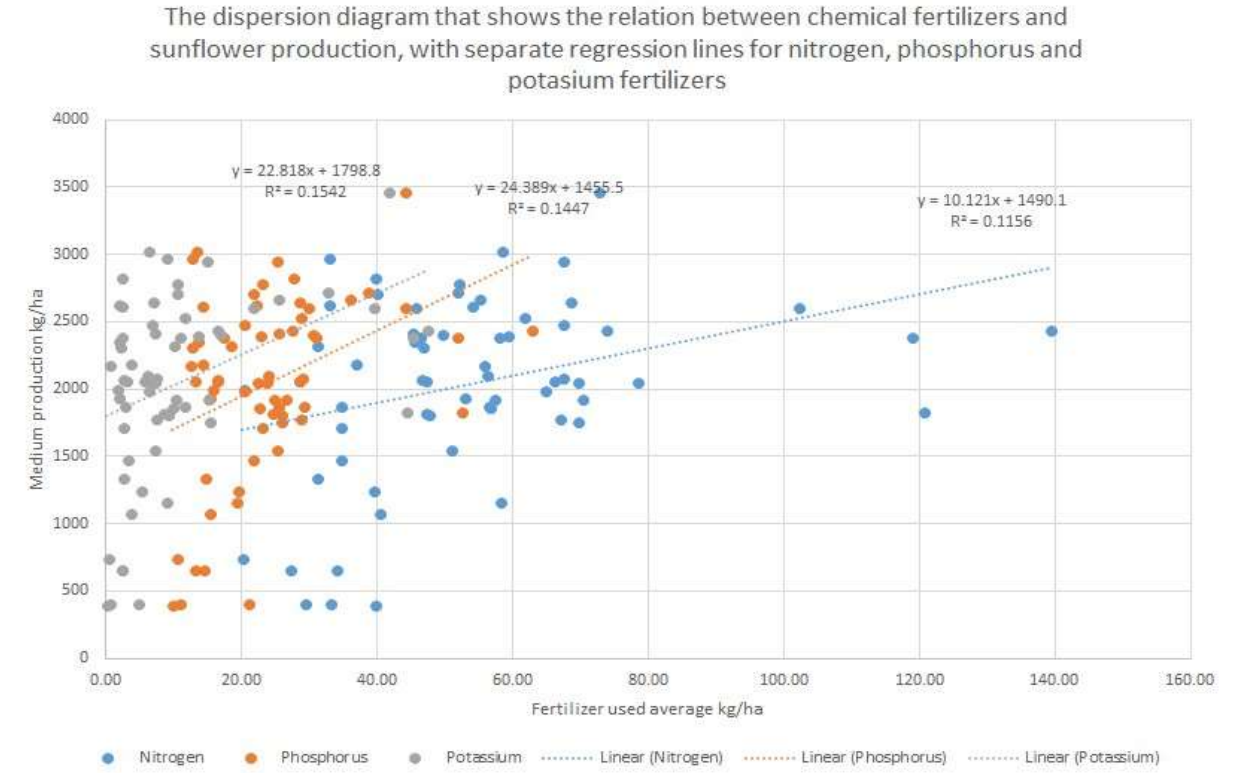

Fig. 4. The dispersion diagram that shows the relation between chemical fertilizers and sunflower production, with separate regression lines for nitrogen, phosphorus and potasium fertilizers
Source: personal processing of NSI data [30].

The analysis of corn production

The analysis of corn production emphasized different models regarding the intake efficiency in contrast with the wheat production.

Table 3. The analysis of the correlation: Wheat production and agricultural inputs

Input Variable	Pearson Correlation	Significance Level
Phosphorus fertilizer	0.367	**
Potassium fertilizer	0.361	**
Tractors	0.322	*
Nitrogen fertilizer	0.273	*
Natural fertilizers	0.260	*
Agricultural combines	0.258	*
Mechanical seeders	0.217	ns
Fungicide	0.166	ns
Herbicide	0.076	ns

Source: personal processing of NSI data [30].
Note: ** significant for p<0.01; * significant for p < 0.05; ns= insignificant.

The analysis of the correlations identified significant relations with both chemical fertilizers, as well as with mechanical equipment, as shown in Table 3.
Unlike the wheat production corn has presented moderate correlations with the mechanical equipment, especially tractors (r = 0.322, p < 0.05). Of all the chemical fertilizers, phosphorus and potassium have shown the strongest correlations (r = 0.367 and r = 0.361, p < 0.01).
The regression analysis for the most significant inputs emphasized complementary models between different types of fertilizers. The phosphorus fertilizer model had a regression coefficient of 59.509 (p<0.003) with a standard error of 1,597.274, explaining 13.5% of the production variation (R^2=0.135) and proving an acceptable independence of the Durbin-Watson=1.902. For the potassium fertilizer, the analysis revealed a regression coefficient of 53.087 (p<0.004) with a standard error of 1,691.138, being responsible for 13% of the variation (R^2= 0.130), proving an adequate independence of the residual value (Durbin-Watson = 1,936).
The regression models explain between 13% and 13.5% of the variation of the corn production, although the influence of the fertilizers applied is significant we can conclude that factors like soil quality and meteorological conditions play a more important role in determining the corn production yield in comparison with the wheat production.

The analysis of barley production

The analysis of the barley production emphasized strong correlations with the chemical fertilizers, having different models in comparison to wheat and corn. Table 4 shows the results of the correlation analysis for different agricultural inputs. Barley showed to have the strongest response to phosphorus fertilizers (r=0.497, p<0.01) and to nitrogen fertilizers (r=0.491, p<0.01), with correlation coefficients that were larger than the ones for the corn production.
The influence of the potassium fertilizer, although significant (r=0.395, p<0.01) was lower in comparison to the other two studied fertilizers.

Table 4. The analysis of the correlation: Barley production and agricultural inputs

Input Variable	Pearson Correlation	Significance Level
Phosphorus fertilizer	0.497	**
Nitrogen fertilizer	0.491	**
Potassium fertilizer	0.395	**
Agricultural combines	0.061	ns
Mechanical cultivators	0.042	ns
Natural fertilizers	0.001	ns
Fungicide	0.139	ns
Herbicide	-0.188	ns

Source personal processing of NSI data [30].
Note: ** significant for p<0.01; * significant for p < 0.05; ns= insignificant.

From regression analysis of the significant relations between fertilizers produced distinctive models, one for each type of fertilizer. The phosphorus model had a regression coefficient of 48.719 (p<0.001) and explained almost a quarter (24.7%) of the variation of the production (R^2 = 0.247) with an adequate independence of the rezidual value (Durbin-Watson = 2.161) and a standard error of 900.273. This statistical relations are visually represented in image 3, that shows the

graphical representation of the barley yield response to different fertilizers in different regions of Romania.

The regression models for barley explain approximately 24-25% of the variation of the production, having a stronger predictive relation in comparison with corn. The mechanical inputs showed a small correlation with the barley production, this find suggesting that managing fertilizers can be more useful for optimizing the yield of the barley crops than mechanical inputs.

The analysis of the sunflower production

The analysis of the production of sunflower created different models, with significant variations regarding inputs efficiency in comparison to other studied crops.

Table 5 shows the correlation coefficients between the agriculture inputs and the sunflower crop production

Input Variable	Pearson Correlation	Significance Level
Potassium fertilizer	0.393	**
Phosphorus fertilizer	0.380	**
Nitrogen fertilizer	0.340	**
Agricultural combines	0.241	ns
Mechanical seeders	0.221	ns
Natural fertilizers	0.205	ns
Fungicide	-0.171	ns
Herbicide	0.041	ns

Source personal processing of NSI data [30].
Note: ** significant for p<0.01; ns= insignificant.

In comparison with other crops in the present study, the sunflower crops proved to have the strongest response to the potassium fertilizers (r=0.393, p<0.01), followed by phosphorus (r=0.380, p<0.01) and nitrogen (r=0.340, p<0.01). The findings are in accordance with the known high potassium need of the sunflower plant for oil production.

The potassium fertilizer model had a regression coefficient of 22.818 (p<0.01) and accounted for 15.4% of the variation of the production (R^2 = 0.154), with an adequate independence of the residual value (Durbin-Watson = 1.870) and a standard error of 6.842. For the phosphorus fertilizer the model has shown a regression coefficient of 24.389 (p<0.01) and explained 14.5% of the variance (R^2 = 0.145), showing an acceptable independence of the residue (Durbin-Watson = 1.764) and a standard error of 7.592.

The regression models explain approximately 14-15% of the variation of the sunflower production, which suggests that while the chemical fertilizers play a significant part, other factors, such as the soil condition and the climate, can have a substantial impact on the production yield. The mechanical entries have presented weaker correlations in contrast with other crops, which suggests the fact that the management of the fertilizers could be more important for the optimization of the sunflower production than the mechanical intervention.

Comparative analysis

The analysis of the inputs-outputs relations for all the four crops show distinctive models regarding the efficiency of the fertilizers and the regional success.

The chemical fertilizers have constantly shown significant correlations with the production of all crops, although with different degrees of impact (Table 6).

Table 6. The comparative analysis of the impact of fertilizers on crops

Fertilizer	Wheat	Corn	Barley	Sunflower
P	0.541**	0.367**	0.497**	0.380**
N	0.523**	0.273*	0.491**	0.340**
K	0.456**	0.361**	0.395**	0.393**
R^2 range	0.21-0.29	0.13-0.14	0.24-0.25	0.14-0.15

Source: personal processing of NSI data [30].
Note: ** significant for p<0.01; ns= insignificant.

The phosphorus fertilizers have shown the strongest correlation with wheat (r=0.541) and barley (r=0.497), while the production of sunflower has shown the biggest correlation with the potassium fertilizer (r=0.393). Corn has shown more moderate correlations among all the types of fertilizers, phosphorus showing the strongest relation (r=0.367).

New successful regional models have appeared for all the studied crops, revealing distinctive tendencies regarding both the inputs efficiency and the regional performance. In what the variance of the inputs efficiency is concerned, the wheat and the barley have shown the

strongest response to the inputs of fertilizers, with R^2 values of 0.29 and respectively 0.25, while the corn and the sunflower have presented more moderate responses, suggesting a higher influence of other environmental factors. Particularly, the mechanical inputs have presented a significant correlation only with the corn production. As for the regional models of performance, the efficiency of the chemical fertilizers varied significantly according to the region, the strongest responses being noticed in the South-east region and South-Muntenia. The impact of the mechanical inputs has presented less regional variations in contrast with the chemical fertilizers, while the efficiency of the natural fertilizers remained low in all the regions and crops.

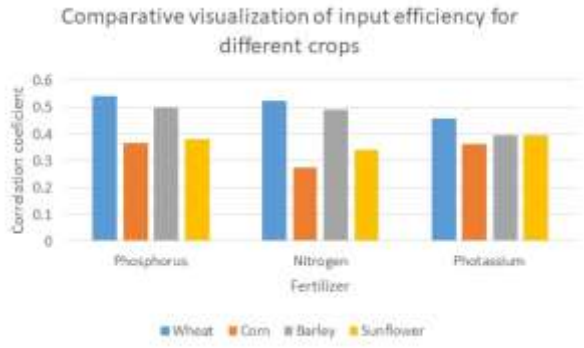

Fig. 5. The comparative visualization of the inputs efficiency amongst crops
Source personal processing of NSI data [30].

The regional distribution of the agricultural production reflects the patterns noticed by Bălan (2014) [3] in his territorial analysis. Despite the territorial distribution, which is relatively balanced, between regions (ranging from12.25% to 15.46% of the national territory) with the exception of București-Ilfov region, the agricultural production varies significantly. This variation is obvious especially in South-Muntenia region and South-East, where a combination of favorable soil conditions adequate climate and extended agricultural areas contribute to higher volumes of production of the main crops.
South-Muntenia and Sount-East regions have constantly shown higher volumes of productions [16].

The persistent regional disparities in the Romanian agricultural field by comparison to the EU model reflects significant structural challenges. As Ciutacu et al. (2015) [5] shows in their comprehensive analysis, while Romania was owning 7.7% of the utilized agricultural area of the EU, it hired 25% of the agricultural working force of the EU in 2010. Their research shows that Romanian farmers received a much smaller support only 158.3 EUR/ha, in comparison to the EU average of 274 EUR/ha, and the total support represented just 33.6% of the sectors gross added value, in contrast to 47.8% the EU average. These structural disadvantages contribute to the explanation of the variation in the regional agricultural productivity and emphasizes the necessity of more balanced support mechanisms.
This comparative analysis suggests that, although chemical fertilizers are essential for all the crops, their optimal use has to be adjusted to specific crops and to regional conditions. The variation of the R^2 values amongst crops indicate different levels of predictability of the results of the production founded on the levels of the inputs, the wheat and the barley showing the most consistent answer to applying fertilizers.

CONCLUSIONS

The analysis of the agricultural inputs and their relation to the vegetal production in the developing regions of Romania has underlined some significant models which have important applications for the management of the agriculture and policy making.
Chemical fertilizers have constantly shown significant correlations with the production f all the studied crops, although with different degrees of impact. Phosphorus fertilizers have shown strong relations with the wheat production (r=0.541) and barley (r=0.497), while potassium fertilizers have shown the strongest correlation with the production of sunflower (r=0.393). These relations suggest that the specific strategies to apply the fertilizers could significantly improve the results of the production. The regional variation in what the efficiency of the inputs is

concerned have appeared as an important factor in the agricultural productivity. The South-East and South-Muntenia regions have generally shown a stronger efficiency for converting the fertilizers input into vegetal productions, especially for the wheat and corn production. This regional variation suggests the necessity of agricultural management strategies adjusted to the local level rather than an unique approach.

The analysis has shown that different crops show different levels of response to the agricultural inputs. The wheat and the barley showed the most consistent and strongest responses to the fertilizers use (R^2 values of 0.21 -0.29 and respectively 0.24-0.25), while the corn and the sunflower have shown more moderate answers (R^2 values of 0.13-0.14 and respectively 0.14-0.15). This variation suggests that the strategies to manage the specific inputs of the crops could optimize the use of resources and improve the efficiency of the production.

These findings have more important implications for the agricultural policy and practice in Romania. The development of guidelines regarding the use of specific fertilizers to each region could improve the efficiency of inputs in different areas. The investment in testing and monitorization of the soil could contribute to the optimization of the usage rate of the fertilizers according to the local conditions. The implementation of the management strategies specific to each crop could improve the results of the production by adjusting the approaches the to the unique needs of each crop. In addition, the continuing the researches regarding other factors that affect the crops yield could offer additional information to optimize agriculture, leading to more comprehensive and efficient agricultural practices.

The results of the study offer support for making decisions based on evidence in the Romanian agriculture, particularly in what the allocation of resources and the strategies of input management is concerned. Still, monitoring and continuously analyzing the input-output relations will be essential to adjusting to the changing agricultural conditions and to the maintaining of a long term improvement of the productivity.

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REFERENCES

[1]Alexandri, C., Luca, L., 2012, The Role of Small Farms in Romania and Their Future in the Face of Challenges of the CAP Post 2013. Problems of Small Agricultural Holdings, 1, 13-30.

[2]Alexoaei, A. P., Robu, R. G., Cojanu, V., Miron, D., Holobiuc, A. M., 2022, Good practices in reforming the common agricultural policy to support the European Green Deal–a perspective on the consumption of pesticides and fertilizers, Amfiteatru Economic, 24(60), 525-545.

[3]Boix-Fayos, C., de Vente, J., 2023, Challenges and potential pathways towards sustainable agriculture within the European Green Deal, Agricultural Systems, 207, 103634.

[4]Burja, C., Burja, V., 2013, Sustainable Development of Rural Areas: A Challenge for Romania. Environmental Engineering and Management Journal, 12(8), 1535-1539

[5]Ciutacu, C., Chivu, L., Andrei, J.V., 2014, Similarities and dissimilarities between the EU agricultural and rural development model and Romanian agriculture. Challenges and perspectives. Bulgarian Journal of Agricultural Science, 20 (4), 738-745.

[6]Chivu, L., Andrei, J.V., Zaharia, M., Gogonea, R.M., 2020, A regional agricultural efficiency convergence assessment in Romania – Appraising differences and understanding potentials. Land Use Policy, 99, 104838

[7]D'Amato, R., De Feudis, M., Troni, E., Gualtieri, S., Soldati, R., Famiani, F., Businelli, D., 2022, Agronomic potential of two different glass-based materials as novel inorganic slow-release iron fertilizers, Journal of the Science of Food and Agriculture, 102(4), 1660-1664.

[8]Dobermann, A., Bruulsema, T., Cakmak, I., Gerard, B., Majumdar, K., McLaughlin, M., ... Zhang, X., 2022, Responsible plant nutrition: A new paradigm to support food system transformation, Global Food Security, *33*, 100636.

[9]Dumitru, E.A., Berevoianu, R.L., Tudor, V.C., Teodorescu, F.-R., Stoica, D., Giucă, A., Ilie, D., Sterie, C.M., 2023, Climate Change Impacts on Vegetable

Crops: A Systematic Review. Agriculture 2023, 13, 1891

[10]Dungait, J. A., Cardenas, L. M., Blackwell, M. S., Wu, L., Withers, P. J., Chadwick, D. R., ... Goulding, K. W., 2012, Advances in the understanding of nutrient dynamics and management in UK agriculture, Science of the Total Environment, 434, 39-50.

[11]Guelfi, D., Nunes, A. P. P., Sarkis, L. F., Oliveira, D. P., 2022, Innovative phosphate fertilizer technologies to improve phosphorus use efficiency in agriculture, Sustainability, 14(21), 14266.

[12]Kuldeep, Singh, A. K., Sajwan, A., Kamboj, A. D., Joshi, G., Gautam, R., ... & Kaur, J., 2024, Advances in precision nutrient management of fruit crops, Journal of Plant Nutrition, 47(19), 3251-3271.

[13]Meerburg, B. G., Korevaar, H., Haubenhofer, D. K., Blom-Zandstra, M., Van Keulen, H., 2009, The changing role of agriculture in Dutch society, The Journal of Agricultural Science, 147(5), 511-521.

[14]Micu, M. M., Dinu, T. A., Fintineru, G., Tudor, V. C., Stoian, E., Dumitru, E. A., ... & Iorga, A., 2022, Climate change—between "myth and truth" in Romanian Farmers' perception. Sustainability, 14(14), 8689.

[15]Ministry of Agriculture and Rural Development, 2014, National Rural Development Programme for the 2014-2020 period, Romania.

[16]Munir, A., Salah, M. A., Ali, M., Ali, B., Saleem, M. H., Samarasinghe, K. G. B. A., ... Anas, M., 2024, Advancing Agriculture: Harnessing Smart Nanoparticles for Precision Fertilization, BioNanoScience, *14*(4), 3846-3863.

[17]Muntean, M.C., Nistor, C., Nistor, R., 2010, Competitiveness of Developing Regions in Romania. WSEAS Transactions on Business and Economics, 7(3), 252-261.

[18]Mustafa, G., Hayat, N., Alotaibi, B. A., 2023, How and why to prevent over fertilization to get sustainable crop production, Sustainable Plant Nutrition (pp. 339-354), Academic Press.

[19]Patel, K. K., Chaudhari, N. M., Gamit, M., Chaudhari, S., 2023, Site Specific Nutrient Management in Precision Agriculture, Agriculture and Food, 44090, 262-264.

[20]Pawlak, K., Kołodziejczak, M., 2020, The role of agriculture in ensuring food security in developing countries: Considerations in the context of the problem of sustainable food production, Sustainability, *12*(13), 5488.

[21]Popescu, A., Dinu, T.A., Stoian, E., Serban, V. 2021, The use of chemical fertilizers in Romania's agriculrure. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 21(4), 469-476.

[22]Popescu, A., Tindeche, C., Marcuta, A., Marcuta, L., Hontus, A., 2021, Pesticides-A problem in Romania's agriculture? Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development 2021(4), 477–486.

[23]Radočaj, D., Jurišić, M., Gašparović, M., 2022), The role of remote sensing data and methods in a modern approach to fertilization in precision agriculture, Remote Sensing, 14(3), 778.

[24]Sapkota, T. B., Jat, M. L., Rana, D. S., Khatri-Chhetri, A., Jat, H. S., Bijarniya, D., ... Majumdar, K., 2021, Crop nutrient management using Nutrient Expert improves yield, increases farmers' income and reduces greenhouse gas emissions, Scientific reports, 11(1), 1564.

[25]Soares, J. A., et al., 2025, Design and performance of a multicomponent glass fertilizer for nutrient delivery in precision agriculture, Journal of Environmental Chemical Engineering, 13(2), 110872.

[26]Timsina, J., Dutta, S., Devkota, K. P., Chakraborty, S., Neupane, R. K., Bista, S., ... Majumdar, K., 2022, Assessment of nutrient management in major cereals: Yield prediction, energy-use efficiency and greenhouse gas emission, Current Research in Environmental Sustainability, 4, 100147.

[27]Tudor, V., Popa, D., Gimbășanu, G. F., 2017, The Analysis of the Cultivated Areas, the Production and the Selling Price for Maize Crops During the Pre-and Post-accession Periods of Romania to the European Union and Trends of Evolution of These Indicators. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 17(2), 387-394.

[28]Tudor, V.C., Stoicea, P., Chiurciu, I.-A., Soare, E., Iorga, A.M., Dinu, T.A., David, L., Micu, M.M., Smedescu, D.I., Dumitru, E.A, 2023, The Use of Fertilizers and Pesticides in Wheat Production in the Main European Countries. Sustainability, 15, 3038. https://doi.org/10.3390/su15043038

[29]National Institute of Statistics, 2024, Gross domestic product, https://insse.ro/cms/sites/default/files/com_presa/com_pdf/pib_tr4r2024_1.pdf, Accessed on 15.03.2025

[30]National Institute of Statistics, Agriculture, http://statistici.insse.ro/tempoins/index.jsp?page=tempo3&lang=ro&ind=AGR200A

[31]Eurostat Statistics Explained, Performance of the agricultural sector, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Performance_of_the_agricultural_sector Accessed on 15.03.2025

[32]World Bank, 2025, Rural population- 5 of total population, European Union, https://data.worldbank.org/indicator/SP.RUR.TOTL.ZS?locations=EU Accessed on 15.03.2025

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ANALYSIS OF SKILLS AND ABILITIES REQUIRED BY THE LABOR MARKET FOR THE DEVELOPMENT OF CIRCULAR ECONOMY IN THE RURAL AREAS OF ROMANIA

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Abstract

This paper proposes a forward-thinking approach to education management by identifying key emerging skills and capabilities that can drive innovative, cross-sector training programs. These efforts are designed to support the circular economy in rural regions and empower the creation of sustainable, future-ready business models based on the smart exploitation of resources and also using the knowledge and entrepreneurial skills needed by students to increase their employment and career opportunities, especially in the rural circular economy. The set of activities in the circular rural economy refers to all the economic activities of production, transformation and marketing of services, agricultural and forestry products and by-products and food, which are carried out by enterprises located in rural areas. The purpose of this questionnaire-based analysis is to identify new skills and personal abilities that students in rural areas need to acquire. Overall, the study concludes that fostering multidisciplinary, skills-based education is key to empowering rural populations and promoting sustainable economic growth through the circular economy.

Key words**:** *education management, circular economy, rural areas*

INTRODUCTION

The circular economy aim is to minimize environmental impact while maximizing resource efficiency [3]. In the rural area of Brăila, Romania, this model presents a valuable opportunity to revitalize the local economy, diversify income sources, and enhance environmental protection [23]. However, successfully implementing the circular economy in rural contexts demands a fundamental shift in how natural resources, agricultural production, and the consumption of goods and services are managed.

An essential part of this transition is the adaptation of farmers' and agricultural workers' knowledge and skills to meet the evolving demands of agriculture within a circular economy framework [9]. In this context, digitalization plays a crucial role in preparing the future workforce, providing tools for acquiring the competencies increasingly sought by employers [18].

To enable this shift in Brăila's rural areas, it is critical that the local workforce possesses a robust set of skills and abilities [13], [11]. These include not only technical knowledge in recycling and waste management [14], but also a solid understanding of ecological and economic processes, technological innovation, and sustainability education [13], [6], [7].

A comprehensive analysis of both short- and long-term skill requirements is necessary, one that reflects the regional context and its development potential [17], [5], [2]. This paper aims to identify the key competencies needed to support the implementation of the circular economy in Brăila's rural areas, considering current labor market needs and the existing landscape of vocational education and training. Additionally, we examine how local authorities and relevant organizations can adapt their strategies to facilitate this transition—placing a strong emphasis on continuous education and the development of human capital capable of addressing the

challenges and opportunities brought about by the circular economy.

MATERIALS AND METHODS

To identify the skills and abilities required by the labor market for the development of the circular economy in the rural areas of Brăila, Romania, a multidisciplinary approach combining theoretical research and field analysis will be used. The purpose of this research is to identify labor market requirements in the region, examine existing skills gaps and suggest directions for training and developing the human resources needed. A quantitative research approach was employed through the use of a structured survey questionnaire. The survey aimed to gather insights from key stakeholders actively involved in rural economic activities, including local employers, agricultural producers, vocational education providers, public authorities, and representatives of environmental organizations.

The questionnaire was designed to explore several key dimensions:

Awareness and understanding of the circular economy concept.

Current and anticipated skills gaps related to circular practices.

The perceived importance of specific technical and soft skills (e.g., digital literacy, sustainable resource management, entrepreneurship, problem-solving).

The role of education and training in preparing the rural workforce.

Opportunities and barriers to implementing circular economy practices.

The survey consisted of both closed-ended and Likert-scale questions, allowing for both statistical analysis and the identification of trends in stakeholder perceptions.

The questionnaire was distributed online and in person over a period of 2024, reaching a sample size of 100 respondents across the Brăila rural area.

The collected data was analyzed using descriptive statistics to identify the most in-demand competencies and to highlight the gaps between current workforce capabilities and future labor market needs. The findings were then interpreted in the context of regional development strategies and the potential for sustainable transformation through the circular economy.

The questionnaire was developed using Google Forms and distributed via email to 100 managers in the agricultural sector in Brăila County, achieving a response rate of 90%.

The questionnaire complies with the regulations of the Ethics Commission of the "Dunarea de Jos" University of Galati, and this interview was conducted with the consent of the interviewees.

The responses were reviewed for completeness and consistency, and only fully completed questionnaires were included in the final analysis.

The equation for calculating the sample size is presented below.

$$n = \frac{N}{1 + N(e)^2} \quad \text{.....(1)}$$

where:

- n is the sample size
- e is the margin of error
- N is the size of the number of agricultural firms in Brăila County.

To ensure data validity, duplicate or incomplete entries were excluded, and logical checks were applied to identify any inconsistencies in the responses.

For 824 agricultural firms from Braila county, the sample of 86 valid questionnaires, a confidence level of 90% was obtained (Table 1).

The analysis was conducted using Microsoft Excel, enabling the identification of key competencies required for the implementation of the circular economy in the local agricultural context.

The results were interpreted in relation to the current labor market needs and the specific characteristics of rural economic activities in Brăila County.

Table 1. Distribution of respondents by age

Variables	Category	No.	%
Sex	Male	40	46.51
	Female	46	53.49
	18–20	9	10.46
	21–30	15	20.2
	31–40	18	14.6
	41–50	23	30.3
	51–60	12	15.6
	>60	9	10.46
Place of birth	Rural	43	50.0
	Urban	43	50.0

Source: Results based on the questionnaires.

Comparing the data obtained from surveys and interviews with the labour market requirements can identify skills gaps and propose measures to close them through training and education.

RESULTS AND DISCUSSIONS

The participation of different age groups in the survey allows us to state that the most truthful answers to the questions in the questionnaire are expressed.
Investigating the number of people who know the concept of circular economy shows that 27.8% of respondents have not heard of this concept (Figure 1).

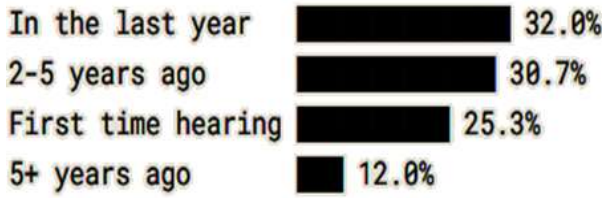

Fig. 1. Answers to the question: When did you first hear about the circular economy?
Source: Own processing based on the survey.

Regarding the need for specialization in the circular economy, the survey shows that over 72% of agricultural managers believe that the implementation of business models in the circular economy requires the training of specialists (Figure 2).

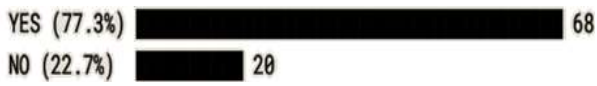

Fig. 2. Answers to the question: Do you think that business needs specialized professionals to implement innovative circular economy models in business?
Source: Own processing based on the survey.

In the last five years, it is noteworthy that new skills have been introduced into the business model regarding communication, IT (Figure 3).

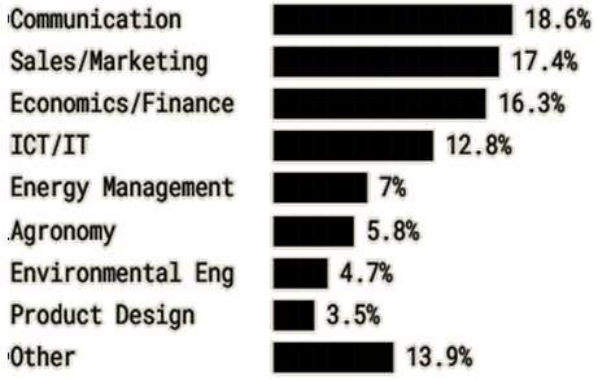

Fig. 3. Answers to the question: What skills have you added to your team (new employees or collaborators) in the last 5 years?
Source: Own processing based on the survey.

For the next five years, the interviewed managers believe that the main skills that will be needed are communication, marketing and environmental engineering (Figure 4).

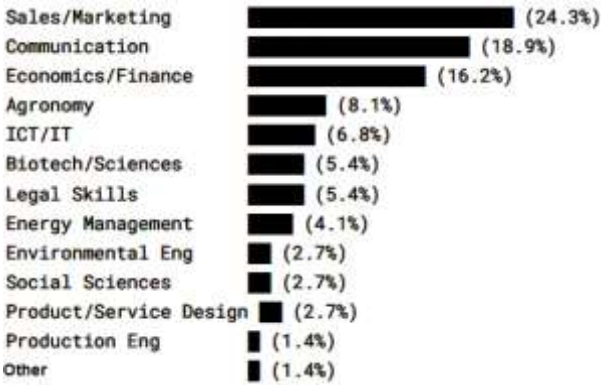

Fig.4. Answers to the question: What skills have you added to your team (new employees or collaborators) in the next 5 years?
Source: Own processing based on the survey.

Managers from rural areas believe that the main skills needed in the circular economy for a career in the economic field are the ability to develop strategies and communication techniques (Figure 5).
The main skills that managers consider essential for a career in industrial production within the circular economy are represented by the ability to maximize the value of by-products obtained, waste management and technological innovations (Figure 6).

Fig. 5. Answers to the question: What are the skills needed on the labor market for a career in the circular economy in rural areas in the economic field?
Source: Own processing based on the survey.

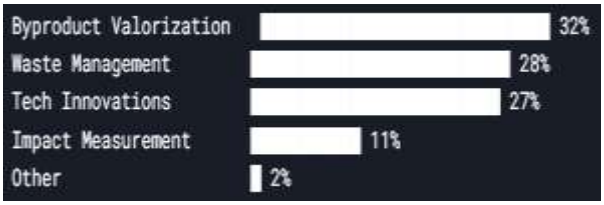

Fig. 6. Answers to the question: What are the skills needed on the labor market for a career in the circular economy in rural areas in the field of industrial production?
Source: Own processing based on the survey.

The main skills that managers consider essential for a career in resources management within the circular economy are represented by the ability to sustainably manage the potential of natural resources (Figure 7).
The main skills that managers consider essential for a career in business management within the circular economy are represented by business management strategies for the circular economy (Figure 8).

Fig. 7. Answers to the question: What are the skills needed on the labor market for a career in the circular economy in rural areas in the field of resource management?
Source: Own processing based on the survey.

Following an in-depth analysis of the labor market in Brăila, along with a thorough review of the relevant academic literature, a series of key skills and competencies essential for the development of the circular economy in the county's rural areas have been identified [8], [4]. These competencies are not only fundamental to supporting the transition toward a sustainable economic model, but also to enhancing regional competitiveness and attracting investment.

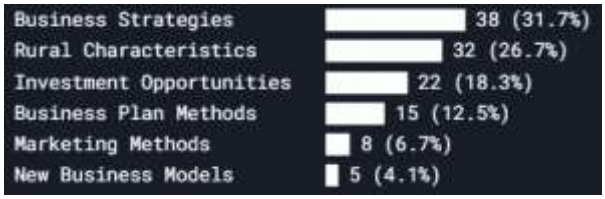

Fig. 8. Answers to the question: What are the skills needed on the job market for a career in the circular economy in rural areas in the field of business management?
Source: Own processing based on the survey.

Within rural contexts, waste management emerges as a core component of the circular economy. Professionals operating in this sector must demonstrate a comprehensive understanding of recycling mechanisms, waste separation techniques, and material reuse strategies.
Also, waste management skills in agriculture are essential to minimize losses and valorize agricultural by-products (eg composting) [12], [1], [15].
Increasing interest in renewable energy sources (eg solar panels, wind turbines) and in technologies that reduce resource consumption requires the vocational training of workers in rural areas.
Implementation of agricultural practices that minimize environmental impact and capitalize on circular processes (eg use of organic fertilizers, crop rotation, efficient water management).
Within the circular economy, farmers and entrepreneurs in rural areas must adopt innovative technologies to reduce waste and increase efficiency in production. This requires knowledge of technologies such as 3D printing, robotics, the use of sensors to monitor the environment and resources.
Digital skills are essential to track material flows and implement smart resource management solutions. These competencies play a critical role in facilitating the transition toward a circular production system [20], [19], [21]. The emergence and growth of businesses grounded in circular economy principles represent a sector with significant potential for innovation and sustainable development.

Farmers and entrepreneurs need to be educated about the economic opportunities of recycling, reusing and reusing materials.

Circular economy business planning and management skills are fundamental to ensure long-term sustainability and profitability. These skills include resource management, green accounting, and knowledge of environmental regulations.

As the circular economy involves multiple sectors (agriculture, industry, recycling), collaboration skills between various entities (companies, local authorities, non-governmental organizations) are essential.

It is essential that workers in rural areas participate in continuing training programs to acquire the new skills required by the circular economy. Education and training play a central role in preparing the workforce for the future.

In many rural areas of Brăila, the infrastructure for recycling and waste management is not sufficiently developed. This is a major obstacle to the implementation of the circular economy, as it requires significant investment in recycling facilities and waste collection centres.

Many farmers and entrepreneurs in rural areas may be reluctant to adopt new technologies and business models.

A key challenge in advancing the circular economy is shifting mindsets and raising awareness about its long-term benefits. In Brăila, as in many other rural regions of Romania, there is a notable lack of specialized vocational training in areas closely tied to the circular economy, including waste management, green technologies, and agricultural innovation.

Romania has access to European funding aimed at supporting the transition toward a sustainable economy. These resources can be strategically invested in infrastructure development, training initiatives, and innovation projects that drive circular practices forward.

Brăila County, with its strong agricultural heritage, stands to gain a considerable competitive advantage by embracing circular economy principles in agriculture. Through more efficient resource management, reduction of waste, and the valorization of agricultural by-products, local farmers can enhance productivity and sustainability.

Strengthening collaboration between local authorities, the private sector, and non-governmental organizations is essential for the successful implementation of circular economy initiatives. Potential projects include the development of recycling centers, digital education platforms, and networks for sharing best practices.

To address the skills gap, it is imperative that public authorities and vocational training providers design educational programs tailored to the needs of the local labor market. These programs should cover critical areas such as waste management, innovation in agricultural practices, and circular entrepreneurship.

Establishing partnerships between local government, businesses, and educational institutions can further support workforce development and accelerate the adoption of circular economy models.

Following the analysis of labor market demands and the skills required to foster the circular economy in Brăila's rural areas, several essential conclusions emerge. The competencies necessary for this transition are both diverse and interdisciplinary, spanning technical and soft skills.

Successful implementation of circular economy practices in Brăila's rural context calls for expertise in waste management and recycling, innovation in agricultural systems, proficiency in green and digital technologies, and strong entrepreneurial and sustainable management capabilities. At the core of these competencies lies the ability to manage resources efficiently and to apply innovative solutions that minimize environmental impact.

Lack of infrastructure and specialized education are significant barriers.

In many rural areas of Brăila, the necessary infrastructure for waste management and recycling is insufficiently developed. This deficit represents a major barrier to implementing the circular economy on a large scale, as resources are not properly harnessed.

Moreover, the absence of targeted professional training programs in the field of circular economy significantly contributes to the skills gap within the local workforce.

There is a significant gap between labor market requirements and available skills, which requires the development of continuous education and training programs adapted to the new economic and ecological realities.

Brăila's agricultural potential represents a strategic advantage in advancing the circular economy. With a well-established tradition in agriculture, the county is well-positioned to integrate circular economy principles into farming practices, generating both economic and environmental benefits. The adoption of sustainable methods—such as composting, water reuse, and efficient resource management—can play a pivotal role in supporting the transition toward a circular agricultural model.

The integration of circular economy practices within the agricultural sector can enhance production efficiency, lower operational costs, and generate new economic opportunities. Access to funding and support from the European Union plays a crucial role in this process. European funds serve as a vital resource for advancing circular economy initiatives in the rural areas of Brăila, enabling investments in sustainable technologies, infrastructure, and training programs.

These funds can be used to develop recycling infrastructure, support technological innovation and implement training and vocational education projects.

Local authorities and businesses can benefit from these funds to develop innovative solutions and encourage the transition to a greener and more sustainable economy.

Continuing education and training are crucial.

One of the key findings of this analysis is the pressing need for continuous training. To ensure the workforce can meet the evolving demands of the circular economy, it is essential for public authorities, educational institutions, and vocational training providers to collaborate in developing and delivering specialized education and training programs tailored to this sector.

These programs should address not only technical competencies, but also essential skills in management and entrepreneurship. A comprehensive skillset is critical for fostering innovation and ensuring the sustainability of circular economy initiatives.

Effective implementation of the circular economy relies heavily on robust collaboration between the public and private sectors. Creating a supportive framework for its development requires the active engagement of local authorities, private enterprises, and non-governmental organizations. This multi-stakeholder collaboration can drive the implementation of joint projects, the formulation of favorable public policies, and the development of innovative economic solutions.

Moreover, public-private partnerships play a key role in facilitating access to financial resources, advanced technologies, and specialized expertise, thereby accelerating the transition to a circular economy [22], [16], [10].

Strategic Recommendations for the Future:

-Development of a Local Strategic Plan for the Implementation of the Circular Economy in Brăila – This plan should outline clear objectives, priority areas for action, and mechanisms for stakeholder coordination to ensure an integrated and effective transition to a sustainable economic model, which includes investments in infrastructure, professional training and the promotion of collaboration between sectors.

-Creation of continuing education and training centres offering courses and specializations in areas such as waste management, green technologies and agricultural innovation.

-Supporting rural entrepreneurship through financing and advisory programs.

-The utilization of European funds to support projects focused on the development of ecological infrastructure and the promotion of technological innovation within the agricultural and industrial sectors.

CONCLUSIONS

For Brăila, the transition to a circular economy presents a major opportunity for both economic growth and environmental sustainability. However, realizing this potential requires strategic investments in the development of key sectors, ensuring a smooth

and successful shift towards a sustainable economic model of workforce skills, in infrastructure and in the formation of sustainable partnerships between local authorities, the private sector and other relevant entities. Through an integrated and strategic approach, the circular economy can become an engine of sustainable development in the rural areas of Brăila.

REFERENCES

[1]Brown, T., 2020, Pathways to Agricultural Skill Development in the Indian Himalayas, Journal of South Asian Development, Vol. 15(2), doi: 10.1177/0973174120943081.
[2]Cartmill, L., Comans, T.A., Clark, M.J., Ash, S., Sheppard, L., 2012, Using staffing ratios for workforce planning: Evidence on nine allied health professions, Human Resource for Health, 10(2), doi: 10.1186/1478-4491-10-2.
[3]Croitoru, I.M., Grigoras, M.A., Popescu, A., , Grigoras, B.A., 2024, Embracing the circular economy: a paradigm shift for sustainable prosperity. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 24(2), 397-406.
[4]Deng, J., Liu, J., Yang, T., Duan, C., 2022, Behavioural and economic impacts of end-user computing satisfaction: Innovative work behaviour and job performance of employees, Comput Human Behav, Vol. 136, 107367, doi: 10.1016/j.chb.2022.107367.
[5]Di Stefano, G., Scrima, F., Parry, E., 2019, The effect of organizational culture on deviant behaviors in the workplace, International Journal of Human Resource Management, Vol. 30(17), 2482-2503, doi: 10.1080/09585192.2017.1326393.
[6]Easmon, C., 2014, People matter: Tomorrow's workforce for tomorrow's world, London J Prim Care (Abingdon), Vol. 6(3), 46-56, doi: 10.1080/17571472.2014.11493415.
[7]Foster, B., Muhammad, Z., Yusliza, M.Y., Faezah, J.N., Johansyah, M.D., Yong. J.Y., ul-Haque, A., Saputra, J., Ramayah, T., Fawehinmi, O., 2022, Determinants of Pro-Environmental Behaviour in the Workplace, Sustainability (Switzerland), Vol. 14(8), doi: 10.3390/su14084420.
[8]Gigol, T., 2020, Influence of authentic leadership on unethical pro-organizational behavior: The intermediate role of work engagement," Sustainability (Switzerland), Vol. 12(3), 118, doi: 10.3390/su12031182.
[9]Grama, A.V., Batrina, S.L., 2024, Adaptation of the farmers' skills to the requirements of the future agriculture. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 24(2), 485-494.
[10]Hafeez, A., Husain, M.A., Singh, S.P., Chauhan, A., Khan, M.T., Kumar, N., Chauhan, A, Soni, S.K., 2023, Implementation of drone technology for farm monitoring & pesticide spraying: A review, Information Processing in Agriculture, 10(2), 192-203, doi: 10.1016/j.inpa.2022.02.002.
[11]Husain, F.N., 2023, Impact of Multiple Intelligences and 21st Century Skills on Future Work Force, International Education Studies, Vol. 16(3), 16-30, doi: 10.5539/ies.v16n3p16.
[12]Katiyatiya, C.L.F., Majaha, J., Chikwanha, O.C., Dzama, K., Kgasago, N., Mapiye, C., 2022, Drought's implications on agricultural skills in South Africa, Outlook on Agriculture Vol.51(3), 293-302. doi: 10.1177/00307270221103289.
[13]Mason, G., 2023, *Work force skills*. Oxford: Oxford University Press, doi: 10.1093/oso/9780195128598.003.0007.
[14]Olaru, B.G., Zecheru, V., 2016, The waste recycling in romania. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 16(3), 191-198.
[15]Pamuzhak, N., Shinkaruk, V., Didur, I., Melnik, V., 2020, Agricultural production of Moldova under conditions of prohibition of pesticides, Agriculture and Forestry, 2(17), doi: 10.37128/2707-5826-2020-2-8.
[16]Rashideh, W., 2020, Blockchain technology framework: Current and future perspectives for the tourism industry, Tourism Manag, Vol. 80, doi: 10.1016/j.tourman.2020.104125.
[17]Roberts, K., Integrating Young People into the Workforce: England's Twenty-First Century Solutions, Societies, Vol. 12(2), doi: 10.3390/soc12020038.
[18]Rosu, M., Marcuta, A., Tindeche, C., Anghel, R.E., Traistaru, C., Marcuta, L., 2022, Study on the perception of students of the faculty of management and rural development regarding the role of digitalization in the training of competences necessary for the integration of graduates in the labor market. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 22(4), 627-634.
[19]Stofkova, J., Poliakova, A., Stofkova , C.R., Malega, P., Krejnus, M., Binasova, V., Daneshjo, N., 2022, Digital Skills as a Significant Factor of Human Resources Development, Sustainability (Switzerland), Vol. 14(20), doi: 10.3390/su142013117.
[20]van Laar, E., van Deursen, A.J.A.M., van Dijk, J.A.G.M., de Haan, J., 2017, The relation between 21st-century skills and digital skills: A systematic literature review, Comput Human Behav, vol. 72, doi: 10.1016/j.chb.2017.03.010.
[21]van Laar, E., van Deursen, A.J.A.M. , van Dijk, J.A.G.M., de Haan, J., 2020, Determinants of 21st-Century Skills and 21st-Century Digital Skills for Workers: A Systematic Literature Review, Sage Journals, doi: 10.1177/2158244019900176.
[22]Wynn, M., Jones, P., Digital Technology Deployment and the Circular Economy, Sustainability (Switzerland), Vol. 14(15), doi: 10.3390/su14159077.
[23]Zink, T., Geyer, R., 2017, Circular Economy Rebound, Journal of Industrial Ecology, Vol. 21(3), 593-602, doi: 10.1111/jiec.12545.

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POLICIES AND FACTORS FOR RURAL DEVELOPMENT IN BULGARIA

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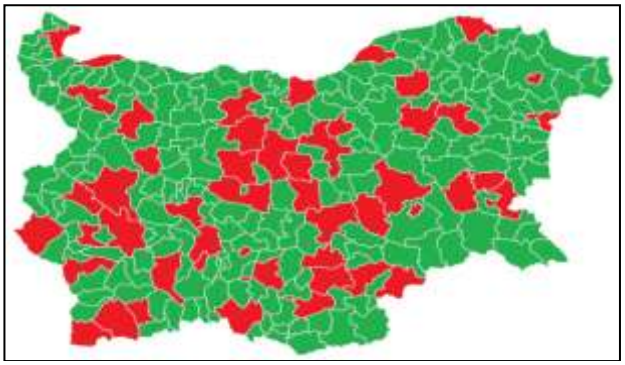
Abstract

Rural areas represent a significant part of Bulgaria and are crucial for regional growth and sustainability. Various policies at the European and national level help to ensure the prosperity of these regions. The main goal of this article is to review through empirical research whether rural areas in Bulgaria take full advantage of their comparative advantages and if the citizens are aware of the main goals in the plan for development for their municipalities. An analysis of the local independence provides information about the dependency of rural municipalities by the government due to the financial transfers they receive, so that is affecting the smaller settlements well-being. The research focuses on basic economic development indicators and the revenue side of municipal budgets. Main results are showing lack of awareness regarding the own revenues in rural municipalities and unconcern for the future policies. Based on the conclusions it can be suggested to increase the attractiveness to the citizens in understanding their responsibilities and have active role in municipalities decisions.

Key words**:** *rural areas, rural development, municipal budget*

INTRODUCTION

Rural areas in Bulgaria are of key importance for the development of the regions. The development of rural regions is directly related to the improving of the economic, social and environmental conditions. [1] In the last few years, dynamics have been observed in this type of areas, not only in investments, but also in their formation and creation of priorities. A number of municipalities were "excluded" from the list of rural areas according to the Strategic Plan for the Development of Agriculture and Rural Areas 2023-2027. There are now new criteria for their determination. It states that a municipality of rural type (rural area) can be defined when there is no populated place with more than 15,000 inhabitants on its territory. Until 2023 a rural area was considered one with a population of more than 30,000 people. After this change, Bulgaria now has a total of 50 urban municipalities and 215 rural municipalities, compared to 237 before the changes in the population criteria. Despite this change, the results show that 81% of the municipalities in the country are of the rural type and this shows the importance of this type of areas for the development at the national level (Map 1).



Map 1. Distribution of municipalities in Bulgaria by type: green – rural; red - urban.
Source: Strategic Plan for the Development of Agriculture and Rural Areas 2023-2027 [13].

The change in distribution automatically excludes part of the municipalities and exclude them from receiving funding through various EU programs and the Common Agricultural Policy (CAP). This creates a challenge for the newly established urban areas and they will face serious problems for the reason that CAP strategies in Bulgaria are focused on creating workplaces, diversifying and developing small enterprises, implementing local development strategies, developing social infrastructure, financing inputs and young farmers, and

infrastructure project. It is also very important that direct payments and rural development programs are the main financing mechanisms [5].

According Table 1, it is visible that from year 2023 there are 46 municipalities that are with population in the range 15,000 – 30, 000, which means they are excluded from the possible funding from the EU CAP.

Table 1. Number of municipalities eligible to EU funding by population

Dynamics of types of municipalities according to population, no.				
	Up to 15,000	From 15,000 to 30,000	Above 30,000	Number of rural municipalities eligible for EU funding
2020	171	51	43	222
2021	172	49	44	221
2022	178	46	41	224
2023	177	46	42	177

Source: National Statistical institute of Bulgaria [9].

The existence of numerous vulnerable places in terms of lack or insufficient local endowment, accessibility, or connectivity imposes that the EU policy programmes to be fully integrated and to be focused on "the reduction of gaps between urban and rural areas, on strengthening physical infrastructure, access to schools, cultural facilities, democratic participation, migrants' integration etc."[12]

This change concerns rather the funding from the European Union and funds from various funds. Municipalities of the urban type, which until now were in the other category, simply do not get the possibility of financing.

A region development could be challenging since they rely only to the European funds from rural development programs and other financial sources. It also strongly depends on the local available resources and the administrative capabilities of local authorities. It is very important to use the resources as potential for regional development as only that way it is possible to have progress in that region. regional development. The key point is how the municipalities can use the potential of their region, so that can lead to the economic and social progress.

The spatial development plans are the technical basis and the political and legal prerequisite of the strategies for accessing funding for programs and projects from national and European funds, which do not help to develop the synergy between regional business, the public sector, and the effect on the living standards of the population.[10]

Rural development does not only mean absorbing EU funds, which are already limited, but also using the potential to maximize income in rural municipalities and thus improve lifestyles to a higher quality. For this purpose, the plans for integrated development of the municipalities, which are part of the system of strategic documents and integrate regional and spatial development, have to determine the current problems and needs, and development potentials of the regions, municipalities and settlements. They are taken into account in the development of investment programs and financial instruments, including those co-financed by the funds of the European Union. [7] They outline a framework of the main goals and stages, as well as the ways of carrying out predetermined procedures, the necessary documentation and the conditions for evaluating their implementation. Emphasis is also placed on the expected results and potential beneficial impacts of the renovation of abandoned industrial sites.[15] Very often different factors, natural features and natural advantages are important in local and regional development of rural municipalities. The strategic plans envisage the development of various sectors, such as tourism [16], industry, investment in production, etc.

It is necessary to emphasize that demographic problems such as migration and aging create "local" challenges, which is why "local" measures are particularly necessary. Moreover, the problems with the overall socio-economic backwardness of many regions in Bulgaria are mainly the result of serious problems at the local level.

There are certain factors showing the progress in the region. We can divide them on two parts – internal and external. First ones are local and they have to be used as advantage when the municipality created their own strategy for development. The External factors are usually far away from the municipality profile and this is something that is missing to the region. In

order to better evaluate the opportunities for rural development we are going to review further the internal factors.

Rethinking and better coordination of the two approaches in policies and practices "up-down" and "bottom-up" is on the agenda. The best way to apply these policies is the financial decentralisation, this way the developed regions can allocate financial resources at local level. Development is not just about increasing the goods consumed by society, but also about providing communities with the opportunity to manage and shape their relationships moving forward. [14].

If we compare Bulgaria with European countries in terms of GDP/per capita, it can be seen that for 2022 we are in last place, reaching 62% of the average values for the EU [10]. Another insurmountable factor is the policies of the EU, especially regarding the environment, the Green Deal and the ambitions for Europe to become the first energy independent continent by 2050 [5].

The situation is similar in neighbouring Romania, where their rural areas have faced and continues to face countless challenges regarding the lack of financial resources. Although Romania is a rich country in natural resources, the rural environment being predominant and having an old tradition in agriculture, certain factors stop or make rural development quite difficult. They are using funds from their National Rural Development Program (NRDP) which grants non-refundable funds in different categories like quality of equipment, investments in production and marketing, ensure risk management, training services etc. [2][3].

MATERIALS AND METHODS

In order to evaluate and analyse the progress of rural areas and their development, information is needed to what extent the citizens are interested in the processes in their municipalities, the priorities set in the plans for integrated development of their settlements.

The survey was conducted in the autumn 2024 among 145 respondents and it is concerning the awareness of the priorities that certain municipality might have places as goal. Along with the targeted questions, demographic data was collected for the respondents to create a more accurate profile in terms of gender, age group and level of education.

The data about the population and the definition of rural areas as such were used from the National Statistical Institute of Bulgaria.

Regarding the financial independence of municipalities, it is used a formula to calculate and compare the own revenues in the municipal budget with the transfers by the central government.

$$C_I = \frac{O_R}{T_{CG}} O_R / T_{CG} \qquad (1)$$

where:

C_I – coefficient of independence

O_R – own revenues in the municipal budget

T_{CG} – transfers to the municipal budget from the central government

the evaluation of the coefficient of independence is presented in table 2.

Table 2. Level of financial dependency of the municipalities by the government, scale, coefficient of independence

level of dependency	value
weak	$C_I \geq 1.5$
significant	$0.5 \leq C_I \leq 1.5$
strong	$C_I \leq 0.5$

Source: OECD [4].

RESULTS AND DISCUSSIONS

In connection with citizens' awareness of the possibilities of implementation of various projects and utilization of funds according to pre-set goals in the plan for integrated development of the municipalities, dynamic results of a survey conducted on the territory of rural municipalities in the Stara Zagora region are observed. One of the most important is about awareness, namely the question in the survey is asking if the respondents have ever heard.

The results are shown in Fig.1.

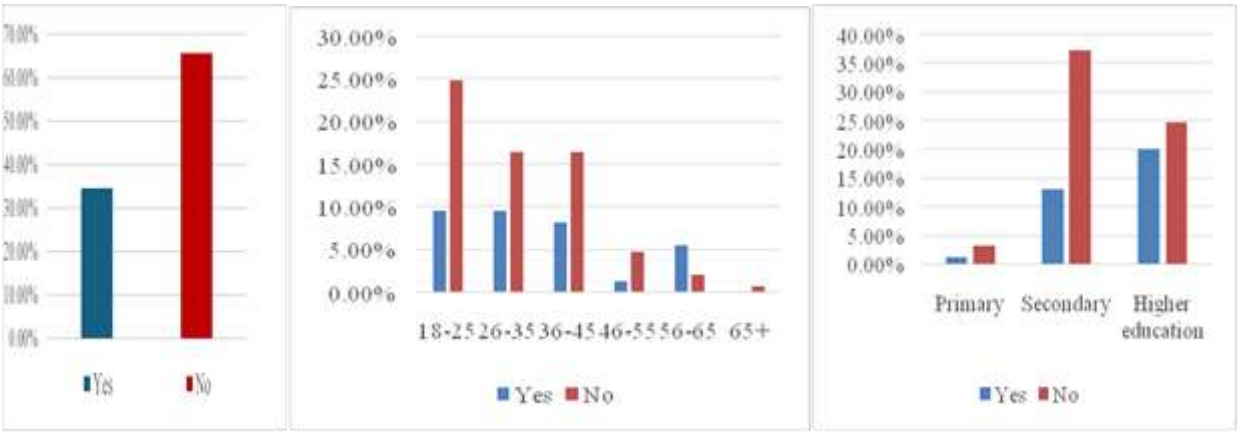


Fig. 1. Have you ever heard of Integrated Development Plan of your municipality 2021-2027, education level, age, %
Source: Own survey in rural municipalities of Stara Zagora region.

The data show that about two-thirds of the respondents have not heard at all that their municipality has developed such a strategic document, and only about 34% are aware of its existence.

Looking at awareness by level of education, it is striking that the more highly educated the respondents are, the more likely they are to be informed about the existence of this strategic plan, and thus 20% of all respondents who have a higher education state that they are aware of the plan, and the largest share of uninformed citizens are those with a secondary education - about 37%.

In the age section of the study, a directly proportional relationship was observed between younger people and higher awareness of the plan. Probably the reason lies in the digitization of all sectors and such kind of documents are available online on the website of the respective municipality, and the older population has less access and it is more difficult to work with computers and the Internet.

Among those who answer that they have heard about this plan, about half say that they are partially aware, and 30% say that they are fully aware of the set priorities in the plan itself. A small number admit that they have only heard about this plan, but are not familiar with its content and which are the main goals (Figure 2).

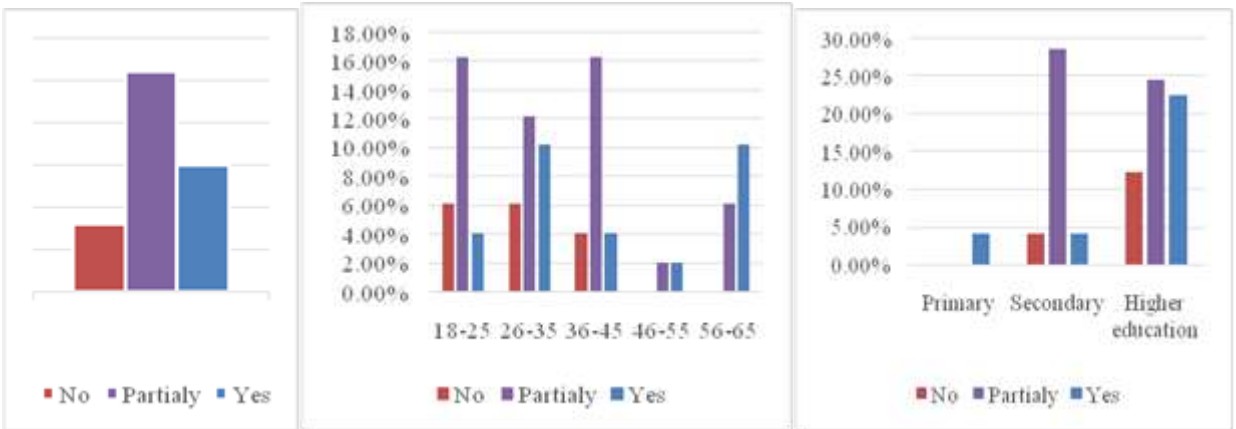


Fig. 2. Are you familiar with the content of the IDP of your home region?, %
Source: Own survey.

We can see that there is a trend among younger respondents to be better aware of the content in their IDP. From the point of view of education, the group with higher education again has the highest share of awareness.

Among those who are familiar or even partially familiar with the plan for development, more than 90% state that they approve the policies and strategies for their municipality. In age groups, the highest approval of the goals is

confirmed for the youngest group in the 18-25 age. According the education level we can observe the highest positive results among those with higher education (Fig. 3).

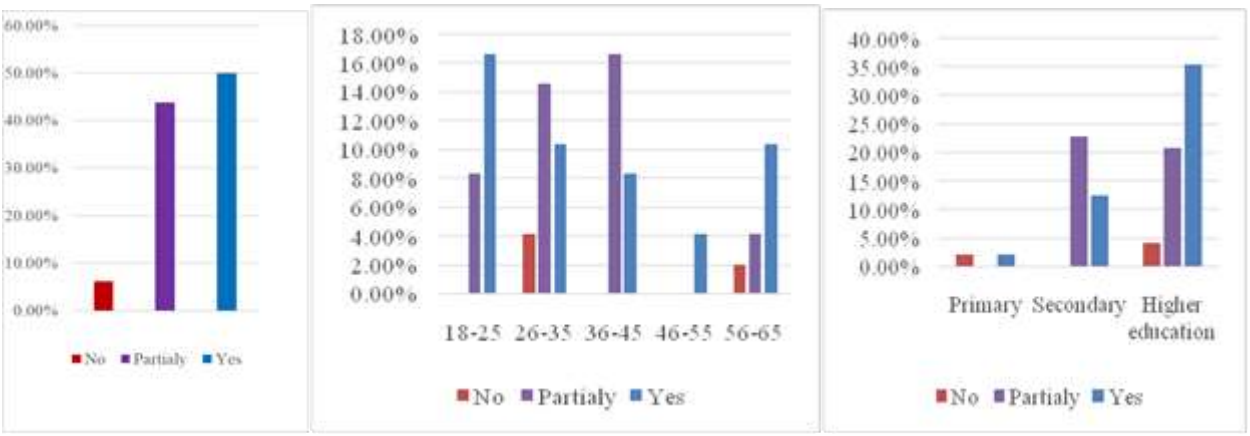


Fig. 3.. Do you approve the goals set in the IDP for your home region?, %
Source: Own survey.

Regarding the **coefficient of independence** of the municipalities in the region of Stara Zagora, which are 7 with population under 15,000 and in Table 3 are shown the results.

Table 3. Coefficient of independence in rural municipalities in Stara Zagora region, data for year 2023

Municipality	**Own revenues, BGN**	**Transfers from central budget, BGN**	**Coefficient of independence**
BratyaDaskalovi	2,045,067	1,001,442	2.042
Gurkovo	1,002,285	2,480,302	0.404
Galabovo	7,198,859	4,057,616	1.774
Maglizh	4,811,238	6,286,977	0.765
Nikolaevo	709,746	876,972	0.809
Opan	1,431,908	1,149,035	1.246
Pavel Banya	3,933,604	5,369,062	0.733
Total	21,132,707	21,221,406	0.996

Source: Own calculations based on data from Ministry of finance, Bulgaria [7].

Based on the coefficient of independence we can confirm that only in two municipalities the dependency from the central government is weak, since they manage to generate more own revenues in their local budgets.

There is one municipality with very strong dependency level with coefficient only 0,4 which means they mainly expect transfers from the central government in order to provide the necessary public services to the people leaving in their region.

The other four municipalities are defined as strongly dependent by the transfers as most of them generate less income in their budget than the funds coming from the government.

CONCLUSIONS

The main conclusions of the conducted empirical research through direct polling of citizens can be summarized as follows:

- The young population is more familiar with and approves of the goals set in the development plan of their municipality
- Respondents with higher education are more familiar and have a positive attitude about the strategic goals set for the development of their region
- Unfortunately, only about a third of the respondents have heard about the development plan of their municipality and know that it is an important document that outlines the development path of their municipality.

Considering the results of the coefficient of independence in the rural municipalities, we can see that for year 2023 more than half of them in the Stara Zagora region are very

dependable from the transfers from central government and some are with lower dependency, but still not possible to cover all local services with their own revenues.

In conclusion, it must be said that regional policies and factors influencing development are insufficiently popular among the population, which shows a lack of involvement of the citizens in what is happening in their region and, in particular, the negative effect is on the less developed municipalities, where less funds from the municipal and national budget reach.

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REFERENCES

[1]Bolohan (Cociorvă), R.M., Bacter, R.V., Bolohan, I., Ștefan, G., 2024, An insightful exploration on the achievement of the sustainable rural development goals. A study case Valea Lupului commune, Iasi county, Romania, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol. 24(2), 193-100.

[2]Cîjmăroiu, G.A., Sperdea, N.M., Vladu M., 2024, The contribution of national rural development programme (NRDP) funds to the development of human resources from the rural environment in the South West Oltenia region, Romania, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol. 24(1), 213-222.

[3]Dobre, C.A., Stoian, M., Hontus, A.C., Chiurciu, I.A., Soare, E., 2024, Component of marketing in authentic Romanian rural tourism, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Vol. 24(1), 335-340.

[4]Kim, J. and S. Dougherty (eds.) (2018), Fiscal Decentralisation and Inclusive Growth, OECD Fiscal Federalism Studies, OECD publishing, Paris/KIPF, Seoul.
https://doi.org/10.1787/9789264302488-en

[5]Korniyenko, G., Kurman, T., Lisova, T., Sharapova, S., Pokalchuk, M., 2024, Development of Rural Areas: Strategies, Challenges and the Role of Agricultural Policy in Achieving Sustainable Rural Development. Economic Affairs, 69 (Special Issue): 11-21, DOI:10.46852/0424-2513.1.2024.3

[6]Marinov, P., Mihailova, M., 2024, Formation of "new forest spaces" in urbanized areas in line with the green deal, 17th International Scientific Conference WoodEMA.

[7]Methodological guidelines for the development and implementation of plans for the integrated development of the municipality (PIRO) for the period 2021-2027 (2020), https://shorturl.at/pwAOF, Accessed on 28 February 2025.

[8]Ministry of finance, Bulgaria, Municipal finances, https://www.minfin.bg/bg/810 Accessed on 28 February 2025.

[9]National Statistical Institute, Population by districts, https://www.nsi.bg/en/content/2975/population-districts-municipalities-place-residence-and-sex Accessed on 28 February 2025.

[10]Petrov, K., Tsonkov, Ts., 2025, Trends in the regional development of medium-sized municipalities with a population between 10 and 50 thousand in Eastern Bulgaria, Edelweiss Applied Science and Technology, Vol. 9(1), 879-895, DOI: 10.55214/25768484.v9i1.4268

[11]Popescu, A., Dinu, T.A., Stoian, E., Șerban V., Stanciu, M., 2024, Regional development in Romania. A brief statistics on socio-economic differences- A multi-criterial approach, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol. 24(4), 661-677.

[12]Proietti, P., Sulis, P., Perpiña Castillo, C., Lavalle, C., Aurambout, J.P., Batista E Silva, F., Bosco, C., Fioretti, C., Guzzo, F., Jacobs, C., Kompil, M., Kucas, A., Pertoldi, M., Rainoldi, A., Scipioni, M., Siragusa, A., Tintori, G., Woolford, J., 2022, New perspectives on territorial disparities, Publications Office of the European Union, Luxembourg, doi:10.2760/581071, JRC126033

[13]Strategic Plan for the Development of Agriculture and Rural Areas 2023-2027 https://sp2023.bg/index.php/bg/selski-rajoni accessed on 28.02.2025, Accessed on 28 February 2025.

[14]Yarkova, Y., Mutafov, E., 2017, Rural areas in Bulgaria–investigation on some factors for development, Eastern European Countryside, 23(1), 51-70.

[15]Zheleva, V., Tsacheva, S., 2022, Possibility to stimulate brownfield tourism and community-led local development. Collective Scientific Book of Faculty of Economics, St. Cyril and St. Methodius University of Veliko Tarnovo, Vol. 6, pp.380

[16]Zheleva, V., 2019, A study on the development of festival tourism in Kazanlak municipality: the case of the Rose festival, Trakia Journal of Sciences, Vol. 17, Suppl. 1, pp. 86-93, doi:10.15547/tjs.2019.s.01.016.

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REORIENTATION OF THE POPULATION FROM ROMANIA TOWARDS THE RURAL AREA – CHANGES GENERATED BY THE COVID-19 PANDEMIC

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Abstract

Since the Covid-19 pandemic imposed, to the entire planet Earth, a state of emergency and isolation, especially the population in urban areas has reoriented towards returning to their birthplaces or migrating to rural areas, attractive in terms of location and infrastructure. The purpose of the paper is to emphasize the difference in the attractiveness of the rural environment, for the years 2020-2023. In order to understand the population`s motivation to relocate, translated into the benefits sought, the survey method was used, through a questionnaire distributed only online, to 87 people from big cities (Bucharest, Ploiesti, Alexandria, Targoviste, Brasov, Timisoara, Cluj-Napoca), who decided to move to the rural area in the pandemic and post-pandemic years. According to data provided by the National Institute of Statistics, the years after 2020 are marked by a clear reversal of the flow of internal migration between areas of residence, in favor of rural. The most conclusive figures are those of 2022 and 2023, when 31.6% and 34.9% of changes of residence take place from urban to rural areas. The entire study shows that the fear of a new life of isolation, as well as the opportunity to work from home, were the reasons that led most people to make this change.

Key words**:** *migration, rural area, benefits, remote work, Covid-19, Romania*

INTRODUCTION

The pandemic caused by the SARS-CoV-2 virus led to major changes in everything related to life in 2020-2023, as evidenced by many socio-economic research worldwide. This is why the migration phenomenon wasn't without major changes, especially as the crisis period lengthened and people were forced to find solutions to ensure a standard of living as close as possible to the one they were used to.

Most of the world's population was impacted by the fact that they couldn't leave their homes, and then by the idea of carrying out all their lucrative activities from home.

These changes, once put into practice, in many fields of activity became permanent and giving people the chance to be able to work from anywhere, no longer being tied to a specific place.

At the same time, it should be noted that the impact of these changes was different, depending on the level of development of each country, but also of each place (Petersen et al., 2024) [23].

According to this paradigm, the migration phenomenon was much more intense during the Covid-19 pandemic in developed and developing countries, compared to poor countries. Taking this into account, the population of Europe was strongly impacted by the imposed changes (Incaltarau et al., 2024) [14].

In the early years of the pandemic (2020 and 2021), the idea was circulated that rural areas were much more vulnerable to this virus, mainly due to a not very well-developed healthcare system (Cuadros et al., 2021; Dudley et al., 2023; Pandey et al., 2022) [3, 5, 22], but also to the advanced age of the resident population (Monnat, 2021; Pickering et al., 2023; Rajib et al., 2020) [16, 25, 26]. Subsequently, it turned out that these speculations weren't founded, and the rural environment became increasingly attractive to the inhabitants of the cities, who either

returned to their parental homes or decided to buy a new home in the countryside.

The motivations are diverse, relating to the social and economic status of each person:

-the desire to be in the middle of nature (Golubchikov, 2021) [10];

-avoiding other situations of isolation at home (Gatti &Procentese, 2021) [8];

-remote activities – lucrative and educational, which no longer required living in big cities (Guzman Rincon et al., 2021) [12].

The study of the specialized literature highlighted the fact that this migratory trend towards rural areas has been recorded in many countries of the world (Gonzalez-Leonardo et al., 2022) [11], some conclusive examples being Italy (De Luca et al., 2020) [4]; Great Britain (Glass et al., 2024) [9]; United States of America (Low et al., 2022; Mueller et al., 2021), Turkey (Oncu et al., 2023) [15, 17, 21]; Brazil (Floss et al., 2020) [7]; Chile (Elejalde et al., 2024) [6]; India (Behera et al., 2021) [1], Nepal (Bista et al., 2022) [2], Nigeria (Ofuoku et al., 2021) [20], Indonesia (Syafitri et al., 2022) [29] and Australia (Ramachandran, 2021) [27].

In general, as other crises have proven over time, the rural economy is a particularly adaptable and resilient one (Philipson et al., 2020) [24]. Most likely, in the coming years, cities will have to adapt to the new expectations of residents and will be in direct competition with rural areas on the periphery (Sharifi & Lee, 2024) [28], with a lower population density, more green spaces, lighter traffic, a quieter, stress-free lifestyle (Halfacree, 2024) [13].

Based on existing data on the counter-urbanization phenomenon generated by the pandemic situation, the proposed objective of the research has been to determine to what extent the attractiveness of the rural environment has changed and what were the grounds that led several Romanians to make a change in their living habits.

MATERIALS AND METHODS

Considering that the study of specialized literature is only a first step in the research process, the study was based on data provided by the National Institute of Statistics of Romania, which recorded unexplained fluctuations in urban-rural migration in 2020-2023. Among those existing at the national level, two basic parameters were chosen, namely:

-residence establishments;

-structure of internal migration flows.

The chosen control was 2019, the year before the pandemic began. Excel was used to analyze the data. Since these figures only indicate people's preferences, but not the reasons behind the decision to change their residential environment, a questionnaire with 15 questions, all with open answers, was prepared and distributed online, via Google Forms.

The questions addressed to the target group are those in Table 1.

Table 1. Questions included in the questionnaire for people who moved to rural areas

No. crt.	Question addressed to the target group
1.	How many members does your family consist of?
2.	What is your age and that of other family members?
3.	Do you own your own car?
4.	During the Covid-19 pandemic, did you work from home?
5.	What is your family's net monthly income?
6.	What city did you live in before you decided to relocate to the countryside?
7.	How far from the city is the new home?
8.	Is your current home new or a parental home/family heirloom?
9.	Please specify the month and year of the move.
10.	What were the factors that led you to relocate to the rural area?
11.	Do you still have the opportunity to work remotely or do you commute to work daily?
12.	Are you happy with your decision to move to the countryside?
13.	Do you plan to stay in the countryside or move back to the city?
14.	Do you think your standard of living has changed for the better or worse as a result of the relocation?
15.	What are the factors that would make you return to the urban environment?

Source: original.

Completing the questionnaire takes about 5-10 minutes and it was ultimately accessed by 87 people who migrated from urban to rural areas during 2020-2023.

The interviews were distributed in a six months period (March – September 2024) and the process of identifying the respondents was the hardest, since there is no database with this

kind of information. In the end, the respondents were family, friends and their neighbours or acquaintances.
That's why the respondents are only from several Romanian cities: Bucharest, Ploiesti, Alexandria, Targoviste, Brasov, Timisoara and Cluj-Napoca, without covering the entire country. This is one of the limitations of the present study.
Giving these facts, no formula was used in order to calculate the nationally representative target group for such research.
The obtained answers weren't intended for statistical processing, but for social purposes, identifying the population habits and perceptions, in dynamic after the pandemic years.
Statistical data were processed in Excel, where conclusive graphs were also generated. The responses received to the online survey were entered into individual tables, one for each question, so that the most important factors could be determined in percentage terms.
Since there are 15 questions and each one needs to be individually analyzed, the graphical representation was excluded, due to lack of space,

RESULTS AND DISCUSSIONS

The first analyzed parameter is that relating to residence establishments, which underwent the most significant changes between 2019 and 2020 (Table 2).
In 2020, the total number of people who chose to change their residence increased by 37.85%, compared to the previous year.
In 2021 and 2022, against the backdrop of events related to the state of health crisis, which was prolonging, the flow of changes of residence was much reduced, so that by the end of 2023 it would return to a value almost identical to that of the year before the start of the pandemic.
At the same time, a constant decrease in the attractiveness of the urban area is observed in 2019-2021, followed by a period of growth in 2022 and 2023, but without reaching the pre-pandemic flow.

Table 2. Data on the population number that lived in each residence environment, during 2019-2023

Residence indicator	2019	2020	2021	2022	2023	2023/ 2019 (%)
	number of people					
Total	202,372	278,961	178,864	191,635	202,418	+0.02
Urban	146,180	128,184	120,779	128,957	133,185	-8.89
Rural	56,192	150,777	58,085	62,678	69,233	+23.21
Rural / Urban (%)	38.44	117.62	48.09	48.60	51.98	+13.54
Rural / Total (%)	27.77	54.04	32.47	32.71	34.20	+6.43

Source: own processing after NIS data [18].

The very significant increase in residential establishments in rural areas in 2020 cannot go unnoticed. Compared to the previous year, there is an increase of 168.32%, so that in the next three years, normal values will return.
To better illustrate the differences that emerged between 2019 and 2023 in terms of people's preference to relocate and their choice of a particular residence environment, the graph in Figure 1 was drawn up.
The number of people for each of the variants (total, urban and rural) is shown in columns, while the line graph highlights the percentage represented by residence establishments in rural areas.

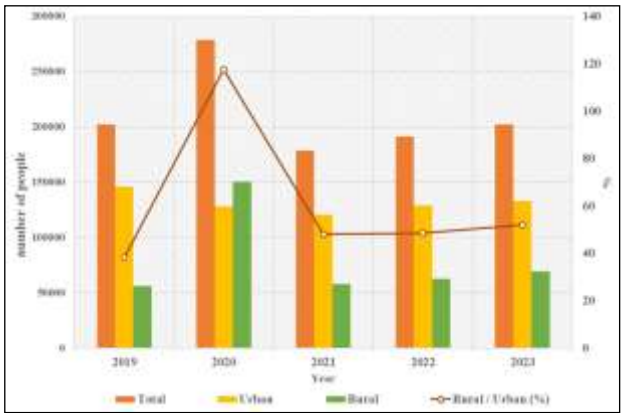

Fig. 1. Graph of population preferences regarding the choice of place of residence in the years 2019-2023
Source: original, after NIS [18] data.

The second parameter taken into study, namely the structure of internal migration flows, is exemplified in the same format, in order to be conclusive and by comparison with the residence establishments preferred by the Romanian population (Table 3).

Table 3. Data on the number of people ensuring the internal migration flow in 2019-2023, depending on the area of residence

Residence environment	2019	2020	2021	2022	2023	2023/2019 (%)
	number of people					
Total	403,221	367,569	374,526	457,872	430,133	+6.67
From urban to rural	113,785	116,491	111,888	144,674	150,299	+32.09
From rural to rural	77,508	73,580	71,089	89,267	83,450	+7.67
From rural to urban	94,306	77,825	84,169	98,414	87,598	-7.11
From urban to urban	117,622	99,673	107,380	125,517	108,786	-7.51

Source: own processing after NIS data [19].

The accelerated growth in the attractiveness of the rural environment, especially urban-to-rural migration, cannot go unnoticed. Data from 2022 and 2023, in particular, indicate that 31.6% and 34.9% of the registered changes of residence were from urban to rural, with the highest number of the four categories of migration environments.

If before the pandemic caused by the SARS-CoV2 virus, migration to the urban environment (rural - urban and urban - urban) amounted to over 52% of the total, starting with 2020 it decreased to 48%, and in 2023 it reached 45%. The afore mentioned decreases automatically led to increases in migration to the rural environment, which reached 55% of the total.

The graphic representation in Figure 2 highlights the internal migration fluctuation.

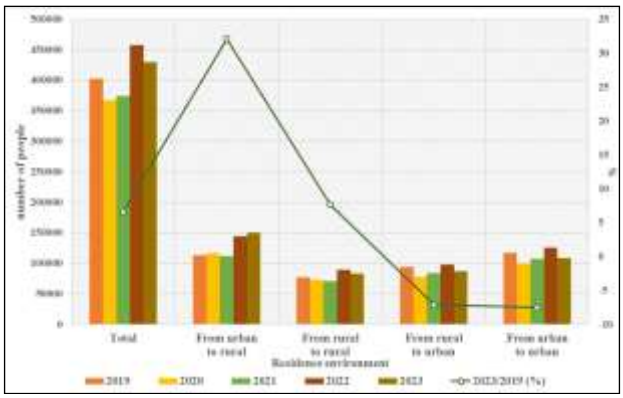

Fig. 2. Graph of the structure of migration flows in terms of the choice of residence environment in the years 2019-2023

Source: original, after NIS [19] data.

Regarding the total migration flow within Romania, it suffers a decrease in 2020 and 2021, which were the first years of pandemic. Nevertheless, in the following two years (2022 and 2023), the growth is accelerated, exceeding the value of the control year (2019). It should be noted that this migration increase, covering the people who moved from one residential environment to another, is best reflected in the relocations from urban to rural areas. The other categories remained relatively constant, compared to the evolution of the total number of people who relocated.

The last stage of the personal research consisted of compiling a questionnaire to find out the reasons that led city dwellers to move to the countryside in 2020-2023, amid the Covid-19 health crisis. After receiving the responses, they were evaluated and conclusions could be drawn.

Regarding ***Question 1*** – "How many members does your family consist of?", it emerged that an overwhelming proportion (91.9%) of those who decided to move to the rural area are family-oriented, and 85.05% have at least one minor child.

This aspect is very important, as the existence of children and the desire to provide them with the opportunity to have their own yard to play in was cited as one of the motivations for relocating to the rural area.

Answers to ***Question 2*** emphasized that 88.5% of the respondents have between 19 and 45 years, while the highest number of family members are kids (Figure 3).

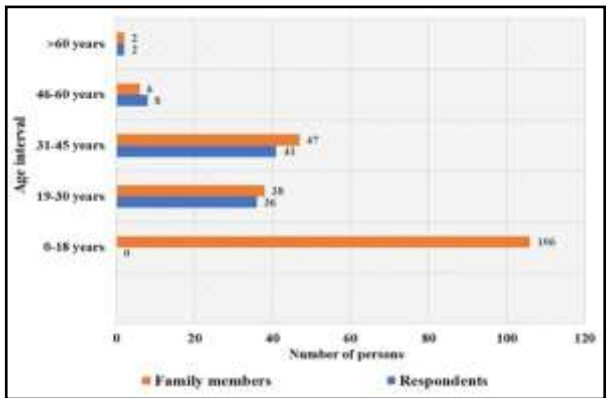

Fig. 3. Distribution graph of the age interval for the respondents and their family members

Source: original, own data.

Regarding ***Question 3***, the answers highlighted

the fact that 94.3% of the 87 respondents have at least one car of their own at family level, an aspect that helps with easier mobility, in case of need.

Question 4 divided the respondents into two broad categories:

-77% are those who were able to carry out their work remotely;

-23% are those who lost their jobs during the pandemic, which is why they were forced to move.

Question 5. Regarding the family's net monthly income, the values were grouped into several ranges, with representatives in each category, which led to the conclusion that this indicator is not representative for making the decision to migrate to the rural area.

Question 6. Much more important is the fact that all respondents moved to the rural area after previously living in large urban centers like Bucharest, Ploiesti, Alexandria, Targoviste, Brasov, Timisoara, Cluj-Napoca (Figure 4).

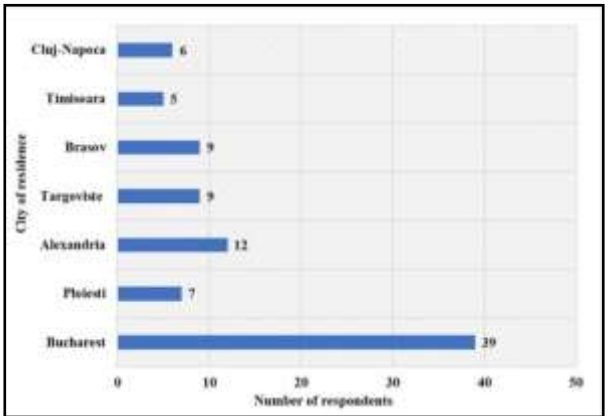

Fig. 4. Distribution graph of the city of residence for the respondents that chose to relocate
Source: original, own data.

Question 7 "How far from the city is the new home?" revealed that the new home was, in 83% of cases, 20-40 km from the former residence, in the immediate vicinity of the city. This percentage correlates with the fact that 77% of respondents kept their jobs and work remotely or in a hybrid system. In the event of a return to the old work schedule, they may commute to the city.

For Question 8, respondents had to choose between two answer options:

-new home – 66% of respondents;

-parental home – 34% of respondents.

Of the 66%, about half were those who moved to their hometowns, where they have parents or more distant relatives.

Particularly interesting was ***Question 9***, regarding the date of moving to the rural area. It turned out that:

-47% of the 87 interviewees relocated in the fall of 2020, about 6 months after the start of the pandemic;

-33% moved during 2021;

-20% moved during 2022.

The impact of the pandemic has diminished over time, which is why people's preference for migrating to rural areas has also decreased, but remains a much more accelerated phenomenon than before 2020. It can be said that the rural area has become more attractive from many points of view.

In response to Question 10, each respondent provided at least two factors that led them to decide on relocation. The most common answers, in order of importance, were:

-the fear of a new period of isolation at home and the impossibility of having a place to sit outside and play for children – mentioned by 71 people;

-the chance to break away from the city, now with the possibility of working from home (remotely) – mentioned by 55 people;

-lower living costs in rural areas – mentioned by 20 people.

Given that this questionnaire was sent out for completion in the second half of 2024, when everything had returned to normal, the role of ***Question 11*** was to determine whether this change had caused many others. It seems that only 21% of respondents still work from home, 37% benefit from a hybrid system (with 1-2 days a week physically, the rest remotely), and the remaining 42% have to commute to work.

However, the benefits of living in the country-side seem to outweigh the disadvantages, as all 87 respondents state that they are satisfied with the move ***(Question 12),*** intend to stay long-term ***(Question 13)*** and consider their standard of living to be much higher **(*Question 14*).**

To the last question **(*Question 15*)**, respondents unanimously stated that they would not want to return to the urban environment. However, several of them completed their answer by

saying that only major changes, impossible to implement at the moment, could make them change their minds:
-pollution levels reduced by over 50%;
-light traffic, including during peak hours;
-significant increase in areas occupied by green spaces and parks;
-reduction in current expenses;
-decreased stress levels.

CONCLUSIONS

The changes generated by the Covid-19 pandemic are substantial at a socio-economic level, aspects that it seems that the population of the entire globe has become accustomed to and which have been integrated into the daily lives of each of us.
With the changes imposed (isolation, remote work, online ordering of goods, etc.), many people have adapted so well to what was offered to them as an alternative that they no longer wanted to return to the pre-pandemic state. Many of these are the ones who decided that the time was right to make a major change, and for this they chose the rural environment.
According to the data presented, migration to rural areas reached unimaginable levels in the very year of the pandemic's onset – in 2020, by the end of the year, the number of those who established their residence in the countryside increased by over 160%, compared to previous years. This aspect correlated with that resulting from our own research, based on the questionnaire.
This trend is also supported by figures that prove that in the years 2020-2023, more and more people moved from urban to rural areas, this being the most significant migration course in Romania. The motivations behind such a change are diverse, but the results are favorable, providing satisfaction to new residents. It is very possible that the Covid-19 pandemic has given rise to a new migratory flow, and the rural area will regain its former glory, to the detriment of large urban centers.

REFERENCES

[1]Behera, M., Mishra, S., Behera, A.R., 2021, The COVID-19-led reverse migration on labour supply in rural economy: challenges, opportunities and road ahead in Odisha. The Indian Economic Journal, 69(3), 392-409.
[2]Bista, R., Parajuli, R., Giri, K., Karki, R., Song, C., 2022, Impacts of COVID-19 pandemic on the livelihoods of rural households in the community forestry landscape in the Middle Hills of Nepal. Trees, Forests and People, 9, 100312.
[3]Cuadros, D.F., Branscum, A.J., Mukandavire, Z., Miller, F.D., MacKinnon, N., 2021, Dynamics of the COVID-19 epidemic in urban and rural areas in the United States. Annals of Epidemiology, 59, 16-20.
[4]De Luca, C., Tondelli, S., Aberg, H.E., 2020, The Covid-19 pandemic effects in rural areas – turning challenges into opportunities for rural regeneration. TeMA Journal of Land Use, Mobility and Environment, Special Issue. http://www.serena.unina.it/index.php/tema/article/view/6844. Accessed on January 22, 2025.
[5]Dudley, L., Couper, I., Kannangarage, N.W., Naidoo, S., Ribas, C.R., Koller, T.S., Young, T., 2023, COVID-19 preparedness and response in rural and remote areas: a scoping review. PLOS Global Public Health, 3(11): e0002602.
[6]Elejalde, E., Ferres, L., Navarro, V., Bravo, L., Zagheni, E., 2024, The social stratification of internal migration and daily mobility during the COVID-19 pandemic. Scientific Reports, 14, 12140.
[7]Floss, M., Franco, C.M., Malvezzi, C., Silva, K.V., dos Reis Costa, B., de Lima e Silva, V.X., Werreria, N.S., Duarte, D.R., 2020, The COVID-19 pandemic in rural and remote areas: the view of family and community physicians on primary healthcare. Reports in Public Health, 36(7), e00108920.
[8]Gatti, F., Procentese, F., 2021, Local community experience as an anchor sustaining reorientation processes during COVID-19 pandemic. Sustainability, 13, 4385.
[9]Glass, J., Shucksmith, M., Chapman, P., Atterton, J., 2024, Rural lives during COVID-19: crisis, resilience and redistributing societal risk. Scottish Geographical Journal, 140(1-2), 49-69.
[10]Golubchikov, Y.N., 2021, COVID-19 pandemic – milestone in rediscovering the rural life. Journal of Settlements and Spatial Planning, 12(1), 63-70.
[11]Gonzalez-Leonardo, M., Rowe, F., Fresolone-Caparros, A, 2022, Rural revival? The rise in internal migration to rural areas during the COVID-19 pandemic. Who moved and where? Journal of Rural Studies, 96, 332-342.
[12]Guzman Rincon, A., Barragan Moreno, S., Cala-Vitery, F., 2021, Rural population and COVID-19: a model for assessing the economic effects of drop-out in higher education. Frontiers in Education, 6, 812114.
[13]Halfacree, K., 2024, Counter urbanisation in post-covid-19 times. Signifier of resurgent interest in rural space across the global north? Journal of Rural Studies, 110, 103378.
[14]Incaltarau, C., Kourtit, K., Pascariu, G.C., 2024, Exploring the urban-rural dichotomies in post-pandemic migration intention: empirical evidence from Europe. Journal of Rural Studies, 111, 103428.

[15]Low, S.A., Rahe, M.L., Van Leuven, A.J., 2022, Has COVID-19 made rural areas more attractive places to live? Regional Science Policy & Practice, 1, 21.
[16]Monnat, S.M., 2021, Rural-urban variation in COVID-19 experiences and impacts among U.S. working-age adults. The Annals of the American Academy of Political and Social Science, 698(1), 111-136.
[17]Mueller, J.T., McConnell, K., Burow, P.B., Pofahl, K., Merdjanoff, A.A., Farrell, J., 2021, Impacts of the COVID-19 pandemic on rural America. PNAS, 118(1), e2019378118.
[18]NIS, Tempo-online – POP304A – Stabiliri de resedinta pe medii de rezidenta, macroregiuni, regiuni de dezvoltare și județe. (Residence arrangements by residence areas, macroregions, development regions and counties.
[19]NIS, Tempo-online – POP311A – Structura fluxurilor migratiei interne urbane si rurale, determinate de schimbarea domiciliului. (The structure of urban and rural internal migration, determined by change of residence).
[20]Ofuoku, A.U., Opia, B.O.P., Ikpoza, E.A., 2021, Impact of COVID-19-induced rural-rural migration on agricultural productivity in Delta State, Nigeria. Scientia Agropecuaria, 12(1), 49-55.
[21]Oncu, M.A., Somuncu, M., Guney, I., Perlik, M., 2023, Rural and alpine gentrification impact on lifestyle mobilities during COVID-19: the Yayla experience at the Taurus Mountains in Turkey. European Countryside, 15(2), 259-280.
[22]Pandey, B., Gu, J., Ramaswami, A., 2022, Characterizing COVID-19 waves in urban and rural districts of India. npj Urban Sustainability, 2, 26.
[23]Petersen, J.K., Winkler, R.L., Mockrin, M.H., 2024, Changes to rural migration in the COVID-19 pandemic. Rural Sociology, 0(0), 1-26.
[24]Phillipson, J., Gorton, M., Turner, R., Shucksmith, M., Aitken-McDermott, K., Areal, F., Cowie, P., Hubbard, C., Maioli, S., McAreavey, R., Souza-Monteiro, D., Newbery, R., Panzone, L., Rowe, F., Shortall, S., 2020, The COVID-19 pandemic and its implications for rural economies. Sustainability, 12, 3973.
[25]Pickering, J., Wister, A.V., O'Dea, E., Chaudhury, H., 2023, Social isolation and loneliness among older adults living in rural areas during the COVID-19 pandemic: a scoping review. BMC Geriatrics, 23, 511.
[26]Rajib, P., Ahmed, A.A., Oluwesen, A., Subhanwita, G., Dan, H., 2020, Progression of COVID-19 from urban to rural areas in the United States: a spatiotemporal analysis of prevalence rates. The Journal of Rural Health, 36, 591-601.
[27]Ramachandran, V., 2021, Urban-rural mobility during COVID-19: the growth of 'cottagecore' in Australia and Aotearoa – New Zealand. Max Planck Institute for Social Anthropology – MoLab Inventory of Mobilities and Socioeconomic Changes. https://www.eth.mpg.de/5851361/urban_rural_mobility_during_covid19. Accessed on January 23, 2025.
[28]Sharifi, A., Lee, C.Y., 2024, The appeal of cities may not wane due to the COVID-19 pandemic and remote working. npj Urban Sustainability, 4, 11.
[29]Syafitri, W., Prestianawati, S.A., Naldi, G.A., 2022, The impact of COVID-19 pandemic on informal sector migrants in rural east Java-Indonesia. International Journal of Professional Business Review, 7(4), 1-14.

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AN INTEGRATED MODEL OF FOOD LOSS AND WASTE DETERMINATION ALONGSIDE THE AGRIFOOD CHAIN

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Abstract

The Food Loss and Waste (FLW) phenomenon is an important issue in the current development of economy as a whole. This phenomenon is emerging in all economic contexts, starting from food production and processing, known as food loss (FL), to the consuming stages, known as food waste (FW). In this matter, identifying key causes and quantifying the impact of FLW is essential. The current paper is an integrated summative description of several research results related to FLW obtained by the authors and elaborated in previous papers. Thus, the paper includes a bird-eye view of the entire model alongside the agri-food chain, taking into account modalities of measuring the FL during its components and a specific measurement of FW on the consuming component. The approach takes into account methodologies and instruments from various domains, such as statistics, data processing, automated learning (e.g., machine learning), System Dynamics or networks. The expected results are the description of the model and the resulted data. Conclusions can be used further to study and challenge the FLW phenomenon causes effects for any interested stakeholders.

Key words**:** *agrifood chain, food loss and waste, modelling, statistics, automated learning*

INTRODUCTION

Food Loss and Waste (FLW) is one of the most pressing challenges of the contemporary agri-food chain ([9] Luo, N. et al. (2022)), with major economic, social and environmental causes ([12] Nijloveanu, D. et al. (2023)) and implications. From production and processing ([17, 18] Omolayo, Y. et al. (2021)), to distribution ([7] Derqui, B. et al. (2016); [1] Arunraj, N.S. et al. (2014)) and consumption ([13, 15] Nijloveanu, D. et al. (2023, 2024), [2] Bucatariu, C. (2014)), food is lost or wasted ([25] Santeramo, F.G. et al. (2021)) in significant quantities, affecting food security ([24] Santeramo, F.G. & Lamonaca, E. (2018)) and the sustainability ([21] Parfitt, J. et al. (2010)) of the agri-food system ([14] Nijloveanu, D. et al. (2023)). In this context, it is essential to identify the causes of FLW, measure its impact and develop effective prevention ([6] De Clercq, D. et al. (2017); [22] Peira, G. et al. (2018)) and intervention models ([10] Magalhães, V.S.M. et al. (2021); ([2] Chandadevi, G. et al. (2019); [8] Graham-Ro., E. et al. (2015)).

This research proposes an integrated approach to the FLW phenomenon ([16] Nijloveanu, D. et al. (2023)), with a focus on the consumption ([3] Chereji, A.I. et al. (2022)) component, using a combination of statistical methods, formal modeling (Petri nets, system dynamics) ([31] Trevisan, C. &Formentini, M. (2023); [20] Pan, S. et al. (2018)), behavioral analysis (questionnaire) and artificial intelligence tools (neural networks and decision trees) ([11] Malefors, C. et al. (2022); [19] Ozcil, I.E. (2024)). Through this approach, the study aims to identify the determinants of food waste behavior ([27] Schanes, K. et al. (2018)), classify consumption patterns ([23] Pocol, C.B. et al. (2020); [4, 5] Chereji, A.I. et al. (2022, 2023)), and build predictive models ([26] Sathiyaraj, R. et al. (2022); [28] Segarra, L. et al. (2019); [29] Shopnil, M. et al. (2023)) that can support the formulation of effective

policies and actions at the consumer level ([30] Singh, B. et al. (2024)).

The research is organized into several steps, the first of which is a bibliographic analysis of the relevant literature, followed by a structural modeling of the food chain's constituents, and then the development of predictions that are intended to be applied to the real world, this results in a coherent and accurate description of how food waste is understood, anticipated, and reduced.

This research aims to comprehensively explore the phenomenon of Food Loss and Waste (FLW) across the agri-food chain, with a particular focus on the consumption component.

The main objective is to identify the determinants of FLW, to model them using formal tools and to develop predictive models based on consumer behavior, in order to substantiate effective policies and measures to reduce food waste.

MATERIALS AND METHODS

The research proposes an integrated and multidisciplinary approach to the FLW phenomenon, combining:

-quantitative methods (descriptive and inferential statistics);

-formal methods (Petri modeling and System Dynamics);

-modern artificial intelligence methods (Machine Learning and Neural Networks);

-applied behavioral analytics.

This combination allows not only a descriptive and explanatory understanding of the FLW phenomenon, but also the development of predictive and operational tools applicable to public policies and sustainable strategies.

Research stages

The research was structured in several complementary stages, carried out chronologically and logically interconnected:

(i)Bibliographic analysis and identification of factors (exploratory stage): The research started with a comprehensive study of the literature that identified the primary causes of food loss and waste (FLW). Using academic sources from Dimensions.ai and the VOSviewer term analysis tool, the identified factors were grouped into five broad categories – behavioral, demographic, biological, economic, and political – each mapped to specific stages of the agri-food chain. Descriptive statistical study and correlational analysis: To quantify the influence of these factors, the next step consisted of a correlational statistical analysis, using data from official sources such as Eurostat [32], FAO [33] and INS Tempo Online [34]. The Pearson correlation coefficient was calculated between the independent variables and the food waste indicators, and the significance of the relationships was statistically tested using the t-test.

(ii)Systemic modeling of the agri-food chain – the Petri Nets approach: The formal modeling stage involved representing the dynamics of losses and food flows using Petri Nets. Using the CPN Tools application, a graphical and mathematical model was built that simulates the states of food (raw materials, processed products, waste) and the transitions between them, highlighting the critical points of the agri-food chain, including recycling processes.

(iii)Behavioral study – ReWaFA questionnaire: To analyze consumer behaviors related to food waste, a structured online questionnaire was developed, distributed at national level (NUTS-2 regions). The questionnaire included questions on food purchasing, storage and management habits, and 364 valid responses were collected.

(iv)Statistical analysis of responses – identification of behavioral patterns: The data obtained were analyzed both univariately (frequencies, means, distributions) and multivariately, by applying the Hierarchical Cluster Analysis (HCA) method. This analysis allowed the identification of distinct behavioral patterns depending on the attitudes, habits and perceptions of consumers regarding food waste.

(v)Predictive Modeling – Neural Networks and Decision Trees: Based on the collected data, an artificial neural network (ANN) model was built in Python using the tensorflow and sklearn libraries. The model was trained on 80% of the data and tested on the remaining 20%, aiming to predict the perceived food waste category (FWP), based on 34 input

variables. The model performance was evaluated by accuracy, precision, recall, F1 score and loss function. In parallel, a second predictive model was developed, based on the CART (Classification and Regression Tree) algorithm, implemented in the Orange software. This model offers superior interpretability and was evaluated by the same indicators as NNA, complemented by ROC–AUC and the MCC coefficient for evaluating binary classification and sensitivity to unbalanced data.

The summary of the stages is shown in Table 1.

Table 1. The summary of the stages

No.	Stage	Objective	Methods	Tools	Result (Data/Model)	Stage in Agrifood Chain
1	Identification of FLW factors (literature review)	To define the main factors influencing FLW	Bibliographic study, term mapping	Dimensions.ai, VOSviewer	Taxonomy of factors (behavioral, economic, etc.)	Entire agrifood chain
2	Statistical analysis of indicators	To determine the relationships between factors and food waste quantities	Pearson correlation, t-test	Eurostat, FAO, INS Tempo Online	Statistically significant relations between variables	Entire agrifood chain
3	Formal modeling	To model the dynamics of FLW processes and flows	Formal modeling, simulation	CPN Tools, CPN IDE	Petri Net model with food states and transitions	Entire agrifood chain
4	Behavioral study (ReWaFaQuestionnaire)	To collect data on consumer food waste behavior	Online questionnaire, convenience sampling	Google Forms	364 structured responses	Consumption component
5	Statistical analysis of survey responses	To identify behavioral patterns related to FLW	Univariate & multivariate analysis (HCA)	Orange 3.37.0 / Excel	Behavioral clusters (consumer profiles)	Consumption component
6	Predictive modeling – Neural Network (NNA)	To predict food waste behavior	Machine Learning – Neural Network	Python (Tensorflow, Sklearn)	Predictive model (numerical or categorical outputs)	Consumption component
7	Predictive modeling – decision tree (DTA)	To classify food waste behavior	Machine Learning – CART algorithm	Orange 3.37.0	Decision tree model with classification outputs	Consumption component

Source: Authors' conception.

The research was structured in several complementary methodological stages, carried out chronologically. It began with a bibliographic analysis to identify factors influencing food losses and waste (FLW), followed by a statistical analysis of relevant indicators. Then, a formal model of the agri-food chain was developed using Petri nets to capture the dynamics of losses by stage. Consumer behavior was investigated through an online questionnaire, and the responses were statistically analyzed and grouped into behavioral patterns. Based on this data, two predictive models — a neural network and a decision tree — were built to identify waste trends at the consumption level. All these stages were supported by rigorous data processing and integration processes.

Data Management

A key component of the research was the collection and processing of data across the agrifood chain, with emphasis on the consumer

level. The data included: (1) historical statistics on food waste and economic trends, (2) results from a dedicated consumer behavior questionnaire, and (3) data generated through applied methods such as factor analysis, system dynamics diagrams, statistical correlations, Petri net modeling, and cluster analysis.

The questionnaire responses (highlighted in Table 2) served as the main dataset for building the prediction models. These were complemented by statistical and historical sources and analyzed using various modelingand analytical tools to uncover patterns and causal relationships in food waste behavior.

Table 2. The data configuration

Data Category	Data Source	Data Generation Method	Resultant Data	Resulted Data Form
Statistical data	Historical datasets	Direct observation and collection	Economic (e.g., GDP per capita), social and environmental indicators	Plots
Statistical data	*Questionnaire*	*Collection*	*FLW behavior indicators*	*Plots*
FLW factor determination	Literature review	Factorial analysis, correlation	Correlation data between factors and FLW amount	Plot, factor diagram
Cause and effect	FLW factor determination	System Dynamic	Cause and effect influences	Cause and effect diagram
Structured data	Literature review, FLW factor determination	Petri nets, graph structures	Agrifood chain dynamic	Petri net
Clusters	Questionnaire	Hierarchical Cluster Analysis (HCA)	Consumer-related FW clusters	HCA dendrogram
Prediction data	Prediction models	NN and DT	Prediction and classification data	Plots, clusters

Source: Authors' conception.

The data used in the research were processed according to the source: historical statistical data were analyzed through correlations and interpolations; questionnaire responses were coded, normalized and divided into training/test sets for predictive models; and derived data (graphs, Petri nets, clusters) were structured and integrated into explanatory and predictive models. This processing allowed for both quantitative analysis and structural understanding of the FLW phenomenon.

RESULTS AND DISCUSSIONS

The following section presents the results obtained in the research on the phenomenon of food losses and waste (FLW), with a focus on consumer behavior. The results are structured according to the methodological steps followed, including bibliographic and statistical analysis, formal modeling of the agri-food chain, analysis of data obtained through the questionnaire, as well as the development and evaluation of predictive models. Each subsection provides a presentation of the data, models or patterns identified, accompanied by interpretations relevant to understanding and combating FLW, especially at the consumption stage.

Results of the bibliographic and statistical analysis

This section presents the conclusions drawn from the literature review and statistical correlations based on historical and economic data on food waste. The main relationships identified between socio-economic indicators and the amount of reported food waste are highlighted.

Following the identification and classification of factors influencing food losses and waste (FLW), five main categories of factors were outlined: behavioral, demographic, biological, public policy and economic. Behavioral factors include purchasing patterns, habits, attitudes,

social norms and educational level, reflecting how individual choices influence waste. The factors are presented in Table 3.

Table 3. The factors that are identified as being influential in the FLW are combined with the food chain

No.	Category		Factor
1	Behavioural		Buying patterns
			Habits
			Attitudes
			Subject norms
			Educational background
2	Demographic		Age
			Number of members in household
			Region
3	Biological		Food perishability
			External biological agents (e.g., COVID-19 pandemic, food toxins, bacteria, viruses)
4	Policy		Social policies related to food waste
			Economic policies related to income
5	Economic	Producer	Productivity
			Management type
		Processing	Number of processing phases
			Quality standards
		Packaging	Package parameters
		Logistics	Logistic parameters
			Storage
		Distribution	Promotions
			Sales volume
			Low prices
		Consuming	GDP per capita
			Income

Source: Authors' conception.

To highlight the causal relationships between the identified factors and the phenomenon of food loss and waste, a cause-and-effect diagram was created using the System Dynamics methodology. This diagram allows for the visualization of interdependencies between variables such as consumer behaviors, public policies, economic conditions, and food product characteristics. The diagram can be seen in Figure 1.

The loop structure highlights both the amplifying loops (e.g. the effect of purchasing habits on the amount of waste) and the regulating ones (e.g. the impact of education or policies on FLW reduction), providing an integrated perspective on the dynamics of the phenomenon.

Fig, 1. The cause–effect diagram of the model built using system dynamics
Source: Authors' conception using Vensim PLE tool.

Formal model results

The formal model of the agri-food chain using Petri nets is presented, highlighting the system states, transitions and flows of food resources, including waste generation and recycling. Observations obtained from the model simulation and interpretation of the system dynamics are included. The resulted Petri net is shown in Figure 2.

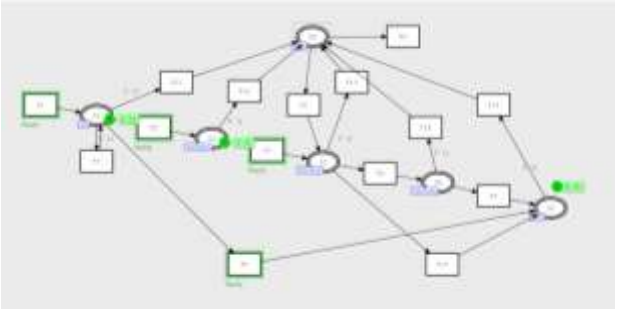


Fig. 2. The model built using Petri nets and graphs
Source: Authors' conception using CPN IDE tool.

The primary goal of the research using Petri nets was to explore the waste cycle within the agri-food chain, with a particular focus on food losses and food waste, in order to identify the most effective strategies for managing waste in the agri-food industry. In the model, the components of the agri-food chain – such as farmers – are represented as states, while the transitions between these states are modeled as processes. Arcs illustrate the links between states and the transformations that occur. For example, transition T1 is connected to state S1, representing the generation of raw materials through agricultural processes. In this case, the food's status within the system is labeled as "Farm Raw Material."

Behavioral study results

This subsection summarizes the data obtained from the consumer questionnaire, focusing on the socio-demographic characteristics of the respondents and their food purchasing, storage and waste behaviors. The data collected through the questionnaire are structured into three main sections: demographic information (age, gender, education, income), food purchasing habits (percentage of income, places of purchase) and perceptions of food waste (quantity, types of products wasted). Figure 3 presents the demographical data.

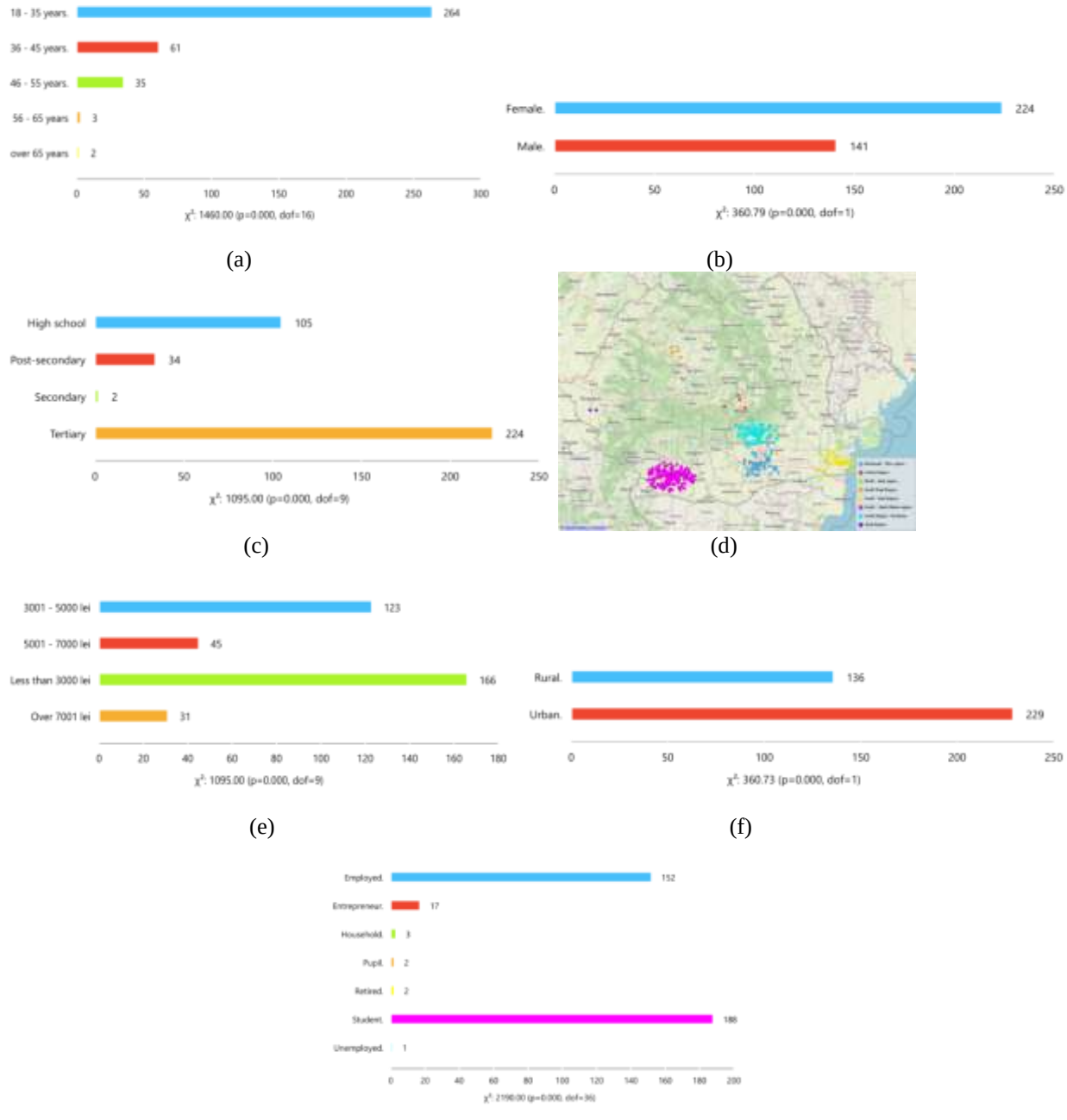
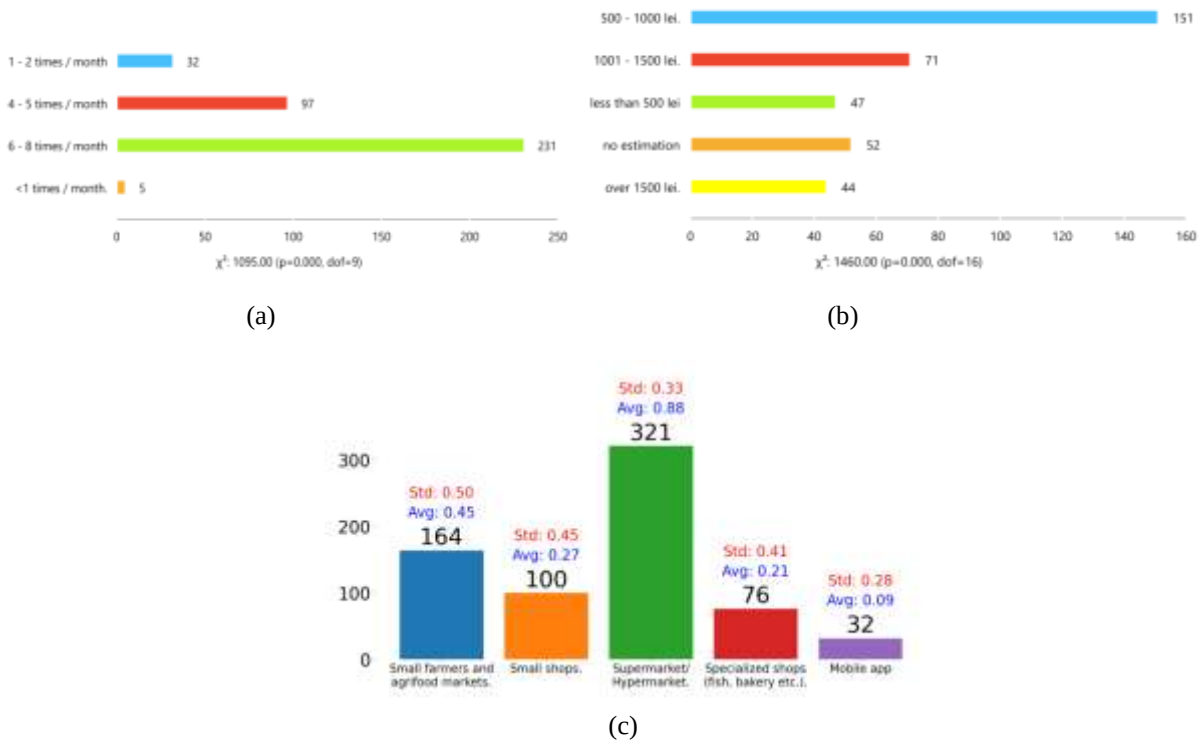


Fig. 3. The presentation of the demographic characteristics of the sample group: (a) age; (b) gender; (c) formal education level; (d) NUTS-2 geographical distribution; (e) monthly income; (f) residence; (g) socio-economic category
Source: Authors' conception from the consumer questionnaire

Demographic data reveals that the majority of respondents fall within the 18–35 age range (approximately 73%), indicating strong interest in the topic among younger individuals. Additionally, over 60% of

participants are women, and the overall education level is high, with a significant proportion holding higher education degrees (ISCED levels 5–8). This suggests a well-informed audience with a solid understanding of food waste issues. Geographically, the majority of respondents come from the South-West region of Romania, which reflects a relatively unbalanced regional distribution. Approximately half of the respondents declare monthly incomes below 3,000 lei, which could influence a more cautious attitude towards waste. The majority of respondents come from urban areas and belong to the blue-collar socio-economic category.

Figure 4 presents the indicators related to food behavior.



(a) (b)

(c)

Fig. 4. The presentation of the food behavior indicators of the sample group: (a) frequency of food purchasing; (b) amount of money spent on food; (c) places chosen for food purchasing.
Source: Authors' conception from the consumer questionnaire.

Purchasing behavior was analyzed by frequency of purchases, monthly spending amount and preferred places for shopping. Most respondents buy food 1–2 times a week (6–8 times a month), spending between 500–1,000 lei per month (approx. 100–200 euro). In terms of purchasing sources, the most common are supermarkets/hypermarkets, followed by direct purchases from small agricultural producers.

Regarding food waste, respondents generally exhibit a responsible attitude, though they acknowledge certain limitations, particularly in managing their time effectively. Most estimate that they waste up to 10% of the total food they purchase. The most commonly discarded items include cooked meals, meat, and dairy products. The main perceived causes of waste are the large quantities of food purchased or cooked and their perishable nature. Food waste is rarely thrown away – it is more often reused, offered as animal feed or preserved. Most respondents also report checking expiration dates regularly; however, selective recycling is rarely practiced.

Common measures taken to reduce food waste include using a shopping list and prioritizing the purchase of local products.

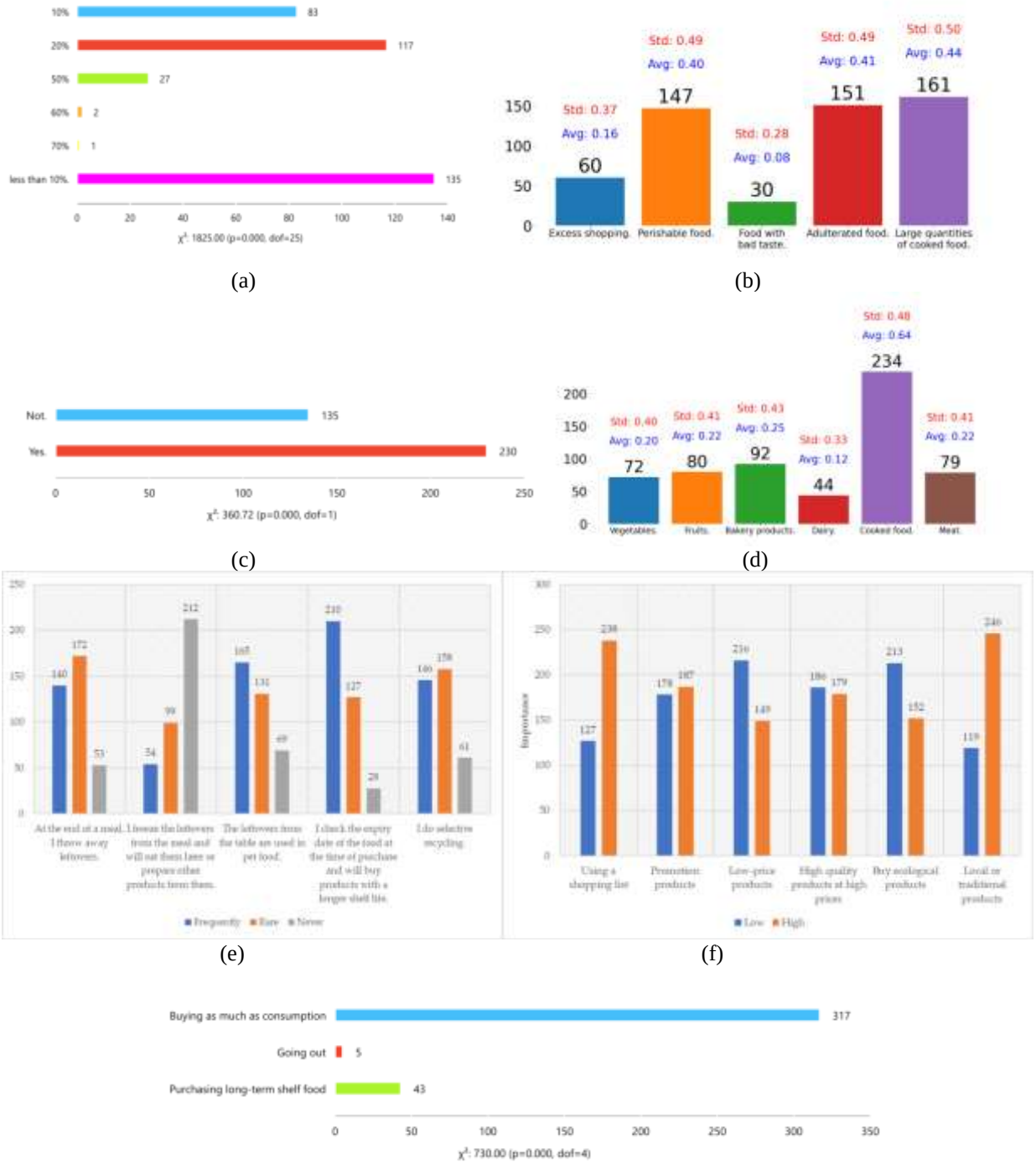


Fig. 5. The presentation of the food waste behavior indicators within the sample group: (a) main perceived causes of food waste; (b) perceived proportion of food wasted relative to total food purchased; (c) proportion of respondents who report discarding unconsumed food; (d) categories of food most frequently wasted; (e) responses to statements related to food waste attitudes and behaviors; (f) factors considered by respondents during the food purchasing process; (g) measures identified by respondents to reduce food waste.
Source: Authors' conception from the consumer questionnaire.

Results of multivariate analysis

Based on the collected data, multivariate classification methods were applied to identify behavioral patterns regarding food waste. The obtained clusters, associated behavioral profiles and relevant interpretations are presented. A dendrogram was resulted, but the image is too wide to be presented here. Thus, the clusters are shown in Table 4.

Table 4. The main clusters resulted in the multivariate analysis

Cluster	No. of respondents	Purchase frequency	Perceived food waste	Leftover management	Recycling	Main cause of waste
C1	22	Frequent	Low	Reused (mainly for pets)	Selective	Spoilage after cooking
C2	77	Frequent	10–20%	Partially preserved	Unpredictable	Perishability, excess food
C3	129	Frequent	~20%	Rarely preserved	Moderate	Excess cooked food
C4	51	4–8 times/month	<10%	Rarely preserved	Unpredictable	Spoilage of cooked food
C5	85	Frequent	10–20%	Occasionally reused (pets)	Slightly positive	Perishability

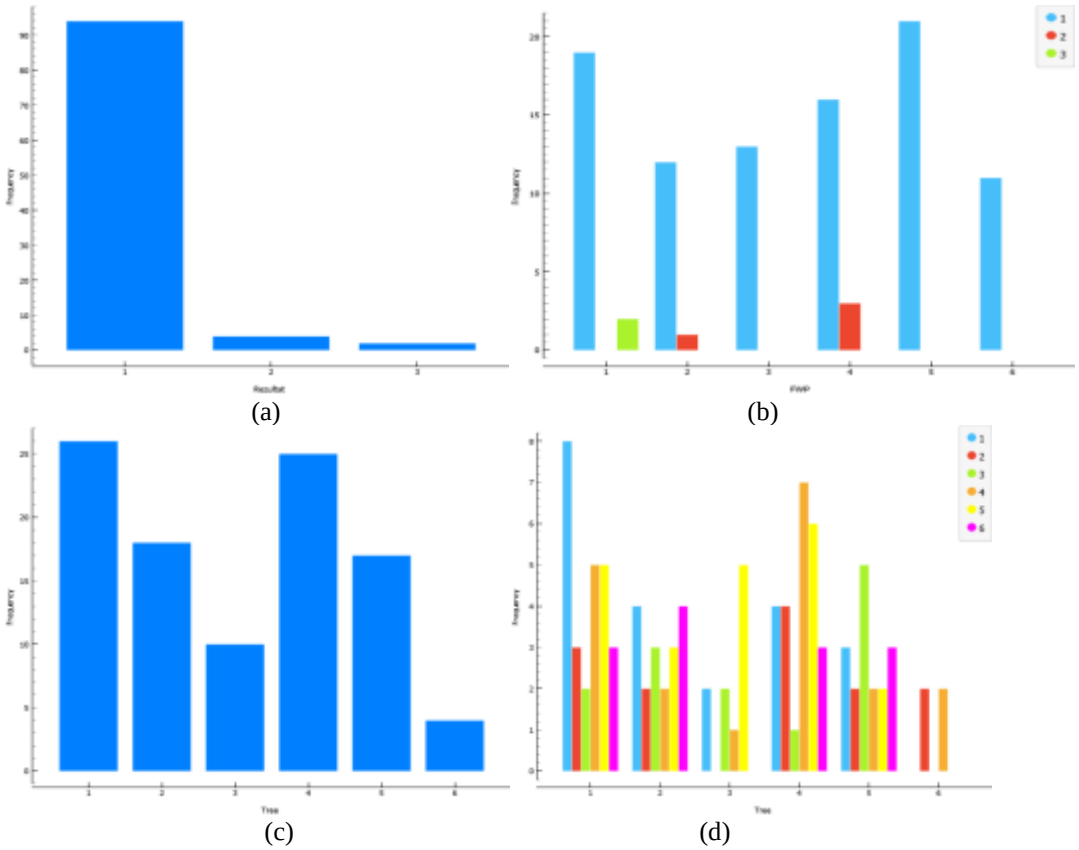
Source: Authors' conception from the consumer questionnaire data using Orange Data Mining tool

The cluster analysis revealed five behavioral patterns regarding food waste.

All clusters share the increased frequency of purchases and the preference for products with a long shelf life, but differ in the perceived level of waste (below 10% to 20%), the way in which waste is managed (from frequent reuse to neglect), recycling (selective or unpredictable), and the main causes of waste (perishability or excess cooked food). These results helped identify key variables for the predictive models and confirmed two of the initial hypotheses of the study.

Results of predictive models

The performance of the two built predictive models: neural network (NNA) and decision tree (DTA) is presented. Details on accuracy, classification scores, confusion matrix and other performance indicators are included. The differences between the two approaches are also discussed.



(a) (b) (c) (d)

Fig. 6. The composition of the classes associated with the new dataset for the Neural Network (NN) approach: (a) the distribution of the predicted classes; (b) the comparison between the predicted classes and the actual (randomly generated) classes.

The composition of the classes associated with the new dataset for the Decision Tree (DT) approach: (c) the distribution of the predicted classes; (d) the comparison between the predicted classes and the actual (randomly generated) classes.

The six classes correspond to the six possible responses to the question, "The perceived percent of food thrown away monthly", which was treated as the dependent variable and encoded on a scale from 1 to 6. The visualized data illustrate the distribution of these classes as predicted by the model.

The first graphic shows the general distribution of the predicted classes, while the second graphic shows a grouped distribution of predicted classes as compared to the initial classes included in the dataset. The classes as determined from the questionnaire responses compared to the classification obtained after the appliance of the classification models for NN and DT are shown in Figure 6.

The neural network demonstrated superior performance, achieving an accuracy of 78% and a Matthews Correlation Coefficient (MCC) of 0.70, indicating a strong correlation between the predicted and actual values.

Confusion matrix analysis showed that the neural model correctly classified the majority of instances, demonstrating robustness and generalization capacity even in the presence of noise or outliers.

In contrast, the decision tree had an accuracy of only 31.5%, with a negative MCC (−0.028) and a ROC–AUC of 0.465, reflecting a performance close to random classification. The model faced overfitting problems and had difficulties in separating classes efficiently.

In addition to the technical aspects, the analysis of the models also highlighted a significant influence of socio-economic variables, especially demographic and economic ones, on the final results.

The 34 variables used contribute in combination to the accuracy of the predictions, and future research will aim to quantify the individual (univariate) influence of each variable to more clearly understand the role of each factor in generating food waste.

CONCLUSIONS

This research offered an integrated approach to the phenomenon of food loss and waste (FLW), combining quantitative methods, formal modeling tools, and predictive techniques to investigate its causes, behavioral patterns, and potential interventions, with a particular emphasis on the consumption stage.

In the first stage, the main factors influencing FLW were identified and classified, structured into behavioral, demographic, biological, political and economic categories, throughout the agri-food chain. Statistical analyses and formal modeling using Petri Nets highlighted the critical points of waste generation and allowed the simulation of food flows, providing a structural understanding of the phenomenon.

The data obtained through the questionnaire highlighted distinct patterns of food behavior, grouped into five clusters, reflecting purchasing habits, perception of waste, reuse of leftovers and recycling behaviors. These patterns were the basis for the development of two predictive models.

Comparing the performances of the neural network model with that of the decision tree showed a clear superiority of the former, with high accuracy (78%), robustness to noisy data and good correlation between predictions and actual values (MCC = 0.70). The decision tree, although easier to interpret, presented a poor performance, affected by overfitting and an inefficient separation of classes (accuracy 31.5%).

In conclusion, the integration of behavioral, socio-economic and structural data in a complex predictive approach represents a valuable tool for understanding and preventing food waste. In future research, it is necessary to deepen the individual influence of variables and extend the applicability of the models in different contexts for the formulation of efficient and personalized public policies.

REFERENCES

[1]Arunraj, N.S., Ahrens, D., Müller, M., Fernandes, M., 2014, Time Series Sales Forecasting to Reduce Food Waste in Retail Industry. In Proceedings of the 34th International Symposium on Forecasting, Rotterdam, The Netherlands, 29 June–2 July 2014.

[2]Bucatariu, C., 2014, Recovery and Redistribution of Safe and Nutritious Food for Human Consumption and Food Waste Prevention and Reduction. In Knowledge and Information for Sustainable Food Systems; FAO: Rome, Italy, pp. 133–150.

[3]Chandadevi, G., Johansson, U., Löfström, T., 2019, Predictive Modeling of Campaigns to Quantify

Performance in Fashion Retail Industry. In Proceedings of the IEEE International Conference on Big Data , Los Angeles, CA, USA, 9–12 December 2019.
[4]Chereji, A.I., Suiugan, D., Beleiu, A.M, 2022, Non-compliant aspects in supermarkets from the perspective of consumer protection. Gen. Elem. Ann. Univ. Oradea Fascicle Ecotoxicol. Anim. Husb. Food Sci. Technol. 2022, 21, 97.
[5]Chereji, A.-I., Chereji, I., Popa, A., Chiurciu, I.-A., Iorga, A.-M., 2023, Consumer Behaviour Regarding Food Waste in Romania, Rural versus Urban. Agronomy 2023, 13, 571. https://doi.org/10.3390/agronomy13020571.
[6]De Clercq, D., Schmidt, F., Gottfried, O., Wen, Z., Fei, F., 2017, A Review of Global Strategies Promoting the Conversion of Food Waste to Bioenergy via Anaerobic Digestion. Renew. Sustain. Energy Rev. 2017, 79, pp. 204–221.
[7]Derqui, B., Fayos, T., Fernandez, V., 2016, Towards a More Sustainable Food Supply Chain: Opening Up Invisible Waste in Food Service. Sustainability, 8, 693.
[8]Graham-Ro., E., Sparks, P., Jessop, D.C., 2015, Predicting household food waste reduction using an extended theory of planned behaviour. Resour. Conserv. Recycl. 101, pp. 194–202.
[9]Luo, N., Olsen, T., Zhang, A., Liu, Y., 2022, Reducing food loss and waste in supply chain operations. Transp. Res. Part E Logist. Transp. Rev. 162, 102730.
[10]Magalhães, V.S.M., Silva, C., M.D.F., Ferreira, L., 2021, Causes and Mitigation Strategies of Food Loss and Waste: A Systematic Literature Review and Framework Development. Sustain. Prod. Consum. 28, pp. 1580–1599.
[11]Malefors, C., Marchetti, S., Secondi, L., Eriksson, M, 2022, Food Waste Reduction and Economic Savings in Times of Crisis: The Potential of Machine Learning Methods to Plan Guest Attendance in Swedish Public Catering during the Covid-19 Pandemic. Socio-Econ. Plan. Sci. 2022, 82, 101041.
[12]Nijloveanu, D., Tița, V., Bold, N., Chiurciu, I.A., Smedescu, C., 2023, Research on the causes of the food waste phenomenon in the European Union. Bulg. J. Agric. Sci. 2023, 29 (Suppl. 1), pp.132–139.
[13]Nijloveanu, D., Tița, V., Bold, N., Dinu, T.A., Fîntîneru, G., Smedescu, D., Peticilă, A.G., Smedescu, C., Fîntîneru, A., Mihalașcu, C., 2024, Developing a model based on a statistical analysis of food loss and waste patterns. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 24(2), 705–712.
[14]Nijloveanu, D., Tița, V., Bold, N., Fîntîneru, G., Smedescu, D., Chiurciu, I.-A., Smedescu, C., Gheorghe Pătrăchioiu, N., 2023, Dynamics food loss and waste causes along the agrifood chain in Romania. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 23(4), 569–580.
[15]Nijloveanu, D., Tița, V., Bold, N., Fîntîneru, G., Smedescu, D., Fîntîneru, A., Tudor, V.C., Smedescu, C., Jerca, E., 2024, A statistical study analysis on exploring consumption patterns regarding food loss and waste. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development 24(1), 685-694.
[16]Nijloveanu, D., Tița, V., Bold, N., Smedescu, D., Fîntîneru, G., Smedescu, C., Popescu, D.A., Gheorghe Pătrăchioiu, N., Matei, M.G., 2023, A mathematical model of waste management and food loss along the agrifood chain. Ann. Univ. Oradea Fascicle: Ecotoxicol. Anim. Sci. Food Sci. Technol. 2023, pp 50–55.
[17]Omolayo, Y., Neff, R.A., Xue, X., Feingold, B.J., 2021, Life Cycle Assessment of Food Loss and Waste in the Food Supply Chain. Resour. Conserv. Recycl. 2021, 164, 105119.
[18] Omolayo, Y., Feingold, B.J., Neff, R.A., Xue, X., 2021, Life Cycle Assessment of Food Loss and Waste in the Food Supply Chain. Resour. Conserv. Recycl. 2021, 164, 105119.
[19]Ozcil, I.E., 2024, Reducing Food Waste Using Machine Learning Models: Forecasting and Optimization Approaches. J. Data Sci. Artif. Intell. 2024, 2, 000136.
[20]Pan, S., Duraisamy, K., 2018, Long-Time Predictive Modeling of Nonlinear Dynamical Systems Using Neural Networks. Complexity 2018, 1, 4801012.
[21]Parfitt, J., Macnaughton, S., Barthel, M., 2010, Food Waste within Food Supply Chains: Quantification and Potential for Change to 2050. Philos. Trans. R. Soc. B: Biol. Sci. 2010, 365, pp. 3065–3081.
[22]Peira, G., Bollani, L., Giachino, C., Bonadonna, A., 2018, The Management of Unsold Food in Outdoor Market Areas: Food Operators' Behaviour and Attitudes. Sustainability, 10, 1180.
[23]Pocol, C.B., Pinoteau, M., Amuza, A., Burlea-Schiopoiu, A., Glogoveţan, A.-I., 2020, Food Waste Behavior among Romanian Consumers: A Cluster Analysis. Sustainability, 12, 9708.
[24]Santeramo, F.G., Carlucci, D., De Devitiis, B., Seccia, A., Stasi, A., Viscecchia, R., Nardone, G., 2018, Emerging Trends in European Food, Diets and Food Industry. Food Res. Int. 2018, 104, pp.39–47.
[25]Santeramo, F.G., Lamonaca, E., 2021, Food Loss–Food Waste–Food Security: A New Research Agenda. Sustainability, 13, 4642.
[26]Sathiyaraj, R., Bharathi, A., Balusamy, B., 2022, Advanced Intelligent Predictive Models for Urban Transportation, 1st ed.; Chapman and Hall/CRC: New York, NY, USA.
[27]Schanes, K., Gözet, B., Dobernig, K., 2018, Food waste matters - A systematic review of household food waste practices and their policy implications. J. Clean. Prod. 182,pp. 978–991.
[28]Segarra, L., Hu Du, E., Ruiz, G.R., Bandera, C.F., 2019, Methodology for the Quantification of the Impact of Weather Forecasts in Predictive Simulation Models. Energies, 12, 1309.
[29]Shopnil, M., Husna, A., Islam, M.N., Sultana, S., 2023, An Ensemble ML Model to Predict the Wastage of Food: Towards Achieving Food Sustainability. In Proceedings of the 2023, IEEE Conference on Networked and Computational Intelligence, Gazipur, Bangladesh, 16–17 June 2023; pp. 1–6.

[30]Singh, B., Kaunert, C., 2024, Salvaging Responsible Consumption and Production of Food in the Hospitality Industry: Harnessing Machine Learning and Deep Learning for Zero Food Waste. In Sustainable Disposal Methods of Food Wastes in Hospitality Operations; IGI Global: Hershey, PA, USA, pp. 176–192.
[31]Trevisan, C., Formentini, M., 2023, Digital Technologies for Food Loss and Waste Prevention and Reduction in Agri-Food Supply Chains: A Systematic Literature Review and Research Agenda. IEEE Trans. Eng. Manag. 2023, 71, pp 12326–12345.
[32],Eurostat, https://ec.europa.eu/eurostat/data/database, Accessed on 6 January 2025.
[33]FAO, https://www.fao.org/home/en, Accessed on 6 January 2025.
[34]NIS, Tempo online, http://statistici.insse.ro:8077/tempo-online/, Accessed on 6 January 2025.

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TRENDS AND CHALLENGES FOR IMPLEMENTING DIGITAL SOLUTIONS IN LAND MANAGEMENT IN BULGARIA

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Abstract

Transformations in agriculture, the implementation of sustainable production models, require more and more digital agriculture to be placed at the heart of the modern agrarian revolution in Bulgaria. Increasing attention is being paid to understanding the need for the application and use of digital technologies as an innovative approach in the farming business. Undoubtedly, digital technologies are the ones that provide an opportunity to improve the economic sustainability of agricultural holdings. Digital solutions in the development of digital agriculture are an indisputable necessity and at the same time are a prerequisite for slowing down the negative economic and social processes, the demographic structure and the trend of depopulation of rural areas. Unfortunately, at this stage in Bulgaria, untimely implementation of effective solutions in connection with the digitalization of processes related to land administration is characteristic. A long-term management perspective is needed, leading to a transition to sustainable land management in every territory, especially in rural areas. This necessitates the need for timely digital solutions for administering land management processes and accelerating the development of a key economic sector, such as agriculture. In this context, the aim of the article is to explore the possibilities of implementing modern software solutions, taking into account the state and trends in the development of agricultural areas and farms in Bulgaria. On the other hand, to identify the problems in assessing the possible income from owned agricultural land and their solution through specialized software applications. The publication includes official data from national and European institutions, as well as own calculations from face-to-face interviews and data from archival protocols of a consulting organization. The research methods used include general scientific, empirical-theoretical and logical-theoretical methods, as well as analytical tools: analysis and summary of literature, graphic, tabular and schematic method for presenting characteristics and trends. The main results show that the number of individuals has the highest relative share compared to the total number of farms (91.43 %). However, individuals process only 37.4% of the UAA, which means that in most cases the use of expensive software solutions is unprofitable when managing small areas. Unfortunately, in Bulgaria, digital solutions for state control and management are still characterized by catching up, not overtaking, development. In conclusion, the issue of a management vision based on information systems and a reliable mechanism for controlling deviations, a synchronized institutional framework and digital solutions before their design and implementation is particularly acute.

Key words**:** *agricultural areas, agricultural land, digital solutions, land management, problems*

INTRODUCTION

The rural development policy is aimed at achieving sustainable development of economic sectors, as the rural area is a place for development not only for agricultural activities, but also offers a good perspective for the development of the economy in a regional scope, through adequate support for business, job creation and sustainable territorial development. Bulgaria is a country with great soil diversity and land use largely changes the environment and landscape. The provision of sustainable land resources requires a long-term management perspective leading to a transition to sustainable land management in every territory, especially in rural areas. In society's quest for a higher level of sustainable development, it is increasingly clear that land, as a limited resource in any territory, is an important tool for preserving and protecting the environment.

Agricultural land has always been and will be an invaluable asset for every economic unit and for every Bulgarian family. As a limited resource, it does not lose its value over time and is an important investment for any enterprising farmer. A real assessment of the market situation and the dynamics in determining the value of agricultural land is an opportunity for a correct assessment of its effective use and management. This is related to making decisions about renting and renting,

determining the average yield and assessing the risks of a specific decision. Effective management of land resources is an important condition for the economic prosperity of any company unit related to the ownership of agricultural assets (Nikolova, 2019) [18].

The transformation in the ownership of agricultural land and the modern economic conditions in the field of agricultural development have caused a number of problems that are related to agricultural territories.

Digital solutions for the administration of land management processes are an indisputable necessity for the accelerated development of the agricultural sector. And this is a prerequisite for slowing down the negative economic and social processes, the demographic structure and the tendency for depopulation of rural areas (Nikolova, 2021); (Chernaeva, 2024); (Chernaev, 2024) [16, 6, 5].

The importance and development of digital technologies in modern agriculture is becoming an increasingly urgent process not only worldwide, but also Bulgaria. That is why it is the basis of the modern agrarian revolution in the Republic of Bulgaria with the possibility of achieving quality results with high added value and sustainable development of the rural economy. It is more than clear that the formal implementation of digital solutions for agricultural business management leads to a decrease in its efficiency within wide limits.

There is a lack of sufficient research on the problems in the Bulgarian scientific literature. related to the implementation of working digital solutions in land management in agriculture. For this reason, the purpose of the study is aimed at studying the trends and challenges facing the implementation of digital solutions in agricultural areas and farms in Bulgaria. The two main research tasks are related to studying the possibilities for implementing modern software solutions, through an analysis of the state and trends in the development of agricultural areas and farms on the one hand, and on the other hand, systematizing the problems in assessing income from agricultural land and their solution through specialized software applications.

The study is a continuation of our previous publication, which examines the problems related to the possibilities of digital solutions for the administration of land management processes (Nikolova, M., Chernaeva, P., Chernaev, P., 2023) [20].

MATERIALS AND METHODS

This publication is based on two types of data - official data published by various institutions - National Statistical Institute of the Republic of Bulgaria (NSI) [13], Eurostat [7], State Fund Agriculture [21], Ministry of Health [12], Ministry of Agriculture and Food-MZH, [9, 10, 11], Bansik and own data collected through face-to-face interviews, on-site visits and archival protocols by an active consulting organization. The research methods used include general scientific research methods, empirical-theoretical and logical-theoretical methods, as well as analytical tools: analysis and summary of specialized literature, graphic, tabular and schematic method for presenting characteristics and trends.

RESULTS AND DISCUSSIONS

Status and Trends in the Development of Agricultural Areas and Agricultural Holdings in Bulgaria for the Application of Modern Software Solutions

In Bulgaria, there are conditions for environmentally friendly sustainable agriculture, because for many years its principles have been violated, the result of the desire to obtain higher yields from the grown crops, without taking into account the effect on the future development of the sector, as well as on the food security of the population (Nikolova, 2022) [17]. At first glance, competitive agriculture is contrary to environmentally friendly agriculture, insofar as the latter has a lower economic effect compared to conventional production. However, the task of sustainable development is, through the joint use of innovative technological solutions on the one hand, and public policies on the other, to ensure the

economic viability of environmentally friendly, natural resources and environmental protection agriculture (Bashev et al., 2019) [2]. Agriculture is a traditional branch of the Bulgarian economy, with particular importance for ensuring food security, raw materials for the food industry and incomes for a large part of the population in rural areas of the country. The most economically significant sectors in crop production are the production of cereals and oilseeds, fruits and vegetables, and in animal husbandry – the production of milk, pork, poultry, beef and lamb and eggs.

When tracing the balance of the territory in terms of permanent use of land properties in Bulgaria as of 31.12.2023, it is evident that the part of the agricultural territory is again the highest - 60,524 km^2 of the total area of the country, which in relative terms represents 54.53%. The forest territory occupies 33.25% and the urbanized territory only 4.76% of the territory of Bulgaria (Fig. 1).

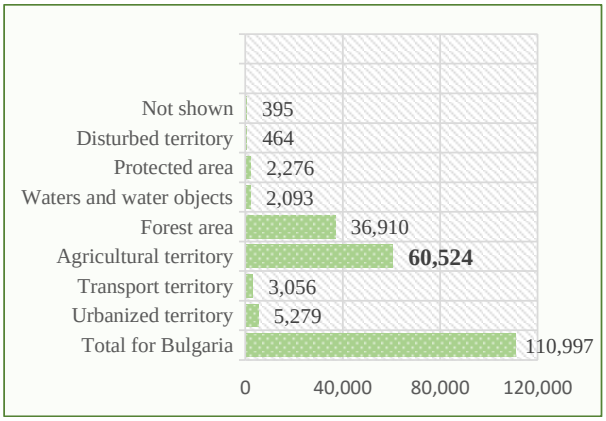

Fig. 1. Balance of the territory by way of permanent use of land properties, 2023
Source: National Statistical Institute [13].

The area with agricultural purpose occupies 47% of the country's territory and amounts to 5.2 million hectares. The areas with agricultural use in our country slightly decreased in the last year of the presented period (2023) by 0.3% to 5,208,482 hectares compared to the previous year. In the last three years, the share of these lands is 47.1% of the total area of the country: orthophoto maps, increasing protected areas, abandoned lands unsuitable for agriculture, etc. Over 96% of it is agricultural area (UAA). The agricultural sector in Bulgaria occupies a low relative share (about 4%) of the economy, despite the fact that our country has the potential to truly transform the sector into a priority for the Bulgarian economy.

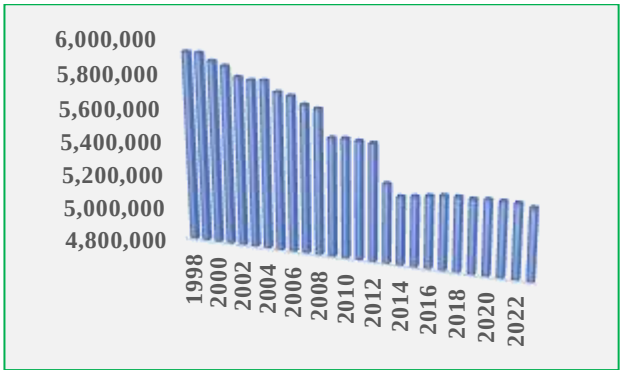

Fig. 2. Dynamics of areas in the agricultural sector, 1998 - 2023
Source: BANSIK, Bulgaria [22].

The gross value added (GVA) in the Bulgarian agricultural sector for 2021 amounted to BGN 4,950 million. As a share in the Bulgarian economy, this amount represents 4.3% of the total GVA. Investments in the sector for the acquisition of long-term tangible assets, as an important condition for increasing the competitiveness of Bulgarian farmers, vary around BGN 1.3 – 1.5 billion. per year.

They are mainly aimed at modernising farms and achieving food and feed safety standards; environmental protection; animal welfare; updating equipment and introducing new technologies; modernization in the processing industry, etc. The total value of agricultural exports in 2021 is a little over 6 billion. The leading groups of products in the structure of agricultural exports are cereals and oilseeds, followed by fats of vegetable or animal origin, etc. (MZX, 2023) [11].

Since the 1990s, the institutional framework of agriculture has undergone a structural transformation. Institutional imperatives and fluctuations in agribusiness development are likely to be permanently the subject of scientific research, as agriculture is a major structurally determining sector of the national economy (Linkova, 2019) [8]. The researchers' aim is to study the main actions that help to avoid negative fluctuations in the development of agribusiness, the result of the structural transformation in the institutional framework of agriculture and the adaptation of

organizational structures to the dynamic changes of the market environment (Nikolova & Linkova, 2020) [15].

In modern conditions, agriculture is facing serious challenges related to the implementation of the "fourth revolution", positive effects are sought, but also possible manifestations of negative ones. (Nenova, 2019) [14]. The goal is to minimize negative manifestations to the highest degree.

The development of agrarian business in the conditions of a transforming economy is an opportunity that can only be realized with effective management of land resources, as an important condition for the economic prosperity of any company unit related to the ownership of agricultural assets. (Nikolova, 2021) [19].

In order to track the general state and trends in the development of agricultural areas and agricultural holdings, it is necessary to consider some specific indicators, namely: used agricultural land (UAA); number of agricultural holdings; distribution of agricultural holdings and UAA by legal status and by statistical regions. A similar opinion has Beluhova-Uzunova (2019) and Beluhova-Uzunova et al (2023) [3, 4]. Also, it is important to know more about employment and land use ownership, both in the short and long term. This allows us to analyze the changes and dynamics in employment and ownership of land use over different ranges, such as duration over time. Table 1 presents official data covering key indicators of the structure of agricultural holdings in Bulgaria.

Table 1. Change in the structure of agricultural holdings by land use

General indicators	2010	2013	2016	2020	Amendment
Agricultural holdings (number)	370,222	254,142	201,014	132,742	**- 68,272**
Utilized Agricultural Area of the agricultural holdings (ha)	3,616,965	3,794,911	3,795,534	3,959,288	**+ 163,754**
Total Utilized Agricultural Area (common land for grazing incl.)* (ha)	4,475,528	4,650,936	4,491,860	4,564,152	**+ 72,292**

Source: Statistics and analyses. Ministry of Agriculture (www.mzh.government.bg) [9, 10, 11].

Table 1 shows that during the years under review the change related to the number of agricultural holdings is aimed at their progressive decrease (2.79 times less) compared to 2010.

The data show that the trend is undoubtedly towards the consolidation of the agricultural business in terms of the use of land resources in individual farms.

Table 2. Utilised agricultural area by statistical regions

Statistical regions	UAA (ha) *Utilized agricultural area (ha)*	Average UAA (ha) *calculated on the basis of the total number of holdings*
North-West	942,446	**61.9**
North Central	803,040	**54.0**
North East	824,760	**50.4**
South East	841,741	**45.9**
South West	480,895	**19.1**
South Central	671,271	**15.7**

Source: Statistics and Analyses, (MZH) [11].

Table 2 shows the UAA in the individual statistical regions.

The northwestern region is characterized by the highest share (61.9 ha) compared to the others.

The South-Western and South-Central regions are distinguished by the least UAA, which is due to the peculiarities in the relief.

Table 3 presents the distribution of UAA in the statistical regions, paying attention to the managed land and in particular to the forms of its use.

It can be seen that in the regions with the least UAA (South West and South Central region) there are relatively the largest number of farms that cultivate mainly their own land. Accordingly, this requires the digital technologies that are implemented to be tailored to the scale of the business.

The data in Figure 3 illustrate the trends regarding the status of agricultural holdings in Bulgaria and their distribution by groups. The figure convincingly shows that the numbers of

individuals is the largest, compared to the other three groups - cooperatives, commercial companies, associations and others, taken separately. Their relative share is also the highest in relation to the total number of holdings in Bulgaria, taken together (91.43%). The comparison of Fig. 3 and Fig. 4 show that natural persons cultivate UAA only 37.4%, which confirms the thesis that they are relatively small-scale, despite the fact that they are the backbone of the Bulgarian agrarian economy.

When managing such small areas, it is usually unprofitable to use expensive software solutions and therefore the information they have is insufficient to make adequate decisions.

Table 3. Distribution of the utilized agricultural area by type of management by statistical regions and districts*

Statistical regions and districts	UAA of farms (ha)		Own land		Land leased or leased, other uses and common land	
	Holdings (number)	Area (ha)	Holdings (number)	Area (ha)	Holdings (number)	Area (ha)
BULGARIA	**127,278**	**4,564,152.4**	**85,509**	**409,118.4**	**97,024**	**4,155,034**
North-West	14,360	942,446.0	9,745	62,411.4	11,545	880,034.6
North Central	13,773	803,039.8	9,502	89,179.0	10,861	713,860.9
Northeast	15,125	824,759.8	9,939	70,825.4	11,792	753,934.4
South Eeastwards	17,204	841,741.1	11,185	79,694.8	13,317	762,046.3
South Western	24,740	**480,894.8**	**14,434**	**25,572.1**	18,984	455,322.7
South Central	42,076	**671,270.8**	**30,704**	**81,435.7**	30,525	589,835.1

*Data on area is presented as a integer, so their sums do not correspond to physical totals.
Source: Statistics and analyses (MA, www.mzh.government.bg) [10, 11].

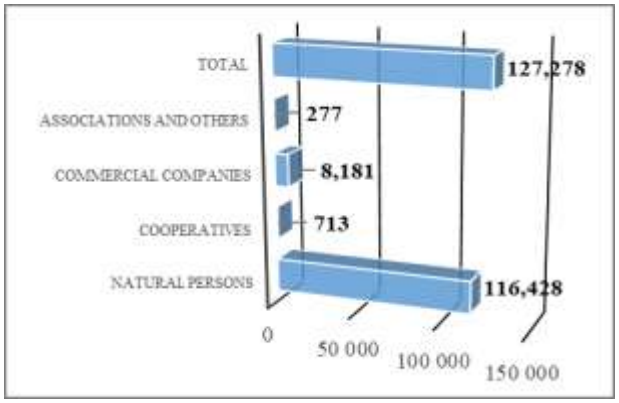

Fig. 3. Distribution of the utilized agricultural area (UAA) by holdings legal status
Source: Statistics and analyses (MZH) [11].

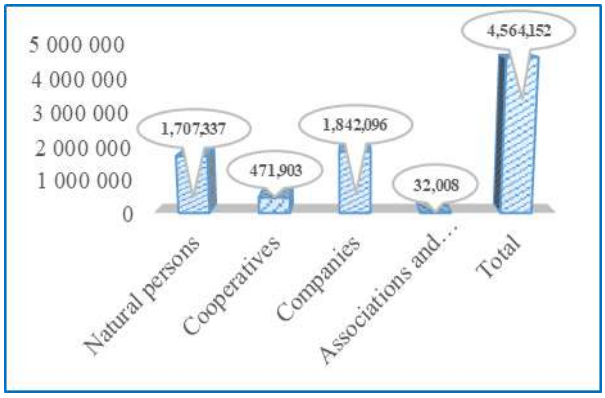

Fig. 4. Area (ha) by ownership type
Source: Ministry of Agriculture (MZH) [11].

For this reason, the need for an appropriate state toolkit to promote digital innovations in small-scale farms is increasingly evident. At this stage, small agricultural producers in Bulgaria find it difficult to implement digital solutions in their business. It is the state that should play a leading role in supporting access to information and digital solutions that are possible and applicable not only for large, but also for small farms.

Estimation of the possible income from the owned agricultural land - problems and their solution through specialized software applications

One of the most important characteristics determining the quality of agricultural land is its category. The visualization below shows the coverage of the individual categories of land, such as area distribution within the Bulgarian territorial boundaries (Figure 5).

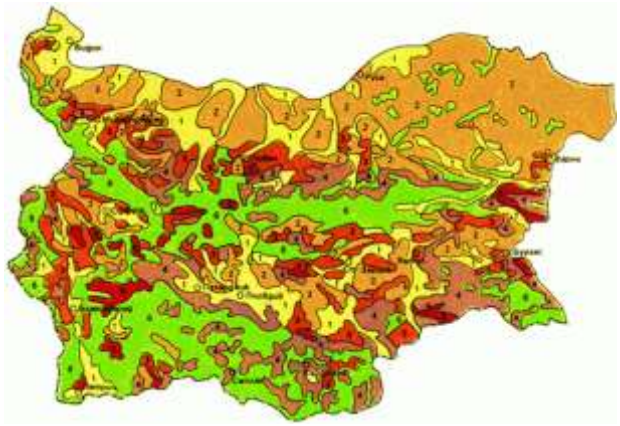

Fig. 5. General distribution map of agricultural land categories
Source: Bglands.2012, http://bglands.weebly.com/, 2012 [1].

In Bulgaria, agricultural land categories are divided into a total of ten quality groups. The conditions for assigning land to individual groups are related to the characteristics and the corresponding assessment of soil and climatic conditions, depending on the suitability of the land for growing specific crops. In this case, this is the average quality score for each of the groups. The highest quality and, accordingly, the most highly valued are the lands of the first two categories, after which their quality continuously decreases to the lowest position - the tenth (MZH, 2018) [10].

The price of land is a direct function of rent, i.e. the income that is received from processing, harvesting and its realization on the market. Accordingly, there are different ways of managing land, depending on the size of the operating agricultural holding. In order to trace the interconnection and problems in the administration of the relationships between the different types of owners and users of agricultural land on the one hand and the applied digital solutions, on the other, we will systematize the main groups of users and owners in Bulgaria.

Types of agricultural land users:

Small owners **= Users**, who usually work "within real limits", harvest their produce and usually sell it on the local market. Since they do not invest enough in machinery (for economic reasons), they are usually dependent on larger producers to use harvesting equipment. However, the income they make is sufficient, especially if it is supplemented by subsidies for producers.

Agricultural cooperatives (usually with "inherited" ownership) are the successor of the old APCs. An agricultural cooperative is a type of company in which one can "participate" with land and other assets (usually inherited), which determine the profitability of the land. The collective body for management and distribution of income, unfortunately, turns the member cooperatives more into landlords (i.e. owners who receive rent for their land), due to the fact that the management does not bring enough profitability so that the dividends from the additional capital can be used for investment in business development. That is, purely psychological inertia "kills" the proprietary thinking of the generation after the restoration of the land and does not allow the development of this business model.

Tenants of the "Family business" type usually start farming with inherited properties and supplement with other people's land, for which they conclude short- or medium-term lease or lease agreements and gradually grow. Since the owners are usually hereditary farmers and/or with appropriate education and management structure, this business model is flexible enough and provides many opportunities for rapid development.

Tenants of the "Holding" type. These are companies with a lot of capital that expand, usually investing funds from other businesses in leasing and managing agricultural land. Since the strategy of these companies allows them to work for a relatively long time without real profit and reinvest in development, they manage to develop on a very large scale. Through many connected companies, one of the largest holdings in Northern Bulgaria, as early as 2010 reached the lease and cultivation of over 120,000 hectares "from Varna to Vidin". As can be seen from Table 1, the process of consolidation of farms is moving almost exponentially and in 2020 users are less than 35% of the number of users in 2010.

Types of agricultural land owners:

-*Small owners* - they usually manage inherited properties by receiving the income from rent or rent and distributing it among themselves. Renting/leasing or participating in

cooperatives is a process that is digitized only by the users. The state has no interest (no taxes are due for agricultural land) and therefore does not administer, but only registers the property. that the burden of declaring the changes - death (inheritance), sale, donation, exchange and all other changes of ownership are registered first in the Property Register (Cadastre Agency, built in 2013-2018), the Registry Agency and only after the fact in the Municipal Agriculture Service. In other words, in the actuality of the ownership data, there is an information vacuum, which is skillfully used by unscrupulous users - this is how the concept of "blank spots" appears.

-Owners - tenants. A large part of the owners are also users of agricultural land, which allows them to receive income from the land directly, i.e. through the sale of production. Here there are problems related to the fact that the form of management of the salary is equated to a natural person, therefore there is no way to conclude a contract and pay rent between the same natural person in his different capacities. In the Agricultural Land Use Act, this issue is regulated by Article 69, but there are many controversial practices regarding the tax legislation. In this case, the digital decisions for accrual, payment and declaration of the amounts paid to the NRA (Art. 73 of the Personal Income Act) have been repeatedly changed in the last few years due to various interpretative decisions.

-Owners - "REIT" or the Special Investment Purpose Company is a joint-stock company which, under the terms and conditions of a special law – the Special Investment Purpose Companies Act (promulgated, SG No. 46/2003), invests the funds raised through the issuance of securities in real estate or in receivables (securitization of real estate and receivables). Such a company may not acquire real estate or receivables, which are the subject of a legal dispute. The law requires the real estate acquired by the company to be located on the territory of the Republic of Bulgaria. In professional circles, Special Purpose Investment Companies (SPICs) are known as Real Estate Investment – REITs . Their main activity is aimed at purchasing land from small landowner companies. Within the borders of our country is the largest such company in the European Union, in terms of the size of the available land. Digitization in the management of these companies is quite a serious part of their budget, and serious solutions such as Xerox, Canon for archiving and scanning all documents and usually individual technological solutions for the legally mandatory revenue reporting system come into play. One of the first such solutions ("Agrosystems") could not be implemented, precisely because of the lack of information about the real location of the properties and their condition at the time of acquisition by the fund, i.e. the information is incomplete if it is based only on documents and does not allow analysis and comparison of the possible profitability.

The majority of landowners in Bulgaria benefit from the rent paid to them by tenants (users) on the basis of a pre-concluded lease or lease agreement between the owner (or his proxy) and the tenant. The main goal is for the rent to be the most attractive for landlords (landowners) compared to that offered by other tenants for the same land. In practical terms, the most common options for determining the amount of annuities are the following:

-"Average yield" per hectare. This option is typical for the majority of cooperatives and tenants in the first stages of the development of private relations in the agricultural business. The study found that in this case, the rent is determined as a *percentage of the average yield of the crops grown or as a percentage of the area of each specific landlord.*

-Determination of **% of the average yield of all crops** sown in the respective business year (usually 15 to 20%) and distribution of income **in "kind"** per member of the cooperatives. Since the land is very heterogeneous (categories, locality, remoteness from the base, making cultivation more expensive, etc.), and very often the owners prefer to receive part of the income in monetary terms, or to increase the production received from one crop at the expense of another, In many places, the next type of rent is imposed;

-Definition of rent as **"% of acres"** (usually about 25-30%). Each owner has the opportunity to determine what crops to sow the

area he rents or rents, and to receive the entire average yield of the respective land/area. The disadvantage of this option is that if an owner owns properties of a worse category (5-6) he is almost always harmed by the fact that high yields of the crops he wants cannot be achieved on his land, which creates conflicts. Because of this, we move on to the next type of rent;

-In the last 2-3 years (2020 - 2023), the average rent payment ranges between BGN 50 and BGN 100 per decare, and of course the black soil in Dobrich is more expensive, with a higher rent (up to BGN 180 for 21-22), while for the semi-mountainous regions, it is much less. Often, tenants "bid" in order to be able to attract additional land. The fact is that during the initial acquisition of land, usually no attention is paid to the **quality of the land** - category, remoteness from the tenant's base, arable land (i.e. whether the property is partially or fully suitable for cultivation in its entirety), etc.

On the basis of this study, several **groups of problems have been identified in assessing the possible income from the owned agricultural land and their solution through specialized software solutions:**

-inclusion of clauses in lease and lease agreements for workability;

-division by categories, localities and the discrepancy between the characteristics in the register and the actual ones;

-incorrect entries in the official documents for uncultivated areas;

-the determination of the rent for multi-category properties;

-concluding long-term contracts on clearly unfavorable terms;

-difficulties in determining the rent based on the size of a particular property;

-offering additional "social" solutions instead of higher rent than cooperatives;

-the practice of "personal use" in operating cooperatives in contradiction with tax legislation.

A negative practice is the inclusion of clauses in the lease and lease agreements, which allow the tenant to reduce the rent according to the categories and arableness of the property. Unfortunately, the information about the parameter of cultivability of the property has changed over the years, and the digital system (under DOS until 2016) does not allow updating this parameter. In 2008, after the start of orthophotography, a map of the workability was made, but its overlay with the map of ownership is not public and available for use.

The other criterion for assessing the income from the specific land is its *division into categories*, localities (i.e. remoteness from the base), whether it is irrigated or not. Here, the mistakes that we commented on when preparing the map of the restored ownership affect the decisions of the tenants, since when calculating rents, work is done mainly on documents. This approach is often complicated, as X BGN/decare, it also depends on other characteristics of the land, such as the "method of permanent use" (according to documents) and the actual condition of the land. Since the official Ordinance No. 5 of 10.05.1999 contains more than 120 different types of permanent use, of which more than 30 could be counted as real arable land, a large part of the challenge for calculating rent using this method is the consolidation of the criterion and the creation of a methodology for Charging. For example, in the registers of the KBC there are entries such as "arable land", fields, desolate fields, grassed fields, sown area, etc., which in practice usually turn out to be arable fields. In the KBC it is assumed that a property can be multi-categorical, i.e. part of it to be in one category, part two in another, and part three in a completely different category, for this reason the concept of "prevailing category" is adopted. It is common practice for tenants to conclude more profitable contracts with landlords who are willing to conclude a longer-term contract. I.e. the impact of the term of the contract and/or its type (lease and lease) on the income from the land is also a matter of negotiations and search for the most profitable option for the Tenant-Lessor. Last but not least, properties with a larger size or more total leased land in one contract also enjoy special, inflated financial conditions. This is due to the fact that the cultivation of a property over 15 decares is relatively easier and with less losses than of a property close to the average size of the properties (about 7.2 decares - for Northern Bulgaria and 5.8 decares - for Southern

Bulgaria). In order to be competitive on the "land market", cooperatives usually offer additional "social" solutions – bread coupons, distribution of oil instead of sunflower, flour instead of wheat, meat or dairy products, etc. In the past, cooperatives often offered another type of relationship "personal use", which is practically a contract for joint processing or a service performed by the cooperative of the individual member-cooperator. This approach has been "copied" by the more progressive tenants since 2008 and works until the "change of generations" in the villages.

The entire set of ways to calculate rent and the possible variations for choice lead to an increase in the opportunities for development of the market related to digital solutions and their improvement in practical conditions. The correct calculation of rent payments is associated with a comprehensive process when implementing digital solutions. That is why these systems find a wide field of applicability and are one of the first to be developed by business practice. At this stage in Bulgaria, digital solutions for control and management by the state are characterized by catching up, not anticipatory development.

CONCLUSIONS

The distribution of agricultural holdings in Bulgaria by legal status shows that the number of natural persons has the highest relative share compared to the total number of farms in our country (91.43%). However, natural persons cultivate only 37.4% of the UAA, which confirms the thesis that they are relatively small-scale, despite the fact that they are the backbone of the Bulgarian agrarian economy. It is usually unprofitable to use expensive software solutions. Therefore, the information they have is insufficient to make adequate management decisions.

The challenges of implementing modern software solutions in agricultural areas and farms are related to the need to promote the implementation of digital solutions in business practice. In this sense, it is the state that is the administrator of the owner-user relationship of agricultural land and holds comprehensive information on the condition of the land resource. It should play a leading role in supporting access to information and digital solutions that are possible and applicable not only for large, but also for small farms.

The set of ways to calculate the rent from agricultural land and the possible variations for choice lead to an increase in the opportunities for development of the market related to digital solutions and their improvement in practical conditions. Systems for implementing digital solutions in calculating rent payments from agricultural land find a wide field of applicability and are one of the first to be developed by business practice. At this stage, digital solutions in Bulgaria are characterized by catch-up, not overtaking, development.

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REFERENCES

[1]Bglands, 2012, http://bglands.weebly.com/, Accessed on 10 December 2024.
[2]Bashev, H., et al., 2019, Assessment of the Sustainability of Bulgarian Agriculture, p. 19. Sofia: Institute of Agrarian Economics.
[3]Beluhova-Uzunova, R., 2019, Trends in concentration of Bulgarian agriculture. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 19(2), 23-30.
[4]Beluhova-Uzunova, R., Shishkova, M., Hristov, K., 2023, Bulgarian agricultural structure and prospects post- 2023. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 23(2), 75-82.
[5]Chernaev, P., 2024, The social effect on rural development of digitalization and automation of livestock farming. "Theory and practice for sustainable management and development of rural areas in Bulgaria" Svishtov: Academic Publishing House "Tsenov", pp. 342-349.
[6]Chernaeva, P., 2024, "Photovoltaic culture" - digitalization or rural development. Theory and practice of sustainable management and development of rural areas in Bulgaria Svishtov: Academic Publishing House "Tsenov", pp. 330-341.
[7]Eurostat database, 2025, https://ec.europa.eu/eurostat/data/database, Accessed on 13 February 2025.

[8]Linkova, M., 2019, Institutional imperatives and fluctuations in the development of agribusiness. Status and problems in the management and development of agriculture Svishtov: Academic Publishing House "Tsenov", pp. 478-485.
[9]Ministry of Agriculture and Food, MZH., 2018, Regulation on the categorization of agricultural lands upon change of their purpose.
[10]Ministry of Agriculture and Food, MZH, 2018, www.mzh.government.bg., Accessed on December 2024.
[11]Ministry of Agriculture and Food, MZH, 2023, (January 1, 2025). www.mzh.government.bg., Accessed on January 2025.
[12]Ministry of Health, 2025, https://www.mh.government.bg/en/, Accessed on February 2025.
[13]National Statistical Institute, https://www.nsi.bg/en, Accessed on December 2024.
[14]Nenova, R., 2019, Proposal of innovations in agriculture of the fourth generation. Status and problems in the management and development of agriculture Svishtov: Academic Publishing House "Tsenov", pp. 76-81.
[15]Nikolova, M., Linkova, R., 2020, Status and problems in the management and development of agriculture. Economic Archive, (1), pp. 15-28.
[16]Nikolova, M., 2021, State and development of the Bulgarian agrarian sector in conditions of an economy transforming towards sustainability. International scientific and practical conference "Sustainable development and socio-economic cohesion in the 21st century - trends and challenges" Svishtov: AP "Tsenov", pp. 523-531.
[17]Nikolova, M., 2022, Sustainable development of agriculture - contemporary aspects and sustainable models. Monograph. Sofia: Valdes-VV-GV.
[18]Nikolova, M., 2019, State of the agricultural land market in the Republic of Bulgaria. State and problems in the management and development of agriculture Svishtov: AI "Tsenov", pp. 261-272.
[19]Nikolova, M., 2021, Digital solutions for the sale of agricultural products. Collection of reports from the Round Table with international participation "Trade - scientific knowledge and business reality", 08.10.2021 Svishtov: AI "Tsenov", pp. 237-246.
[20]Nikolova, M., Chernaeva, P., Chernaev, P., 2023, Digital solutions for the administration of land management processes in the republic of Bulgaria. Third International Scientific Conference IDARA-2023 „Innovative development of agricultural business and rural areas“, 28 – 29.09.2023 Sofia: Publishing Complex – UNWE, pp. 228.241.
[21]State Fund Agriculture, Bulgaria, 2025, https://bg.linkedin.com/company/dfz-bg, Accessed on March 2025.
[22]***BANSIK, Bulgaria.

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PRACTICES AND CHALLENGES IN HUMAN RESOURCE MANAGEMENT IN AGRICULTURAL FARMS IN ROMANIA: A QUALITATIVE APPROACH

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Abstract

The lack of in-depth qualitative studies exploring Romanian farmers' perspectives on human resource management highlights the need for dedicated research on this topic. The present study examines the challenges farmers face in recruiting and retaining the workforce, developing farms, and ensuring their continuity. The research employed a qualitative method based on individual semi-structured interviews, and the analysis of the collected data was conducted through an examination of word frequency and semantic relationships within the interviews. The findings highlight significant challenges in attracting and retaining qualified personnel, particularly in less attractive rural areas. Farmers are aware of the need for continuous professional training and partnerships with educational institutions to enhance employee skills. Additionally, the development of an effective succession plan is identified as a viable solution to address current challenges. The managerial implications of the study include diversifying recruitment channels, using online platforms, and developing strategic partnerships.

Key words**:** *agricultural sector, human resources, employment, succession plan, challenges*

INTRODUCTION

The agricultural sector in the European Union has developed both quantitatively and qualitatively since the Second World War [34], with agriculture playing a multifunctional role [28]. It contributes to ensuring food security, protecting the environment, fulfilling a crucial economic role, and serving a significant social function [28]. If, historically, the primary function of agriculture was to meet the population's food needs, today this role entails the sustainable use of natural [18], material and human resources required for production processes. Resources engaged in economic activities become factors of production, with the main factors in agriculture being: labour, natural capital (land), physical capital and intangible capital [28]. Among these, land resources hold particular significance, being part of the primary factors category. The relationships between the factors of production affect, on the one hand, the productivity and profitability of agricultural processes and, on the other hand, reflect the trends and directions of change within the agricultural sector [19].

According to the latest statistical data provided by [9], the utilized agricultural area in the European Union represents approximately 38.4% of the land fund, with variations among member states. In Romania, according to information provided by the National Institute of Statistics, agricultural land accounts for 61.37% of the total land fund, placing the country among those with abundant land resources [15]. Although Romania's agricultural potential, driven by its land resources, is significant, the sector's low performance and competitiveness are attributed to the inefficient utilization of these resources, according to [35]. In 2020, the most recent year for which statistical data is available, there were 9.1 million farms in the European Union [9]. A downward trend in the number of farms is evident, particularly among small farms, with a decrease of approximately

37% recorded between 2005 and 2020 [9]. Of all the farms registered in the EU, more than half are crop farms, approximately 20% are specialized in animal husbandry, with the remainder being mixed farms. Nearly one-third of the total number of farms in the EU are located in Romania, although the majority are subsistence and semi-subsistence farms – less than 5 hectares in size [9]. The study conducted by Tudor (2014) shows that bipolarity is the defining feature of Romanian agriculture, with 30% of the utilized agricultural area (UAA) being exploited by these small farms, characterized by low productivity and insufficient technical equipment, while half of the UAA is managed by commercial farms, which are much better capitalized. In addition to the efficient use of agricultural land, the labour force is a determining factor in achieving agricultural production, influencing both productivity and competitiveness in this sector [29]. According to the agricultural census conducted by Eurostat in 2020 [9], the labour force employed in agriculture represented 4.2% of the total, with a declining trend. Romania leads the rankings in terms of the agricultural workforce, with approximately 20% of the labour force working in this sector in 2020. Our country was followed by Bulgaria, Greece, and Poland [9]. On the opposite end, countries such as Sweden, Germany and Belgium had less than 2% of their population employed in agriculture. The largest decrease in the population employed in this sector between 2005 and 2020 was observed in Romania, at nearly 12% [9]. The decline in the agricultural workforce is linked to the depopulation of rural areas, the loss of attractiveness of the agribusiness sector, as well as the consolidation of farms, which led to a reduced demand for labour in agriculture [25]. Although the support provided through the Common Agricultural Policy (CAP) has had a favourable impact on the economic sustainability of the agricultural sector, the CAP has failed to balance agricultural incomes with those from the non-agricultural sector and to increase the attractiveness of the sector [12]. Most farm managers in the European Union are at least 55 years old, with the percentage of younger managers, under 40 years old, being relatively low, at around 11.9% [9]. This characteristic of the agricultural workforce is highlighted by [29] and [6], who emphasize the ageing phenomenon, with middle-aged and elderly individuals predominating in agricultural work [36]. Low incomes from agriculture sometimes discourage young people from getting involved in this sector [30]. Thus, a complex picture of the demographic and gender structure of the agricultural workforce emerges, highlighting the challenges related to the sustainability of this sector. According to Eurostat data [9], 68.4% of all farm managers are men. While young people generally manage larger farms, older individuals manage most subsistence and semi-subsistence farms. According to [30], agricultural workers possess multiple skills necessary for farm management, but the level of professional training remains low. [25] draw attention to the importance of increased quality of human capital in agriculture, which can contribute to increased labour productivity and higher incomes. A well-designed and implemented recruitment process can significantly contribute to improving the quality of human capital in this sector. As emphasized by [8], recruitment is an essential human resource management tool in agriculture, especially in the current context, with its success depending on the methods chosen. Thus, the application of effective methods can either maintain or undermine a farm's competitive advantage [8]. The results of the same study show that farm managers prefer traditional recruitment methods, based on: recommendations, internal recruitment, recruitment of candidates who approach the employer directly, and collaborating with the Labour Office. The least used methods are those related to outsourcing recruitment services and using intermediary agencies [8]. Interaction with potential candidates, the process of recruiting and hiring them, constitutes a significant responsibility for farm managers, both from an individual and societal perspective [33]. On the other hand, the attractiveness of the agricultural sector to the younger generation, according to [13], depends on the benefits offered in job advertisements. Thus, their results demonstrate that the most

appreciated benefits are holidays and free time, while the least appreciated are those related to achieving a balance between professional and personal life. According to [16], employee satisfaction in the agricultural sector is strongly influenced by financial aspects. However, there are differences in motivational factors depending on age, education, and the position held on the farm. The attractiveness of jobs in agriculture is also influenced by the employer brand, which reflects the image and reputation of the farm. This can be supported through an organizational culture based on respect and recognition, the effective implementation of human resources activities, the establishment of efficient management processes, and increasing the level of general public awareness regarding the farm's activities [36]. At the same time, the results obtained by [14] show that organizational culture, self-esteem and motivation at the workplace significantly influence employee performance. The recruitment and retention of good employees, according to [23], depend on the employer's ability to highlight the farm's culture. Thus, farms that encourage continuous professional training and commitment to the success of the farm can recruit and retain dedicated employees [23]. The importance of professional training is highlighted by [24], who shows that insufficient training of farm employees or their lack of skills increases the risk of incorrect interventions or harmful decisions, negatively affecting the performance and sustainability of the farm. In the opinion of [1], building a set of competencies that support farm employees' adaptation should start with educational institutions that train specialists in the agricultural field. Creating a bridge between the educational system and the economic environment is essential, and the involvement of employers in developing skills training programs and offering internships for students and pupils are just a few examples of initiatives that can contribute to improving the quality of human resources on farms [1]. Human resource management in agricultural holdings should focus on individualized tools that consider the stages of the employee's life and career [16]. Work within farms is evolving, according to [22], depending on changes in the distribution of responsibilities, the structure of work organization (flexibility versus specialization) and the degree of autonomy granted to employees. This evolution of work organization and adaptation to the needs of employees are closely linked to the broader challenges of the agricultural sector, such as farm succession, an issue identified worldwide [32]. Family farm succession represents a process influenced by a combination of socio-economic factors, which vary from one region to another. The issue of farm succession in the European Union is amplified by the ageing of farmers, the abandonment of agricultural land in certain regions and the depopulation of rural areas [6]. Farm succession is thus limited by multiple constraints and barriers, which threatens the competitiveness and sustainable development of the agricultural sector. These factors contribute to creating a complex context in which farm succession is becoming an increasingly difficult process. A key factor in succession in family farms is the migration of young people to urban areas, which reduces the number of potential successors [10]. In addition to this phenomenon, another factor complicating succession is gender differences, which influence women's perceptions and involvement in the process. Thus, women are less involved in the generational transfer of agricultural holdings because they perceive agricultural activities as less attractive [5]. At the same time, [2] shows that succession is influenced by social norms, traditions, and the legislative framework, which vary between European countries. Factors such as the social acceptance of agriculture and the perception of the quality of life in rural areas influence the decision to take over a farm. Thus, in determining the succession decision, cultural factors and social norms are often complemented by economic aspects, such as the profitability of the farm [26]. At the same time, according to [5], an opinion supported by [32], education, access to professional training, family and community support, as well as agricultural policies and financial incentives (such as subsidies or programs for young farmers), play an essential role in determining succession. On the other hand, [3] highlight the

impediments in the succession process, which are represented by a smaller farm size, respectively a low economic viability, as well as the lack of family support. The socio-emotional factors and family support playing a key role in the long-term success of family farms are aspects also mentioned by [27]. To overcome these barriers, public policies and support measures become crucial in facilitating the succession process. Another important aspect is the perception of economic risks associated with succession, such as taxation, long-term costs, and the risk of property fragmentation. According to [21], these risks, along with existing public policies, discourage farmers from proceeding with the transfer process, leading to significant delays.

At the same time, [26] argue that farm succession is an essential component for the long-term resilience and sustainability of agriculture, that it is more than just a family issue, and that public policies (as supporting measures) should be adapted to address the diversity of regional and sectoral challenges. In the context of these challenges, alternative succession options are also emerging, providing viable solutions for farmers facing difficulties with the family transfer. While succession is generally discussed primarily in terms of transfer to family members, [31] show that succession can also occur through sale to third parties or strategic partnerships, the farmer's choice being influenced by the size of the farm, the family structure, and their long-term goals.

Building on the lack of in-depth qualitative studies exploring the perspective of Romanian farmers on human resource management, the present research aims to achieve the following objectives: evaluating human resource management practices in agricultural farms in Romania, including recruitment, selection and employee evaluation methods; identifying the main challenges farmers face in managing human resources and the strategies used to overcome these challenges; analyzing farmers' intentions regarding the development of their farms in the coming years, including expanding the team, diversifying activities and training employees; investigating the impact of the employer brand and employee loyalty policies on their retention and motivation; exploring succession plans in agricultural farms and identifying the factors contributing to the success of these plans.

MATERIALS AND METHODS

In order to achieve the proposed objectives, the authors used a qualitative research method based on the semi-structured interview. The main aspects addressed during the interview were related to the description of the farm (3 questions), human resource management (15 questions), farm activity management (2 questions) and farm succession (13 questions). The interviewed participants were represented by 15 farmers from Romania. The Nvivo program, version 12.2.0.443 (32-bit), Pro edition, developed by QSR International, was used for data analysis. The interview transcripts were grouped into 15 separate Word Document (*.docx) files and imported into the program. Each file was then transformed into a profile of the analyzed farm by introducing and assigning case classifications, using the relevant variables found in the interview guide, both from the farm description section (year of establishment, county, area, type, form, etc.) and from the other topics of interest (intention to expand the area and hire new employees, method of promoting job advertisements, employee qualification level, salary bonus, career plan, succession plan). Furthermore, each uploaded and classified profile provided annotations for the four main themes included in the interview guide: description, human resource management, activities and succession. These themes were analyzed separately when considered appropriate (e.g., word frequency). The information thus uploaded into the program facilitated navigation, classification, and the frequency of the variables of interest. The focus of this analysis was on interpreting the frequency of encountered words and the relationships between them. Thus, "word cloud" and "word tree" graphics were generated to illustrate the frequencies and relationships between words encountered in the interviews and to facilitate the identification of farmers' issues and the proposal of solutions to address them.

RESULTS AND DISCUSSIONS

Farm description and general context

In terms of typology and size, farms vary significantly in terms of area (Table 1), ranging from 35 ha to 5,000 ha, with the majority (n=6) falling within the 2,401 - 4,800 ha range, with an average size of 2,124 ha. Most farms focus on field crops (n=11), with a few exceptions – mixed farms that also include livestock (n=1) or vegetable farming (n=3). Additionally, from the analysis of the 15 interviews with farmers (R1-R15), it is observed that the majority of the farms are organized as LLCs (Limited Liability Companies) (n=13), followed by those categorized as FE (Family Enterprises) (n=1) and SA (Joint Stock Companies) (n=1). The period of establishment of the farms varies from 1992 to 2019, and 80% of the farms analyzed were established before 2010, which may indicate stability and continuity in the sector. In terms of location, most of the analyzed farms (n=6) were located in Ialomița County, followed by Brăila (n=3). Other represented counties were Călărași, Galați, Iași, Tulcea and Vrancea.

Table 1. Area of farms analyzed

Area (ha)	Number of farms
0-25	0
26-75	1
76-150	2
151-300	0
301-600	0
601-1,200	5
1,201-2,400	0
2,401-4,800	6
over 4,800	1

Source: own results.

Regarding farm owners and managers, their age ranges from 31 to 65 years, many of them having agricultural education, although there are some exceptions with non-agricultural education (n=3). The farm administrator was most often the farm owner (n=6) or one of the managers (n=6). Most farm administrators are in the 46-50 age range (n=6), followed by those in the 31-35 age range (n=4) and those aged between 36-40 years (n=3). Most farmers expressed their intention to expand the size of their farms (n=9) or at least maintain the current area (n=5). Only one farm (R11) reported intentions to reduce its size due to economic or administrative difficulties.

Human resources management

Recruiting employees from the local community is preferred by most farmers. They recruit using recommendations or by spreading job advertisements through word of mouth within the community, while online job ads and collaboration with educational institutions are considered complementary methods. Similar results were reported by [8], who showed farmers' preference for traditional recruitment methods. At the same time, [4] observes that there is very poor collaboration between farmers and regional labour offices, and the use of online recruitment platforms is a rare practice.

Regarding the challenges encountered in the area of human resources, felt by the majority of farms (n=11), the most common issues are the lack of qualified labour and high staff turnover. The problem of lack of adequate employee training is highlighted by several farmers, who report that many of the available candidates do not meet the minimum requirements. The aforementioned difficulties were reported by R4, R5, R6 and R11. The results of previous studies identified in the literature draw attention to the insufficient training of the workforce employed in agriculture [29], especially considering that the reduction in the number of agricultural workers should be compensated by increasing the professionalism of those who continue to work in this sector [20]. [17] emphasize the importance of training specialists in the agricultural sector and anticipating the demand for these employees on the labour market [17].

At the same time, the farmers participating in the study mention difficulties in finding and retaining employees, especially in more isolated rural areas. These challenges were also reported by [6], who draw attention to the vulnerability of the agricultural workforce in depopulated or less attractive rural areas.

The results of this study indicate that the partnership with the County Employment Agencies (AJOFM) was used only by larger farmers or those with specific needs (R8). As

identified solutions, some farmers have developed partnerships with universities and agricultural high schools to train and hire young people. Farmers seem to be accustomed to volunteering or internship activities, as only four farms (R4, R6, R14, R15) out of the total interviewed reported not having any students or interns on their farms. In some cases, farms provide accommodation for employees from other regions (R1), while others use local networks and referrals to identify potential employees (R3, R14). All farmers intend to either maintain their current number of employees (n=8) or expand their teams due to farm growth (n=7). Thus, maintaining the current team is preferred by farmers with already stable and efficient teams (R1, R2, R3, R7, R9, R10, R11, R14), while expanding the teams is targeted by farmers planning to increase cultivated areas and intending to hire additional staff for farm activities (R4, R5, R6, R8, R12, R13, R15). Therefore, farmers seem to want to maintain or increase the size of the team depending on the farm's needs. For example, R4 and R5 plan to hire agricultural machinery operators, and R12 intends to hire a storekeeper and a mechanic. Such targeted approaches suggest a tendency for moderate and cautious expansion. From the analysis of the responses, we can deduce that there is a close relationship between recruitment challenges and reliance on the local community. Farmers facing major difficulties in finding qualified staff tend to rely more on local relationships and recommendations, which may reflect a compromise solution in the face of a lack of better options. Additionally, education and professional training are seen as long-term solutions to address these challenges, indicating an awareness of the need to invest in human resource development to ensure the ongoing sustainability of the farms. Farmers often assess (n=12) the skill level of their employees between 7 and 8 (out of a maximum score of 10), mentioning that continuous training and the use of modern technology are essential to maintaining a high level of competence. Employee training is also conducted through internal courses. An exception is made by R13, a farm with a foreign owner, which gives a score of 2 to its employees. As strategies for employee training, it can be noted that participation in specialized conferences or visits to other farms are rarely encouraged (R1). Thus, to address their needs, farmers expand their training methods to include: internal training – farmers can opt for on-the-job training, sometimes with the help of specialized companies or equipment suppliers (R1); collaboration with educational institutions – farmers can collaborate with universities and high schools to train young people who will later be employed (R8).

Thus, training of farm workers is extremely important, whether it takes place internally or externally, an aspect also emphasized by [11], who shows that a high level of training will help farm employees to better use the information they receive, access government support programs, and adapt more easily to changes in the socio-economic environment. Additionally, the digitalization of agri-food production systems requires the development of digital skills among the agricultural workforce [7].

Regarding the benefits offered to employees beyond salary, most of the farmers participating in the study (n=9) provide mixed packages, while R3 and R5 only grant financial supplements to their employees. Three farms (R4, R6 and R8) provide only one type of benefit, namely agricultural services, agricultural products and excursions. On the other hand, R2 is the only farm that reported not offering any benefit other than salary. A concerning fact for the agricultural workforce might be that two-thirds of the interviewed farms stated they do not have a well-established career plan for their staff. Related to this situation, in a similar study, [16] emphasize the urgent need to integrate career planning strategies into the human resource policies of agricultural holdings.

In the present study, the farms that mentioned having a career plan for their employees were R1, R8, R9, R10 and R12. On the other hand, farmers often have (n=11) succession plans for their business; the cases where such plans are not present are mainly due to the legal and administrative forms of organization. The importance of legislative aspects is also

highlighted by authors such as [2], respectively [5].

Word frequency and relationships

From the word cloud graphic (Figure 1) resulted from the data analysis using the Nvivo program, it can be observed that "farm" is the most frequently mentioned word, which is not at all unexpected. However, it is also notable that the word "succession" is used prominently, both because it does not have many widely known synonyms and because it is the reference term for the respective action, but also because it was a main theme of the study.

Fig. 1. The most common words found in the transcripts of the 15 interviews with farmers
Source: Own results.

Beyond these two terms, discussions centered around the employees and their evaluation processes are also distinguishable, given the focus of a significant portion of the interview on the mechanisms of labour management in agriculture, as well as on the family, again, through the lens of the succession issue (Table 2).

Table 2. Word frequency (%). Words include all encountered grammatical forms

Word	%
farm	2.23
activity	1.23
succession	0.78
plan	0.75
employee	0.65
family	0.59
assessment	0.42
studies	0.32

Source: Own results.

The frequent appearance of terms like "human resource" and "recruitment" in the interviews highlights a constant focus on employee management. The term "local community", in its various forms, is a central term, emphasizing the importance of local relationships in recruitment and farm management.

At the same time, the frequent mention of the workforce may underscore the significant challenges farmers face in their recruitment efforts. Words such as "problems", "difficulties" and "unprepared" highlight challenges related to the quality and availability of the workforce. On the other hand, the terms "training", "instruction" and "investments" may indicate the desires or efforts to improve employee competencies. The frequent pairing of "recruitment" and "local" suggests that farmers primarily rely on local resources. Similarly, "employment" and "recommendation" are closely related words, reflecting that recommendations are a preferred method of employment. Training and education are also frequently mentioned, especially in the context of collaboration with educational institutions. Last but not least, farmers have also discussed strategies to promote their professional needs, which is why references to "advertisements" appear often.

Breaking down the most frequently encountered words across the main themes of the interview (Figure 2), differences in the construction of the discourse can be observed, influenced by the questions addressed.

Thus, the farm description is predominantly characterized by references to indicators such as turnover, land area or owner characteristics. On the other hand, the human resources and the management of activities sections include frequent references to candidates and employees, as well as various career plans, recruitment and retention strategies.

Fig. 2. The most frequent words encountered in the transcripts of the 15 interviews with farmers, distributed across the topics of interest into which the interview guide was divided: farm description (top-left), human resources (top-right), farm activity management (bottom-left), and farm succession (bottom-right).
Source: Own results.

Finally, the section dedicated to succession issues clearly focuses on this concept. Regarding the way in which farmers relate to their future intentions (Figure 3), they express thoughts about expanding the land area, as well as hiring personnel and developing partnerships (in this case, with a recruitment company).

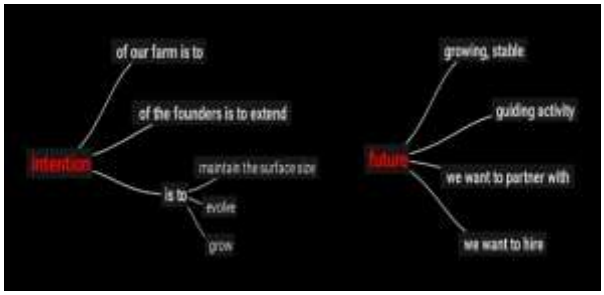

Fig. 3. How farmers relate to future intentions
Source: Own results.

Regarding the way farmers relate to candidates for deficient positions and the methods of evaluating them (Figure 4), candidates are selected based on aptitude tests and recommendations from the community, but they are not always the most suitable. The evaluation is not necessarily based on strict criteria, but practical aspects are taken into consideration.

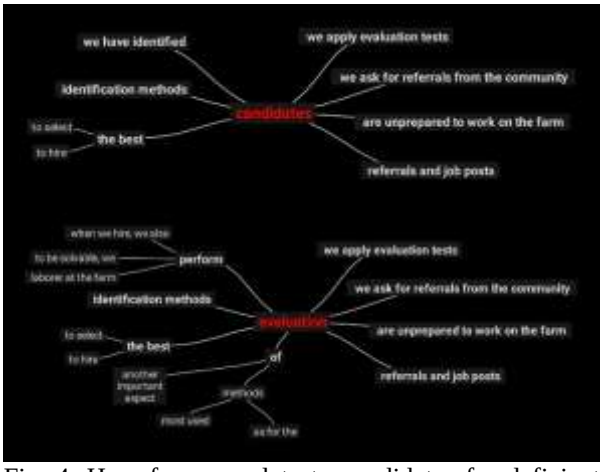

Fig. 4. How farmers relate to candidates for deficient positions and the methods of evaluating them
Source: Own results.

A strong consensus can be observed among farmers regarding the obstacles in recruiting labour from other areas. At the same time, in the discourse of many farmers, there is noticeable dissatisfaction with recruiting a high-performing workforce.

Fig. 5. The way farmers relate to work, especially the workforce
Source: Own results.

The lack of workforce is associated with challenges and risks, primarily linked to the scarcity of skilled labour.
The solutions were mentioned as such by the interviewees only in the context of succession, and the most accessible solution, family succession, was also the most frequently invoked.

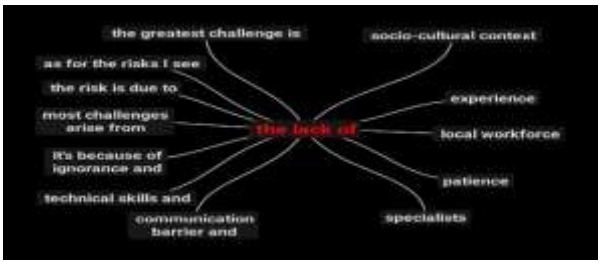

Fig. 6. How farmers perceive the lack of workforce
Source: Own results.

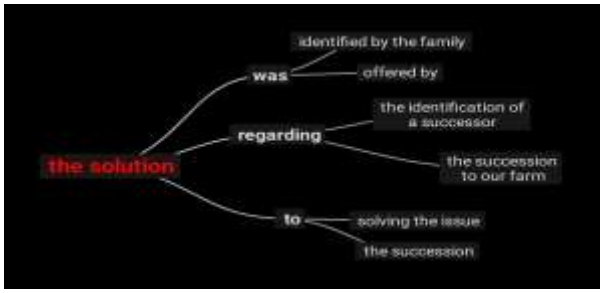

Fig. 7. The way farmers relate to solutions
Source: Own results.

CONCLUSIONS

Farmers in Romania face major difficulties in recruiting and retaining a qualified workforce, especially in remote rural areas. The existence of a well-trained workforce is essential, and its lack can negatively affect farm efficiency. However, there is a constant concern for training and developing teams, through various methods adapted to the needs and specific context of each farm. In the future, it is expected that farm teams will either be maintained or expanded based on the farms' growth plans. Solutions identified by participants include expanding partnerships with educational institutions and offering continuous training programs. At the same time, investments in better working conditions for employees (such as accommodation or additional benefits) could attract workers from other regions. Developing an effective succession plan, which includes the early identification of potential successors, the development of their skills through dedicated training programs, and the creation of a clear framework for the transfer of responsibilities, represents, in the opinion of the interviewed farmers, a viable solution to ensure the continuity of agricultural farms.

The managerial implications of the study are reflected in the following recommendations, which can support the improvement of farm performance and sustainability: diversifying recruitment channels by more actively integrating digital platforms and fostering closer collaboration with educational institutions; investing in training through continuous training programs for employees, in collaboration with equipment suppliers and universities.

REFERENCES

[1]Bencheva, N., Tepavicharova, M., Wrzochalska, A., 2017, Characterstics and Trends in the Development of Professional Competence of the Human Capital in the Agricultural Sector. Problems of Agricultural Economics, 1(350).

[2]Bertolozzi-Caredio, D., 2024, The farm succession effect on farmers' management choices. Land Use Policy, 137, 107014.

[3]Bertolozzi-Caredio, D., Bardaji, I., Coopmans, I., Soriano, B., Garrido, A., 2020, Key steps and dynamics of family farm succession in marginal extensive livestock farming. Journal of Rural Studies, 76, 131-141.

[4]Bolokan, D., 2020, Recruitment infrastructure within the agricultural and agrifood sector: Post-Soviet and neocolonial entanglements between "Eastern" and "Western" Europe. Social Change Review, 18(Winter), 39-77.

[5]Breitenbach, R., Foguesatto, C. R., 2023, Should I stay or should I go? Gender differences and factors influencing family farm business succession in Rio Grande do Sul, Brazil. Land Use Policy, 128, 106597.

[6]Carbone, A., Subioli, G., 2016, The generation turnover in agriculture: The ageing dynamics and the EU support policies to young farmers. In The Common Agricultural Policy after the Fischler Reform, 375-390. Routledge.

[7]Christiaensen, L., Rutledge, Z., Taylor, J. E., 2021, The future of work in agri-food. Food Policy, 99, 101963.

[8]Drahotová, K., Adamová, M., Soukupová, N., Jindrová, A., 2020, Recruitment aspects in the agricultural sector: survey of enterprises in the Czech Republic. AGRIS on-line Papers in Economics and Informatics, 12(2), 53-62.

[9]Eurostat, 2022, Key figures on the European food chain, 2022 edition. https://ec.europa.eu/eurostat/web/products-key-figures/w/ks-fk-22-001, Accessed on 11 January 2025.

[10]Foguesatto, C. R., de Vargas Mores, G., Kruger, S. D., Costa, C., 2020, Will I have a potential successor? Factors influencing family farming succession in Brazil. Land Use Policy, 97, 104643.

[11]Gasson, R., 1998, Educational qualifications of UK farmers: A review. Journal of Rural Studies, 14(4), 487-498.

[12]Guth, M., Smędzik-Ambroży, K., Czyżewski, B., Stępień, S., 2020, The economic sustainability of farms under common agricultural policy in the European Union countries. Agriculture, 10(2), 34.

[13]Heřmanová, M., Kuralová, K., Prokop, M., Pilař, L., 2024, The Attractiveness of Employee Benefits in Agriculture from the Perspective of Generation Z. Agriculture; Basel, 14(7).

[14]Iis, E. Y., Thayib, A., Yunus, M. M., Adam, M., Sofyan, H., 2024, Performance of Employees in Agriculture and Plantation Agency of Aceh. Jurnal Organisasi dan Manajemen, 20(1), 17-35.

[15]Institutul Național de Statistică (National Institute of Statistics). (n.d.). http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table, Accessed on 10 January 2025.
[16]Jankelová, N., Joniaková, Z., Romanová, A., Remeňová, K., 2020, Motivational factors and job satisfaction of employees in agriculture in the context of performance of agricultural companies in Slovakia. Agricultural Economics/Zemedelska Ekonomika, 66(9).
[17]Klupšas, F., Serva, E., 2009, Changes of specialist and qualified employee demand in agrarian sector of Lithuania. Management Theory & Studies for Rural Business & Infrastructure Development, 17(2).
[18]Kumar, A., Trivedi, A., Nandeha, N., Niveditha M.P., 2024, Sustainable Agriculture Development and Optimum Utilization of Natural Resources: Striking a Balance. Journal of Scientific Research and Reports, 30(5), 477-486.
[19]Kusz, D., 2014, Modernization of agriculture vs sustainable agriculture. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 14(1), 171-178.
[20]Kuznetsova, A., Kolevid, G., Kostyaev, A., Nikonova, G., Akhmetyanova, A., 2019, Reproduction of the qualified personnel of working professions in agriculture. Hradec Economic Days, 9(1), 11-22.
[21]Leonard, B., Farrell, M., Mahon, M., Kinsella, A., O'donoghue, C., 2020, Risky (farm) business: Perceptions of economic risk in farm succession and inheritance.
[22]Malanski, P. D., Ingrand, S., Hostiou, N., 2019, A new framework to analyze changes in work organization for permanent employees on livestock farms. Agronomy for Sustainable Development, 39(1), 12.
[23]Moore, S. J., Durst, P. T., Ritter, C., Nobrega, D., Barkema, H. W., 2020, Effects of employer management on employee recruitment, satisfaction, engagement, and retention on large US dairy farms. Journal of Dairy Science, 103(9), 8482-8493.
[24]Ndregjoni, A., 2024, Identification and analysis of human resources risk on farms, encouragement for sustainable development. Conferencii,(9)1.
[25]Peng, B., Melnikiene, R., Balezentis, T., Agnusdei, G. P., 2024, Structural dynamics and sustainability in the agricultural sector: the case of the European Union. Agricultural and Food Economics, 12(1), 31.
[26]Pitson, C., Bijttebier, J., Appel, F., Balmann, A., 2020, How much farm succession is needed to ensure resilience of farming systems?. EuroChoices, 19(2), 37-44.
[27]Plana-Farran, M., Gallizo, J. L., 2021, The survival of family farms: Socioemotional wealth (SEW) and factors affecting intention to continue the business. Agriculture, 11(6), 520.
[28]Pocol, C. B., 2013, Economie rurală: identitate și actualitate (Rural Economy: identity and actuality) AcademicPres, Cluj-Napoca.
[29]Popescu, A., Dinu, T. A., Stoian, E., Șerban, V., 2021, Efficiency of labor force use in the European Union's agriculture in the period 2011-2020. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 21(3), 659-672.
[30]Popescu, A., Tindeche, C., Marcuță, A., Marcuță, L., Honțuș, A., Angelescu, C., 2021, Labor force in the European Union agriculture-traits and tendencies. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 21(2), 475-486.
[31]Rech, L. R., Binotto, E., Cremon, T., Bunsit, T., 2021, What are the options for farm succession? Models for farm business continuity. Journal of Rural Studies, 88, 272-278.
[32]Rodriguez Lizano, V. A., Montero-Vega, M., Sibelet, N., 2020, Which variables influence the succession process in family farms? A literature review. Cahiers Agriculture Vol.29, Art. no. 39, 11p.
[33]Stenbacka, S., 2019, Responsibilities, caring practices and agriculture: farmers' perspectives on recruitment and employer–employee relationships. Sociologia Ruralis, 59(2), 255-274.
[34]Streimikis, J., Yu, Z., Zhu, N., Baležentis, T., 2022, Achievements of the European Union member states toward the development of sustainable agriculture: A contribution to the structural efficiency approach. Technological Forecasting and Social Change, 178, 121590.
[35]Tudor, M. M., 2014, Utilization of land resources in agriculture–opportunity or risk for Romanian agri-food sector competitiveness. Procedia Economics and Finance, 8, 720-728.
[36]Urbancova, H., Richter, P., Kucirkova, L., Jarkovska, M., 2017, Employer branding in the agricultural sector: making a company attractive for the potential employees. Agricultural Economics/Zemědělská Ekonomika, 63(5).

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CONSUMER PREFERENCES DEPENDING ON THE VARIETY OF FRESH PEPPERS, FOR HELPING FARMERS, WHAT CULTIVARS TO GROW

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Abstract

Rich in nutrients, especially vitamin A and vitamin C, with an impressive range of colors, sweet peppers are loved for their pleasant taste and mild flavor. Used in many different culinary recipes, peppers bring variety to the Romanian diet. People's preferences for sweet peppers are important for producers, so they can grow cultivars that are appreciated by consumers. In addition, pepper breeders are also interested in these preferences, so they can focus on creating varieties that answer the consumer's demands. This study presents a sensorial analysis of more than 40 sweet pepper cultivars in the period 2022-2024. Every year, in the first weekend of October, the Faculty of Horticulture is the host of the "Horticultural Autumn of Bucharest" event. The visitors had the opportunity to taste and evaluate the sweet pepper cultivars. Several varieties were assessed every year, indicating how Romanian preferences have evolved during this period. The common indicators evaluated in all three years are color, taste, size, and shape. Juiciness and flavor are extra indicators evaluated only in 2022, and pericarp thickness is an extra indicator evaluated only in 2023. The best-ranked cultivar in 2022 was "Temes F1", in 2023 it was "SVPB 1112", and "Patrol F1" was highly appreciated in 2024. With an average production of 80 t/ha and an average selling price of 4.5 lei in 2024, the profit rate for the sweet pepper crop is close to 1.4 %, being one of the profitable crops in Romania.

Key words**:** *Capsicum annuum L., trends, consumer preference, sensorial analysis*

INTRODUCTION

Native to Central and South America, peppers have an important health and economic value. Loved due to their pleasant taste and mild flavor, sweet peppers (*Capsicum annuum L.*) are used in daily-based diets worldwide. Every year, new cultivars are introduced, pleasing people with a variety of colors and shapes, but also promoting health and nutritional qualities (Żurawik et al., 2021) [26].
Sweet pepper, also known as bell pepper, is mainly cultivated for its pleasant taste, flavor, and diverse colors with nutritional benefits. Paprika is a well-known condiment made from dried red sweet peppers used in various dishes all over the world, containing useful molecules (Kostrzewa et al., 2023; Sood et al., 2023) [13, 24].
As a source of antioxidants, vitamins, carotenoids, flavonoids, polyphenols, or lycopene, peppers, both sweet and spicy, protect the human body against free radicals and play an important role in disease prevention (Medina-Juarez et al, 2012; Batiha et al., 2020; Pham-Huy et al., 2008) [15, 2, 18]. It is known that having a rich fruit and vegetable diet is a powerful and helpful method for maintaining good health. Using diet to prevent chronic diseases is a highly recommended method in times when the world's population is increasing and medical support is sometimes expensive (Ribes-Moya et al., 2014, Sanatombi, 2023) [21, 22].
The color diversity of peppers is due to carotenoids, anthocyanins, and chlorophyll content, which is also responsible for different tastes. Different colors mean different

bioactive compounds, and new varieties have been developed lately to benefit our health (Choi et al., 2023; Dludla et al., 2023; Pratas et al., 2024) [7, 9, 20].

It is proven that fertilization methods influence the quality of peppers, and the yield is affected without fertilizer supplements (Becherescu et al., 2023) [3].

The producers use it for their crops with good results. In recent years, organic fertilization has been preferred by consumers, and current results show that fruit quality is increased as the vitamin C content, dry matter, and total soluble solids contents are increased, influencing the taste and flavor of peppers and subsequently human health as well (Barcanu-Tudor et al., 2018; Bușterchi et al., 2024; Toma et al., 2020) [1, 5, 25].

Genetic diversity and pepper population structure are studied at present based on agro-morphological and microsatellite markers (Sood et al., 2023) [24].

Romania has good soil and climate conditions to produce various types of vegetables, tomatoes, and peppers, occupying an important place in the cultivated area and production (Soare et al., 2016; Popescu, 2018; Giuca, 2021) [23, 19, 10].

In this context, the purpose of the study is to provide an overview of the evolution of people's preferences for sweet peppers, studied in three consecutive years. The objective is to make the connection between the consumer's preferences related to sweet peppers, and producers, who can make a profit from growing the preferred cultivars.

MATERIALS AND METHODS

In 2022, the sensorial test included 43 sweet pepper varieties, in 2023, the test was made with 53 varieties, and in 2024, 57 varieties were included. Fifteen varieties were assessed in all three years. Four varieties were evaluated in 2022 and 2023, six varieties were evaluated in 2023 and 2024, and four were evaluated in 2022 and 2024.

Sweet pepper varieties were cultivated in the southeast part of Romania, and some varieties were cultivated in the west of Romania. The same cultivar was provided from different counties with specified names (Table 1).

Table 1. Sweet pepper cultivars enrolled in tasting sessions

2022	2023	2024
1425 F1 Matca-Galați	Ar 371039	Apulum F1
Ardanza F1 Matca-Galați	Ardanza F1	Ardanza F1
Ardanza F1 Pucheni-Dâmbovița	Barbie F1	Asteroid
Barbie F1 Izbiceni-Olt	Barlem F1	Barbie F1
Beniel F1 Izbiceni-Olt	Burabella Rz F1 - Galați	Barlem F1
Bihar F1 Rusănești-Olt	Burabella Rz F1 - Giurgiu	Belo Uvo
Burati F1 Izbiceni-Olt	Burabella Rz F1 - Olt	Beniel F1
Burati F1 Matca-Galați	Burabella Rz F1 - Prahova	Blanciana F1
Burati F1 Prahova-Ploiești	Burrati Rz F1 - Dâmbovița	Burabella F1
Carcassone F1 Izbiceni-Olt	Burrati Rz F1 - Galați	Buratti F1
Carcassone F1 Pucheni-Db	Burrati Rz F1 - Prahova	Carcasson F1
Carpatin F1 CâmpiaTurzii-Cluj	Bw 1623 Rz F1	Carpatin F1
Coloreta F1 Matca-Galați	Bw 1624 Rz F1	Coloreta F1
Daciana F1 CâmpiaTurzii-Cluj	Carcasson F1	Eugenia F1
Galia F1 CampiaTurzii-Cluj	Carpatin F1	Favorit
Hek 500 F1 CampiaTurzii-Cluj	Coloreta F1	Hek 21 P685 F1
Ipon F1 Tecuci-Galați	Daciana F1	Hmc 572207 F1 (1)
Isabel F1 Ceptura De Jos	Galia F1	Hmc 572207 F1 (2)
Isabel F1 Matca-Galați	Galia F1	Insignia
Kaamos F1 Matca-Galați	Isabel F1	Isabel F1
Kaprima F1 Izbiceni-Olt	Kaprima F1	Kaprima F1 (1)
Kaptur F1 Dumbrăvești-Prahova	Kaptur F1	Kaprima F1 (2)
Kaptur F1 Izbiceni-Olt	Kr Rz 1505 - Galați	Kaprima F1 (3)
Kr 1505 Matca-Galați	Kr Rz 1505 - Olt	Kaptur F1 (1)
Lores F1 Matca-Galați	Kr Rz 1505 - Prahova	Kaptur F1 (2)
Napoca F1 CâmpiaTurzii-Cluj	Kubat F1	Karpathos F1 (1)
Palermo Obedius F1 Racoviță	Lores F1	Karpathos F1 (2)
Palermo Radius F1 Racoviță	Mauricio F1	Kr 1505 Rz F1
Palermo River F1 Racoviță	Nirvin F1	Kubat F1 (1)
Palermo Yosemite F1 Racoviță	Piedone F1	Kubat F1 (2)
Piedone F1 Matca-Galați	Posonium F1	Kubat F1 (3)
Potaisa F1 Dumbrăvești-Prahova	Pritannia F1	Kubat F1 (4)
Pritannia F1 Izbiceni-Olt	Red Jet Rz F1 - Galați	L 80
Rubicon F1 Tecuci-Galați	Red Jet Rz F1 - Prahova	L225
Scorilo F1 CâmpiaTurzii-Cluj	Redpia F1	Massouda Rz F1
Temes F1 Drăgășani-Valcea	Silver Star F1	Moscato F1
Tiberius F1 CâmpiaTurzii-Cluj	Svpb 1112	Napoca F1 (1)
Traian F1 CâmpiaTurzii-Cluj	Tallante F1	Napoca F1 (2)
Turda F1 CâmpiaTurzii-Cluj	Tiberius F1	Patrol F1
Valahia F1 CâmpiaTurzii-Cluj	Top Gear Rz F1 - Dâmbovița	Piedone F1
Vitalica F1 Clinceni-Olt	Top Gear Rz F1 - Giurgiu C	Potaisa F1
Vitalica F1 Matca-Galați	Top Gear Rz F1 - Giurgiu V	Pritannia F1
Vitalica F1 Prahova-Ploiești	Top Gear Rz F1 - Olt	Scorilo F1
	Top Gear Rz F1 - Prahova	Sv 0102 F1
	Turda F1	Sweet Palermo

		Chocolony Rz F1
	Valahia F1	Sweet Palermo Obedius Rz F1
	Verdejo F1	Sweet Palermo Radius Rz F1
	Vinalles Rz F1	Sweet Palermo Yocarino Rz F1
	Vitalica Rz F1 - Dâmbovița	Tallante F1
	Vitalica Rz F1 - Galați	Temes F1
	Vitalica Rz F1 - Giurgiu	Tiberius F1
	Vitalica Rz F1 - Olt	Tonton F1
	Vitalica Rz F1 - Prahova	Topgear Rz F1
		Turda F1
		Verdejo F1
		Vitalica Rz F1 (1)
		Vitalica Rz F1 (2)

Source: Original data from the sensorial analysis.

The testing sessions were conducted as a part of the event ”Horticultural Autumn of Bucharest”, an event that is currently held at the start of October every year, at the Faculty of Horticulture. The hedonic method was used for testing the preferences, with five points on the scale. The criteria range used for evaluation for every indicator was from 1, meaning ‘I don’t like it’ (insufficient), to 5, meaning ‘I love it’ (excellent).

The common indicators for expressing quality in all three years were: size, shape, color, and taste. In 2022, juiciness and aroma were extra indicators tested, and in 2024, the thickness of the pericarp was the extra indicator tested.

The respondents for all tasting sessions were participants of the ”Horticultural Autumn of Bucharest” event, from a wide economic background, with ages between 9 and 77 years old. Sixty-six assessors participated in 2022, 63 in 2023, and 31 assessors responded in 2024.

For an objective evaluation, the average score was calculated for every sweet pepper cultivar, in every year tested. Data analysis was done using the Microsoft Excel Software, version 2401.

RESULTS AND DISCUSSIONS

All the scores were summed per year, and the varieties were ranked from the highest value to the lowest. The best score in 2022, with 26.8 points from a total of 30 points, is the ‘Temes F1’ variety from Drăgășani, Vâlcea County, followed by ‘Ardanza F1’ with 26.1 points, ‘Kaamos F1’ and ‘Coloreta F1’ with 26.0 points, all from Matca – Galați county.

In 2023, the highest scores went to line ‘SVPB 1112’ with 18.2 points from a total of 25 points, followed by ‘Coloreta F1’ with 17.8 points, ‘Red Jet RZ F1’ from Galați county with 17.7 points, and ‘Verdeho F1’ with 17.6 points.

The same variety ‘Red Jet RZ F1’ but from Prahova County scored 17.5 points, close to the first-ranked varieties, meaning that this variety was appreciated by respondents even if it was cultivated in different areas of the country.

2024 brings ‘Patrol F1’ to the top with 22.6 points from a total of 25 points, followed by ‘Insignia’ with 22.3 points. ‘Kubat F1’ and ‘Pritannia F1’ both with 21.9 points, and also ‘Napoca F1’, ‘Carpatin F1’, and ‘Coloreta F1’ had close values: 21.7 points.

Figure 1 shows that the differences between varieties are quite small, and the top five have varieties with close values, making it very difficult to express an exact ranking.

The size, shape, color, and taste were indicators common for all three years analyzed. These indicators are related in the literature to fertilization use and water supply. The size is usually influenced by fertilization methods, grafting, and constant water amount, while the color, taste, and quality performance are attributed to organic fertilization (Brezeanu et al., 2022; Caruso et al., 2019; Cojocaru et al., 2022; Homma et al., 2022; Jasim et al., 2019; Murcia-Asensi et al., 2024) [4, 6, 8, 11, 12, 16]. Regardless of the technology used, the best score for size in 2022 goes to two varieties: ‘Coloreta F1’ from Matca – Galați and ‘Temes F1’ from Drăgășani – Vâlcea both with 4.7 points. ‘Galia F1’ from CâmpiaTurzii – Cluj and ‘Kaprima F1’ along with ‘Kaptur F1’ from Izbiceni – Olt had 4.6 points, followed by eleven varieties with 4.5 points. (Fig. 2).

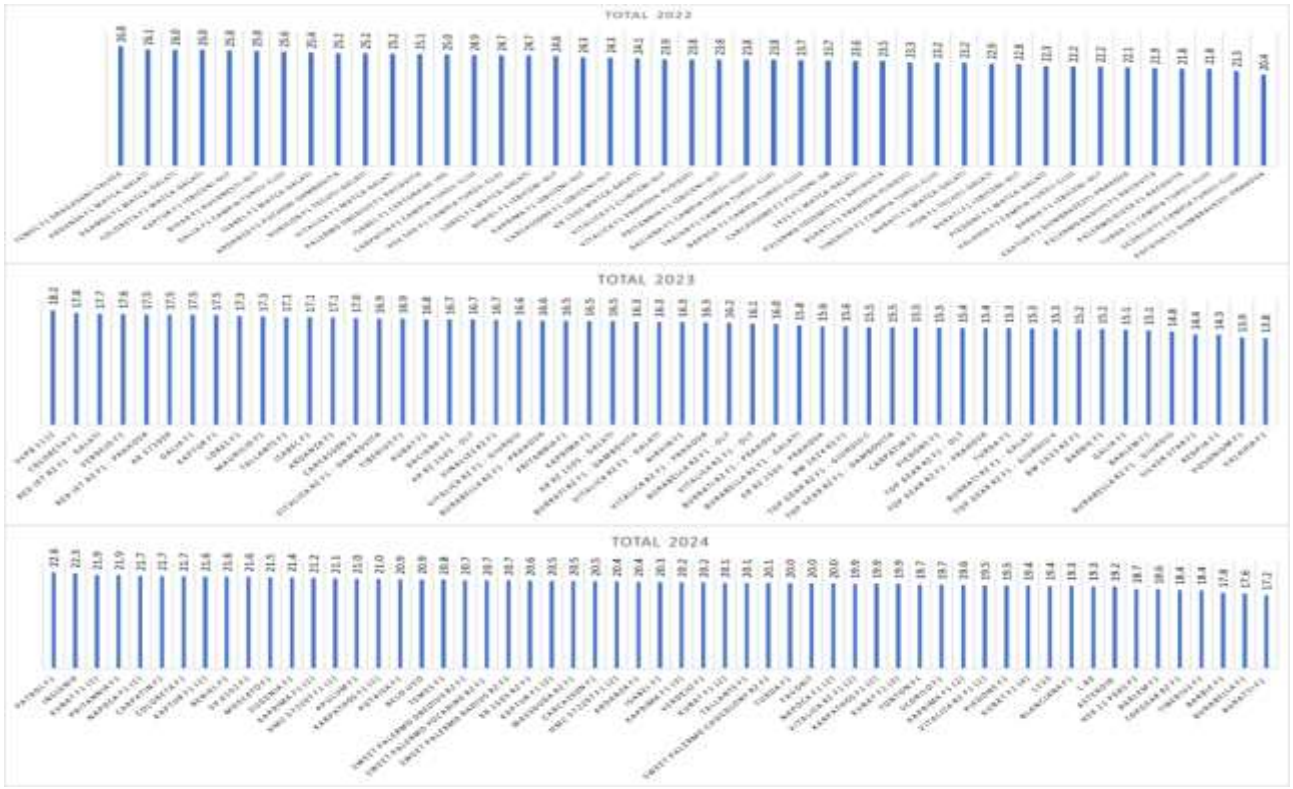

Fig. 1. Total score for sweet pepper varieties, tested in 2022, 2023, and 2024
Source: Original data

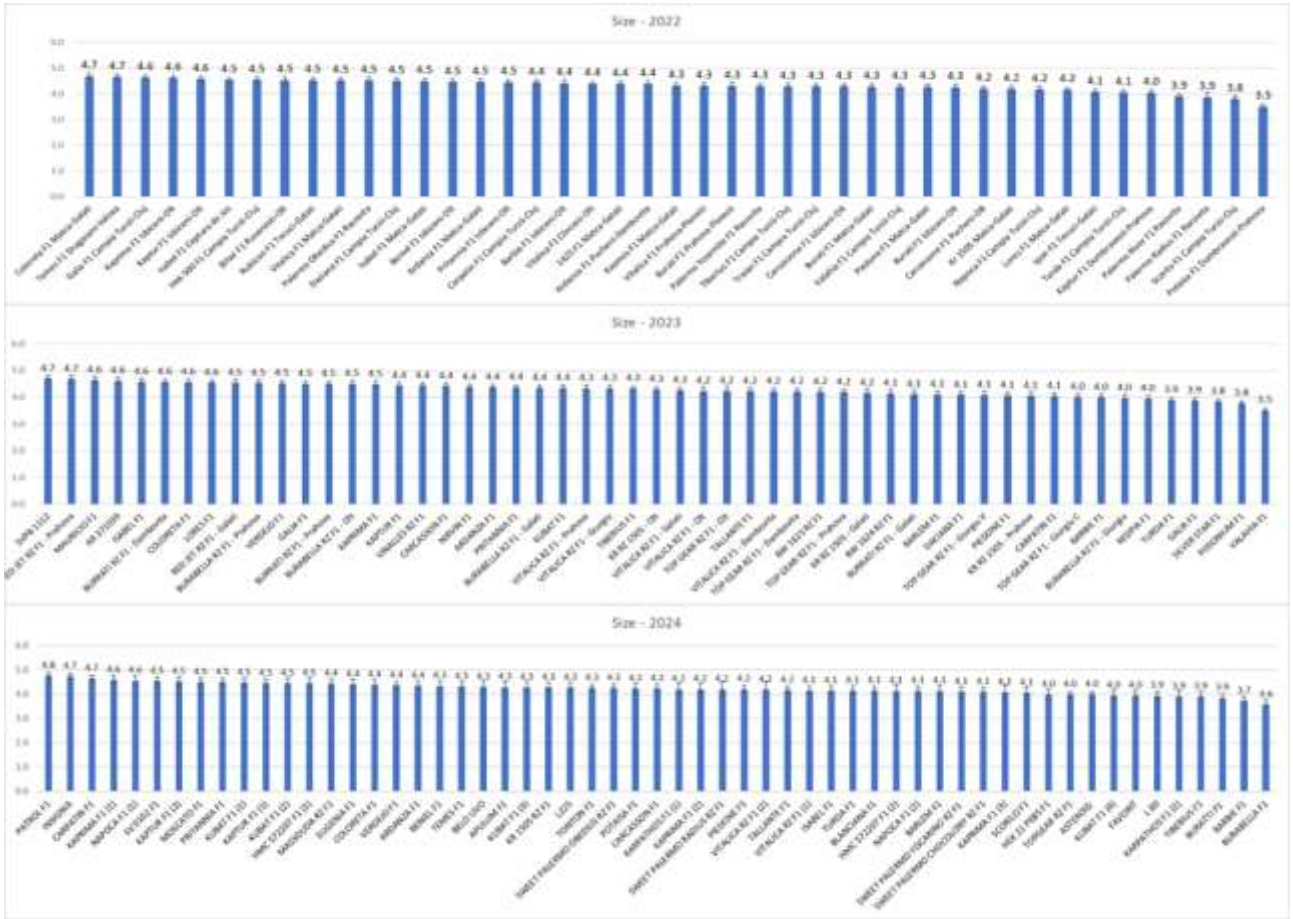

Fig. 2. Size appreciation in 2022, 2023, and 2024. Error bars represent the standard error of the mean.
Source: Original data.

In 2023, the line 'SVBP 1112' and 'Red Jet RZ F1' from Prahova had the highest rank with 4.7 points. Next was 'Mauricio F1', the line 'AR 37 1039', 'Isabel F1', 'Burrati RZ F1' from Dâmbovița, 'Coloreta F1', and 'Lores F1', all with 4.6 points. With 4.5 points, there were seven varieties (Figure 2).

The highest rank in 2024, with 4.8 points, is occupied by 'Patrol F1', followed with 4.7 points by 'Insignia' and 'Carpatin F1', and continued by 'Kaprima F1' and 'Napoca F1' with 4.6 points.

Besides size, the shape of sweet peppers was also evaluated, and the best scores in 2022 go to 'Galia F1' from Câmpia Turzii – Cluj, 'Temes F1' from Drăgășani – Vâlcea, and 'Vitalica F1' from Matca – Galați, all with 4.6 points. 'Kaptur F1', 'Coloreta F1', and 'Carpatin F1' scored 4.5 points, and 'Isabel F1', 'Rubicon F1', 'Kaprima F1', 'Pritannia F1', 'Bihar F1', 'Daciana F1', 'Burati F1', 'Ardanza F1', and 'Carcassonne F1' scored 4.5 points.

Having the highest score for size in 2023, the line 'SVPB 1112' also had the highest score for shape in the same year, along with the line 'AR 371039' with 4.6 points. 'Isabel F1', 'Kaptur F1', 'Red Jet RZ F1' from Prahova and Galați, 'Verdeho F1', 'Galia F1', and 'Mauricio F1' scored 4.5 points, followed by ten varieties with 4.4 points.

In 2024, 'Insignia F1' and 'Patrol F1' are also at the top, the first variety with 4.8 points, and the second one with 4.6 points. 'Kubat F1', 'Napoca F1', 'Kaprima F1', and 'Kaptur F1' gathered 4.5 points each (Fig. 3).

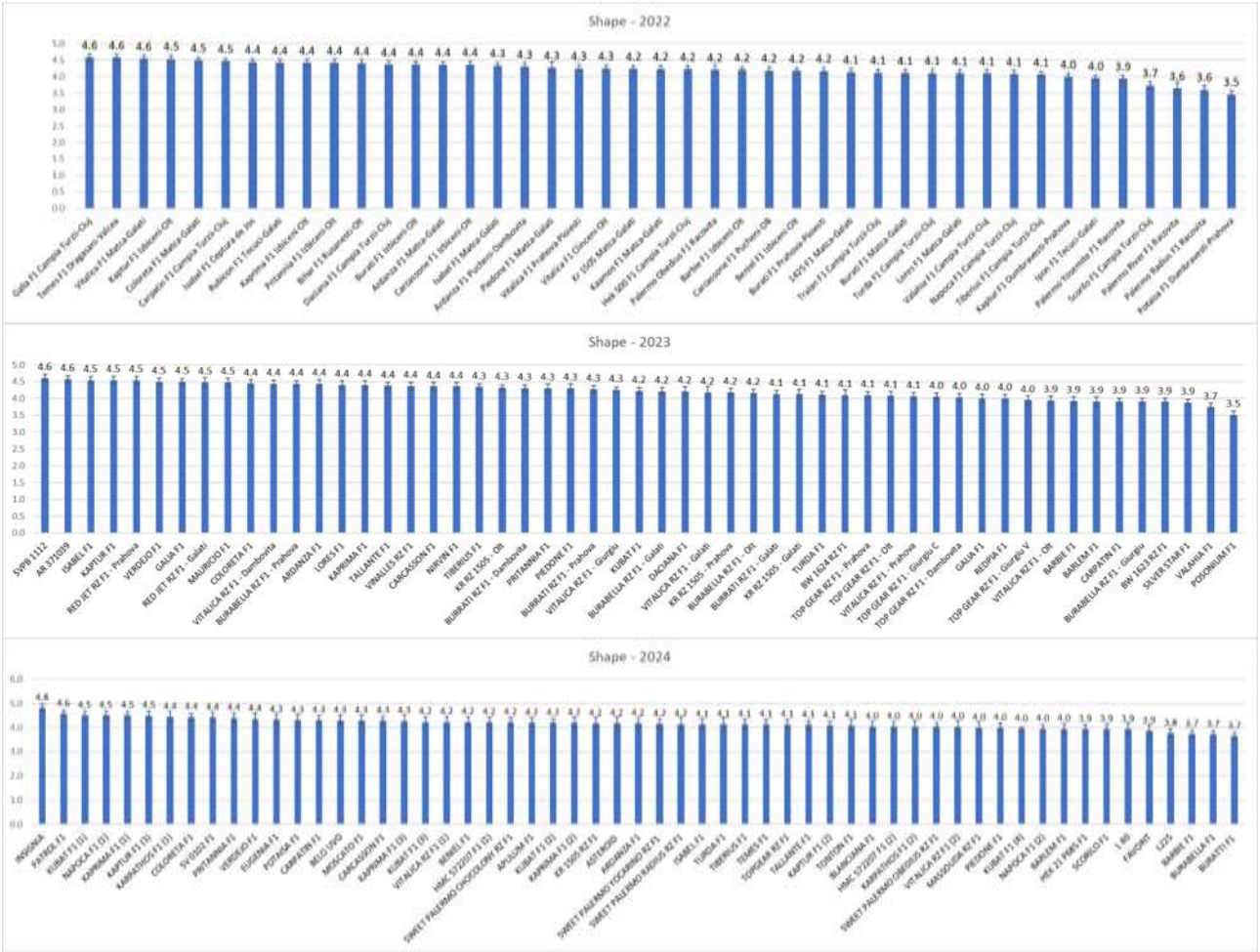

Fig. 3. Shape appreciation in 2022, 2023, and 2024. Error bars represent the standard error of the mean
Source: Original data.

At the tasting sessions, the color of sweet pepper varieties was evaluated with the same criteria, and the best scores in 2022 went to 'Vitalica F1' and 'Coloreta F1 from Matca – Galați, and also for 'Temes F1' with 4.6 points. For 4.5 points, there are twelve varieties: 'Hek

500 F1', 'Kaptur F1', 'Kaprima F1', 'Galia F1', 'Ardanza F1', 'Palermo Obedius F1', 'Daciana F1', 'Carpatin F1', 'Bihar F1', 'Carcassone F1', 'Kaamos F1', and 'Rubicon F1'.

The line 'SVPB 1112' had the best score for color also in 2023, with 4.7 points. 'Talante F1' ranked the same value. 'Verdeho F1' was next with 4.6 points, and seven varieties gathered 4.5 points: 'Red Jet RZ F1', 'Coloreta F1', 'Kaptur F1', 'Carcassone F1', 'Daciana F1', 'Galia F1', and 'AR 371039'.

The same varieties with the highest scores in size and shape also had the best scores in color in 2024. 'Patrol F1', 'Insignia F1', 'Coloreta F1' and 'Kubat F1' had 4.6 points, followed by 'Carpatin F1', 'Kaptur F1', 'Beniel F1' and 'Pritannia F1' with 4.5 points, and 4.4 points ranked eleven varieties: 'Napoca F1', 'Carcassone F1', 'Potaisa F1', 'Moscato F1', 'Massouda RZ F1', 'Favorit', 'SV 0102 F1', 'HMC 572207 F1', 'Karpathos F1, 'Temes F1', and 'Sweet Palermo Radius RZ F1' (Fig. 4).

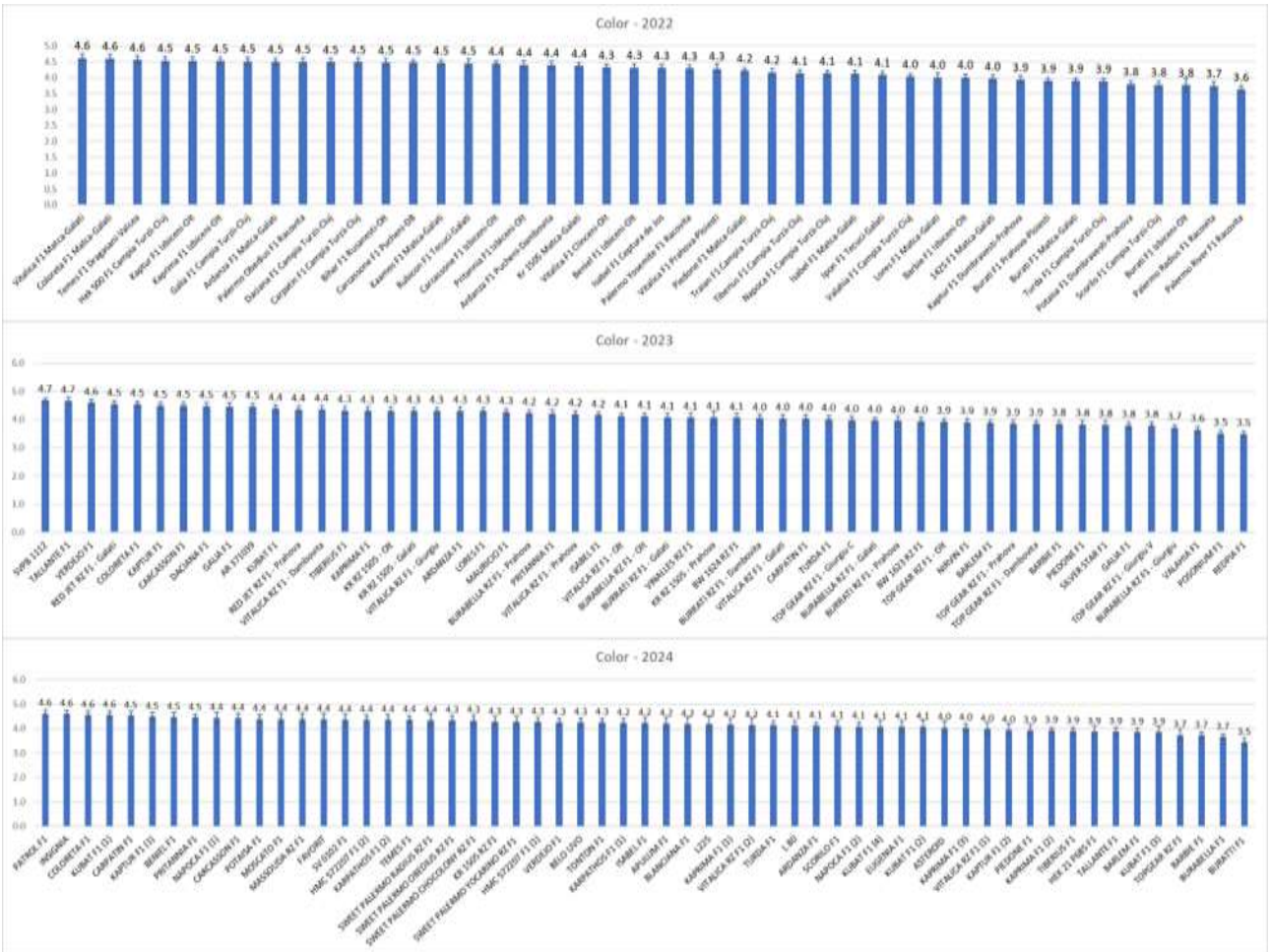

Fig. 4. Color appreciation in 2022, 2023, and 2024. Error bars represent the standard error of the mean
Source: Original data

The taste criteria respected the trend and the varieties with the best scores for size, shape, and color, ranked in the same positions for taste. 'Kaamos F1', 'Temes F1', and 'Ardanza F1' from Matca – Galați were favorites in 2022 with 4.3 points, followed by 'Lores F1', 'Isabel F1', and 'Ardanza F1' from Pucheni – Dâmbovița with 4.2 points. 'Bihar F1', 'Coloreta F1', and 'Kaptur F1' gathered 4.1 points.

'SVPB 1112' had the highest score for taste in 2023, along with 'Coloreta F1' with 4.2 points. 'Red Jet RZ F1' from Galați and 'Lores F1' gathered 4.1 points, followed by six varieties with 4.0 points: 'Galia F1', 'Ardanza F1', 'Verdejo F1', 'Kaptur F1', 'Daciana F1', and 'Red Jet RZ F1' from Prahova.

For the year 2024, the varieties ranked first in taste criteria were some varieties with average scores in the other criteria. 'Sweet Palermo Obedius RZ F1' had the highest score with 4.3 points, followed by 'Sweet Palermo Yocarino RZ F1', 'Sweet Palermo Radius RZ F1', 'Pritannia F1', 'Patrol F1', and 'Eugenia F1' with 4.2 points. The rank is completed by 'Beniel F1' and 'Coloreta F1' with 4.1 points (Fig. 5).

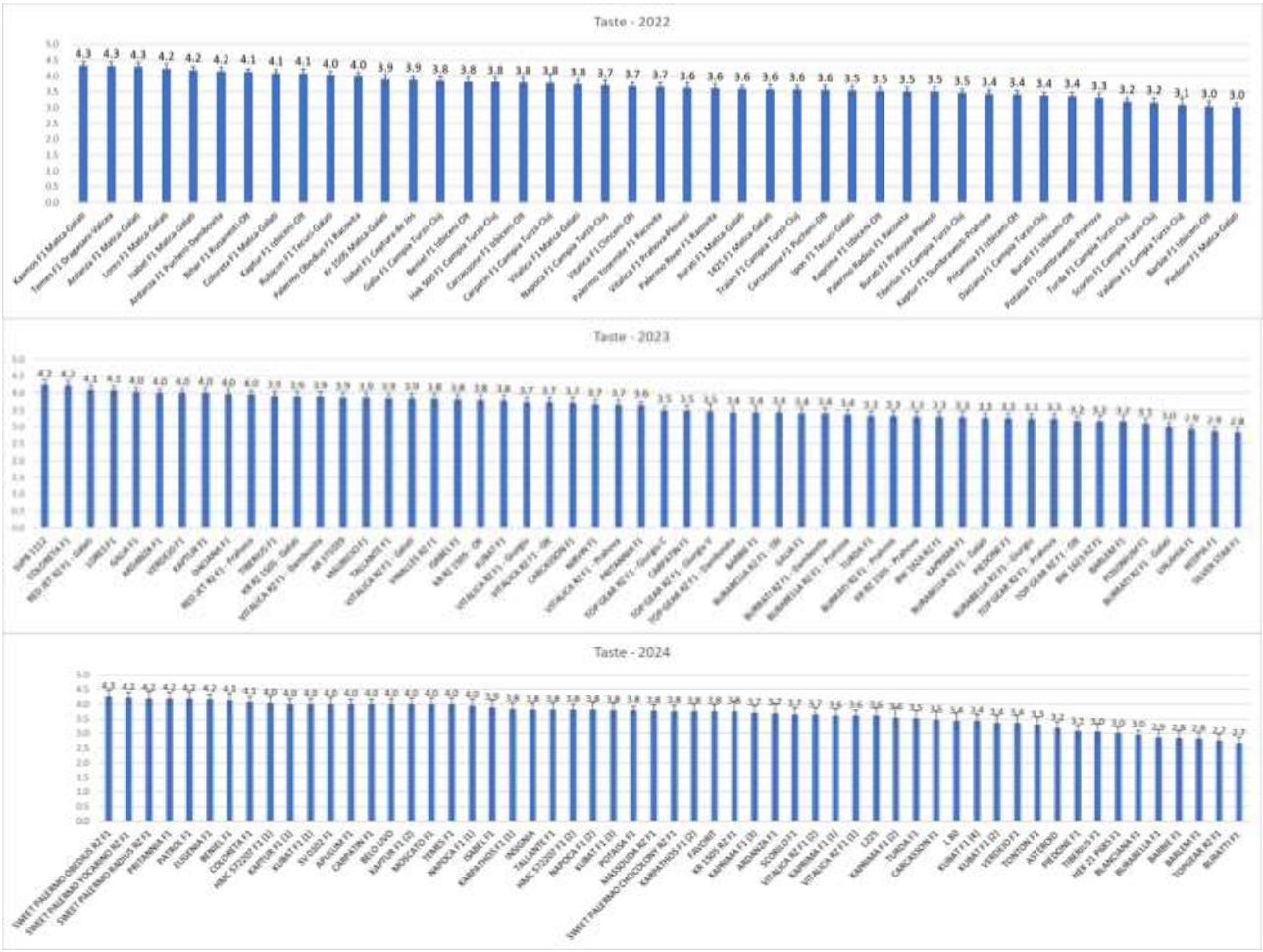

Fig. 5. Taste appreciation in 2022, 2023, and 2024. Error bars represent the standard error of the mean
Source: Original data

In 2022, there were two extra criteria evaluated in the tasting session: juiciness and flavor. These two criteria didn't change the ranking in general; the same varieties had the biggest scores, but they gave more weight to the total scores.

In the first positions for juiciness were placed 'Temes F1' from Drăgășani – Vâlcea and 'Kaamos F1' from Matca – Galați, scored 4.4 points, followed by 'Galia F1', 'Ardanza F1' from Matca – Galați, 'Lores F1', 'Coloreta F1', 'Kaptur F1', 'Isabel F1', and 'Bihar F1' with 4.2 points.

Not only for juiciness but for flavor too, 'Kamos F1' and 'Temes F1' from Drăgășani – Vâlcea are the varieties with the biggest score – 4.3 points, followed by 'Ardanza F1' from Matca – Galați with 4.2 points. 'Isabel F1' and 'Bihar F1' are also ranked in third place with 4.1 points (Fig. 6).

The additional criteria in 2024 were pericarp thickness, an indicator with a direct implication for fruit weight, and yield (Madosa et al., 2008) [14]. The cell wall structure, the texture, is an important factor for the consumer's sensory experience as well as for fruit hardness and storage resistance.

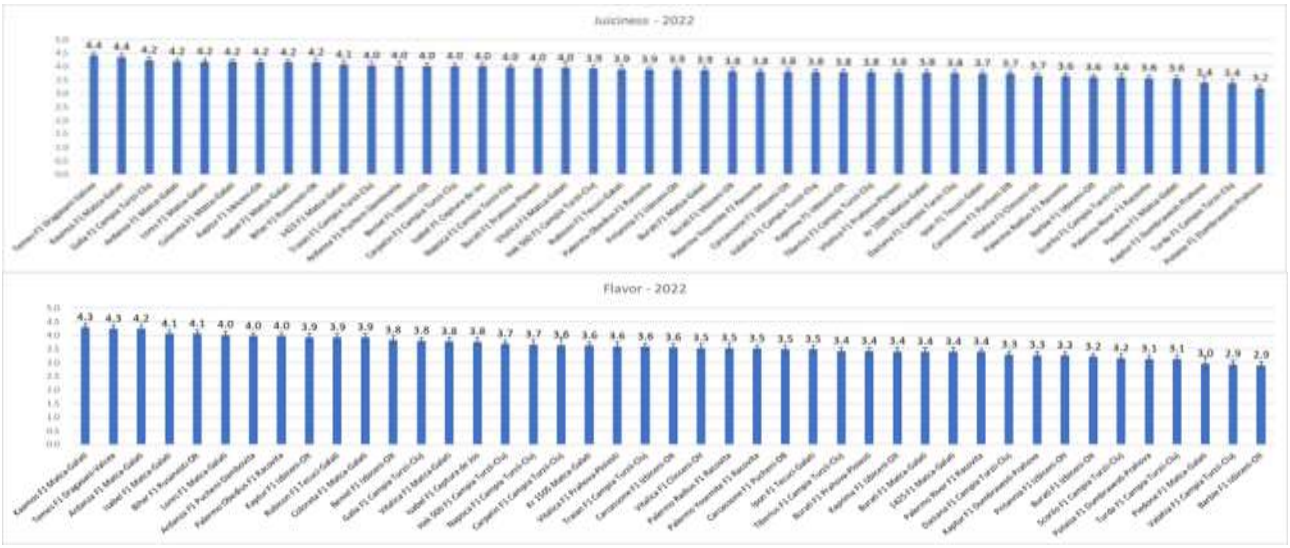

Fig. 6. Additional criteria 2022 (juiciness and flavor). Error bars represent the standard error of the mean
Source: Original data.

The sweet pepper has a crisp texture, and although it is considered a non-climacteric fruit, it loses its crispness and firmness if stored for a long time (O'Donoghue et al., 2020) [17].

The consumer's preferences were 'Patrol F1' with 4.5 points and 'Beniel F1', 'Eugenia F1', 'Kubat F1', and 'Pritannia F1' with 4.4 points, followed by seven hybrids with 4.3 points (Fig. 7).

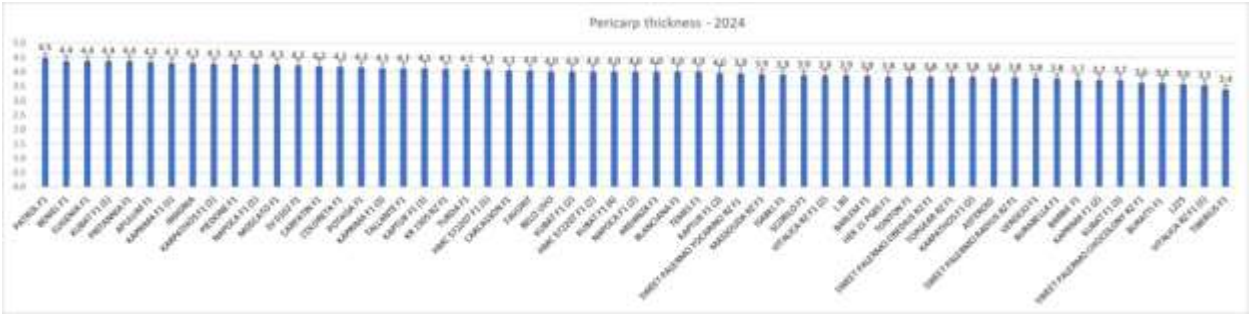

Fig. 7. Additional criteria 2024 (pericarp thickness). Error bars represent the standard error of the mean
Source: Original data.

The producers manifested interest in participating in the three consecutive years in the tasting event at the Faculty of Horticulture to discover the consumer's choices, fifteen varieties of sweet peppers being assessed every year.

Consumers' predilections changed from year to year (Fig. 8) for the common traits (size, shape, color, and taste). Most hybrids remain constant in the consumer's favorites with slight ups and downs. 'Ardanza F1', 'Barbie F1', 'Burati F1', 'Isabel F1', 'Piedone F1', 'Vitalica F1', and 'Tiberius F1' had a consistent decrease of almost 1 point each in all three years.

'Carpatin F1', 'Kaptur F1', 'Pritannia F1', and 'Turda F1' had a slightly increased average with a range between 0.5 and 1 point.

Consistency is seen at 'Carcassonne F1', 'Coloreta F1', 'Kaprima F1', and 'Kr 1505 F1' with fluctuations under 0.5 points (Fig. 8).

Assessed only in 2022 and 2023 were four varieties: 'Daciana F1', 'Lores F1', 'Valahia F1' varieties which remain constant in people's choices, and 'Galia F1' with a decrease of 1.3 points (Fig. 9).

Fig. 8. Comparison of sweet pepper varieties assessed every year for size, shape, color, and taste
Source: Original data.

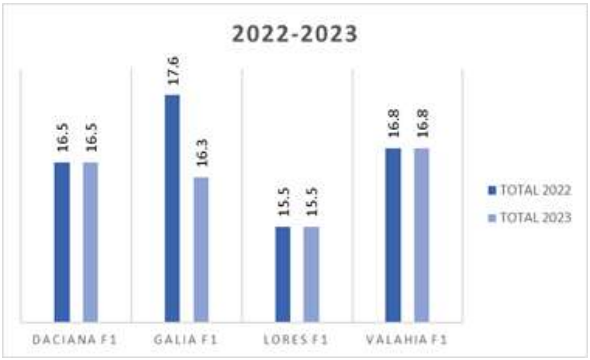

Fig. 9. Sweet pepper varieties common in 2022 and 2023
Source: Original data.

Six varieties were assessed only in 2023 and 2024, and all of them showed an increase between 1.7 and 3.5 points (Fig. 10).

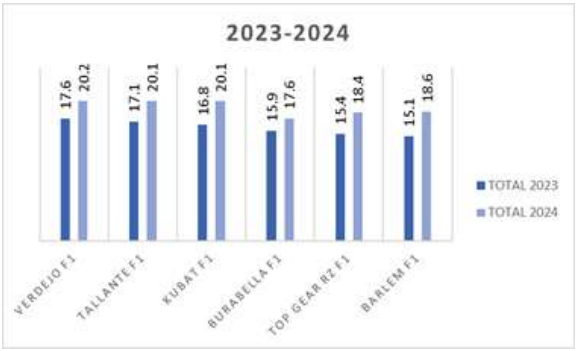

Fig. 10. Sweet pepper varieties common in 2023 and 2024
Source: Original data.

For 2024, the financial data indicates that the sweet pepper crop is a profitable one. With an average production of 80 t/ha, an average production cost of 99,000 lei, and an average selling price of 4.5 lei/kg, the average profit for 1 ha is 262,000 lei, showing a profit rate of 1.4% (original data from one producer who participated with 8 varieties at the sensorial analysis). A detailed financial analysis will be performed in a further article.

CONCLUSIONS

There were four indicators assessed in all tasting sessions: size, shape, color, and taste, with additional flavor and juiciness indicators in 2022 and pericarp thickness indicator in 2024. As expected, the hybrids with the highest total scores also had the best scores for every criterion tested.

The highest-ranked hybrid in 2022 is 'Temes F1', followed by 'Ardanza F1', 'Kamos F1', and 'Coloreta F1'. For 2023, the highest-ranked cultivar is 'SVPB 1112', followed by 'Coloreta F1' and 'Red Jet RZ F1'. In 2024, the top is occupied by 'Patrol F1', 'Insignia F1', 'Kubat F1', and 'Pritannia F1'.

Sensorial tests show the consumer's favorite varieties at one moment in time. Analyzing three consecutive years and having hybrids assessed on all three tasting sessions brings new information about how these varieties are perceived from year to year and is a significant tool for breeders who work to improve the quality of cultivars.

The consumers are expressing their preferences, but the growers have the final decision, which involves the financial data for every crop and variety. With an average profit rate of 1.4%, the sweet pepper crop could be a good investment, linking the consumer's preferences with a good financial rate.

REFERENCES

[1]Barcanu-Tudor, E., Drăghici, E. M., Dobrin, A., Stan, A., Constantin, C., Zugravu, M., Bujor, O., 2018, Preliminary study related on yield and quality potential of two new sweet peppers varieties obtained at V.R.D.S

Buzău. Scientific Papers. Series B, Horticulture. Vol. LXII, 2018, Vol. LXII.

[2]Batiha, G. E.-S., Alqahtani, A., Ojo, O. A., Shaheen, H. M., Wasef, L., Elzeiny, M., Ismail, M., Shalaby, M., Murata, T., Zaragoza-Bastida, A., Rivero-Perez, N., Magdy Beshbishy, A., Kasozi, K. I., Jeandet, P., Hetta, H. F., 2020, Biological Properties, Bioactive Constituents, and Pharmacokinetics of Some Capsicum spp. And Capsaicinoids. International Journal of Molecular Sciences, 21(15), 5179. https://doi.org/10.3390/ijms21155179

[3]Becherescu, A., Hoza, G., Sala, F., 2023, Elements of productivity and production quality in peppers in relation to the variety and applied fertilization. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 23(1), 57-66.

[4]Brezeanu, C., Brezeanu, P. M., Stoleru, V., Irimia, L. M., Lipșa, F. D., Teliban, G.-C., Ciobanu, M. M., Murariu, F., Puiu, I., Branca, F., Murariu, O. C., 2022, Nutritional Value of New Sweet Pepper Genotypes Grown in Organic System. Agriculture, 12(11), Article 11. https://doi.org/10.3390/agriculture12111863

[5]Bușterchi, I., Teliban, G.-C., Popa, L.-D., Burducea, M., Puiu, I., Vl, N.-V., Agapie, A. L., Matei, G., Bodale, I., Irimia, L.-M., Cojocaru, A., Tenie, M., Stoleru, V., 2024, Qualitative and agroproductive results regarding successive crop of sweet pepper in protected spaces. Scientific Papers. Series B, Horticulture, Vol. LXVIII, No. 2 2024, Vol. LXVIII(No. 2).

[6]Caruso, G., Stoleru, V. V., Munteanu, N. C., Sellitto, V. M., Teliban, G. C., Burducea, M., Tenu, I., Morano, G., Butnariu, M., 2019, Quality Performances of Sweet Pepper under Farming Management. Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 47(2), 458–464. https://doi.org/10.15835/nbha47111351

[7]Choi, M.-H., Kim, M.-H., Han, Y.-S., 2023, Physicochemical properties and antioxidant activity of colored peppers (*Capsicum annuum* L.). Food Science and Biotechnology, 32(2), 209–219. https://doi.org/10.1007/s10068-022-01177-x

[8]Cojocaru, A., Stan, T., Teliban, G. C., Nicolae, F., Stoleru, V., 2022, The effect of irrigation on morphological parameters on three long sweet pepper cultivars. Lucrări ştiinţifice Seria Horticultură, 65 (2) / 2022, USV Iaşi, 65 (2).

[9]Dludla, P. V., Cirilli, I., Marcheggiani, F., Silvestri, S., Orlando, P., Muvhulawa, N., Moetlediwa, M. T., Nkambule, B. B., Mazibuko-Mbeje, S. E., Hlengwa, N., Hanser, S., Ndwandwe, D., Marnewick, J. L., Basson, A. K., Tiano, L., 2023, Bioactive Properties, Bioavailability Profiles, and Clinical Evidence of the Potential Benefits of Black Pepper (*Piper nigrum*) and Red Pepper (*Capsicum annum*) against Diverse Metabolic Complications. *Molecules*, *28*(18), Article 18. https://doi.org/10.3390/molecules28186569

[10]Giuca, A.D., 2021, Analysis of the vegetable sector in Giurgiu county, Romania. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 21(4), 271-278.

[11]Homma, M., Watabe, T., Ahn, D.-H., Higashide, T., 2022, Dry Matter Production and Fruit Sink Strength Affect Fruit Set Ratio of Greenhouse Sweet Pepper. Journal of the American Society for Horticultural Science, 147(5), 270-280. https://doi.org/10.21273/JASHS05228-22

[12]Jasim, M. M., Hoza, G., Shalal, H. H., Neață, G., 2019, The impact of N fertilizer and Trichoderma sp on the growth and yield of two sweet pepper varieties under the greenhouse. Scientific Papers. Series B, Horticulture. Vol. LXIII, No. 1, 2019(Vol. LXIII).

[13]Kostrzewa, D., Mazurek, B., Kostrzewa, M., Jóźwik, E., 2023, Carotenoids and Fatty Acids Obtained from Paprika *Capsicum annuum* by Supercritical Carbon Dioxide and Ethanol as Co-Extractant. Molecules, 28(14), 5438. https://doi.org/10.3390/molecules28145438

[14]Madosa, E., Ciulca, S., Velicevici, G., Avadanei, C., Sasu, L., Cioroga, A., Frișkan, I., 2008, Study of correlations between component characters of production capacity of sweet pepper (*Capsicum anuumm* L, var. *Grossum*). Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Horticulture. 65(1), 90-94.

[15]Medina-Juárez, L. Á., Molina-Quijada, D. M. A., Del Toro-Sánchez, C. L., González-Aguilar, G. A., Gámez-Meza, N., 2012, Antioxidant activity of peppers (*Capsicum annuum* L.) extracts and characterization of their phenolic constituents. Intersciencia 37(8), 588-593.

[16]Murcia-Asensi, C., Fita, A., Luis-Margarit, A. de, Guijarro-Real, C., Raigón, M. D., Blanca-Giménez, V., Díez-Diaz, M., Rodríguez-Burruezo, A., 2024, Grafting in Capsicum peppers as a strategy to mitigate the effects of climate change on yield and quality factors. Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 52(1), 13653–13653. https://doi.org/10.15835/nbha52113653

[17]O'Donoghue, E. M., Somerfield, S. D., Chen, R. K. Y., Tiffin, H. R., Hunter, D. A., Brummell, D. A., 2020, Cell wall composition during expansion, ripening and postharvest water loss of red bell peppers (*Capsicum annuum* L.). Postharvest Biology and Technology, 168, 111225. https://doi.org/10.1016/j.postharvbio.2020.111225

[18]Pham-Huy, L. A., He, H., Pham-Huy, C., 2008, Free Radicals, Antioxidants in Disease and Health. International Journal of Biomedical Science : IJBS, 4(2), 89–96.

[19]Popescu, A., 2013, Considerations on Romania's vegetable market. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 13(4), 227-234.

[20]Pratas, A., Malhão, B., Palma, R., Mendonça, P., Cervantes, R., Marques-Ramos, A., 2024, Effects of apigenin on gastric cancer cells. Biomedicine & Pharmacotherapy, 172, 116251. https://doi.org/10.1016/j.biopha.2024.116251

[21]Ribes-Moya, A. M., Pereira, L., Guijarro-Real, C., Raigon, M. D., Fita, A. M., Rodriguez-Burruezo, A., 2014, Mineral Content in Capsicum Pepper Landraces: Effect of the Genotype and the Ripening Stage. Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Horticulture, 71(2).

[22]Sanatombi, K., 2023, Antioxidant potential and factors influencing the content of antioxidant compounds of pepper: A review with current knowledge. Comprehensive Reviews in Food Science and Food Safety, 22(4), 3011–3052. https://doi.org/10.1111/1541-4337.13170

[23]Soare, E., Dobre, I., David, L., 2016, Economic analysis in vegetable sector of Romania. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 16(4), 333-338.

[24]Sood, T., Sood, S., Sood, V. K., Badiyal, A., Anuradha, Kapoor, S., Sood, V., Kumar, N., 2023, Characterisation of bell pepper (*Capsicum annuum* L. var. *Grossum* Sendt.) accessions for genetic diversity and population structure based on agro-morphological and microsatellite markers. Scientia Horticulturae, *321*, 112308.https://doi.org/10.1016/j.scienta.2023.112308

[25]Toma, M., Popescu, S., Alexe, C., Chira, A., 2020, Behavior of the sweet pepper at short-term storage, depending on crop fertilisation schedule. Scientific Papers. Series B, Horticulture. Vol. LXIV, No. 1, 2020, Vol. LXIV,(No. 1).

[26]Żurawik, A., Jadczak, D., Panayotov, N., Żurawik, P.,62021, Antioxidant properties of pepper (*Capsicum annuum* L.) depending on its cultivar and fruit colouration. Plant, Soil and Environment, 67(11), 653–659. https://doi.org/10.17221/333/2021-PSE

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CHALLENGES, OPPORTUNITIES, AND INNOVATIONS IN TOURISM IN THE NEW NORMAL: EVIDENCE FROM RURAL TOURISM SITES IN THE PHILIPPINES

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Abstract

This study explores how rural tourism sites in Southern Leyte, adapted their tourism packages during and after the pandemic, focusing resilience and sustainability. A multi-case study methodology was used in this paper with 10 informants whom were owners/managers of the hotel or beach resorts. Data were collected through in-depth interviews using Seidman's phenomenological interview paradigm. The results revealed the following: (a) the tourism sector faces challenges and opportunities spanning diversifying revenue streams, business operation, enhancing guest experience, building resilience, and marketing and promotion; (b) key adjustments in tourism packages under the new normal include marketing and promotion strategy, focus on safety and hygiene, adapting activities services, enhancing guest experience, price and policies considerations; (c) the valuable lessons gleaned from successful tourism packages implemented beyond the province's borders includes marketing strategies, financial sustainability, customer focus, and adaptability and innovation. The study contributes to understanding sustainable tourism strategies, offering insights into how the industry can remain resilient amid disruptions.

Key words: *multi-case study; tourism; pandemic; business operation; reinvention*

INTRODUCTION

Tourism makes a significant contribution to a country's economy and is widely regarded as a primary industry worldwide. The tourism industry in a developing country such as the Philippines is exploited and developed primarily for its economic benefits, with the long-term goal of creating a sustainable tourism industry [7]. The tourism sector's interdependence with other industries resulted in more beneficial to the whole economy. In other words, tourism triggers other services to prosper as it draws more foreign and domestic tourists paying for the goods and services within the circular economy. Furthermore, because of the country's low agricultural outputs, farm tourism can be a farm diversification strategy to supplement income in rural communities [52].

In 2019, the travel & tourism sector contributed 10.4% to global GDP; a share which decreased to 5.5% in 2020 due to ongoing restrictions to mobility. In 2020, 62 million jobs were lost, representing a drop of 18.5%, leaving just 272 million employed across the sector globally, compared to 334 million in 2019 [51]. Yet, the pandemic also catalyzes change, pushing stakeholders to innovate and adapt to survive. While the global tourism industry has since rebounded, the lessons learned during the pandemic highlight the importance of resilience and adaptability. In terms of tourism potential, the province of Southern Leyte has a great to exhibit, sell, grow, and improve. There are world-class dive sites, caves, extreme adventure sites, waterfalls, crater lake trekking, fish feeding, scuba diving and whale shark interaction, island escapades and beach fun. Tourism attractions could be discovered in almost every municipality.

Recently, the COVID-19 pandemic has taken its toll on the Philippines' tourism industry, as it has on the tourism industries of other countries. The suspension of travel also resulted in the closure of businesses to prevent the virus from spreading further. Other

participants, such as the travel industry, shopping malls, restaurants, and other establishments, were also impacted. The pandemic affects many industries and occupations beyond the tourism sector [42]. As a result, the government's support for tourism is strongly recommended, as the tourism industry's recovery can have positive spillover effects on other sectors and the entire spectrum of occupations in the labor market.

Recognizing the adaptability of travel packages is crucial for facing upcoming difficulties, not just during moments of crisis such as the pandemic. Common risks such as natural disasters, economic downturns, and political instability are abundant within the sector. Examining how tourism businesses adapted during the pandemic can offer important insights into effective resilience tactics for future crises. For example, rural tourism destinations in Southern Leyte, Philippines, faced significant disruption, but their ability to pivot services, innovate marketing, and maintain operations under strict health protocols illustrated their resilience. These adaptations are essential for understanding how the sector can prepare for unforeseen disruptions.

The Philippines' tourism arm, the Department of Tourism, launches various programs to help tourism recovery. Some businesses are starting to open and offer services following COVID-19 regulations. Protocols such as headcounts per group, sanitizers in entrances, and curfew hours are implemented. However, the movement of people is not just factored by restrictions, but also by the willingness of people to travel. The COVID-19 pandemic has instilled fear in everyone that both private and public sectors have instituted countermeasures, both-related and health- and safety-related, to combat the spread of the contagious virus [43]. People are also scared to travel in fear of the consequence they might have to pay for health and budget-related expenses.

To encourage customers, players of the tourism sector started to offer different packages. An example is offering complimentary rescheduling of flights by the aviation industry and the inclusion of RT-PCR tests by the hospitality industry. Southern Leyte is an emerging tourist destination in the Visayas. Its tourism is significantly affected, just like other tourist destinations. In this context, this study is to investigate how the tourism industry in the province of Southern Leyte re-invent their tourism packages in response to the COVID-19 pandemic.

This study investigates how rural tourism sites in Southern Leyte adapted their packages during and after the pandemic. The focus is identifying strategies promoting business resilience, sustainability, and enhanced customer experiences. It aims to contribute to the literature on tourism resilience by offering insights that extend beyond COVID-19, emphasizing the adaptability of tourism enterprises to maintain relevance in an ever-changing global environment. Additionally, the research provides practical implications for stakeholders in developing crisis management plans that include flexible, innovative approaches. Furthermore, the specific objectives of this study are:

(i)Determine the challenges and opportunities faced by the tourism sector in the province;

(ii)Investigate the adjustments and reinventions made in their tourism packages to attract tourists under the new normal; and

(iii)Reflect from the lessons learned of successful tourism packages offered in the province in redesigning the existing tourism packages.

This study aims to illustrate how tourism enterprises can leverage lessons from the pandemic to prepare for future disruptions, ensuring sustainability and growth in the long term. The findings can help local governments and tourism operators design policies and strategies that enhance the sector's resilience, benefiting local communities and economies.

Theoretical framework

This study relies on Wohlwill's (1974) adaptation theory, which states that people's reactions to their environments are dependent on their adaptation level [50]. Everyone adapts to a certain stimulus or set of environmental circumstances. In this research, the COVID-19 phenomenon serves as the stimulus affecting the tourism environment as reflected in Figure 1. While tourism activities have not yet resumed, the tourism industry's adaptability to

changes and the pandemic must be commended [29]. Crises are regular occurrence in the tourism sector [13, 20]. Many destinations are affected by natural and human-made crises and, over the years, have developed tactics and strategies of resilience and mitigation [46]. The COVID-19 pandemic has negatively impacted different sectors of tourism [20, 21], ultimately causing the industry to shut down for months.

Figure 1 illustrates the conceptual framework, showing how Adaptation Theory, Resilience Theory, and Crisis Management interact to shape the study's focus on tourism adaptability and reinvention.

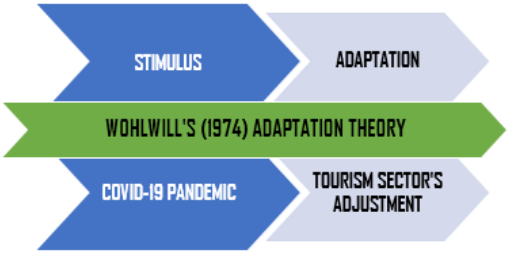

Fig 1. The theoretical and conceptual framework
Source: Authors' elaboration.

The COVID-19 pandemic has affected tourism in such ways that regional revenue was involved and the income of the people, especially those who work closely with tourists, such as local guides [16]. The demand for micro, small, and medium enterprises (MSMEs) has also decreased, especially those related to food and souvenir sectors. To battle concerns, the people are trying to rise from the economic downturn by trying various new business alternatives, including utilizing social media to sell MSMEs products and services. Moreover, [33] claim that consumer behavior has been permanently altered by the pandemic, with an increasing demand for secure, eco-friendly, and custom-made travel adventures. This change has resulted in the rise of "micro-tourism," where tourists choose smaller, quieter locations that provide distinctive, genuine experiences. These trends indicate a shift from mass tourism, underscoring the importance for local tourism businesses to adjust by providing specialized services that meet these changing preferences.

The theory of adaptation highlights the importance of being flexible and innovative when facing environmental pressures. Tourism businesses that can quickly adapt their services, operational methods, and marketing plans are more prepared to handle disruptions caused by health crises, natural disasters, or economic downturns. This research investigates how rural tourism businesses in Southern Leyte modified their offerings and services amid the pandemic, uncovering tactics that supported resilience and future viability. The knowledge acquired from this flexible behavior can be used in broader conversations about tourism resilience, highlighting the importance of incorporating flexibility into the sector's fundamental operations. To complement Adaptation Theory, this study also integrates concepts from Resilience Theory and Crisis Management. Resilience Theory in tourism explores how destinations and businesses can "bounce back" after disruptions. It highlights the capacity to not only survive crises but to emerge stronger by learning from challenges and implementing new strategies [46]. Resilience requires the development of robust frameworks that allow quick adaptation, such as diversifying revenue streams, embracing digital marketing, and enhancing safety protocols. This study identifies these resilience strategies as they were applied during the pandemic and assesses how they can serve as models for future disruptions.

Through various efforts have been made since June 2020 to reopen the industry, most sectors continue to struggle, and the tourism became as one of the hardest-hit industries [13]. Hence, the need to analyze and suggest programs that will help local tourism be back at its foot, especially now that travel borders are starting to open, is greatly significant.

MATERIALS AND METHODS

Research design

The researchers used a qualitative research design to learn how the tourism industry reinvents its tourism packages during the COVID-19 pandemic. It used a multi-case study methodology [54] because it will use a

set of case studies from rural tourism sites. A case study is a detailed examination of a specific case [31]. It investigates a contemporary phenomenon in- depth and, in its context, allowing researchers to deal with complex social situations [12]. Using multiple cases also improves the external validity or generalizability of research findings [37].

A tourist site is a place of attraction that tourists visit for its inherent or demonstrated natural or cultural worth, historical significance, natural or architectural beauty, leisure, and entertainment. Beach sites, natural regions, towns and cities, and cultural and heritage places are all examples of tourism destinations. We only have beach places and natural places in Southern Leyte.

Research setting

The study focuses on tourism sites (Table 1) located throughout a rural province's municipalities.

This province is one of the Eastern Visayas' emerging tourist destinations. This study will use the registered beach places and natural places that cater to both domestic and international tourists. Meanwhile, the researchers contacted the provincial trade and industry office to seek assistance in determining potential contacts for each tourism site and verify the presented basic information.

Table 1. Case study tourism sites basic information

Case Study Tourism Sites	Types of Tourism	Location	Status
Case 1	Beach	Magallanes, Limasawa, Southern Leyte	Operating
Case 2	Natural	Asuncion, Maasin City, Southern Leyte	Operating
Case 3	Beach	Lugsongan, Limasawa, Southern Leyte	Operating
Case 4	Beach	Triana, Limasawa, Southern Leyte	Operating
Case 5	Beach	Buscayan, Macrohon, Southern Leyte	Operating
Case 6	Beach	San Agustin, Limasawa, Southern leyte	Operating
Case 7	Hotel	Villa Jacinta, Macrohon, Southern Leyte	Operating
Case 8	Beach	Villa Jacinta, Macrohon, Southern Leyte	Operating
Case 9	Beach	Poblacion, Hinunangan, Southern Leyte	Operating
Case 10	Beach	Buscayan, Macrohon, Southern Leyte	Operating

Source: Authors' preparation.

Sampling procedure

The researchers used purposive sampling to better match the sample to the research goals and objectives, thereby improving the quality of the data and outcomes [6]. It entails identifying and selecting exceptionally knowledgeable or experienced individuals about the phenomenon under consideration [10, 11]. The sample was selected through purposive sampling, ensuring that participants had direct experience managing tourism businesses during the pandemic. While the sample size may seem small, qualitative research prioritizes depth over breadth, and the chosen method allowed for comprehensive, in-depth interviews that yielded rich, detailed insights.

Sample

This study includes 10 informants presently living within the province. It must meet the

following criteria: (a) informants were the owner/manager of the registered hotel or resort for at least 1 year before the pandemic, (b) informants actively involved in the operations of their hotels or resorts, and (c)informants are willing to take part in the study. Although the sample size of 10 informants provided in-depth insights, it limits the findings' generalizability. The experiences and strategies identified in this study may only represent some rural tourism enterprises in other regions or larger-scale tourism operations.

Data collection method

The researchers primarily collected qualitative data through in-depth interviews using Seidman's (1998) three-part phenomenological interview paradigm [47]. The first phase allows people to relive and describe their first encounter with the COVID-19 phenomenon. The interviews allowed informants to reflect on their experiences before, during, and after the pandemic. Questions were designed to explore the changes to their tourism packages, marketing strategies, operational adjustments, and lessons learned. This method enabled the researchers to gather detailed, qualitative data that reflected the informants' challenges and innovative solutions. The second phase focuses on the particulars of the informants' most recent encounters with the phenomenon. The third stage entails pondering the meaning informants attribute to the experience. It focuses on informants' intellectual and emotional connections in their jobs and personal lives. All three phases were combined into a single interview. Meanwhile, the researcher employed validation of the interview guide at three levels: internal testing, expert evaluation, and field testing.

Data analysis framework

This study employs [53] five-phase data analysis framework. The first phase involves compiling the data in some order. The second phase breaks down the collected data into smaller fragments or pieces and assigns new labels or codes. Codes are reassembled and arrayed using tables, graphics, and lists in the third phase. The fourth stage is interpreting, which involves developing a new narrative supported by tables or illustrations. The final step is to wrap things up. Data were systematically organized and coded to identify recurring themes and then analyzed to draw connections between the adaptive strategies employed by different tourism enterprises. The themes were further examined to determine how they align with the adaptation, resilience, and crisis management theoretical frameworks.

Ethical considerations

The study employed Creswell's (2018) ethical framework to ensure that researchers adhere to appropriate ethical norms throughout their research activities [11]. Before conducting the research, the researchers will obtain permission from the university, tourism site owners, and participants. Second, the researchers will make their goal clear from the start and ensure that people sign the consent form voluntarily. The researchers will inform participants about how the data will be used while protecting their privacy and identity. The researchers will ensure that all sources cited in the paper are appropriately attributed. Finally, the researchers gave credit for all sources used in the study provided copies of the report to participants.

RESULTS AND DISCUSSIONS

The pandemic in 2020 has affected many lives, not only households and communities but also the tourism industry. The results of the in-depth interviews revealed several key themes that illustrate how rural tourism businesses in Southern Leyte adapted their strategies during the pandemic. Qualitative interviews were conducted with owners of resorts to assess impacts on tourism from COVID-19 for this study. The themes outlined here all relate to broader strategies about adapting beyond the pandemic environment and therefore ensuring long-term resilience and sustainability. The results revealed the following important highlights:

Challenges and adaptation strategies faced by the tourism sector in the province

Theme 1: Diversifying revenue streams

Many tourism businesses experienced severe loss in revenue because of restricted travels and low inflow of tourists. Most businesses resorted to diversified sources of revenues as a way of checking the loss and keeping them

operational. For instance, many resorts ventured into new service packages; these included day-use packages with provisions such as tent hiring and kayak services to target the local market that had short-distance traveling. These new offerings provided additional income streams and catered to the needs of local guests looking for short, nearby getaways. Income generation during the COVID-19 pandemic has significantly impacted tourism within a province, affecting various aspects of society; it is essential to consider factors like advanced payment methods, managing cash flow, developing fresh packages, and exploring other revenue streams. By incorporating advanced payment methods (e-payment), tourism resorts can guarantee upfront revenue, reducing the impact of cancellations and no-shows [1]. This is evident in the participant's statement: *"The introduction of local-friendly packages, such as affordable tent rentals and day-use amenities, helped to keep the business afloat. "-P8*

The implication of the result is that these businesses-maintained cash flow in the restrictive periods by creatively diversifying their offerings and leveraging on resources. An advance payment can be encouraged if the incentive, such as discounting or flexible cancellation policies are provided, given that the policy of refund and safety measures to be adopted is communicated clearly. Most people consider discounts and flexible cancellation policies as incentives that can influence consumer behavior. Similarly, risk-seeking consumers would want free cancellation policies in online hotel booking, especially when there is an automatic rebooking service in place [34]. While cancellation windows are getting tighter, penalties do not necessarily rise, indicating a rather subtle approach to encouraging bookings [45].

The financial health of hotels and resorts is indeed crucial for survival; in the survival of any tourism business, controlling finances is very crucial However, the COVID-19 pandemic has affected the world's tourism industry significantly and caused financial challenges due to lockdowns, travel restrictions, and a decrease in consumer willingness to travel [25]. During the research, two beneficiaries revealed that they cannot rely solely on their own income to sustain their hotel. Hotel owner must search for alternative sources of income or financial management strategies to pay bills.

Indeed, in the creation of new packages and experiences is very important for the satisfaction of customers and profitability in the tourism industry. The challenges that recognize more than the traditional sightseeing tours, which focus on meaningful and transformative experiences to improve customer engagement and increase revenue [41]. However, it is important to note that even though new experiences are important, they need to be inclusive and accessible to all customer segments. This involves understanding the expectations and experiences of access tourists to enhance the accessibility and inclusiveness that can lead to destination competitiveness and financial gains in tourism [9]. This means there is a search for novel and meaningful experiences by tourists [41]. There is also the need for inclusivity for all tourists, who may have access requirements [9]. As such, the players in the tourism industry should focus on diversifying their offers to meet the changing demands of travellers while ensuring accessibility and inclusiveness to maximize market reach and profitability.

Theme 2: Streamlining business operation

The COVID-19 pandemic has affected economies all over the world [8]. Regarding business operations, one thing that is evident so far is that the pandemic has significantly reduced business operations all over the world. The pandemic underscored the need for businesses to streamline operations to reduce costs and increase efficiency. Normal business operations are the need of the organizations to meet the daily tasks [3]. Sometimes, in certain circumstances such as the present coronavirus pandemic scenario, organizations cannot run business operations smoothly [23] as the health and safety of organization employees do and should come first [38]. There are a few significant categories that come out when one assesses the challenges and opportunities in the tourism industry in the province. These include managing closures from lockdowns, handling

bill payments, covering operational expenses, addressing damaged facilities, managing limited employee availability, offering restricted services, maintaining jobs, and managing water shortages. The vulnerability of small businesses to closures during the pandemic, with a disproportionate compared to larger businesses, leads to a concentration of market share among the latter [15]. Results reflect that the disturbance in the normal business operations eventually makes the organizations end up losing or fail [5]. Lockdowns because of COVID-19 outbreaks have shut many tourism firms temporarily leading to a great financial loss and a strain in running the companies. The inability to pay salaries and meet the financial obligation will affect meeting rent, utilities, and paying back loans.

Tourism companies would have to negotiate terms for receiving their money from the owners of the properties, banks, and suppliers or obtain loans and find new income-generating streams such as selling goods or gift certificates to raise additional revenue. Maintaining the correct working capital and proper financial management techniques will ensure that small businesses stay financially secure and profitable at such a trying time [14]. Meanwhile, two of the participants continued working through the lockdown to ensure they could pay the bills. Despite the pandemic, they continued operating to ensure they could pay their workers. However, the impact of the lockdowns has been significant, causing a noticeable decline in business operations. COVID-19 is causing severe damage to economies and societies; it has affected the business operations and lowered business activities significantly [48]. Staff shortages arising from illness, travel restrictions, or unwillingness to go back to work can hinder business operations and service quality.

As a result of COVID-19, governments have placed restrictions on people and vehicles movement and suspended business activities [36]. To manage the limited availability of employees, tourism businesses can engage their staff in cross-training across multiple roles, offer flexible work arrangements or incentives to attract and retain talent. It could even be a change in the services offered or operating hours. It is not a weakness; it is rather a secret for making them stand out, since it is all about personal engagement with guests. Personal interactions can do much even with limited circumstances.

Theme 3: Enhancing Guest experience

As travellers' safety and cleanliness concerns grew, improving the guest experience became a top priority. Businesses implemented strict hygiene measures, including contactless check-ins, frequent facility sanitation, and hygiene kits. These actions comforted visitors and established confidence, resulting in increased contentment and return trips. Furthermore, firms were concerned with making it a personal and safe space. They highlighted unique experiences for small, intimate groups.

The studies collectively indicate that the COVID-19 pandemic has led the hospitality industry to adopt guest safety, personalization, and affordability while continuing to highlight beautiful surroundings and service costs. This is interesting to note as even though the focus is on research in luxury hotels, for example, there have been findings from certain studies such as [17], who discovered that customer satisfaction due to convenience and reduced perceived risk increases because of digital technology use in services like mobile applications, contactless check-in, and virtual reality. These innovations are now integral to modern tourism marketing. They would likely determine the future of the industry, and [27] examined the survival strategies of home-based accommodations and small-scale tourism enterprises. The smaller businesses have embraced "intact hospitality" to avoid direct contact with guests who are looking for secluded areas. On the other hand, safety and well-being of guests should be at the forefront, especially during the COVID-19 pandemic and its global health concerns. The thematic analysis by [19] shows that personalization and hygiene have become more important in the guest experience. Self-service technologies are used to enhance customer satisfaction and reduce perceived risk. Opportunities can be found by focusing on cleanliness and hygiene standards, clearly communicating safety

measures, and using technology like contactless check-in and digital payments to minimize contact and build guest trust. The result implies that challenges could include implementing and ensuring compliance with health and safety procedures, managing guest expectations, and adjusting operations to meet evolving regulations. This is evident in the participant's statement: *"We also had protocols, such as handwashing stations and tarpaulins, with information posted. We strictly followed the protocols, but there were always limitations."-P8*

This is also apparent because of the economic burden on the industry as indicated by the devastating impacts and bankruptcy risks for hotels [49]. Affordability can open up tourism to more visitors by addressing this factor. Challenges include cost cutting without losing quality and remaining competitive. There are opportunities in diversified income streams and tiered pricing for different budgets.

In this theme, the guest experience during the COVID-19 pandemic has highlighted the importance of change in the hospitality industry regarding safety, personalization, and affordability. Adaptation reduces direct interaction to a minimum and increases appeal in the eyes of those guests who demand privacy and silence. Moreover, maintaining the most severe health protocols while balancing the changes with operations will help cater to guest expectations as well as support compliance with regulations. Still, it presents opportunities to enhance hygiene levels, embrace technology with contactless services, and introduce price flexibility. The statements of the participants reflect the sense of security and comfort these efforts were able to provide at such times, thereby giving an edge to the resilience of the industry while trying unexampled times and providing quality for a guest experience.

Adjustments and reinventions made in their tourism packages to attract tourist under the new normal

Tourism businesses in our province have adjusted and innovated their approaches to attract visitors amidst the new normal. Nevertheless, businesses demonstrated resilience and creativity in response to these obstacles by adapting their marketing tactics to attract customers in the changing landscape. They revamped marketing strategies, adapted service activities, and enhanced overall guest experiences to align with the "new normal."

Theme 1: Safety and hygiene measures

The COVID-19 pandemic totally changed the tourism industry. Businesses across the globe rushed to adopt their services as safety and hygiene became the top priority. Each business started enforcing strict measures about safety. Some of these changes included temperature screenings, face masks on everyone, social distancing policies, and sanitation stations. Temperature checks, mask mandates, social distancing, and sanitation stations were some of the adaptations that were implemented. Although the measures started as a pandemic response, they have now taken on a life of their own. They are now the new normal ways of ensuring sustainable and safe tourism that will be ongoing. The paper discusses changes in business offerings in tourism to meet safety and hygiene guidelines. Current studies indicate that tourist destinations are imposing stringent health protocols, such as strict hygiene practices, adherence to safety regulations, provision of hygiene facilities, and crowd control measures to avoid overcrowding [54]. Additionally, there is a focus on the distribution of preventive tools and educating tourists and service providers on health protocols in a bid to ensure that all parties involved are guaranteed a safe environment [28]. The results imply strict protocols that entail temperature checks, QR codes to trace contacts, and even more recently, vaccine cards. Besides adhering to government requirements, it puts the minds of the visitors at ease about maintaining cleanliness and safety standards within those establishments.

Theme 4: Adaptive marketing and promotion strategies

The continuous inflow of new tourists is playing a crucial role in the prospering tourism industry in our region, offering crucial support to native businesses and preserving the vibrancy of our neighborhoods. However, it is necessary to accept the fact that attracting new visitors is a tough task. Businesses are now starting to rely more on digital marketing strategies, especially social media campaigns,

to target potential customers and boost local tourism. Some businesses observed that "digital marketing became a lifeline," keeping them on people's minds and active participation in their audience. Verbal communication is significant in these terms of addressing the concerns. The result suggests that word-of-mouth is an effective marketing tool. Travelers can become directly interested in our province through personal recommendations. Even just the name of a resort ignites curiosity and recognition, often leading to prospective guests knowing who owns the resort.

The integration of online advertisement strategies during the COVID-19 pandemic has been the key factor for hotels and resorts looking to maintain or boost their occupancy rates. These movements and physical commerce restrictions resulted in higher reliance on digital platforms for marketing purposes [2]. During the conduct of the research one of the beneficiaries disclosed that using digital marketing is essential for accessing opportunities, allowing them to connect with travelers as they plan their future vacations.

On the other hand, two beneficiaries admitted that they made a mistake by not utilizing digital marketing because they were unsure how to effectively promote their resort. This is evident in the interview results: *"That is where we made a mistake; we did not prioritize marketing since the beginning, and we do not know how to start in promoting our resort. That is why we were slow in utilizing social media."-P1*

The outcome indicates that the proprietor of the hotel should use channels such as Facebook and Instagram and their ability to effectively showcase beauty of the province and attraction is something to be very admired. For resorts fully to exploit digital marketing opportunity, it should consider developing appropriate coordinated strategies in line with unique offerings and target demographics while as well ensuring its staff is correctly trained on digital marketing practices by [40]. They can also find creative ways to stretch their marketing budget and reach your target audience, from targeted social media ads to strategic partnerships with travel bloggers.

Theme 3: Adapting activities services

In response to the COVID-19 pandemic, the tourism industry made radical adjustments and reinventions in the new normal to attract tourists. It included bettering the service activities to fulfil the shifting needs and demands of the traveller. New travel trends such as staycations, wellness and spa tourism, and eco-tourism, have emerged to cater to tourists' preferences for nature-preserved regions and their needs for private space, social distancing, and cleanliness [39]. It is found that improvement in pull factors such as service quality and travel activities increase domestic tourism [32]. The pandemic has caused many changes in consumer behavior that are here to stay. A recent study by [39] noted that there is an emergent interest in wellness tourism, nature-based holidays, and ecotourism accommodations. People's awareness of their health and safety and the environment made them choose destinations with respect to clean, safe, and sustainable tourism-related practices. This opportunity further allows countryside tourism destinations to attract visitors by showcasing their environment, absence of large crowds, and sustainability.

One participant introduced the provision of food services. Others were not provided for, without prior arrangements. Another participant adopted social distancing policies between cottages to ensure their guests' safety. Other interviewees mentioned taking efforts towards offering water-activity such as kayaking to entice visitors to enjoy better while visiting and staying; they indeed appear proactive by diversifying their services. While, other participant underlined obvious communication to limit the amount of visitors that would bring in congestion.

The results show these initiatives are proactive measures to support the needs of travellers such that there is a delicate balance between safety, pleasure, and accessibility. From these strategies and changes among local tourism businesses, it clearly shows how they have been keen on adjusting to the new reality to attract visitors.

Theme 4: Enhancing guest experience

One of the adjustments and reinventions in tourism packages have been directed toward improving the experience of the guest to attract more tourists. The new experience in tourism reveals that immersion, escapism, and fun are factors that positively influence satisfaction and loyalty [24], whereas service quality does not directly influence customer loyalty; however, it does impact customer satisfaction, which is an essential component of the guest experience [18]. These have also been areas of concentration for these organizations, from producing serene ambiance. The replies from the respondents demonstrate diverse approaches which have been undertaken to create experiences for visitors and accommodate changing expectations of visitors. A respondent commented that the guests especially enjoy the resort during sunset hours, attributing this to natural beauty, which has become an attraction feature. To further enhance guest experiences, acoustic nights have been promoted, and promotional offers, such as 50% discounts on room rates have been successful in attracting many guests. The flexibility to set up tent has also been a more popular option for guests. These new and updated tourism packages would bring into tourism businesses what they need during this new normal. The business firms showed how well they adjusted with natural attraction offerings, kept prices in the affordable range, added new amenities, and organized new events to please their customers. This makes the businesses not only new customers but also ensures return visitors have an experience which they will remember and look forward to in the future.

Theme 5: Flexible booking policies

Under the new normal, tourism businesses have changed their packages to suit the change in travel preferences and safety. Knowing the uncertainty of the travellers, businesses introduced flexible booking and cancellation policies. The policies made the customers feel secure in making plans without fear of losing money if things changed. The flexibility helped build customer trust and encouraged more bookings, setting a precedent for future crises where consumer confidence may be affected. The concept of price transparency and perceived value now comes into play when attracting post-pandemic tourists and stresses sustainable business practices; [30] additionally state that consumers have been compelled by the pandemic to pursue flexibility in their travel planning. Moreover, this new definition of authenticity in the tourism marketing indicates a transformation in the packaging and pricing of experiences in accordance with evolving consumer perceptions [12]. Multi-dimensional risk perceptions need to be overcome in the formulation of the tourism packages that reduce anxieties and increase visitor confidence [35]. These trends indicate the dynamism in tourism strategies as they respond to the contemporary challenges and opportunities facing the tourism industry. One of the participants showed how one processes the step-by-step procedures from securing a permit down to operating through the local regulation of the Tourism Office in implementing new normal. Here, one could already observe this as to how one of the respondents said his words of statement: *"That is how our procedure is. Once confirmed, I will be asking for a permit through the Tourism Office because they have an approval which gives us permission to operate."-P5* These views indicate the operating challenges faced by tourism enterprises, especially taking proactive measures that allow them to maintain their business operations while continuing to develop the guests' experience within an evolving context.

Lessons learned of successful tourism packages offered in the province in redesigning the existing tourism packages

It has shown that long-term strategies for continuing rural tourism during future disruptions would be provided by the improved opportunities. With functional flexibility at the forefront, the main strategic requirement is streamlined operation and responsiveness to emerging demand trends. Third, an investment in online engagement, such as through digital marketing, social media, and online booking sites, would help reach wider populations. Strict adherence to hygiene and safety measures forms a core part of the daily routine that maintains customer confidence for

standards of safety. Such findings go to indicate that adaptability and innovation are very essential towards survival in tourism during any pandemic and even when concerns about the future are relevant. By taking these steps, rural tourism enterprises shall strengthen their foundation, ready themselves in case of emergencies, and ensure a long-term sustainability.

Considering the insights brought about by effective tourism packages, a diversified strategy is required for renovating current tourism alternatives. Understanding tourist behavior, crisis management, and the industry trends, especially with the COVID-19 outbreak, are crucial aspects that cannot be overemphasized [4]. Current studies state that resilience in the tourism industry is necessary to better cope with future crises. For example, [4] examines the way destinations that have learned to adapt to the changes could recover faster than those who still depend on the old models. The findings indicated that diversified revenue streams, flexible operational models, and robust digital marketing strategies put businesses in a competitive advantage in terms of recovery. This indicates the need for adaptation and innovation, especially for smaller businesses, which might require more resources compared to large chains.

Additionally, the importance of knowledge management systems needs to be acknowledged as well [26]. In fact, such systems can be adapted in the tourism sector as capturing and sharing best practices for different regions improves the design and management of packages for tourism. Finally, translating the practical experiences of the campaigns from well abandonment campaigns [55], might mean gathering tourist feedback and operational insights. The former would be crucial to refining and improving tourism packages as it could better meet traveller needs and expectations.

One critical element highlighted is that of marketing strategies. Online marketing has been emphasized on to reconnect with customers and maintain the visibility. Similarly, another interviewee commented that doing online marketing would benefit the business a lot. This is particularly evident from the statement presented by the interviewee: "*…and engaging in online marketing can really benefit your business very much."-P1*

Financial sustainability became of top importance. During such conditions of economy, variation in sources of revenue helps a business thrive. That is how this strategy goes hand in hand with survival under uncertain circumstances. Indeed, as one participant attested: "*In this current situation, we should not rely on our usual means of earning money; we should look for other ways to earn."-P3*

A good customer focus is a must for success. Respondents have emphasized the willingness to implement practices that are guest-centric and safe. This finding suggests that the customer care focus does not only ensure great experiences for guests but also creates positive word-of-mouth and repeat visits.

It is essential to be able to adapt and innovate in the face of unexpected problems. One participant was noted to be proactive in new normal practices. The other participant emphasized preparedness for unexpected events. Additional, one participant further remarked that there should be an open communication with the government regarding safety measures. The findings about the successful tourism packages in this province indicate that it needs innovative marketing strategies, financial feasibility, customer focus, and adaptability. If they are to redesign their packages in a successful manner within tourism businesses, they should welcome online marketing, diversify sources of income, take care of the guest, and have preparedness for unprecedented events. We should also consider the motivational factors for tourists, including their need for relaxation and the possibility of increasing their knowledge of tourism, which are very important when redesigning tourism packages [44]. Innovation is also very important in enabling sustainable tourism. Innovative practices can be incorporated into the redesign of tourism packages to ensure that they meet the needs of the tourists while still conserving the resources of the destination [22]. These proactive and innovative approaches ensure that businesses stay competitive and provide memorable experiences for their guests in the new normal.

CONCLUSIONS

This study examined how tourism businesses in the rural area of Southern Leyte modified their businesses and services during and after the emergence of COVID-19. While the spotlight continues to be on battling the pandemic, findings present more holistic approaches toward creating resilient and sustainable tourism. Businesses taking adaptive actions such as diversifying revenue streams, streamlining business operation, enhancing guest experience, building resilience, and marketing and promotion show the importance of being prepared for external disruptions whether these come from health crises, natural disasters, or economic changes. This study demonstrates changes in the tourism sector in response to the pandemic. These include the strategic shift in marketing and promotional strategies, safety and hygiene, activity choices to change according to the changing preferences of consumers, better guest experiences, and shifting packages according to the shift in travel trends while maintaining the aspect of safety. These fluid techniques demonstrate the resilience of the industry to bounce back with new ideas when challenged.

Lastly, the research learns valuable lessons from successful tourism packages implemented in destinations in the Philippines. It points out the importance of effective marketing plans, financial feasibility, customer-oriented strategies, flexibility, and creativity. These tutorials provide guidelines and guidance for tourism businesses to improve their strategies and products and position themselves for continuous growth and success in the dynamic tourism industry.

REFERENCES

[1]Ahmad, W., Amran, N. H., Ali, N. A. M., Yusuf, A. A., 2023, A blessing in disguise: COVID-19 pandemic and the emergence of e-payment. Information Management and Business Review, 15(1(I)SI), 27-36. https://doi.org/10.22610/imbr.v15i1(I)SI.3387

[2]Akel, G., Candan, G., 2022, Adoption of online advertising by small and medium enterprises. In Moving businesses online and embracing E-commerce: Impact and opportunities caused by COVID-19 (pp. 180-198). IGI Global. https://doi.org/10.4018/978-1-7998-8294-7.ch009

[3]Akpan, I. J., Udoh, E. A. P., Adebisi, B., 2020, Small business awareness and adoption of state-of-the-art technologies in emerging and developing markets, and lessons from the COVID-19 pandemic. Journal of Small Business & Entrepreneurship, 34(2), 123–140. https://doi.org/10.1080/08276331.2020.1820185

[4]Aldao, C., Blasco, D., Espallargas, M. P., 2022, Lessons from COVID-19 for the future: Destination crisis management, tourist behaviour and tourism industry trends. Journal of Tourism Futures (ahead of print). https://doi.org/10.1108/JTF-02-2022-0059

[5]Bryce, C., Ring, P., Ashby, S., Wardman, J. K., 2022, Resilience in the face of uncertainty: Early lessons from the COVID-19 pandemic. In COVID-19 (pp. 48-55). Routledge.

[6]Campbell, S., Greenwood, M., Prior, S., Shearer, T., Walkem, K., Young, S., Bywaters, D., Walker, K., 2020, Purposive sampling: Complex or simple? Research case examples. Journal of research in Nursing, 25(8), 652-661. https://doi.org/10.1177/1744987120927206

[7]Capistrano, R. C., Notorio, P. A., 2021, A content analysis of the future of tourism through the presidential state of the nation address in the Philippines (1987-2019). Journal of Tourism Futures, 7(1), 131-146. https://doi.org/10.1108/JTF-05-2020-0075

[8]Chang, S. E., Brown, C., Handmer, J., Helgeson, J., Kajitani, Y., Keating, A., Noy, I., Watson, M., Derakhshan, S., Kim, J., Roa-Henriquez, A., 2022, Business recovery from disasters: Lessons from natural hazards and the COVID-19 pandemic. International Journal of Disaster Risk Reduction, 80, 103191. https://doi.org/10.1016/j.ijdrr.2022.103191

[9]Cockburn-Wootten, C., McIntosh, A., 2020, Improving the accessibility of the tourism industry in New Zealand. Sustainability, 12(24), 10478. https://doi.org/10.3390/su122410478

[10]Creswell, J., Plano Clark, V., 2011, Designing and conducting mixed method research (2nd ed.). SAGE Publications.

[11]Creswell, J. W., 2018, Qualitative, quantitative, and mixed methods approaches+ a crash course in statistics. SAGE publications.

[12]Denscombe, M., 2017, EBOOK: The good research guide: For small-scale social research projects. McGraw-Hill Education (UK).

[13]Dolnicar, S., Zare, S., 2020, COVID19 and Airbnb–Disrupting the disruptor. Annals of Tourism Research, 83, 102961. https://doi.org/10.1016/j.annals.2020.102961

[14]Eton, M., Mwosi, F., Mpora, E., 2022, Financial management practices scale businesses' profitability: Viewpoint of Kabale Municipality, Uganda. Annals of Management and Organization Research, 3(3), 165-178. https://doi.org/10.35912/2685-7715

[15]Fairlie, R., Fossen, F. M., Johnsen, R., Droboniku, G., 2023, Were small businesses more likely to permanently close in the pandemic? Small Business Economics, 60(4), 1613-1629. https://doi.org/10.1007/s11187-022-00662-1

[16]Fatimah, S., Naldi, J., Syafrini, D., Alhadi, Z., Putra, A., 2021, Public historian period pandemic: Impact overview COVID-19 to tourism sector and sustainability society economy Bukittinggi. Ilkogretim Online, 20(1), 1597-1603. https://doi.org/10.17051/ilkonline.2021.01.168

[17]Ghaderi, Z., Butler, R., Beal, L., 2022, Exploring home-based accommodation operators' responses to COVID-19: Implications of untact hospitality adoption. Tourism Management Perspectives, 43, 100979. https://doi.org/10.1016/j.tmp.2022.100979

[18]Ginting, N. C. A., Sianturi, M., Ariesa, Y., 2023, The influence of service quality and price on guest loyalty during the COVID-19 pandemic with guest satisfaction as an intervening variable at Hotel Grand Cityhall Medan. Priviet Social Sciences Journal, 3(7), 1-8. https://doi.org/10.55942/pssj.v3i7.227

[19]Girija, S., Sharma, D. R., Kaushal, V., 2023, Exploring dimensions of the customer experience at budget hotels during the COVID-19 pandemic: An etnography approach. Qualitative Market Research: An International Journal, 26(4), 320-344. https://doi.org/10.1108/qmr-03-2022-0039

[20]Gössling, S., Scott, D., Hall, C., 2020, Pandemics, tourism and global change: A rapid assessment of COVID-19. Journal of Sustainable Tourism, 29(1), 1-20. https://doi.org/10.1080/09669582.2020.1758708

[21]Hall, M. C., Prayag, G., Fieger, P., Dyason, D., 2020, Beyond panic buying: Consumption displacement and COVID-19. Journal of Service Management, 32(1), 113-128. https://doi.org/10.1108/JOSM-05-2020-0151

[22]Heslinga, J. H., Hillebrand, H., Emonts, T., 2019, How to improve innovation in sustainable tourism? Five lessons learned from the Austrian Alps. Journal of Tourism Futures, 5(1), 35-42. https://doi.org/10.1108/jtf-09-2018-0054

[23]Hussain, S., Xuetong, W., Hussain, T., Khoja, A. H., Zia, M. Z., 2021, Assessing the impact of COVID-19 and safety parameters on energy project performance with an analytical hierarchy process. Utilities Policy, 70, 101210. https://doi.org/10.1016/j.jup.2021.101210

[24]Jafar, R. M. S., Ahmad, W., 2023, Tourist loyalty in the metaverse: The role of immersive tourism experience and cognitive perceptions. Tourism Review, 79(2), 321-336. https://doi.org/10.1108/TR-11-2022-0552

[25]Kaushal, V., Srivastava, S., 2021, Hospitality and tourism industry amid COVID-19 pandemic: Perspectives on challenges and learnings from India. International Journal of Hospitality Management, 92, 102707. https://doi.org/10.1016/j.ijhm.2020.102707

[26]Khatib, M. E., Al Jaberi, A., Al Mahri, A., 2021, Benchmarking projects' "lessons learned" through knowledge management systems: Case of an oil company. iBusiness, 13, 1-17. https://doi.org/10.4236/ib.2021.131001

[27]Kiryakova-Dineva, T., Bozhkova, R., 2021, Public health risk environment for Bulgarian SMEs (guest houses and family hotels) in the COVID-19 pandemic. Risk, crisis, and disaster management in small and medium-sized tourism enterprises (pp. 77-102). IGI Global. https://doi.org/10.4018/978-1-7998-6996-2.ch004

[28]Kiswantoro, A., 2021, Distribution of prevention tools and socialization of health protocols for tourist visitation services in facing the new normal post COVID-19 pandemic. Jurnal Abdimas Pariwisata, 1(2), 38–51. https://doi.org/10.36276/jap.v1i2.17

[29]Kristiana, Y., Pramono, R., Brian, R., 2021, Adaptation strategy of tourism industry stakeholders during the COVID-19 pandemic: A case study in Indonesia. The Journal of Asian Finance, Economics and Business, 8(4), 213-223. https://doi.org/10.13106/jafeb.2021.vol8.no4.0213

[30]Krupenna, I., Horbatiuk, Y., 2022, Influence of the concept of sustainable development of tourism on the formation of marketing strategies of tourist companies. Bulletin of the Khmelnytskyi National University, 2(2), 203-209. https://doi.org/10.31891/2307-5740-2022-304-2(2)-32

[31]Lichtman, M., 2023, Qualitative research in education: A user's guide. Routledge. https://doi.org/10.4324/9781003281917

[32]Luvsandavaajav, O., Narantuya, G., 2021, Understanding of travel motivations of domestic tourists. Journal of Tourism and Services, 12(22), 1-22. https://doi.org/10.29036/jots.v12i22.253

[33]Marcuta, L., Popescu, A., Marcuta, A., Tindeche, C., Smedescu, D., 2021, The impact of the COVID-19 crisis on tourism and its recover possibilities. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 21(1), 495-500.

[34]Masiero, L., Viglia, G., Nieto-Garcia, M., 2020, Strategic consumer behavior in online hotel booking. Annals of Tourism Research, 83, 102947. https://doi.org/10.1016/j.annals.2020.102947

[35]Maulana, N., Astuti, R. D., Sukamdani, H. B., Tjiptoherijanto, P., 2022, Risk perception in the post COVID-19 pandemic era: An analysis of tourist accommodation and travel behavior in the new normal era. Sustainability, 14(22), 14758. https://doi.org/10.3390/su142214758

[36]Medel, D., Meza, L., Galimov, A., Baezconde-Garbanati, L., Sussman, S., 2020, Notes from the field: Vape shop business operations compliance in the wake of COVID-19. Evaluation & the Health Professions, 43(2), 135-137. https://doi.org/10.1177/01632787209232

[37]Merriam, S., 1998, Qualitative research and case study applications in education. Jossey-Bass Publisher.

[38]Murphy, A. A., Karyczak, S., Dolce, J. N., Zechner, M., Bates, F., Gill, K. J., Rothpletz-Puglia, P., 2021, Challenges experienced by behavioral health organizations in New York resulting from COVID-19: A qualitative analysis. Community Mental Health Journal, 57, 111-120. https://doi.org/10.1007/s10597-020-00731-3

[39]Narmadha, V., Anuradha, A., 2022, Paradigm change in tourist preferences towards evolving new normal tourism and travel trends. Handbook of Research on Changing Dynamics in Responsible and Sustainable

Business in the Post-COVID-19 Era (pp. 406-418). IGI Global. https://doi.org/10.4018/978-1-6684-2523-7.ch019

[40]Oborah, J. O., 2021, Digital marketing strategies adopted by hotels in Abuja, Nigeria. The International Journal of Business & Management, 9(10), 12-34.

[41]Pandey, S., Chaudhary, P., Darda, P., 2021, TOROOTS: Marketing and promoting the experiential travel and tourism. Management Dynamics, 21(2), 27-41. https://doi.org/10.57198/2583-4932.1045

[42]Pham, T. D., Dwyer, L., Su, J. J., Ngo, T., 2021, COVID-19 impacts of inbound tourism on Australian economy. Annals of Tourism Research, 88, 103179. https://doi.org/10.1016/j.annals.2021.103179

[43]Qiu, R. T., Wu, D. C., Dropsy, V., Petit, S., Pratt, S., Ohe, Y., 2021, Visitor arrivals forecasts amid COVID-19: A perspective from the Asia and Pacific team. Annals of Tourism Research, 88, 103155. https://doi.org/10.1016/j.annals.2021.103155

[44]Rehman, A., Alnuzhah, A. S., 2022, Identifying travel motivations of Saudi domestic tourists: Case of Hail province in Saudi Arabia. GeoJournal of Tourism and Geosites, 43(3), 1118-1128. https://doi.org/10.30892/gtg.43333-927

[45]Riasi, A., Schwartz, Z., Chen, C. C., 2019, A paradigm shift in revenue management? The new landscape of hotel cancellation policies. Journal of Revenue and Pricing Management, 18, 434-440. https://doi.org/10.1057/s41272-019-00189-3

[46]Ritchie, B. W., Jiang, Y., 2019, A review of research on tourism risk, crisis and disaster management: Launching the annals of tourism research curated collection on tourism risk, crisis and disaster management. Annals of Tourism Research, 79, 102812. https://doi.org/10.1016/j.annals.2019.102812

[47]Seidman, I., 1998, Interviewing as qualitative research: A guide for researchers in education and the social sciences. Teachers College Press.

[48]Shen, W., Yang, C., Gao, L., 2020, Addressing business crisis caused by COVID-19 with collaborative intelligent manufacturing technologies. IET Collaborative Intelligent Manufacturing, 2(2), 96-99. https://doi.org/10.1049/iet-cim.2020.0041

[49]Sucheran, R., 2021, Preliminary economic impacts of the COVID-19 pandemic on the hotel sector in South Africa. African Journal of Hospitality, Tourism and Leisure, 10(1), 115-130. https://doi.org/10.46222/ajhtl.19770720-90

[50]Wohlwill, J., 1974, Human adaptation to levels of environmental stimulation. Human Ecology, 2, 127-147. https://doi.org/10.1007/BF01558117

[51]World Travel & Tourism Council, 2022, Global economic impact & trends 2022.

[52]Yamagishi, K., Gantalao, C., Ocampo, L., 2024, The future of farm tourism in the Philippines: Challenges, strategies and insights. Journal of Tourism futures, 10(1), 87-109. https://doi.org/10.1108/JTF-06-2020-0101

[53]Yin, R., 2011, Applications of case study research. SAGE Publications.

[54]Yin, R., 2014, Case study research: Design and methods (5th ed.). SAGE Publications.

[55]Zulkipli, S. N., Saw, L. J., 2019, (December), Knowledge and experiences combined under one hood: Lessons learned from Peninsular Malaysia Well Abandonment Campaign. In *SPE* Symposium: Decommissioning and Abandonment (p. D021S007R004). SPE. https://doi.org/10.2118/199200-ms

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ADDRESSING THE CROSS-SECTORAL STRATEGY GAP IN SLOVAK RURAL DEVELOPMENT: A CASE STUDY ANALYSIS

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Abstract

Rural development in Slovakia faces significant challenges due to the absence of a comprehensive, cross-sectoral strategy that integrates efforts across various governmental and local entities. This case study explores the impacts of this strategic gap, drawing on recent data and stakeholder insights from Slovakia's involvement in the EU Rural Pact and the PoliRuralPlus project. Analysis shows that the fragmentation of responsibilities among ministries and local agencies hinders Slovakia's ability to implement cohesive policies for rural revitalization. Key challenges include inefficient resource allocation, lack of stakeholder coordination, and missed opportunities for economic development. This paper presents an assessment of the barriers to cross-sectoral coordination, proposes a framework for integrated rural policy, and discusses how a structured strategy could foster sustainable rural development. The proposed framework includes the establishment of an Inter-Ministerial Rural Development Council, a Joint Rural Development Fund, and enhanced community-led development mechanisms. Findings suggest that implementing these measures could significantly improve policy coherence, optimize resource use, and enhance rural resilience. The study concludes with recommendations for policy integration, future research directions, and best practices for fostering long-term rural sustainability.

Key words**:** *rural development, economic revitalization, PoliRuralPlus project, Common Agricultural Policy, sustainability, governance*

INTRODUCTION

Slovakia, a landlocked country in Central Europe, is predominantly rural, with approximately 40% of its population residing in rural areas (European Commission, 2023) [4].

These regions are primarily shaped by agriculture, forestry, and tourism, while small and medium-sized enterprises (SMEs) play a crucial role in sustaining local economies (Mura, Kljucnikov, 2018) [10]. However, rural Slovakia faces significant socio-economic challenges, including an aging population, youth outmigration, and limited access to modern infrastructure and public services (OECD, 2022) [12].

Figure 1 shows the decline of the rural population in Slovakia from 2000 to 2024. This trend highlights the demographic challenges facing rural areas, including depopulation and aging populations (International Monetary Fund, IMF, 2024) [4].

Despite the importance of rural areas to Slovakia's overall development, there is a notable absence of a horizontal, cross-sectoral approach from state authorities regarding rural policy.

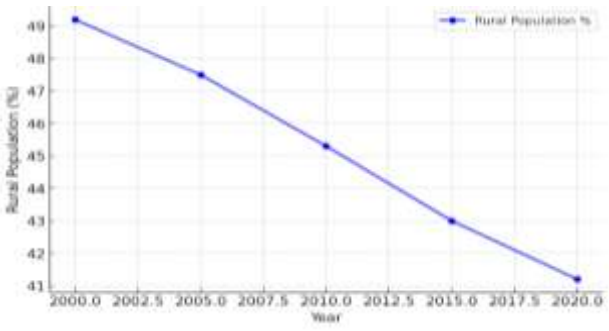

Fig. 4. Rural population Decline in Slovakia
Source: IMF, 2024 [7].

Slovakia's rural development policy operates under the framework of the Common Agricultural Policy (CAP), yet strategic integration across sectors remains insufficient. This disconnection limits the potential of CAP

Pillar II interventions to foster resilient rural territories.

There is no strategic document specifically focusing on rural areas. Therefore, rural development remains fragmented, with different ministries and agencies addressing specific issues in isolation (Ministerstvodopravy a výstavby SR, 2016) 8]. This lack of coordination results in overlapping efforts, inefficiencies, and missed opportunities to create synergies (Ministerstvodopravy a výstavby SR, 2016) [9].

Effective rural policies require a holistic approach that integrates economic, social, environmental, and cultural dimensions across all levels of government (OECD, 2022) [11]. Establishing mechanisms for horizontal cooperation between ministries and vertical alignment between national, regional, and local levels is crucial to achieving sustainable and comprehensive rural development. Integrating environmental goals, such as biodiversity conservation and climate adaptation, into rural economic planning remains a systemic challenge in Slovakia.

While various policies exist across different sectors, rural areas form a single, interconnected entity requiring an integrated and strategic approach. The need for a well-coordinated framework that aligns resources, priorities, and governance structures is imperative to address the pressing challenges and unlock new opportunities for a sustainable rural future in Slovakia.

The purpose of this paper is to present a case study which reflects the challenges due to the absence of a comprehensive, cross-sectoral strategy that integrates efforts across various governmental and local entities in Slovakia, drawing on recent data and stakeholder involvement in the EU Rural Pact and the PoliRuralPlus project.

MATERIALS AND METHODS

This study employs a mixed-method approach, incorporating qualitative and quantitative data from policy documents, stakeholder interviews, and case studies (Creswell, Plano Clark, 2018) [1]. Data were collected through the PoliRuralPlus project and EU Rural Pact initiatives, including several conferences organized in the years 2003-2005 (PoliRuralPlus, 2023; European Commission, 2022) [13, 2]. The methodology includes a policy analysis framework to evaluate governance structures and resource allocation efficiency (Howlett, et.al., 2020) [6]. Additionally, interviews with policymakers, local government and municipalities and cities representatives, and rural stakeholders provide insights into the practical challenges of rural development coordination.

A key component of this study involved consultations with various ministries, including the Ministry of Agriculture and Rural Development, the Ministry of Environment, the Ministry of Economy, the Ministry of Transport, the Ministry of Interior and the Office of the Government. These consultations highlighted the need for a more structured and integrated approach to rural development, leading to the proposal for a cross-sectoral working group under the leadership of the Ministry of Agriculture and Rural Development.

Furthermore, a series of conferences were organized jointly with the Ministry of Agriculture and Rural Development, the Association of Municipalities and Cities of Slovakia, various civil society organizations (CSOs), and governmental institutions. These conferences facilitated stakeholder engagement, enabling representatives from diverse sectors to discuss challenges, share best practices, and contribute to the development of an inclusive rural policy framework (Reed, 2008) [14].

The study also leveraged input from regional development agencies and EU-funded rural initiatives to inform policy recommendations. By integrating insights from these multi-level consultations, this research provides a robust foundation for proposing mechanisms to enhance cross-sectoral cooperation and policy coherence in Slovakia's rural development landscape.

RESULTS AND DISCUSSIONS

The results of this study emphasize several key findings related to the fragmentation and inefficiencies in rural development policy in Slovakia. The primary observation is the significant lack of coordination among ministries and local actors, which impedes the effective implementation of rural development strategies. This institutional fragmentation undermines Slovakia's ability to fully capitalize on the EU's CAP instruments for sustainable rural transformation.

This fragmentation is evident in several ways:

Inefficient Resource Allocation: A major consequence of the sectoral approach is the inefficiency in resource distribution. Funding from different government sources often overlaps, leading to misallocation of financial resources that could otherwise be used more effectively (OECD, 2020) [11]. For example, agricultural subsidies provided by the Ministry of Agriculture do not always align with the environmental goals set by the Ministry of Environment, resulting in missed opportunities for more sustainable rural growth.

Fig. 5 illustrates the sectoral budget allocation for rural development in Slovakia for 2024. The data shows that agriculture receives the highest share (40%), followed by infrastructure (25%), while other critical sectors such as education, environment, and digitalization receive significantly less funding (European Commission, 2023) [3].

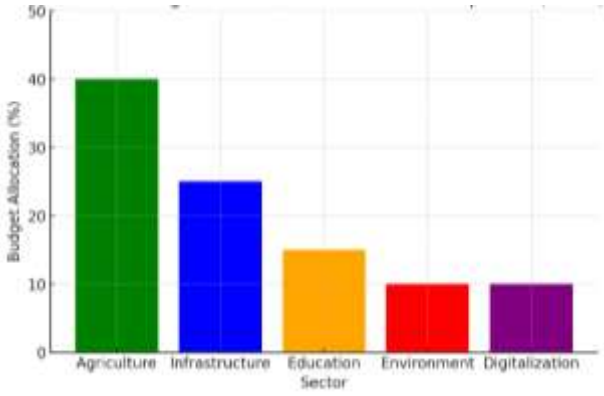

Fig. 5. Sectoral Budget Allocation for Rural Development
Source: IMF, 2024 [7].

This imbalance may contribute to the challenges of modernization and sustainability in rural areas.

Inadequate Stakeholder Coordination Despite the existence of numerous rural development initiatives, there is a glaring lack of coordination between local governments, civil society organizations (CSOs), and business entities (ENRD, 2021) [5]. Many local stakeholders' express frustration at the absence of a unified vision and strategy for rural development. This lack of alignment between key actors has led to reduced participation in policy discussions, leaving important local insights and expertise untapped.

Missed Economic Opportunities The fragmentation of rural policy has also led to missed opportunities for rural economic development. The lack of integrated policies for agriculture, tourism, and small-scale manufacturing results in the sectors operating in silos, instead of leveraging synergies that could boost rural economies. For instance, the development of rural tourism is often hindered by inadequate infrastructure investments and disconnected policies from ministries over seeing transportation and environmental protection (OECD, 2016).

Limited Community-Led Development: Another critical gap identified in the research is the insufficient emphasis on community-led development. Rural communities often lack the capacity and tools to participate meaningfully in the decision-making process regarding local development. This has led to a sense of disengagement and disempowerment among rural citizens, further exacerbating challenges like youth out migration and demographic decline (European Commission, 2022) [2].

The case studies highlight both successful and failed attempts at fostering cross-sectoral collaboration in rural Slovakia. For example, in the Gemer-Malohont region, overlapping funding for infrastructure and agrotourism projects failed to produce long-term employment or economic resilience. In contrast, initiatives that involved active cooperation between municipalities and regional agencies led to visible improvements in service delivery. However, these successes remain isolated and do not form part of a broader, national strategy.

Policy Recommendations:

Institutionalize Cross-Sectoral Cooperation: Formalizing the Inter-Ministerial Rural Development Council (IMRDC) should be prioritized, with clear mandates for coordinating rural policies across ministries. This council should meet regularly and ensure that rural development is central to decision-making processes across all sectors—agriculture, environment, economy, transport, and social affairs. Additionally, it should serve as a platform for monitoring the implementation of rural policies and assessing their effectiveness.

Strengthen Regional and Local Capacity

A key recommendation is to invest in the capacity-building of local governments and rural communities. This includes providing training for local leaders, community members, and small-scale entrepreneurs in policy advocacy, project design, and resource management. Developing local expertise and empowering communities will increase the effectiveness of rural development initiatives and enhance local ownership of development projects.

Design a National Rural Development Strategy for 2040

Slovakia should adopt a long-term, forward-looking rural development strategy for 2040. This strategy must reflect the diverse needs of rural areas and integrate economic, social, and environmental objectives. It should include clear goals for enhancing digital infrastructure, fostering sustainable tourism, improving transport connectivity, and promoting local entrepreneurship. Moreover, the strategy should prioritize rural depopulation and aging by offering tailored incentives to retain youth and attract skilled professionals.

Leverage EU Funding and Partnerships

Slovakia should further align its rural development policies with EU initiatives, particularly the EU Rural Pact, and maximize the potential of EU funding programs. Strengthening partnerships with other EU member states and utilizing regional cooperation networks can also support cross-border rural development projects. Collaborative initiatives in technology transfer, renewable energy, and sustainable agriculture could provide opportunities for knowledge exchange and shared resource optimization.

Foster Public-Private Partnerships

Encouraging collaboration between the public and private sectors is crucial for fostering innovation and investment in rural areas. Slovakia should create incentives for private-sector investments in rural areas, particularly in industries such as renewable energy, rural tourism, and sustainable agriculture. The government could facilitate this by offering tax incentives, subsidies, or co-funding schemes for businesses that establish operations in rural regions.

Improve Data Collection and Decision-Making Tools

Establishing a centralized rural data platform that integrates socio-economic, environmental, and infrastructural data would enable more informed decision-making. By investing in digital tools, Slovakia can track progress, identify emerging challenges, and tailor policies to specific rural needs. Additionally, this platform should be used to engage local communities and stakeholders in real-time decision-making and monitoring.

Promote Bottom-Up Policy Development

To enhance community engagement in rural development, the government should institutionalize bottom-up policy development. This means creating formal channels for rural residents to participate in policy consultations and local development planning. Citizens, local businesses, and NGOs should be directly involved in the creation of rural policies to ensure they reflect the realities and needs of the people who live in these areas.

Proposed Framework for Integrated Rural Development

Based on the findings, this study proposes several key elements for creating a more cohesive and integrated rural development policy in Slovakia:

(i)**Inter-Ministerial Rural Development Council (IMRDC)**

Establishing a high-level coordination body, composed of representatives from various ministries and local agencies, would help align efforts and ensure that rural development strategies are not only sector-specific but also cross-sectoral. This body should be tasked with

setting shared goals, aligning resource allocation, policies elaboration and facilitating improved communication between ministries, regional authorities, and rural stakeholders. The natural leader for this is the Ministry of Agriculture and Rural Development of the Slovak Republic and contributing Ministries are: Environment, Interior, Education, Youth and Sports, Trade and other ministries.

(ii)**Vision for more attractive rural areas**

A suitable solution to deepen inter-ministerial cooperation, including territorial cooperation, is to formulate a common vision for more attractive rural areas by 2040. Intentions and measures in the field of rural development must respond not only to the pressure of social practice, but above all to the increasing limits of the demographic resources of rural areas and the social capital of the territory. Prioritisation needs to be seen as one segment of multi-sectoral relevant actions in order to overcome traditional sectoral thinking and translate it into a joint effort uniting different actors and different departments under a common goal, strengthening the synergies of different support mechanisms.

(iii)**Joint Rural Development Fund (JRDF)**

The creation of a dedicated fund for rural development could help streamline funding allocation and reduce inefficiencies. The fund should support projects that integrate multiple sectors (agriculture, tourism, transport, etc.) and focus on long-term sustainability. A collaborative approach to fund management would ensure that investments are not only aligned with national strategies but also with the local priorities of rural communities.

(iv)**Limited Community-Led Development Mechanisms**

Encouraging rural communities to take a more active role in policy development and decision-making processes is crucial. Strengthening participatory mechanisms—such as local forums, advisory boards, and capacity-building programs—will empower communities to drive their own development agendas. This approach can also increase local buy-in, ensuring that policies reflect the true needs and aspirations of rural populations. The adequate involvement of rural actors in policy-making and decision-making processes has long been absent or insufficient. Proper consultation mechanisms need to be developed to help rural areas face unprecedented crises and challenges.

(v)**Cross-Sectoral Data Sharing and Technology Platforms**: Leveraging digital tools and platforms for data sharing and coordination will improve transparency and help streamline processes. A centralized digital platform for rural development data could facilitate better decision-making by providing up-to-date information on demographic trends, economic activities, environmental conditions, and policy implementation. These platforms could also serve as a tool for fostering communication between various stakeholders and monitoring progress in real-time.

CONCLUSIONS

The research highlights the pressing need for a cross-sectoral approach to rural development in Slovakia. The fragmentation of responsibilities among ministries and local agencies undermines the effectiveness of rural policies and hampers the long-term development of rural areas. By implementing an integrated framework, including the establishment of the Inter-Ministerial Rural Development Council, the creation of the Joint Rural Development Fund, and strengthening community-led development mechanisms, Slovakia can address these challenges and create a more resilient and sustainable rural future.

Policy integration, both horizontally across ministries and vertically across national and local levels, is essential for achieving the goals of rural revitalization. Furthermore, fostering collaboration between governmental bodies, regional development agencies, civil society, and the private sector will create a more inclusive, adaptive, and forward-thinking rural development model. Slovakia's involvement in the EU Rural Pact and the PoliRuralPlus project has provided valuable lessons and insights that can inform future policy-making.

Policy-makers should institutionalize mechanisms that systematically incorporate territorial data and stakeholder insights into rural policy cycles, in line with the EU's Long-

Term Vision for RuralAreas (2040). Evidence-based policy making and capacity building must underpin future strategies if Slovakia aims to achieve resilient, inclusive, and climate-adaptive rural regions.

The study concludes with several recommendations for future research and policy actions. Future research should explore the effectiveness of the proposed framework in different rural regions of Slovakia, identifying best practices and refining mechanisms for cross-sectoral cooperation. Moreover, additional case studies from other EU member states could provide valuable comparative insights into the challenges and successes of integrated rural policies.

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REFERENCES

[1]Creswell, J. W., Plano Clark, V. L., 2018, Designing and conducting mixed methods research (3rd ed.). SAGE Publications.

[2]European Commission, 2022, The EU Rural Pact. https://rural-vision.europa.eu/rural-pact_en, Accessed on 7 February 2025.

[3]European Commission, 2023, Analysis of the CAP Strategic Plan – Slovakia. https://agriculture.ec.europa.eu, Accessed on 11 December 2024.

[4]European Commission, 2023, CAP Strategic Plan: Slovakia. https://agriculture.ec.europa.eu/cap-my-country/cap-strategic-plans/slovakia_en, Accessed on 11 December 2024.

[5]European Network for Rural Development, 2021, Stakeholder involvement in rural policy. https://enrd.ec.europa.eu Accessed on 11 December 2024.

[6]Howlett, M., et.al., 2020, Studying public policy: Policy cycles and policy subsystems (4th ed.). Oxford University Press.

[7]Medzinárodný menový fond "International Monetary Fund), 2024, Slovak Republic: Selected Issues. https://www.elibrary.imf.org/view/journals/002/2024/076/article-A002-en.xml Accessed on 11 December 2024.

[8]Ministry of Transport and Constructions of the Slovak Republic (Ministerstvo dopravy a výstavby Slovenskej republiky) 2016, National Administration of the Republic for habitat (Národnáspráva Slovenskej republiky pre-Habitat) III. https://habitat3.org/wp-content/uploads/HABITAT_anglictina_web.pdf Accessed on 12 December 2024.

[9]Ministry of Transport and Constructions of the Slovak Republic (Ministerstvo dopravy a výstavby Slovenskej republiky), 2016, National Administration of the Republic for habitat III. https://habitat3.org/wp-content/uploads/HABITAT_anglictina_web.pdf Accessed on 12 December 2024.

[10]Mura, L., Kljucnikov, A., 2018, Small businesses in rural tourism and agrotourism: Study from Slovakia. Economics & Sociology, 11(3), 286-300. https://www.economics-sociology.eu/files/17_627_Mura_Kljucnikov.pdf Accessed on 12 December 2024.

[11]OECD, 2020, Rural Well-being: Geography of Opportunities. OECD Publishing. https://doi.org/10.1787/d25cef80-en Accessed on 19 November 2024.

[12]OECD, 2022, Tackling the challenges of population ageing in the Slovak Republic. https://www.oecd.org/en/publications/tackling-the-challenges-of-population-ageing-in-the-slovak-republic_03edcf77-en.html Accessed on 19 November 2024.

[13]PoliRuralPlus, 2024, Deliverables and documentation. https://poliruralplus.eu Accessed on 14 February 2025

[14]Reed, M. S., 2008, Stakeholder participation for environmental management: A literature review. Biological Conservation, 141(10), 2417–2431. https://doi.org/10.1016/j.biocon.2008.07.014

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LOCAL PRODUCER GROUPS IN ROMANIA: AN EUROPEAN CONTEXTUAL ANALYSIS

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Abstract

In the European Union, numerous small family farms are operated by over 11 million farmers, who often work independently. The highest concentration of small farms is in Romania. Due to this fragmentation, small agricultural producers can be disadvantaged in contracts with the processing and retail sectors, where there is a greater consolidation. To strengthen the negotiating power of small farms, the EU supports the formation of producer organizations (POs) and interprofessional organizations, allowing collaboration with other actors in the supply chain. This trend is currently most common in the fruit, vegetable, and dairy sectors. EU funding and support measures are available, but POs must meet strict criteria regarding membership numbers and production volume. At the local level, producer groups (LPGs) help supply markets and adapt agriculture to climate change. In this context, the aim of this paper is to analyse the territorial distribution and typology of local producer groups in Romania. The study relies on secondary data collected from European and national authorities, complemented by information from scientific databases. Statistical methods, including hierarchical clustering and Pearson correlation analysis, were applied to identify relevant territorial patterns. The results have shown that Romanian POs are concentrated in counties with well-developed agriculture and a tradition of cooperation, while their uneven distribution reflects economic, social, and cultural factors. Public policies tailored to regional needs can stimulate associations, supporting sustainable agricultural development and enhancing the competitiveness of Romanian products. The proposed analysis provides an overview of the territorial and sectoral distribution of producer groups, highlighting regional clusters useful for shaping future agricultural policies.

Key words: *local groups, producers, agriculture, Romania*

INTRODUCTION

Increasing the competitiveness of the agri-food sector is a priority for European authorities. Reducing the European Union (EU) market's dependence on certain imports of food/feed for animals/other inputs needed in agriculture can enhance the food security of the European area. At the European level, the creation of producer organizations (POs) and their associations (APOs) represents a priority, facilitated through various support measures. Forms of association can represent opportunities to optimize production costs for local farmers, means of collaboration in harvesting/storage/processing, or marketing of products.

The development of largefood retail chains requires large batches of agricultural products (especially fruits and vegetables), and producer association facilitates the delivery of such volumes, strengthening the collective bargaining power of local farmers. These negotiations also apply to agricultural inputs, and discounts for purchasing larger quantities of fertilizers, fuel, or plant protection treatments can be substantial.

EU recognizes the important role of these associative forms, with the possibility of legal registration/official recognition. This status offers these associative forms several advantages, such as exemption from certain competition regulations and easier access to European funds for collective investments, particularly in the fruit and vegetable sector. These associative organizations can adopt various legal forms, including agricultural cooperatives. The establishment of transnational producer associations is carried

out through the affiliation of members from two or more EU member states.

Official recognition is granted by the competent authority of the member state where the established organization has its main headquarters, provided that certain conditions are met regarding the existence of a significant number of members or a relevant volume of marketable production achieved within that state's territory [3].

According to the research conducted by Schin, Vîrlănuță, and Stanciu (2027), associative forms in agriculture can play an essential role both in the national and European economic context. The study highlights the importance of strengthening farmers' organizational capacity, considered a resilience tool against economic fluctuations and international competition. Agricultural association and cooperation can represent strategic advantages in accessing new markets, securing raw materials and resources, negotiating commercial contracts, or attracting European funding.In the Central and Eastern European countries, including Romania, the sustainable development of associative structures can be affected by legislative, economic, and cultural barriers. Unlike in Western Europe, where these forms of organization are well represented, in the eastern part of the continent they are present in a reduced or moderate proportion. Active support measures from public authorities, a predictable legislative framework, and the development of entrepreneurial and cooperative spirit among local farmers are needed [11].

The role and importance of producer associations is a subject of interest in the scientific literature. The bibliometric study conducted by Bhunia and Singh (2025) shows that there is a series of articles addressing this topic. The authors mention that association in the form of producer groups presents both the advantages of a cooperative structure (facilitating access to credit, training programs, enhanced negotiation capacity, technical facilities) and the dynamism and efficiency of private companies [1].

The role of producer associations in Czech agriculture is analysed by Lista (2012), who mentions that especially in organic production, there is a higher appetite among farmers for associative forms. Compared to other activity sectors, the involvement of farmers in Local Action Groups is lower [5].

In the horticultural sector in Romania, producer association may be the only way to ensure production success, fair incomes for farmers correlated with the volume of labour performed, and significant added value for the national economy. To join an associative form, Romanian farmers must be convinced that association does not affect their property rights over land and that producer groups represent a chance to increase the sector's competitiveness on a free European market [6].

The analysis based on fuzzy-set Qualitative Comparative Analysis (fsQCA) can be used to evaluate the performance of agricultural cooperatives in Romania. The success of agricultural producer associations depends on the combined action of multiple factors. From this perspective, it is necessary to achieve a harmonization between the support provided by public institutions, the leadership capacity at the organizational level, and the social capital of the organizations [4].

The growth of associative forms in Romanian agriculture, particularly cooperatives, has been substantial in recent years, driven by favourable legislative frameworks and the availability of European funding opportunities. Despite these advantages, many producer groups still face issues of trust, internal governance deficiencies, low professionalism, or difficulties in marketing production. The potential for cooperative development in Romania ishigh but insufficiently exploited. A strategic and coherent approach is needed for the sustainable development of the national agri-food sector [7].

A qualitative survey, based on interviews, among agricultural producers in Călărași County, shows that their participation in associative forms can offer them significant advantages, related to negotiation capacity, optimization of production costs, and application of technological advances in agriculture. The cohesion of associated members is, however, an important factor for the success of economic activity [2].

The aim of this paper is to analyse the distribution and specialization of local producer groups in Romania within the broader European context. The specific objectives are to identify territorial clusters of producer organizations and to explore regional factors influencing their development.

MATERIALS AND METHODS

Open access sources were used for documentation, available through databases such as Google Scholar, Clarivate, or ResearchGate. The information was supplemented with reports from European and national authorities, producer associations, and relevant online media publications.

The data used in this research were retrieved from official online sources, specifically from the websites of the Ministry of Agriculture and Rural Development, the National Institute of Statistics, and the European Commission.

Artificial intelligence tools were used for data ordering, technical editing, and improving the English language used in the article. The data were statistically processed, graphically represented, and interpreted.

The hierarchical analysis of counties, carried out based on the distribution of producer groups by field of activity, was performed using Ward's method and the Euclidean distance measure.

Pearson analysis was applied to evaluate Pearson correlation coefficients between county pairs, based on the structure of producer groups according to the fields for which they were officially recognized.

Certain parts of the data analysis (e.g., correlation matrix calculation, dendrogram generation, and visual formatting) were supported with the assistance of ChatGPT, a large language model developed by OpenAI (version GPT-4, 2025), used for programming guidance and figure optimization.

The results obtained were compared with other relevant information from the scientific literature for validation.

RESULTS AND DISCUSSIONS

European context

Within the EU, forms of association among agricultural producers are mainly found in thefruit and vegetable production sector, as well as in the dairy sector (Figure 1).

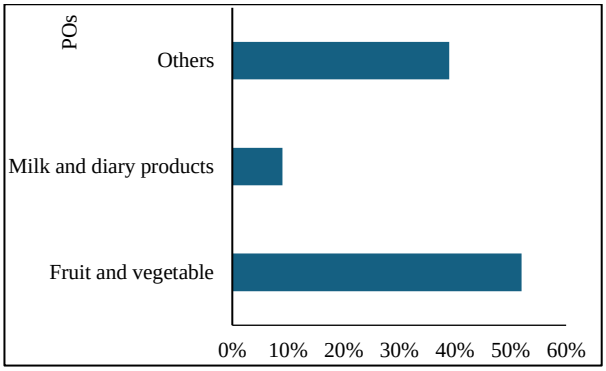

Fig. 1. POs distribution in EU, by activity
Source: Authors, by using [3].

The data made available by the European Commission in this field is not up to date, with the latest data having been published in 2018 [3].

Only in Lithuania, Estonia, and Luxembourg there were no recognised agricultural POs. According to the cited source, at the European level, around 3,681 recognised POs were active in 2018, more than 50% of them being in France, Germany, and Italy (Figure 2).

Only in 7 member states are there more than 100 POs. Among these, 80 transnational associations were recognised in 2017 [3].

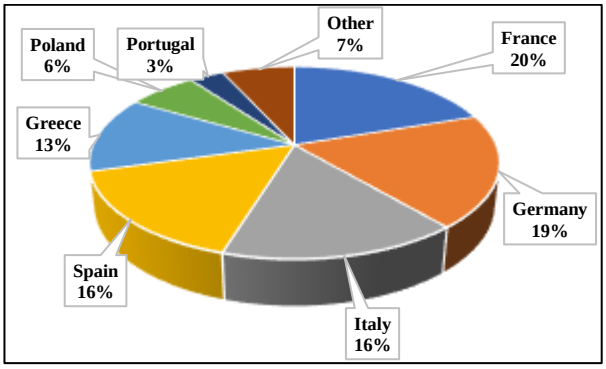

Fig. 2. POs distribution in EU, by countries
Source: Authors, by using [3].

Producers' organisations in Romania

The information updated in March 2025, presented by the Ministry of Agriculture and Rural Development, shows that 402 POs were registered in Romania.

The distribution of associative forms by fields of activity is presented in Figure 3.

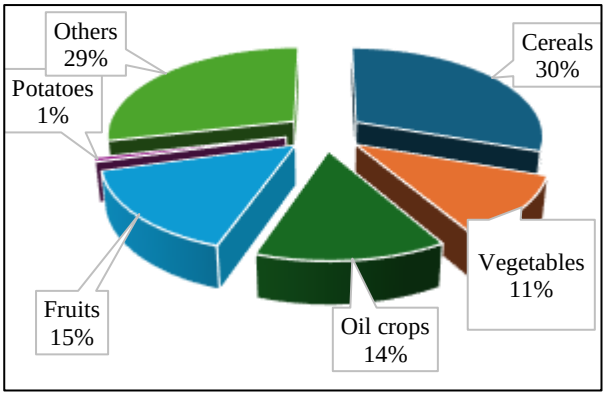

Fig. 3. POs distribution in Romania, by activity
Source: Authors, by using [8].

The data presented in Figure 3 show an uneven distribution of association by field of activity, due to tradition, the specific characteristics of farms, and natural conditions.

Cereal cultivation accounts for around 30% of producer groups, making it the best-represented sector in Romania. This distribution is practically in line with the specific nature of Romanian agriculture, which is dominated by large agricultural holdings in the traditional cereal-growing areas of the Bărăgan Plain, the Western Plain, and Dobrogea.

The fruit sector (15%) and the oil crops sector (14%) together account for 29%, which indicates a significant orientation of agricultural producer groups towards specialized crops whose industrial processing results in products with high added value. Vegetable production, with 11% of producer groups, holds a significant share, with associations located especially in the southern part of the country (Olt, Dâmbovița, Ialomița counties), where there is a tradition and development of greenhouse/tunnel infrastructure, and the demand from large urban markets such as Bucharest, Craiova, and Brasov stimulate producer organization.

Other categories are represented by producer groups and recognised organisations from the milk and dairy products sector (approx. 6%), pork meat (2.72%), sheep and goat farming, beekeeping (bee products), poultry/eggs, potatoes, medicinal and aromatic plants, or multiple combinations. Many of these areas involve combinations of products or niche sectors, which justifies grouping them under the general title "Others."

The distribution of producer groups and recognised organisations at county level is presented in Figure 4. According to the data presented, there is an uneven distribution of these associative forms across counties and development regions of Romania.

There is no county in Romania where at least one agricultural producer association is not registered. Counties with only 1–2 associative groups (Caraș-Severin, Vaslui, Olt, Bacău, Gorj) should benefit from increased attention from the authorities to encourage the association of agricultural producers (promotion actions, entrepreneurship training, dedicated funding, etc.).

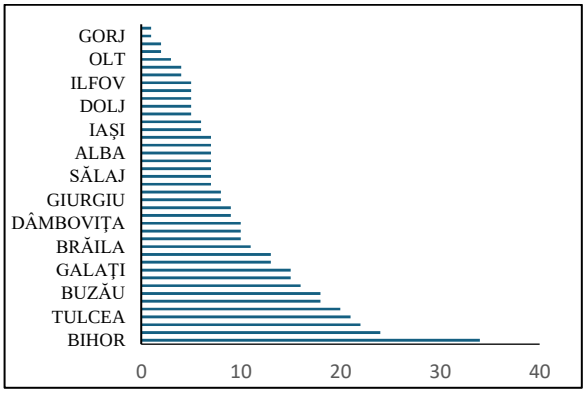

Fig. 4. POs distribution in Romania, by counties
Source: Authors, by using [8].

Under represented counties, with fewer than 5 groups (Caraș-Severin, Vaslui, Olt, Bacău, Botoșani), where farmers probably lacked local institutional support, show a weak culture of cooperation, or face administrative barriers.

The counties that register a medium level of association, with 10–20 producer groups, show a positive evolution of the association phenomenon, representing evidence of a significant development potential that can be strengthened through the implementation of tailored public policies(Ialomița, Brăila, Prahova, Cluj, Giurgiu, Maramureș, Teleorman). Meanwhile, counties with more than 20 recognised producer groups (Covasna, Suceava, Buzău, Satu Mare) should benefit from an adequate infrastructure for collecting and processing agricultural raw materials or from the development of important local markets nearby.

The leader of the ranking is Bihor County, where 36 producer groups are officially recognised. It can thus be concluded that this county has a well-developed associative agricultural structure, most likely based on a cooperative tradition and regional support measures.

Figure 5 presents a dendrogram (hierarchical tree) generated through hierarchical clustering (Ward's method), which classifies Romanian counties according to the similarity of the structure of activity fields of the officially recognised producer groups as of March 2025. For each county, the name coding used complies with the current legislation and is represented by a county code [10].

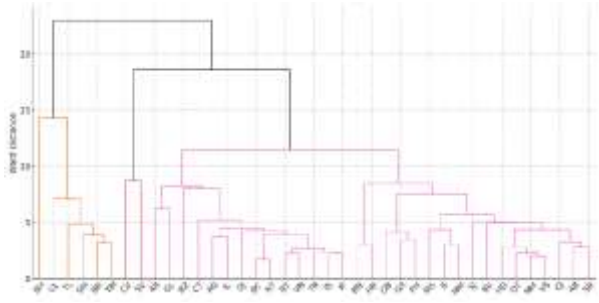

Fig. 5. Dendrogram Analysis – Clustering of Romanian Counties by Producer Group Structure
Source: Authors, by using [8] and AI instruments [9].

The analysis based on hierarchical clustering proposes a grouping of counties according to how similar they are in terms of organisational structure (e.g., the proportion of groups in cereals, vegetables, dairy, etc.).

The clustering process creates natural clusters (groups of counties with similar association patterns), using an algorithm that first "joins" the most similar counties, then merges them into increasingly larger groups. The dendrogram in Figure 5 is a visual map of the similarities between the analysed counties, from the perspective of the association profile of agricultural producers (i.e., what types of products are associated and in what proportions). The counties, represented on the x-axis, are identified by their official codes (BH, CJ, IS, etc.), and the y-axis represents the Ward distance – a measure of the difference between profiles.

Based on the analysis, the counties were grouped into four clusters:

- *Cluster 1*: *Cereal and oilseed profile*

Counties BR, CL, IL, TR, GR, BZ, located in the southeast and south of the country, are characterised by extensive agriculture dominated by field crops. Producer groups are focused on cereal and oilseed cultivation, and sometimes vegetables.

- *Cluster 2*: *Mixed model with dairy, sheep, and fruit.*

Counties BN, SJ, MS, AB, SV, located in Transylvania and northern Moldova, are characterised by a diversity of agricultural activities, with a focus on dairy products, sheep farming, orchards, and processing of plant-based products.

- *Cluster 3: Underdeveloped groups or isolated profiles*

Includes VS, OT, MH, CS – counties with few producer groups, often with only one domain represented. These may face administrative restrictions or lack a cooperative tradition.

- *Cluster 4: Peri-urban and diversified areas*

Includes counties AG, PH, DB, CJ, IS, characterised by a diversified product portfolio and better market access. Producer groups in these counties may combine crop production with horticulture and primary processing of agricultural raw materials.

Figure 6 presents the Pearson correlation coefficients between pairs of counties, based on the structure of producer groups according to the sectors in which they were officially recognised. The correlations quantify the similarity of the associative agricultural profile between counties.

Values close to 1 are characteristic of counties with a very similar associative agricultural profile, while those close to 0 describe counties with no obvious similarities. If negative values had been recorded (none were identified in this analysis), they would be due to opposite structures.

Identified regional trends

Clear clusters of high correlation were highlighted. The counties of Argeș, Dâmbovița, Ialomița, Teleorman, and Călărași (South-Muntenia region) show correlations>0.8 between them, which likely indicates an associative model focused on vegetables, fruits, and dairy — a pattern

characteristic of the southern region and peri-urban areas.

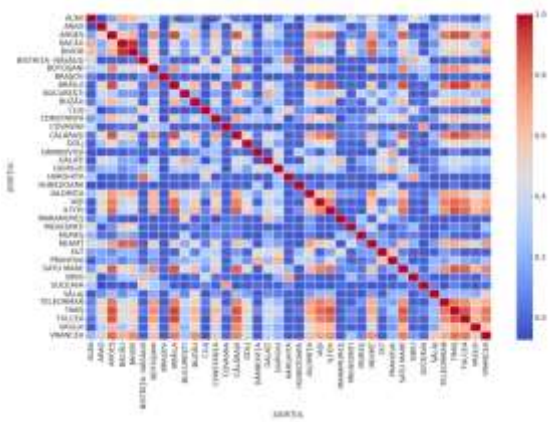

Fig. 6. Pearson Correlation Between Counties.
Source: Authors, by using [8], and [9].

Counties such as Brăila, Galați, Constanța, and Buzău (South-East) are part of similar groups in cereals and oilseeds, characterised by an extensive model of commercial agriculture, while Cluj, Alba, and Mureș reflect associations in dairy, sheep, and fruit production, based on the cooperative tradition of Transylvania. Moderate but significant correlations were identified among counties such as Timiș, Arad, and Satu Mare, which are characterised by a mixed profile, lower specialization, but a relatively homogeneous structure.

Correlations identified between Bacău, Suceava, and Neamț are modest in intensity but indicate a shared direction in producer association, especially in dairy production.

Some isolated or weakly correlated counties (Bucharest, Ilfov) do not show relevant correlations (atypical profile, lack of agricultural land).

Counties such as Mehedinți, Gorj, and Caraș-Severin are characterised by a low presence of producer groups, and therefore weak correlations with other counties, while Vaslui and Vrancea, positioned more marginally, may suggest a lack of organisation or a unique profile.

From a practical perspective, the chart can serve as the foundation for developing regional cooperation and marketing support programs, providing a way to identify model regions with potential for replicating associative structures. The analysis of the chart may contribute to agri-food clustering strategies or the development of regional centres of excellence. In regions with high correlations, it is recommended to promote inter-county partnerships and common short supply chains, while in counties with a unique profile, customised assistance and incentives for diversifying association domains could be targeted. In weakly correlated counties, it is necessary to strengthen entrepreneurial and technical training programs for farmers, as well as to recognize community-level leadership capable of facilitating the establishment of producer organisations or groups.

CONCLUSIONS

The research results highlight the existence of regional disparities in Romania regarding the development of producer groups as associative working structures. To address these disparities, adequate support policies and action strategies tailored to the specific characteristics of each region or county are needed. The modern data analysis methods used in the study—such as Pearson correlations and AI-assisted statistical processing techniques—enabled the identification of significant patterns that can serve as a solid foundation for strategic decision-making at the national level.

The cooperation of agricultural producers through the development of associative forms is essential for increasing the competitiveness and resilience of Romanian agriculture.

REFERENCES

[1]Bhunia, S., Singh, P. K., 2025, Producer organizations in the last 25 years: A bibliometric analysis and meta-review of the literature. Humanities and Social Sciences Communications, 12, 200. https://doi.org/10.1057/s41599-025-04526-3.

[2]Crețu, O. R., Tudor, V. C., 2020, Economic and social impact of associations in groups of agricultural producers – A case study in Romania. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 20(2), 183–188. https://managementjournal.usamv.ro/pdf/vol.20_2/Art23.pdf, Accessed on March 14, 2025.

[3]European Commission, 2025, (March 8), Producer and interbranch organisations. Agriculture and Rural Development. https://agriculture.ec.europa.eu/common-agricultural-policy/agri-food-supply-chain/producer-

and-interbranch-organisations_en, Accessed on March 10, 2025.
[4]Florea, A. M., Bercu, F., Radu, R. I., Stanciu, S., 2019, A fuzzy set qualitative comparative analysis (fsQCA) of the agricultural cooperatives from Southeast region of Romania. Sustainability, 11(21), 5927. https://doi.org/10.3390/su11215927.
[5]Lista, T., 2012, The role of farmers in Local ActionGroups: The case of the national network of the Local Action Groups in the Czech Republic. Agricultural Economics (AGRICECON), 58(9), 433–442. https://doi.org/10.17221/148/2011-AGRICECON.
[6]Micu, M. M., 2015, Analysis of the opinion of the agricultural producers from the fruit tree growing sector on the intention to join in an associative form. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 15(3), 163–168. https://managementjournal.usamv.ro/pdf/vol.15_3/Art27.pdf. Accessed on March 04, 2025.
[7]Răducu, C., Georgescu, M., 2022, Agricultural cooperatives in Romania – current state andperspectives. In I. L. Rákosy & M. Georgescu (Eds.), Proceedings of the 34th International Business Information Management Association Conference (pp. 15809–15818). IBIMA Publishing, https://doi.org/10.5555/20230392790.
[8]Ministry of Agriculture and Rural Development, MARD, 2025, (March 27). Grupurile de producători și organizațiile recunoscute [Recognized producer groups and organizations]. https://www.madr.ro/grupurile-de-producatori-si-organizatiile-recunoscute.html.Accessed on March 01, 2025.
[9]OpenAI. (2025). ChatGPT (April 2025 version) [Large language model], https://chat.openai.com, Accessed on March 04, 2025.
[10]Romania's Government, 2003, (Decembrie 31). Lista cuprinzând codurile județelor din România – Normă (List comprising the county codes of Romania – Regulation). Law 5. https://lege5.ro/Gratuit/giztqmjz/lista-cuprinzand-codurile-judetelor-din-romania-norma?dp=giytamjsheyts.Accessed on March 06, 2025.
[11]Schin, G., Vîrlănuță, F. O., Stanciu, S., 2017, The association of agricultural producers – National and European perspectives. In K. S. Soliman (Ed.), Proceedings of the 29th IBIMA Conference: Education Excellence and Innovation Management through Vision 2020: From Regional Development Sustainability to Global (Vol. 1, pp. 1621–1627). IBIMA Publishing. https://www.researchgate.net/publication/317351304_The_Association_of_Agricultural_Producers__National_and_European_Perspectives.Accessed on March 04, 2025.

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BEEKEEPING: ECONOMIC AND SOCIAL IMPORTANCE, GLOBAL TRENDS AND DEVELOPMENT STRATEGIES IN EUROPE AND ROMANIA

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Abstract

Beekeeping plays an important role in the economies of European Union countries, with specific programs to support the beekeeping sector implemented in all member states. However, the sector faces challenges such as the lack of predictive market information, competition in the global market, changing consumer preferences, the introduction of modern technologies, and more. This article explores the basic economic parameters of honey production, consumption, export and import at national, European, and global levels. It forecasts trends in the growth of bee populations, honey production, and consumption using data from relevant sources (FAO, Eurostat, National Institute of Statistics-NIS) through a forecasting model. Furthermore, it discusses strategic development directions in Europe and Romania. The research highlights the sector's potential and the need for integrated policies that support both bee health and beekeepers' incomes.

Key words**:** *beekeeping, socio-economic importance, trends, directions*

INTRODUCTION

Beekeeping, or apiculture, has a significant economic and social impact, contributing to the development of communities and environmental protection through biodiversity conservation. This activity provides direct economic benefits through the production of honey and other valuable bee products, and indirect benefits through the essential role of bees in pollinating agricultural crops. Additionally, in rural areas, beekeeping is a vital source of food and income, reducing poverty and providing economic stability (Adjare, S.O., 1990)[3].

Pollination performed by bees is indispensable for agricultural production, contributing to maintaining stable agricultural yields, supporting food security, and enhancing the competitiveness of the agri-food sector (European Commission, 2022) [10]. According to FAO (2021) [13], approximately 75% of global food crops and 35% of total agricultural production depend on pollination. This includes oilseed crops (rapeseed, sunflower), fodder plants (alfalfa, clover), vegetables, and fruits, as well as high-value crops such as almonds, coffee, and citrus, essential for dietary diversity and local economies (Klein, A. M., et al., 2007; Potts, S. G., et al., 2010; FAO, 2021) [18, 29, 14]. The global value of pollination services exceeds USD 200 billion annually (FAO, 2021)[14].

Beekeeping plays a significant role in the global and local economy through the revenues it generates. Bee products, including honey, wax, propolis, and royal jelly, had a global market estimated at USD 9.3 billion in 2023 (Bee Culture, 2023) [4]. Major honey-exporting countries include China, Argentina, Ukraine, and India, while the European Union and the United States are among the largest importers (FAO, 2021) [14]. Romania is one of the largest honey producers in the European Union (European Commission, 2022; FAO, 2021) [10, 14], with over half of its honey destined for export, beekeeping contributes to the rural economy and bolsters the country's reputation as a producer of high-quality honey (MADR, 2021) [23]. With relatively low investments, beekeeping can generate supplementary income, contributing to the financial stability of small-scale farmers and marginalized communities, thereby reduce

poverty and food insecurity, by increasing household resilience to economic shocks (Abro, Z., et al., 2022; Popescu A., et al., 2024, Prodanović, R., et al., 2024) [1, 26, 30].

The interdependence between beekeeping, ecosystems and agricultural production profoundly impacts food availability, accessibility and security, not only by increasing the production of fruits, vegetables and oilseeds but also by providing a nutrient-rich food product (Bogdanov, S., et al., 2008; Akanda, M. K. M., et al., 2024) [5, 2]. Honey is a natural energy source, widely used in many cultures as a traditional sweetener and functional food (Kumar, K. S., et al., 2010) [19]. Additionally, bee products have a long history of use in natural medicine and cultural practices. In many parts of the world, honey is used to treat wounds, colds, and digestive issues, reflecting its social and cultural value (Crane, 1999) [8].

Beekeeping activities often involve women and youth, contributing to social inclusion and reducing unemployment. In many rural communities, women participate in honey production and processing, gaining economic independence (Prodanović, R., et al., 2024) [30].

Beyond its economic and social dimensions, beekeeping plays an essential role in biodiversity conservation and sustainable environmental management through agroecological practices that minimize synthetic inputs and chemical treatments. These practices help preserve soil fertility, water quality and the overall integrity of natural ecosystems (Pocol et. al., , 2021; Prodanović, R., et al., 2024) [25, 30]. Sustainable beekeeping supports biodiversity, especially in regions with threatened habitats (IPBES, 2019) [17]. By providing these ecosystem services and conserving the genetic diversity of plant populations, beekeeping helps mitigate the impact of climate change. Moreover, creating income sources less exposed to climatic risks contributes to the resilience of rural communities (Prodanović, R., et al., 2024) [30].

Beekeeping plays a crucial role in the economies of European Union countries, with the EU being a major player in the beekeeping market and Romania is among the leading honey producers in the EU. Programs to support the beekeeping sector are implemented in EU member states. However, the sector faces challenges such as the lack of predictive market information, global market competition, changing consumer preferences, lack of international import standards and regulation and more (Popescu A., et al., 2020, 2021, Różański, K., 2022) [27, 28, 31]. Addressing these issues requires a nuanced understanding of global beekeeping trends and targeted strategies to enhance its sustainability. This article explores the basic economic parameters of honey production, consumption, export and import at national, European, and global levels. It forecasts trends in the growth of bee populations, honey production and consumption using data from relevant sources (FAO, Eurostat, NIS) through a forecasting model. Furthermore, it discusses strategic development directions in Europe and Romania.

The research highlights the sector's potential and the need for integrated policies that support both bee health and beekeepers' incomes.

MATERIALS AND METHODS

The research is based on the processing and analysis of secondary data sourced from statistical databases (FAO, EUROSTAT, NIS) and Romania's National Strategic Plan (PNS). The indicators used for analyzing the economic importance of beekeeping include the number of bee families, the number of beekeepers, the number of bee families per beekeeper, honey production, annual honey consumption per person, honey imports, honey exports, and the national balance of honey import and export.

To establish the evolution and determine the dispersion degree of the indicators over the analyzed period, fixed-base indices and the coefficient of variation were used, calculated as:

Cvar (%) = (Standard deviation / Mean) * 100

To identify trends in the analyzed indicators, the annual growth rate was calculated using the formula:

Growth rate (%) = ((Geometric mean (analyzed period) - 1) * 100)

To determine the significance of the difference between calculated means, the t-test was employed, interpreted for probabilities of 95%, 99%, and 99.9% (tcal >t theoretical) (Savoiu Gh, 2011) [32].

To establish trends in the analyzed indicators, a second-degree equation of the form ax^2 + bx + c was used. Quadratic regression (or second-degree regression) is a non-linear regression model used to analyze the relationship between variables and estimate trends that are not directly proportional, i.e., when the relationship between variables forms a curve.

This type of regression is often used to analyze long-term consumer trends, especially when there are seasonal, economic, or consumption behavior-related fluctuations that do not exhibit linear evolution.

In the field of beekeeping, indicators such as honey production, the number of bee colonies, or other variables may exhibit a non-linear evolution over time.

For instance, an initial fast increase in production can be followed by stagnation or decline due to ecological, economic or climatic factors. The quadratic model allows for identifying such an evolution (e.g., in the form of a parabola that shows growth followed by decline).

Once the mathematical relationship is identified, the trend can be extrapolated for future years.

This is useful for estimating future values of the indicators, providing guidance for strategic planning. For example, farmers or decision-makers can plan resources or support measures based on the predictions.

The quadratic model enables the identification of a maximum or minimum point, depending on the parameters of the equation. In beekeeping, this point might indicate the moment when production reaches a peak and begins to decline (e.g., due to reduced biodiversity or climate changes).

If the actual trends of beekeeping indicators are curvilinear, a linear model may overestimate or underestimate future values.

The quadratic model provides greater accuracy, better reflecting real fluctuations.

Quadratic regression can also include the effects of other independent variables, such as investments in beekeeping or the impact of climatic factors, forming more complex models.

For honey production, if data shows an increase in production in recent years followed by stagnation, quadratic regression can model this evolution, providing an estimate for when production might begin to decline.

Similarly, for bee colonies, if the number initially increases but then decreases due to bee mortality (e.g., the colony collapse disorder phenomenon), quadratic regression can help quantify the rate of decline and estimate the critical point.

By extrapolating into the coming years, scenarios regarding the evolution of the beekeeping sector can be created, aiding in informed decision-making for agricultural policies or economic interventions.

Quadratic regression is, therefore, a valuable tool for understanding and predicting the evolution of the beekeeping sector in the context of complex trends.

RESULTS AND DISCUSSIONS

Evolution of the number of bee families, honey production, and international honey trade balance at the global level and in some EU countries.

Despite the numerous challenges facing the sector (climate change, pesticide use, and habitat loss) and warnings about their effects on colony trends (IPBES, 2019) [17], the number of bee colonies increased in all regions between 2010 and 2022 (Table 1).

With higher growth rates compared to the global average, recorded in Oceania and Europe, their share improved relative to 2022, driven by a decline in the share held by Africa and America. Asia and Europe together account for approximately 70% of the world's bee families.

Table 1. Evolution of the number of bee colonies in the EU and on the continents during the period 2010-2022

Year	MU	UE27	Africa	America	Asia	Europe	Oceania	Worldwide
2010	mil bee col.	12.35	16.08	11.02	35.93	16.85	0.76	80.65
2011	mil bee col.	12.76	15.92	10.95	36.56	17.28	0.69	81.40
2012	mil bee col.	13.02	16.62	10.93	37.73	18.11	0.71	84.10
2013	mil bee col.	13.12	16.42	11.12	39.15	18.27	1.01	85.97
2014	mil bee col.	13.76	16.80	11.28	40.52	19.01	1.06	88.66
2015	mil bee col.	14.14	16.94	11.32	41.70	19.66	1.04	90.66
2016	mil bee col.	14.67	17.14	11.25	41.99	20.23	1.19	91.80
2017	mil bee col.	15.14	17.70	11.15	42.17	20.63	1.40	93.05
2018	mil bee col.	16.91	18.31	11.61	42.65	22.34	1.58	96.50
2019	mil bee col.	17.67	17.93	11.66	43.38	23.29	1.65	97.91
2020	mil bee col.	18.58	18.08	11.55	43.75	24.04	1.46	98.88
2021	mil bee col.	19.67	17.17	11.67	44.67	24.90	1.43	99.85
2022	mil bee col.	19.88	17.46	11.71	45.34	25.12	1.36	101.00
2022 Vs 2010	mil bee col.	7.53	1.38	0.69	9.41	8.27	0.60	20.35
	%	*161.0*	*108.6*	*106.3*	*126.2*	*149.1*	*178.1*	*125.2*
Annual rhythm	%	*4.05*	*0.69*	*0.51*	*1.96*	*3.38*	*4.93*	*1.89*
2022 structure	%	19.68	17.29	11.59	44.89	24.87	1.35	*100*

Source: FAOSTAT, 2024, https://www.fao.org/faostat/fr/#data/QCL [15].

From Table 1, it can be observed that globally, the number of bee colonies increased by over 20.35% between 2010 and 2022. The dominant continent in terms of the number of bee colonies is Asia, followed by Europe, Africa, and America, a hierarchy that remained consistent throughout the analyzed period (Figure 1). Interestingly, in Oceania, although the number of bee colonies is much smaller due to unfavorable climatic conditions, the number of colonies increased by 78.1% from 2010 to 2022. Europe also experienced significant growth, with an increase of 49.1% in 2022 compared to 2010.

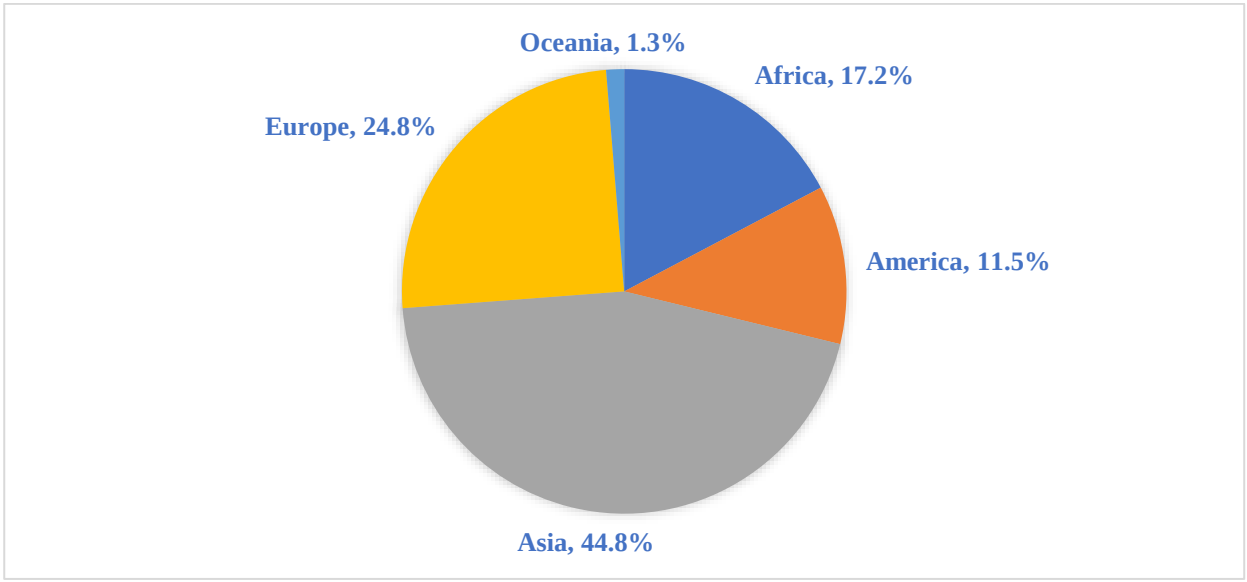


Fig. 1. Share of the bee colonies' number by continents in 2022 (%)
Source: FAOSTAT, 2024, https://www.fao.org/faostat/fr/#data/QCL [15].

According to FAO data, global honey production increased from 1.4 million tons in 2000 to over 1.9 million tons in 2023. Asia (China, India, Turkey) dominates global production, followed by Europe and South America (FAO Reports on Apiculture, 2023) [14].

The highest production is recorded in Asia, accounting for approximately 49% of global production, with a significant increase (27.9%) during the analyzed period. Asia is also the only continent where increases in average honey production per bee colony were recorded during the same period (Table 2).

In Europe and the EU, although some of the highest growth rates in bee colony numbers were recorded during the analyzed period, this trend is not fully reflected in honey production.

The average yield per bee colony decreased during the period analyzed (Table 3).

Table 2. Evolution of honey production in the EU and continents during the period 2010-2021

Year	MU	EU 27	Africa	America	Asia	Europe	Oceania	Worldwide
2010	Th. to	202	167	362	678	353	28	1587
2011	Th. to	217	156	373	732	376	20	1657
2012	Th. to	186	166	381	773	350	23	1692
2013	Th. to	203	169	363	787	378	32	1730
2014	Th. to	202	194	354	816	373	32	1769
2015	Th. to	250	214	320	832	424	33	1824
2016	Th. to	224	199	335	910	387	33	1863
2017	Th. to	239	184	334	914	406	27	1866
2018	Th. to	246	191	357	829	424	32	1834
2019	Th. to	228	150	350	825	397	37	1759
2020	Th. to	230	152	339	840	404	40	1775
2021	Th. to	216	152	346	867	384	33	1781
Average	Th. to	220	175	351	817	388	31	1761
	Th. to	14	-15	-16	189	31	5	194
2021 vs 2010	%	106.9	91.0	95.6	127.9	108.8	117.9	112.2
Annual rhythm	%	0.6	-0.9	-0.4	2.3	0.8	1.5	1.1
2021 Structure	%	12.13	8.53	19.43	48.68	21.56	1.85	100.00

Source: FAOSTAT, 2024, https://www.fao.org/faostat/fr/#data/FBS [15].

The continents of Africa and America recorded declines in honey production during the analyzed period. However, overall, global honey production increased by 12.2% during the analyzed interval.

An increase in the number of bee colonies does not automatically guarantee a proportional increase in honey production. While the number of colonies may grow, honey production can be affected by external factors such as climate, pollution, bee health, and the availability of food sources (flowers and plants). For example, during periods of drought or unfavorable weather conditions, even if the number of bee colonies increases, honey production may remain constant or even decrease (FAO, 2018) [11].

A bee colony can produce less honey in a year, even if the total number of colonies increases. Factors influencing efficiency include bee health, diseases, and parasites that affect productivity. In a study by Brodschneider and Crailsheim (2010), it was demonstrated that poor bee health can significantly reduce the amount of honey produced [6].

Moreover, bees are not always active in honey production throughout the year (especially in areas with cold winters), which can limit annual honey production, even if the bee population grows.

Honey production is also influenced by economic conditions and the demand for honey in the market. Even if the number of bee colonies increases, this does not immediately translate into a corresponding increase in honey production. For instance, honey prices can fluctuate, and beekeepers may choose to sell honey at higher prices or focus on other factors, such as increasing bee colonies to support crop pollination.

In certain regions (e.g., Europe or America), despite an increase in the number of bee colonies, honey production has not grown at the same pace due to factors such as climate change, pollution, or agricultural practices that reduce the availability of nectar for bees.

Table 3 reveals a significant decline in honey production per bee colony in Europe and Oceania, where the percentage decreases are the most pronounced. Conversely, regions in America and Asia experienced more stable trends with moderate increases.

Africa recorded a greater increase in honey production per bee colony, although levels remain below those of other regions.

China is the largest honey exporter, while the United States and the European Union are the main importers.

The global honey market reached a value of USD 9.3 billion in 2023, according to a Bee Culture report (2023) [4].

Table 3. Evolution of honey production per bee colony in the EU and on continents during the period 2010-2021

Year	MU	EU27	Africa	America	Asia	Europe	Oceania	Worldwide
2010	kg	16.4	10.4	32.8	18.9	20.9	36.8	19.7
2011	kg	17.0	9.8	34.1	20.0	21.8	29.0	20.4
2012	kg	14.3	10.0	34.9	20.5	19.3	32.4	20.1
2013	kg	15.5	10.3	32.6	20.1	20.7	31.7	20.1
2014	kg	14.7	11.5	31.4	20.1	19.6	30.2	20.0
2015	kg	17.7	12.6	28.3	20.0	21.6	31.7	20.1
2016	kg	15.3	11.6	29.8	21.7	19.1	27.7	20.3
2017	kg	15.8	10.4	30.0	21.7	19.7	19.3	20.1
2018	kg	14.5	10.4	30.7	19.4	19.0	20.3	19.0
2019	kg	12.9	8.4	30.0	19.0	17.0	22.4	18.0
2020	kg	12.4	8.4	29.4	19.2	16.8	27.4	18.0
2021	kg	11.0	8.9	29.6	19.4	15.4	23.1	17.8
2021 vs 2010	%	67.1	85.2	90.3	102.9	73.6	62.6	90.6

Source: Own calculation based on data from FAOSTAT, 2024, https://www.fao.org/faostat/fr/#data/FBS [15].

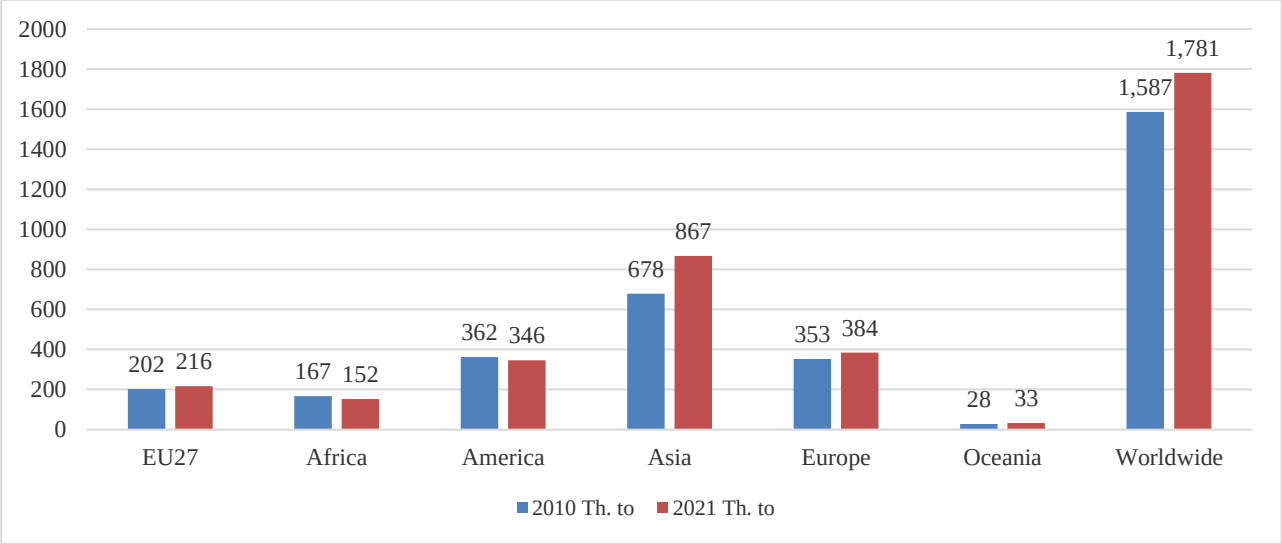


Fig. 2. Evolution of honey production in the EU and on continents, 2010 and 2021
Source: FAOSTAT, 2024, https://www.fao.org/faostat/fr/#data/FBS [15].

Regarding the balance of honey trade and its evolution during 2010–2021, the balance was negative throughout the analyzed period for Europe (average of -124.7 thousand tons) and Africa (-6.8 thousand tons).

Table 4. Evolution of the international honey trade balance in the EU27 and on continents during the period 2010-2021

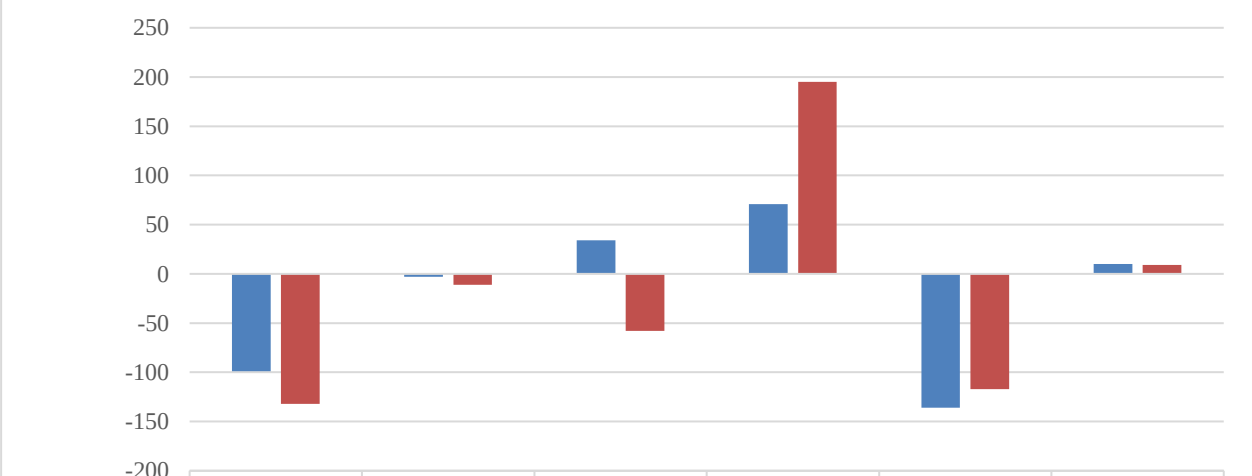
Year	MU	EU 27	Africa	America	Asia	Europe	Oceania
2010	Th. to	-99	-3	34	71	-136	10
2011	Th. to	-104	-3	35	83	-139	7
2012	Th. to	-101	-7	32	87	-128	8
2013	Th. to	-109	-5	7	106	-129	11
2014	Th. to	-119	-7	-8	127	-123	6
2015	Th. to	-131	-5	-21	148	-134	5
2016	Th. to	-128	-7	11	103	-109	4
2017	Th. to	-143	-8	-34	126	-118	4
2018	Th. to	-141	-9	-1	124	-140	5
2019	Th. to	-131	-7	-36	120	-122	7
2020	Th. to	-132	-10	-22	131	-101	9
2021	Th. to	-132	-11	-58	195	-117	9
Average	Th. to	-122.5	-6.8	-5.1	118.4	-124.7	7.1
2021 vs 2010	Th. to	-33.0	-8.0	-92.0	124.0	19.0	-1.0

Source: FAOSTAT, 2024, https://www.fao.org/faostat/fr/#data/FBS, [15].

In America, the trade balance was positive in the initial years of the analysis but turned negative in 2017 (average of -5.1 thousand tons) (Table 4).

Oceania (average of +7 thousand tons) shows a positive balance, while Asia is the continent

with an average of +118.4 thousand tons, increasing from 71 thousand tons in 2010 to 195 thousand tons in 2021 (Table 4, Fig. 3).



	UE27	Africa	America	Asia	Europe	Oceania
2010 Th. to	-99	-3	34	71	-136	10
2021 Th. to	-132	-11	-58	195	-117	9

Fig. 3. The difference in the international honey trade balance in EU27 and continents between year 2010 and year 2021
Source: FAOSTAT, 2024, https://www.fao.org/faostat/fr/#data/FBS, [15].

The differences in honey trade balances between 2010 and 2021 are illustrated in Figure 3.

Asia's dominance in honey trade is well-documented (Market Research Future, 2021) [22], driven by economic, geographical, and cultural factors. Asia, particularly China, India, Turkey, and other regional countries, plays a major role in global honey production and exports due to unique advantages (FAO, 2020) [12].

For example, China, the leading honey exporter, produces vast quantities at relatively low costs due to diverse climates, abundant natural resources, and inexpensive labor. According to the Food and Agriculture Organization of the United Nations (FAO), China contributes over 20% of global production. Other Asian countries, like India and Turkey, have developed large-scale beekeeping practices, combining modern technologies with traditional methods (FAO Reports on Apiculture, 2021) [15]. Another contributing factor to Asia's surplus trade balance is the variety of ecosystems that support diverse honey production, including rare and sought-after varieties. For example, Asia's vast monocultures (e.g., rapeseed or sunflower fields) support intensive beekeeping focused on efficiency.

Although there are frequent criticisms of the quality of honey produced in some Asian regions, particularly accusations of adulteration or the addition of syrups, and Mouriquand (2023) [21] note that European and American markets have imposed restrictive measures to limit imports of Asian honey. Despite this, its competitive prices remain attractive. Eva Crane, in her work *The World History of Beekeeping and Honey Hunting* (1999), emphasizes Asia's long-standing beekeeping traditions and their impact on global markets. According to Honey Market Reports (2023), exports from Asia have continued to grow despite stringent regulations in Europe and North America [16].

The commercial strategy of Asian countries, which includes the export of not only raw honey but also processed apiculture products such as pollen, propolis, and beeswax, also explains their strong position in international markets.

Evolution of honey consumption worldwide and in certain European Union countries

Honey consumption per capita varies significantly across continents and countries, influenced by factors such as cultural traditions, the accessibility of apiculture products and dietary habits. As shown in Table 5, some of the highest per capita consumption levels have been recorded in Africa, Europe, and Oceania. Asia, on the other hand, registers the lowest per capita honey consumption.

Analyzing the averages over two periods, there are noticeable negative declines in some regions, contrasted with significant positive growth in others, particularly in America (Figure 4).

Table 5. Evolution of honey consumption per capita by continents, during the periods 2010-2014 and 2015-2021

Area/MU	2010	2014	Average 2010-2014		St Dev	Rhythm	2015	2021	Average 2015-2021		St Dev	Rhythm	Average 2015-2021 vs Average 2010-2014		
	kg/cap/ year	kg/cap/ year	kg/cap/ year	TOP	kg/cap/ year	%	kg/cap/ year	kg/cap/ year	kg/cap/ year	TOP	kg/cap/ year	%	kg/cap/ year n	%	Signific.
Africa	1.49	1.47	1.370	1	0.103	-0.3	1.56	0.98	1.21	1	0.224	-7.5	-0.260	113.2	Θ
America	0.34	0.31	0.340	4	0.017	-2.3	0.3	0.37	0.32	4	0.029	3.6	0.010	106.3	***
Asia	0.14	0.15	0.150	5	0.005	1.7	0.15	0.14	0.15	5	0.010	-1.1	0.000	100.0	ΘΘΘ
Europe	0.63	0.62	0.640	2	0.018	-0.4	0.63	0.58	0.6	2	0.021	-1.4	-0.020	106.7	ΘΘΘ
Oceania	0.62	0.62	0.600	3	0.025	0	0.62	0.58	0.6	3	0.045	-1.1	-0.020	100.0	ΘΘΘ

Source: FAOSTAT, 2024, https://www.fao.org/faostat/fr/#data/QCL [15].

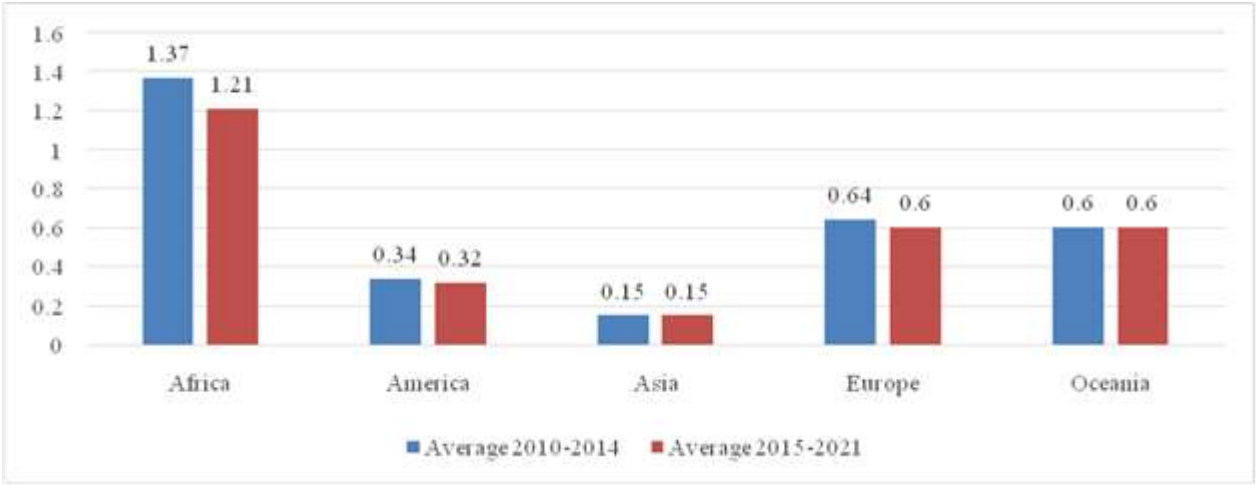


Fig. 4. Average honey consumption (kg) per capita by continents during the periods 2010-2014 and 2015-2021
Source: FAOSTAT, 2024, https://www.fao.org/faostat/fr/#data/QCL [15].

Table 6. Evolution of honey consumption per capita in some European Union countries during the periods 2010-2014 and 2015-2021

Area/MU	2010	2014	Average2010-2014		Stdev	Annual rhythm	2015	2021	Average 2015-2021		Stdev	Annual rhythm	Average 2015-2021 vs Average 2010-2014		
	kg/cap / year	kg/cap / year	kg/cap / year	TOP	kg/cap / year	%	kg/cap / year	kg/cap / year	kg/cap / year	TOP	kg/cap / year	%	kg/cap / year	%	Signific.
UE	0.64	0.65	0.64	7	0.022	0.4	0.68	0.66	0.67	8	0.018	-0.5	0.02	95.5	***
Austria	1.15	1.25	1.18	1	0.042	2.1	1.12	1.1	1.09	1	0.094	-0.3	-0.16	108.3	ΘΘ
Belgium	0.59	0.63	0.62	8	0.017	1.7	0.63	1.03	0.62	10	0.194	8.5	-0.01	100.0	N
Bulgaria	0.23	0	0.08	13	0.102	-43.5	0.13	0.48	0.15	12	0.154	24.3	0.15	53.3	**
Germany	1.13	1.02	1.04	3	0.059	-2.5	1.02	0.81	0.99	2	0.085	-3.8	-0.03	105.1	***
Finland	0.51	0.51	0.51	11	0.002	0	0.51	0.9	0.63	9	0.163	9.9	0.12	81.0	N
France	0.59	0.61	0.58	10	0.026	0.8	0.67	0.59	0.68	6	0.074	-2.1	0.07	85.3	**
Poland	0.12	0.11	0.12	12	0.004	-2.2	0.11	0.28	0.13	13	0.064	16.8	0.02	92.3	N
Romania	0.57	0.6	0.62	9	0.049	1.3	0.8	0.79	0.8	5	0.041	-0.2	0.20	77.5	***
Slovenia	1.19	1.04	1.15	2	0.301	-3.3	1.18	0.92	0.98	3	0.182	-4.1	-0.06	117.3	ΘΘΘ
Slovakia	0.86	0.86	0.86	4	0.003	0	0.86	0.64	0.86	4	0.108	-4.8	0.00	100.0	N
Spain	0.66	0.7	0.69	6	0.053	1.5	0.71	0.62	0.68	7	0.057	-2.2	-0.02	101.5	ΘΘΘ
Sweden	0.75	0.8	0.79	5	0.033	1.6	0.8	0.34	0.6	11	0.202	-13.3	-0.20	131.7	N

FAOSTAT, 2024, https://www.fao.org/faostat/fr/#data/QCL [15].

There is a great diversity in honey consumption patterns across European Union countries (as shown in Table 6).

Austria holds the top spot for honey consumption per capita, with an average of 1.18 kg per capita during the 2010–2014 period, followed by a significant decrease to 1.1 kg per capita in the 2015–2021 period, representing an annual decline of -0.3%.

Germany, close behind Austria, ranked third during the first period and rose to second place during 2015–2021, with an average consumption of 0.99 kg per capita.

Romania ranked ninth during the first period but rose to fifth place during the second, with an average consumption of 0.8 kg per capita. Poland and Bulgaria consistently recorded the lowest honey consumption per capita in both periods (Fig. 5).

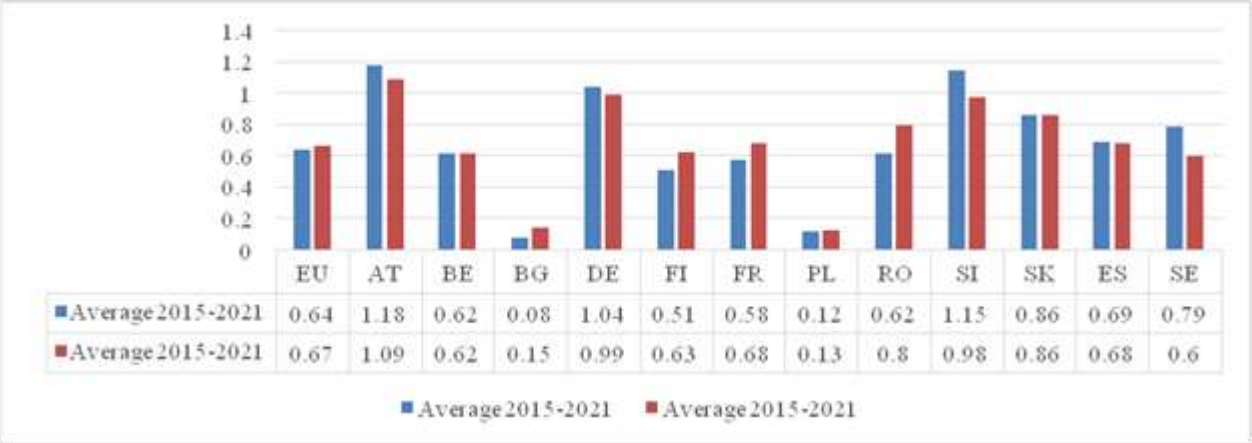


Fig. 5. Average honey consumption (kg) per capita in some European Union countries during the periods 2010-2014 and 2015-2021

Source: FAOSTAT, 2024, https://www.fao.org/faostat/fr/#data/QCL [15].

Determining trends in beekeeping indicators and projections for 2023–2030

The trend in the growth of bee colonies worldwide was calculated using the equation:

$Y(\text{global bee colonies}) = -0.0441x^2 + 2.416x + 77.437$ ($R^2 = 0.993$, $r = 0.996$) (Fig. 6).

Globally, based on projections using the second-degree trend equation, the adjusted average number of bee colonies is expected to reach 108.7 million by 2030, compared to 80.6 million in 2010. This projection is bounded by a 95% confidence interval, with a lower limit of 104.4 million colonies and an upper limit of 113 million colonies.

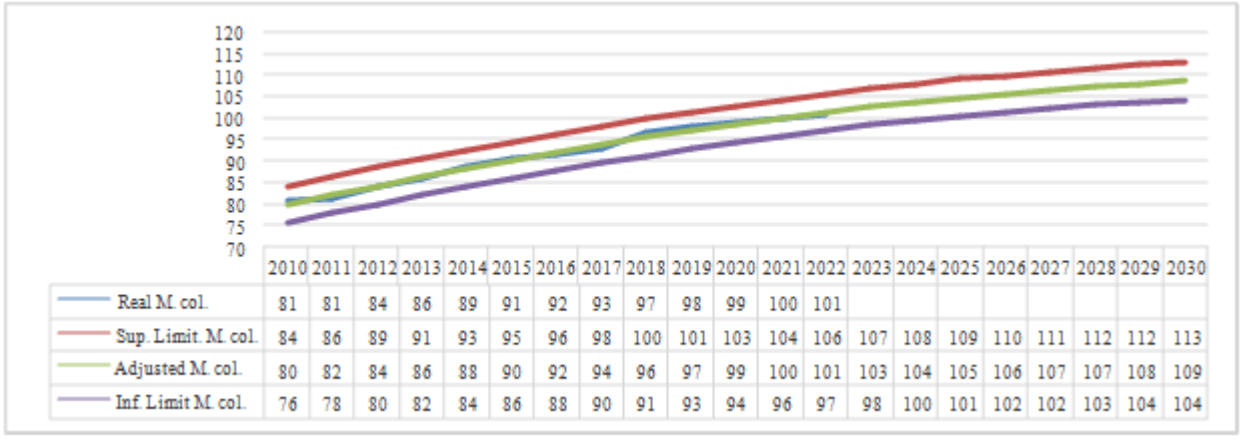


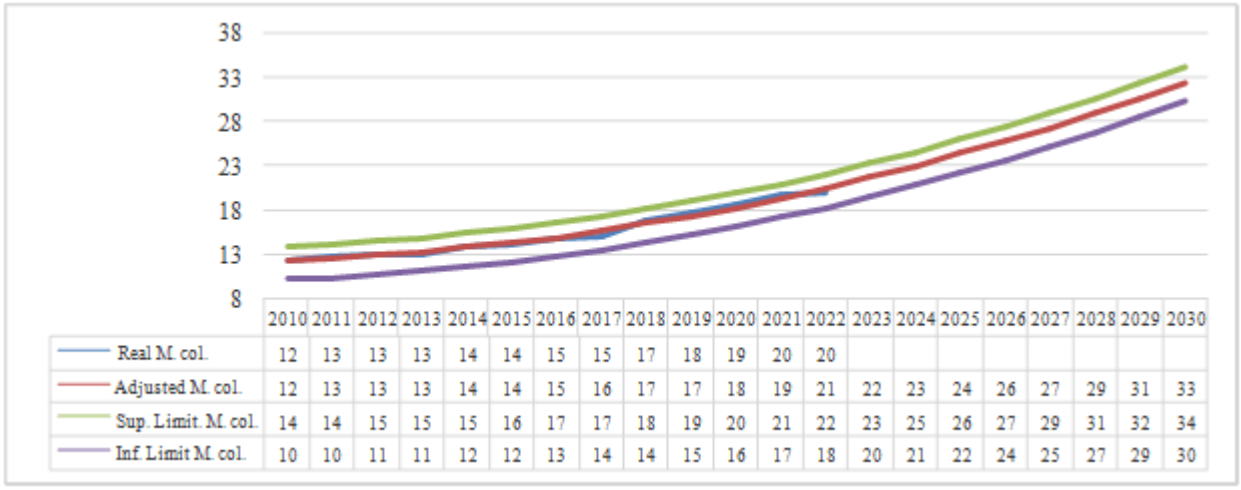
Fig. 6. The trend in the number of bee colonies, worldwide during the period 2023-2030 and the 95% confidence limits (t= 2.17: DL= 12)

Source: Own calculations.

Trend in the Growth of Bee Colonies within the EU-27 was calculated using the equation:

Y(EU bee colonies) = 0.0411x^2+0.1006x+12.221 (R^2=0.985, r=0.992) (Fig. 7).

The trend in the number of bee colonies within the European Union (EU-27) was calculated, showing significant growth projected between 2023 and 2030. By 2030, the number of colonies is expected to reach 34.1 million, with confidence limits ranging from 30.3 million to 32.5 million colonies.



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Real M. col.	12	13	13	13	14	14	15	15	17	18	19	20	20								
Adjusted M. col.	12	13	13	13	14	14	15	16	17	17	18	19	21	22	23	24	26	27	29	31	33
Sup. Limit. M. col.	14	14	15	15	15	16	17	17	18	19	20	21	22	23	25	26	27	29	31	32	34
Inf. Limit M. col.	10	10	11	11	12	12	13	14	14	15	16	17	18	20	21	22	24	25	27	29	30

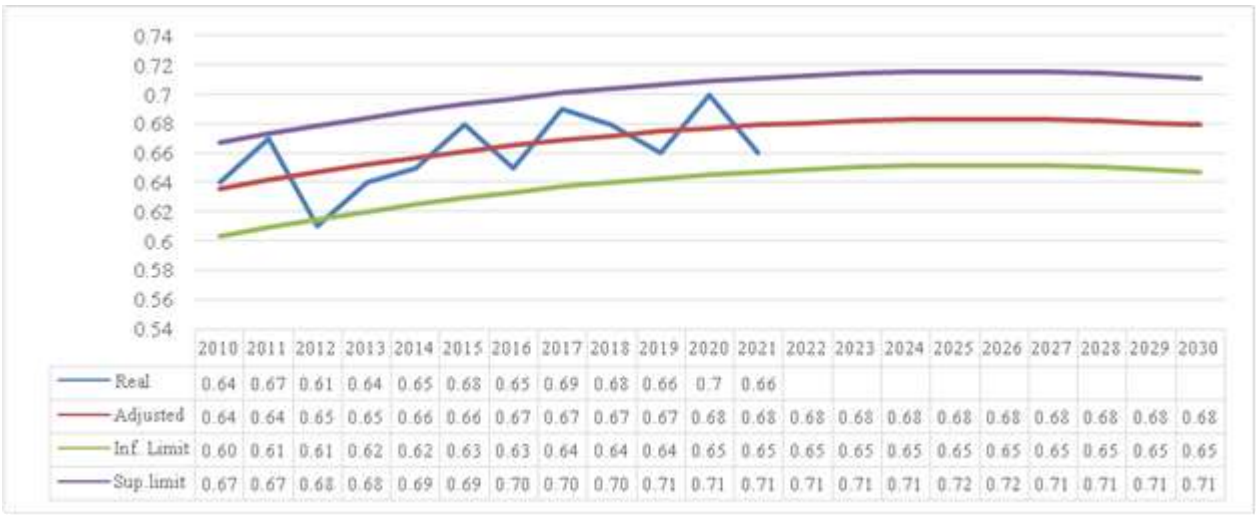
Fig. 7. The trend in the number of bee colonies in the European Union during the period 2023–2030 and the 95% confidence limit
Source: Own calculations (t= 2.17: DL= 12).

Projection of Annual Honey Consumption per Capita in the EU

At the European Union level, the projected annual honey consumption per person, based on the trend given by the regression equation:

$Y(kg/person/year) = -0.0002x^2 + 0.0066x + 0.6289$ ($R^2 = 0.3322$, $r = 0.576$)

It will range between 0.68 kg/person/year and 0.71 kg/person/year, with a 95% probability. This indicates a stagnation compared to the year 2021 (Fig. 8).



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Real	0.64	0.67	0.61	0.64	0.65	0.68	0.65	0.69	0.68	0.66	0.7	0.66									
Adjusted	0.64	0.64	0.65	0.65	0.66	0.66	0.67	0.67	0.67	0.67	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68
Inf. Limit	0.60	0.61	0.61	0.62	0.62	0.63	0.63	0.64	0.64	0.64	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Sup. limit	0.67	0.67	0.68	0.68	0.69	0.69	0.70	0.70	0.70	0.71	0.71	0.71	0.71	0.71	0.71	0.72	0.72	0.71	0.71	0.71	0.71

Fig. 8. The trend of the honey consumption per capita in the European Union during the period 2023–2030 and the 95% confidence limits
Source: Own calculations (t= 2.17: DL= 12)

Programs and development directions for beekeeping at the European and Romanian levels

Programs supporting the development of beekeeping

In EU member states, the beekeeping sector has been supported through the instruments of the Common Agricultural Policy (CAP) since the second half of the 1990s. Until the end of 2022, this support was implemented through voluntary National Apiculture Programs [23], developed and executed by each EU member state. Starting January 1, 2023, beekeeping support is provided through sectoral interventions, a component of the CAP Strategic Plans for the 2023–2027 period. These plans are designed at the national level and define how each EU country will direct support to achieve the economic, environmental, and social objectives of the CAP.

According to EU Regulation 2021/2115, seven types of interventions are available to member states, funded by the European Agricultural Guarantee Fund (EAGF). Member states select the most suitable interventions based on the specific characteristics of their national beekeeping sector.

a) Beekeeping Sectoral Plan in Romania's National Strategic Plan

For the 2023–2027 period, Romania's National Strategic Plan for the beekeeping sector includes the following measures:

-Advisory services, technical assistance, training, information dissemination and the exchange of best practices;

-Acquisition of equipment by associative organizations for wax processing to produce artificial combs, as well as equipment for honey packaging;

-Combating hive pests and diseases, especially varroosis;

-Rationalization of transhumance;

-Repopulation of hives, including bee improvement programs;

-Support actions for apiculture product testing laboratories, aimed at reimbursing physical-chemical and residue analyses to certify honey quality—this serves as a protective measure against the recent influx of low-quality honey imports;

0Promotion, communication, and marketing, including market monitoring activities.

Each EU member state benefits from specific funds for implementing these measures, and projects are monitored at the national level to ensure their efficiency and impact (European Commission, 2022) [10]. For the 2023–2027 period, the total amount allocated to the Romanian beekeeping sector through these interventions is estimated at €60,816,300 (National Strategic Plan 2023–2027).

b) In addition to the support provided under CAP Pillar I, complementary measures funded through the European Agricultural Fund for Rural Development (EAFRD) under Pillar II aim to strengthen beekeeping operations.

These include:

-Investments for small-scale agricultural holdings practicing beekeeping;

-Establishment and strengthening of operations run by young farmers in the beekeeping sector;

-Investments to develop livestock farms, where beekeeping subsector investments are eligible;

-Investments in processing, conditioning, and storage of agricultural products;

-Establishment of producer groups.

c) Research and Innovation Projects

The European Union funds research projects in the field of beekeeping, aimed at:

-Bee health and disease prevention.

-Development of innovative technologies for hive monitoring and production improvement.

-Studies on the impact of climate change on bees and pollinators.

These research projects are implemented through programs such as Horizon Europe, which support innovation and the sustainable growth of the beekeeping sector (FAO, 2021) [14].

2. National Beekeeping Development Programs

a) The National Beekeeping Program (PNA) in Romania was established in 2008 as part of a broader plan to support the national beekeeping sector. Over the years, the program has been adjusted and expanded, and since 2021, the measures and funds allocated for beekeeping have been included in the National Strategic Plan (PNS) for the 2023–2027 period [23].

The PNS includes support measures and subsidies for beekeepers:
-Support for improving bee colony health and disease control.
-Subsidies for organic beekeeping and best beekeeping practices.
-Investments in beekeeping equipment and infrastructure.
-Continuous professional training for beekeepers.
These measures aim to strengthen Romania's beekeeping sector, increase competitiveness, and protect the environment (Ministry of Agriculture and Rural Development, 2023) [23].
b) Subsidies for Bees and Pollinators' protection
Under its national environmental policy, Romania has implemented support measures for pollinators' protection, including bees 'protection. These measures include:
-Promoting the use of bee-friendly pesticides.
-Creating protected habitats for pollinators as part of national environmental and rural development programs.
These initiatives are essential for preserving biodiversity and ensuring sustainable agricultural production (Ministry of Environment, 2022) [24].

Development Directions

Apiculture is undergoing continuous development, with its future shaped by the need to address global challenges while leveraging the economic and ecological opportunities of the sector. At both European and national levels, clear trends and strategies are emerging, focusing on modernization, sustainability, and increased efficiency in beekeeping.
The European Union is concerned with both beekeeping and the marketing of honey. Article 55 of Regulation (EU) No. 1308/2013 stipulates that each member state must have a national program covering up to 50% of hive-related expenses. Directive (EU) 2024/1438 introduces strict requirements for honey labeling, mandating the clear specification of both the floral and geographical origin of honey to increase transparency for consumers [9]. This directive amends Directive 2001/110/EC to combat the practice of blending honey from various sources without proper disclosure. Efforts are also underway to harmonize regulations across the EU, ensuring better protection for local producers. At the same time, Regulation (EU) 2017/625 establishes measures to control and combat honey adulteration by producers within and outside the EU. Additionally, a platform has been launched to exchange data on bee health (CAgr, 2024)[7].
Considering the role of beekeeping in economic sustainability and biodiversity, development proposals aim to strengthen the sector's resilience and competitiveness at both European and Romanian levels.
Development of sustainable and organic beekeeping. There is a growing demand for organic beekeeping products in Europe, making organic apiculture a significant opportunity. The European Union supports this type of beekeeping through funding and regulations promoting sustainable production methods (e.g., initiatives like the *EU Pollinators Initiative*) (European Commission, 2022) [10]. European beekeepers are encouraged through integrated measures to adopt practices that minimize environmental impact, avoid pesticide use, and protect local biodiversity. Thus, stimulating the acquisition of modern equipment, certified organic beehives, identifying and protecting regions with high biodiversity, creating a national brand for Romanian organic honey, promoting the benefits of organic honey to consumers, etc. would support organic production and contribute to raising beekeepers' awareness of this market opportunity.
Certification of organic beekeeping products is becoming increasingly important. Financial support measures to cover costs associated with organic certification, including inspections and required documentation, as well as simplifying the certification process, would encourage more beekeepers to adopt organic practices. This would provide beekeepers with the opportunity to access broader international markets with higher prices for organic products (Kumar et al., 2024) [20].
Digitalization and innovation in beekeeping. Modern beekeeping increasingly relies on

digital technology. Across Europe, many beekeepers are adopting hive monitoring systems, which include sensors for temperature, humidity, and bee movement. These technologies enable beekeepers to monitor hive health and respond quickly to problems. Research projects, such as "BeeProtect", exemplify the implementation of smart technologies in apiculture (Bee Culture, 2023) [4]. Investment support measures in beekeeping that encourage the adoption of IoT devices, artificial intelligence systems, big data, blockchain, remote sensing, and mobile applications would provide Romanian beekeepers with the tools needed to improve efficiency and competitiveness, both locally and internationally.

The automation of honey harvesting and other apicultural processes reduces costs and increases efficiency. The use of modern equipment, such as automatic centrifuges and machines for wax extraction, is growing. These innovations enable beekeepers to enhance their productivity and improve the quality of their products.

Professional training and apicultural education. In Europe, many countries offer training and education programs for beekeepers. These programs should focus on adapting to modern technologies, utilizing digital tools and implementing sustainable beekeeping practices to address ecological and economic challenges. Additionally, supporting apicultural education initiatives to prepare beekeepers to tackle climate change and other risks is vital (European Commission, 2022) [10].

Support for apicultural research is another crucial aspect of the sector's development. The European Union funds research projects aimed at improving bee health, the quality of apicultural products, and pollination methodologies. The participation of beekeepers' associations alongside universities and research institutions in such initiatives is essential for identifying practical solutions to challenges such as diseases and the decline in bee populations (FAO, 2021) [13].

Market development for apicultural products. At both European and global levels, there is growing interest in high-quality honey and apicultural products with proven health benefits, such as royal jelly and propolis. Romania has significant potential to become an important exporter of organic honey and other apicultural products to international markets. These products are increasingly valued for their health benefits and are in high demand, especially in markets such as Asia and North America (Bee Culture, 2023) [4].

Within the European context, beekeepers are encouraged to invest in marketing their products by promoting the unique characteristics of honey and other apicultural goods (e.g., promoting honey and apicultural products with protected geographical indication (PGI)). Increasing visibility in international markets and educating consumers about the benefits of these products is essential for boosting demand (Kumar et al., 2024) [19].

Sustainability, bee protection, and diversity. The European Union has implemented policies to reduce the use of harmful pesticides and support initiatives to conserve bees' natural habitats. These measures include ecological protection zones and awareness programs for both beekeepers and farmers (FAO, 2021) [14].

Another important direction for the development of apiculture is the promotion of diversity in beekeeping practices. Romania has immense resource potential that could be harnessed through integrated measures to encourage: expanding the range of products (e.g., propolis, royal jelly, wax, pollen, and bee venom), developing innovative, high-value-added products (e.g., dietary supplements, natural cosmetics), protecting and conserving local genetics, as well as integrating beekeeping with other agricultural activities, such as agritourism, diversifying beekeeping practices and promoting more resilient bee species can help maintain hive health and reduce risks associated with diseases and climate change (IPBES, 2019) [17].

The development directions of beekeeping are oriented towards sustainability, innovation and environmental protection. In Europe and in Romania, beekeeping can benefit from support through favorable European policies, education and continuous training, and beekeepers can exploit modern technologies to

improve production and access wider external markets. It is essential that the beekeeping sector responds to global challenges and contributes to sustainable development, while protecting biodiversity and supporting local economies.

CONCLUSIONS

Beekeeping significantly contributes to agricultural production through pollination, which is estimated to be worth over $200 billion annually. It supports ecosystem stability and rural economies, playing a strategic role in food production and biodiversity conservation. Analyses indicate a global increase in the number of bee colonies and honey production, although there are regional variations. Asia leads both in production and exports due to floral diversity and favorable economic conditions, supported by low per capita honey consumption. In Europe, steady growth is observed, largely due to legislative support.

Stress factors such as climate change, habitat loss, pesticide use, and diseases affect bee health. Approximately 40% of pollinator species are threatened, necessitating targeted support policies.

Directive (EU) 2024/1438 introduces strict standards for honey labeling, requiring the disclosure of floral and geographical origins. Additionally, national and European programs support bee health, organic beekeeping, and technological innovation, including the digital monitoring of hives.

By 2030, trend models predict a continuous increase in the number of bee colonies and honey production, while per capita consumption in the European Union will stagnate. This stabilization highlights the need for market diversification and the promotion of apicultural products.

The integration of organic beekeeping, digitalization of operations and continuous beekeeper training are necessary. Establishing a strong legislative framework and educating consumers about the benefits of apicultural products are priorities for ensuring sustainability.

The analysis shows the need for an integrated approach to protect bees, modernize beekeeping and respond to global challenges. Legislative support and technological innovation will be essential to increase the sustainability and competitiveness of the beekeeping sector.

REFERENCES

[1]Abro, Z., Kassie, M., Tiku, H.A., Taye, B., Ayele, Z.A., Ayalew, W., 2022, The Impact of Beekeeping on Household Income: Evidence from North-Western Ethiopia. Heliyon 2022.

[2]Akanda, M. K. M., Mehjabin, S., Parvez, G. M., 2024, Honey for Nutrition and Health Benefits: An Overview. Honey in Food Science and Physiology, 33-56.

[3]Adjare, S.O., 1990, Beekeeping in Africa.FAO Agricultural Services Bulletin.

[4]Bee Culture, 2023, Honey Statistics: A Deep Dive into the Hive, https://media.market.us/honey-statistics/, Accessed on October 2024.

[5]Bogdanov, S., Jurendic, T., Sieber, R., Gallmann, P., 2008, Honey for nutrition and health: a review. Journal of the American college of Nutrition, 27(6), 677-689.

[6]Brodschneider, R., Crailsheim, K., 2010, The influence of dietary protein on the honeybee (*Apis mellifera* L.) colony performance: A review. Apidologie, 41(3), 1-15

[7]Cotidianulagricol (CAgr), 2024, Health status of bees, https://www.cotidianulagricol.ro/starea-de-sanatate-a-albinelor-parteneriatul-pentru-date-reprezinta-o-piatra-de-hotar-in-campania-europeana/, Accessed on November 2024.

[8]Crane, E., 1999, The World History of Beekeeping and Honey Hunting. Routledge, Londra.

[9]Directive (EU) 2024/1438 amending Directive 2001/110/EC on honey - Directive (EU) 2024/1438, https://eur-lex.europa.eu/legal-content/RO/TXT/?uri=CELEX:32024L1438, Accessed on January 2025.

[10]European Commission, 2022, EU Policy for Pollinators and Beekeeping.

[11]FAO, 2018, The state of the world's pollinators. Food and Agriculture Organization of the United Nations, http://www.fao.org, Accessed on September 2024.

[12]FAO, 2020, Honey Production and Trade, *FAO* Statistical Yearbook, https://www.fao.org/statistics/en/. Accessed on September 2024.

[13]FAO, 2021, Global Importance of Pollinators. Food and Agriculture Organization.

[14]FAO, 2021, Reports of the Food and Agriculture Organization of the United Nations on honey production and trade. https://www.fao.org, Accessed on September 2024.

[15]FAOSTAT, 2024, Data on Apiculture, https://www.fao.org/faostat/fr/#data/QCL, Accessed on October 2024.

[16]Honey Market Reports, 2023, Recent analyses of the global honey market, https://www.reportlinker.com/, Accessed on November 2024.
[17]IPBES, 2019, Global Assessment on Pollinators and Ecosystem Services.
[18]Klein, A. M., Vaissière, B. E., Cane, J. H., Steffan-Dewenter, I., Cunningham, S. A., Kremen, C., Tscharntke, T., 2007, Importance of pollinators in changing landscapes for world crops. Proceedings of the Royal Society B: Biological Sciences, 274(1608), 303-313.
[19]Kumar, K. S., Bhowmik, D., Biswajit, C., Chandira, M. R., 2010, Medicinal uses and health benefits of honey]: an overview. J. Chem. Pharm. Res, 2(1), 385-395.
[20]Kumar, Ashutosh & Vahoniya, Dilip & Rajwadi, Alvira. (2024). Navigating the Honey Markets Across Europe and Africa. Asian Journal of Agricultural Extension Economics & Sociology. 42. 266-275. 10.9734/ajaees/2024/v42i52436.
[21]Mouriquand, D., 2023, Buzz off! Nearly half of honey in European markets is fake, according to EU investigation. Euronews. https://www.euronews.com/culture/2023/03/27/buzz-off-nearly-half-of-honey-in-european-markets-is-fake-according-to-eu-investigation, Accessed January 2025
[22]Market Research Future, 2021, Honey Market Research Report – Forecast to 2027, https://www.marketresearchfuture.com/.Accessed on September 2024.
[23]Ministry of Agriculture and Rural Development, Romania, 2023, National Beekeeping Program, https://www.madr.ro/programul-national-apicol.html, Accessed on August 2024.
[24]Ministry of Environment, Romania, 2022, Pollinator Protection Projects, https://www.mmediu.ro. Accessed on August 2024.
[25]Pocol, C.B., Šedík, P., Brumă, I.S., Amuza, A., Chirsanova, A., 2021, Organic Beekeeping Practices in Romania: Status and Perspectives towards a Sustainable Development, Agriculture, 11, 281
[26]Popescu A., Dinu T.A., Stoian E., Serban V. 2024, Beehives and honey production - a brief statistics in the world and European Union 2000-2022 and honey bees between interlinked crisis of biodiversity, pollution and climate change. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 24(3), 655-676.
[27]Popescu A., Dinu T.A., Stoian E., Serban V., 2021, Honey Production In The European Union In The Period 2008-2019- A Statistical Approach. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 21(2), 461-474.
[28]Popescu, A., Dinu, T.A., Stoian, E., Serban, V., 2020, Bee honey production concentration in Romania in the EU-28 and global context in the period 2009-2018, Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 20(3), 413-430.
[29]Potts, S. G., Biesmeijer, J. C., Kremen, C., Neumann, P., Schweiger, O., Kunin, W. E., 2010, Global pollinator declines: trends, impacts, and drivers. Trends in Ecology & Evolution, 25(6), 345-353.
[30]Prodanović, R., Brkić, I., Soleša, K., Ljubojević Pelić, D., Pelić, M., Bursić, V., Vapa Tankosić, J., 2024, Beekeeping as a Tool for Sustainable Rural Development, Journal of Agronomy Technology and Engineering Management (JATEM) 7(2):1054-1066
[31]Różański, K., 2022, Current Problems Facing Apicultural Activity. Studia Iuridica, (95), 408-420.
[32]Savoiu, Gh., 2011, Econometrics, Universitara house Publishing.

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ENERGY EFFICIENCY OF AGRICULTURAL TECHNOLOGIES THROUGH THE CREATION OF A SUSTAINABLE MODEL: A CASE STUDY OF GREENHOUSES

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Abstract

Ecological sustainability in agriculture involves the responsible and efficient use of natural resources, promoting practices that protect the environment and ensure long-term productivity. The paper aims to achieve the conceptual design of an agricultural greenhouse, including the elements necessary for the automation of installations to accomplish optimal energy efficiency. A generalized input-output optimized model was developed for a controlled agricultural technological process of plant growth. The model can identify the functional links between the variables of an agricultural technological process and allows for the global or partial optimization of the process, based on economic-organizational and technical-ecological criteria. Considering the cycle of crop cultivation in protected spaces, a calculation is also presented regarding the optimization of the duration of the operating cycles, taking into account various factors, in order to maximize production and minimize costs, in a sustainable and economic framework. The integration of automated systems in agricultural greenhouses significantly improves efficiency, reduces energy consumption, and boosts productivity. By utilizing IoT, automation, and data logging, these systems enable optimal environmental control and remote monitoring, ultimately maximizing both economic and environmental benefits in greenhouse farming.

Key words**:** *energy efficiency, automation, agriculture, greenhouse, input-output model, economic sustainability*

INTRODUCTION

Sustainability in agriculture represents an integrated approach that ensures efficient food production while protecting the environment and resources for future generations (Çakmakçı et al., 2023) [3].

The concept of energy is not limited to large infrastructures but also focuses on efficiency, where reducing energy costs involves both changing ideologies and human behaviour, as well as adopting modern technologies (Sorrell, 2015) [27].

Agriculture in the Balkan region of Europe is characterized by high energy consumption due to harsh winters and significant greenhouse heating requirements (Knez et al., 2022) [11].

A major challenge in promoting a mindset shift among farmers and optimizing energy use for year-round crop production is the way energy is generated and managed in this region (Sulewski et Wąs, 2024) [29].

Agricultural greenhouses are robust structures built from durable materials such as glass, metal, or polycarbonate panels, supported by sturdy steel or aluminium frames. They provide superior thermal insulation, maintaining a constant temperature year-round, and are equipped with heating and mechanical ventilation systems to operate efficiently even in extreme weather conditions (Maraveas et al., 2023) [17].

They are mainly used for intensive crops, including flowers, vegetables, or exotic plants,

allowing full control over environmental factors such as temperature, humidity, light, and ventilation (Morgan, 2022) [20].

However, these benefits come at a high cost, both for construction and maintenance, due to the materials and automation equipment required.

Therefore, modernization of greenhouses cannot be carried out without investments (Kusz, 2014) [14].

The Romanian legislative framework regulating measures to increase energy efficiency across all sectors, including agriculture, alongside Romania's Energy Strategy 2020-2030, supports the use of renewable sources such as solar energy and biomass, and the modernization of agricultural infrastructure to reduce energy consumption (ME-RO, 2020) [19]. Additionally, agricultural projects focused on energy efficiency and the use of renewable energy are being promoted, and farmers are supported through subsidies for purchasing modern equipment and upgrading greenhouses (RO law, 2014) [25].

European regulations on energy efficiency in agriculture set measures to promote energy efficiency, with a target to reduce energy consumption by 32.5% by 2030, encouraging the use of modern technologies and renewable sources. The European Green Deal supports the transition to sustainable and efficient agriculture through the "Farm to Fork" initiative, focused on reducing emissions and increasing the use of renewable energy. The Common Agricultural Policy (CAP) 2023-2027 supports these goals with funding for farm modernization, installation of solar panels, and the digitalization of agricultural processes for more efficient energy use (Directive EU, 2018) [6].

Agricultural greenhouses allow the extension of the growing season, promoting the cultivation of plants outside their natural season, and improve yields by providing optimal growing conditions. At the same time, greenhouses contribute to resource efficiency by reducing water and energy losses through modern technologies, and offer effective pest control through isolation and monitoring (Al-Qudah et al., 2025) [2].

Intelligent systems dedicated to farmers, through which they gain complete control over agricultural greenhouses, involve automating functions that provide full control of the facility.

Important results have been achieved in tomato growing in protected areas (Jeca and Smedescu, 2023; Toma-Diaconu and Vochin, 2024) [10, 31], but they require investments in modern integrated greenhouses (Zbanca and Negritu, 2013) [36].

These systems allow growers to create optimal growing conditions for agro-food products, including smart electrical installations (lighting, outlets, interior or exterior blinds for shading/shutters, insulation systems, etc.), heating, ventilation, and air conditioning (HVAC) systems, as well as remote control of the greenhouses (Dhanaraju et al., 2022) [5].

Depending on the complexity of the greenhouse, the design of the installations, and their level of automation, energy consumption can be reduced by 20-30% (Muñoz-Liesa et al., 2022; Trépanier et al., 2025) [21, 32]. By automating the installations, the sources that power the equipment can be controlled, eliminating unnecessary costs (Tayefeh et al., 2024) [30].

The main objective of the study is to provide a practical solution capable of reducing the energy costs of agricultural greenhouses, water usage, and crop yield while minimizing human intervention. The proposed greenhouse management system will integrate functions such as lighting control, temperature and humidity regulation, shade control system, CO_2 level monitoring, and remote-control capabilities.

MATERIALS AND METHODS

1.Smart Greenhouse: Key Components and Process

Equipment Used

The equipment used in the greenhouse automation process features a direct KNX connection, eliminating the need for any adapter interface.

KNX is a standard in the field of automation for industrial and agricultural buildings. It is regulated by the international standard

ISO/IEC 14543-3, the European standards CENELEC EN 50090 and CEN EN 13321-1, as well as the Chinese standard GB/Z 20965.

KNX has a significant connection with agricultural greenhouses, as it can be used for the automation and optimization of essential greenhouse systems. This open standard enables the automatic control of temperature, humidity, ventilation, and lighting, ensuring optimal conditions for plants. Additionally, KNX can manage automated irrigation by integrating soil moisture sensors, optimizing water consumption. Moreover, it can help reduce costs through efficient energy management and the integration of renewable energy sources. KNX facilitates connectivity with IoT devices and allows real-time monitoring of greenhouse parameters, thereby enhancing agricultural efficiency and productivity.

In order to ensure data transfer between all components of the greenhouse management system, a solution is needed to address the communication with isolated devices, ensuring that all components communicate in a unique common language: in short, a system such as the KNX BUS, independent of the manufacturer and the application domain. In the KNX environment, all devices are connected to the same BUS (twisted pair, RF, power lines, or IP/Ethernet), allowing them to communicate with each other.

KNX devices (Figure 1) can include: sensors or actuators required for controlling various building systems, such as lighting, interior or exterior shading/blinds, insulation systems, security systems, energy management, heating, ventilation, and air conditioning systems, signalling and monitoring systems, interfaces with building service and control systems, remote control, metering, audio/video control, household appliances, etc.

All these functions can be controlled, monitored, and signalled through a unified system without the need for additional control centers.

Moreover, the lighting can be automatically controlled based on the intensity of natural light, thus maintaining a specified minimum level in each location and reducing energy consumption (Lee et al., 2024) [15].

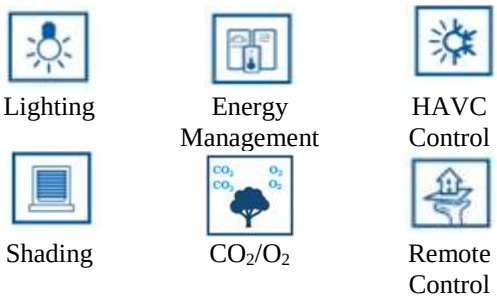

Fig. 1. Example of a KNX control system
Source: Own adaptation based on [13].

By interconnecting all communication devices into a single BUS, the design and installation time is significantly reduced. Engineering Tool Software (ETS), a manufacturer-independent software applicable across different domains, allows for the design and configuration of installations containing KNX-certified products. Since the software is manufacturer-independent, the system integrator can combine products from various manufacturers with different communication media (twisted pair, radio frequency, power line, or IP/Ethernet), all within a single installation. Additionally, a KNX installation can be easily adapted to new applications and is highly expandable. New components can be easily connected to the existing BUS installation (KNX RO, 2025) [12].

ETS (Engineering Tool Software) is a program that runs on the Windows operating system, allowing the development and configuration of control systems for the automation of smart agricultural greenhouses. In general, greenhouse software helps optimize design, management, and maintenance processes by leveraging advanced technological solutions.

Climate management software, such as Priva Compass, HortiMaX, and Argus Controls, enables automated control of temperature, humidity, irrigation, and lighting, while also providing real-time monitoring and reporting. For efficient water management, applications like Rain Bird IQ, Netafim CMT, and HydroPoint Baseline optimize irrigation and water consumption, reducing waste and improving efficiency. Sensor integration for monitoring and analysis is facilitated by solutions such as Climate FieldView, FarmLogs, and Grodan e-Gro, which analyze

climate data and suggest optimal adjustments (Ray et al., 2024) [24].

Lighting Control

Lighting control in agricultural greenhouses is essential for ensuring optimal plant growth conditions, especially during periods of insufficient natural light or in covered greenhouses. Supplemental lighting, usually provided by LED lamps, helps extend photosynthesis periods, stimulating plant development and improving yield production. It aids in regulating growth rates, ensuring uniform plant development, and reducing stress caused by the lack of natural light. Additionally, optimizing lighting reduces energy consumption and costs, enhancing the overall efficiency of agricultural production.

Lighting control can be performed simultaneously based on predefined scenarios or separately for each lighting group. On/off lighting will be controlled using multifunction switches. By using LED bulbs, energy consumption can be reduced by up to 30% (Ganandran et al., 2014) [9].

Table 1 provides a comparison of the advantages and disadvantages of LED (Light Emitting Diode) lighting versus HPS (High Pressure Sodium) lighting.

Table 1. Advantages and Disadvantages (LED vs. HPS)

Description of characteristics	LED	HPS
Lifespan (average 10 hours/day)	>50,000 h	22,000 h
Additional consumption (start, stop, cool)	NO	YES
Energy efficiency (electricity converted into light)	90-95%	18-23%
UV radiation and toxic material content	NO	YES
Light dispersion without a reflector	YES	NO
Multiple optional color temperatures	YES	NO
Instant ignition and "0.0s" cooling times and operating frequency	YES	NO
Possibility of low voltage power supply	YES	NO
Higher mechanical shock resistance	YES	NO
Constant light flux and flicker-free	YES	NO

Source: Own adaptation based on [35].

In access and auxiliary areas, dimmable lighting is recommended, with the possibility of adjusting light intensity and/or maintaining a constant intensity.

Energy savings of between 28% and 66% can be achieved by maintaining the lighting at an intensity of 500-700 lux, depending on the season, weather, and the building's geographical location.

However, in industrial or plant areas, stronger lighting of over 1,000 lux is required. This is also relevant for agricultural greenhouses, especially for plants that need strong lighting to support photosynthesis and rapid growth. In greenhouses, supplemental lighting is often used to compensate for the lack of natural light or to extend daylight periods under insufficient lighting conditions (Singh et al., 2014) [26].

For example, for plants growing in a greenhouse, such as vegetables or flowers, a light intensity between 1,000 and 2,000 lux may be necessary to support optimal development, especially during active growth stages or in winter periods when natural light is limited.

Stronger lighting can also be used to stimulate certain processes, such as flowering or fruiting, depending on the needs of the specific crop.

However, it is important for the lighting to be properly adjusted, as too strong or too weak light can negatively impact plant development.

Temperature control

Temperature control can be done zonally by closely monitoring a set of temperature values, either from multifunctional switches or a mobile phone.

Additionally, there is the possibility of simultaneous control of multiple rooms or based on pre-established schedules according to requirements, such as winter/summer mode, day/night mode, freeze temperature alarm, and overheating alarm.

The temperatures mentioned earlier are examples; for each type of space, temperatures will be set according to needs. In each room, the required temperature can be adjusted by +/- 5°C locally, from the temperature controller's buttons.

Cooling of the spaces will be done by automatically controlling the windows/blinds or the ventilation system.

Temperature control in agricultural greenhouses is essential for ensuring optimal conditions for plant growth and development, directly influencing their health, production, and quality.

Correct temperatures stimulate physiological processes, prevent heat stress, and reduce the risk of diseases, ensuring seasonal flexibility and energy efficiency. Thus, careful

temperature management contributes to producing uniform, high-quality products and increasing the sustainability of protected agriculture (Akpenpuun et al., 2023) [1].

Shading control

The automation solution can include control of interior or exterior electric blinds for shading.

Control can be done both locally and remotely.

This type of control can also be paired with time schedules for automatic operation. The greenhouse management system will also allow the operation of the blinds through specific software.

With the help of a weather station, an automatic shading system for areas directly exposed to solar radiation can be implemented.

Automatic shading of certain sections or greenhouse walls involves the automatic control of blinds/shutters based on the position of the sun.

The weather station determines the position of the sun and the solar radiation on a building facade, thus determining the optimal position of the blinds. Additionally, the position of the blinds' slats is crucial.

In the summer, during the hottest periods of the day, the blinds/shutters are lowered to reflect heat, and the slats are rotated to allow as much natural light as possible into the greenhouse. In contrast, in the winter, the blinds/shutters are opened when the sun shines to capture heat.

This automatic control mode can be turned off at any time, and the blinds/shutters will remain in the desired position.

By using interior or exterior shading blinds, shutters, or insulation systems, energy savings of up to 40% can be achieved (Eigbrett, 2015) [8].

The control of blinds or shutters in agricultural greenhouses plays a crucial role in regulating light and temperature, protecting plants from overexposure or heat loss.

These systems prevent heat stress, optimize the photosynthesis process, and contribute to energy efficiency by reducing reliance on other cooling or heating methods.

By maintaining a balanced microclimate, the blinds and shutters ensure healthy plant growth and improve production quality.

CO_2 level control

Monitoring gases such as carbon dioxide, oxygen, ammonia, carbon monoxide, and nitrogen oxides are essential in an agricultural greenhouse to ensure an optimal growing environment.

CO_2 stimulates photosynthesis, while oxygen supports the respiration of plants and microorganisms in the soil.

Pollutants such as carbon monoxide or ammonia can become toxic at high concentrations, affecting plant health and productivity.

Maintaining optimal concentrations, monitored by specialized sensors, is crucial to prevent plant stress and maximize agricultural production.

Monitoring and controlling CO_2/O_2 levels in spaces is an important aspect when considering plant health, safety, and energy efficiency. The air inside greenhouses must maintain an optimal level, typically between 400-1,000 ppm, to stimulate plant growth and productivity.

Humidity control

Humidity control in both the atmosphere and soil in greenhouses is essential for maintaining an optimal environment for plant growth, preventing diseases, and maximizing production.

Atmospheric humidity influences the plant transpiration process and gas exchange, and excessive levels can encourage the growth of mold and fungal diseases.

On the other hand, insufficient humidity can lead to plant dehydration and water stress.

Regarding the soil, the moisture level plays a crucial role in water absorption by the roots. Soil that is too dry can hinder plant development, while excessive water can cause root rot and the growth of pathogens.

For effective control, specialized sensors are used to continuously monitor moisture levels and enable automated interventions. Atmospheric humidity sensors, such as DHT22 or SHT31, measure relative humidity and send data to a centralized system. Meanwhile, soil moisture sensors, like YL-69 or SEN0193, detect the water content in the soil and can activate automated irrigation.

The automation system receives the data from the sensors and controls the equipment.

When atmospheric humidity exceeds the optimal threshold, fans or dehumidifiers can be activated, and if the soil becomes too dry, the system can automatically start irrigation.

Remote control

The visualization solution provides the ability to read the status of greenhouse functions and send commands from within the greenhouse or adjacent spaces via a Wi-Fi network or remotely through an internet connection.

Such a solution is designed for convenience, allowing full access to all greenhouse functionalities (lighting, setpoint temperature, blind/shutter control, scenarios) via a tablet or mobile phone.

The proposed equipment is the Wiser for KNX, which allows communication between multiple protocols such as IP, KNX, ModBus, and BACnet.

With this logic controller, it is possible to control the lighting, blinds or shutters, as well as the heating and ventilation systems, thus ensuring optimal conditions to meet all the specific requirements of the plants in the greenhouse.

Distinct time schedules can be created depending on the type of crops or time period. Since the KNX system can record consumption data for gas, water, and electricity, this data can be retrieved in the visualization and displayed in graphs that show consumption over time, whether by week, month, or year.

RESULTS AND DISCUSSIONS

1. Development of a Generalized Input-Output Model for Greenhouse Cultivation

Greenhouse vegetable cultivation technology may or may not include operations such as fertilization, irrigation, phytosanitary treatments, plant support, artificial pollination, and climate control, depending on the crop requirements and the type of protection used.

Achieving high-yield production depends on factors such as the correct selection of varieties, optimal management of environmental conditions, appropriate application of fertilizers and phytosanitary treatments, as well as efficient control of irrigation and pests.

Figure 2 shows the general diagram of vegetable cultivation in a protected system.

From this phytotechnical flow diagram, it can be concluded that the process of vegetable cultivation in greenhouses is generally complex and tailored for each type of vegetable.

The technological phases require control using a process computer with high reliability.

Its communication with the process is achieved through process interfaces with a maximum of x inputs and y outputs (x - the number of parameters taken from the process as response variables, r; y - the number of commands generated to control the process, c).

Starting from the generalized technological action system, the construction of the optimization system begins with defining a generalized input-output model for the agricultural process of obtaining vegetable crops.

The structure of the generalized input-output model, for which the following groups of variables are introduced, considered as vector variables:

I. Input variables (factors of the process) that play the role of causes, which are, from a technical standpoint, controlled and commanded quantities, structured into the following groups:

a)Input variables related to the greenhouse infrastructure (I), such as strength, reliability, and equipment, which influence the overall system performance and the efficiency of operations, ensuring optimal conditions for plant development and protection from external factors.

b)Input variables related to the plants (P), such as appearance, size, taste and aroma, texture, environmental resistance, and nutritional content, which determine the quality of the final product and the plants' ability to adapt to greenhouse growth conditions, thereby influencing yield and crop viability.

c)Input variables related to the environment (E), such as temperature, atmospheric humidity, soil moisture, and light intensity, which directly influence plant growth and development, having a significant impact on production and crop quality.

d)Input variables related to actions (A), such as greenhouse preparation, planting, plant care (irrigation, fertilization, pest protection), and harvesting, with each action being essential to ensuring optimal and healthy production.

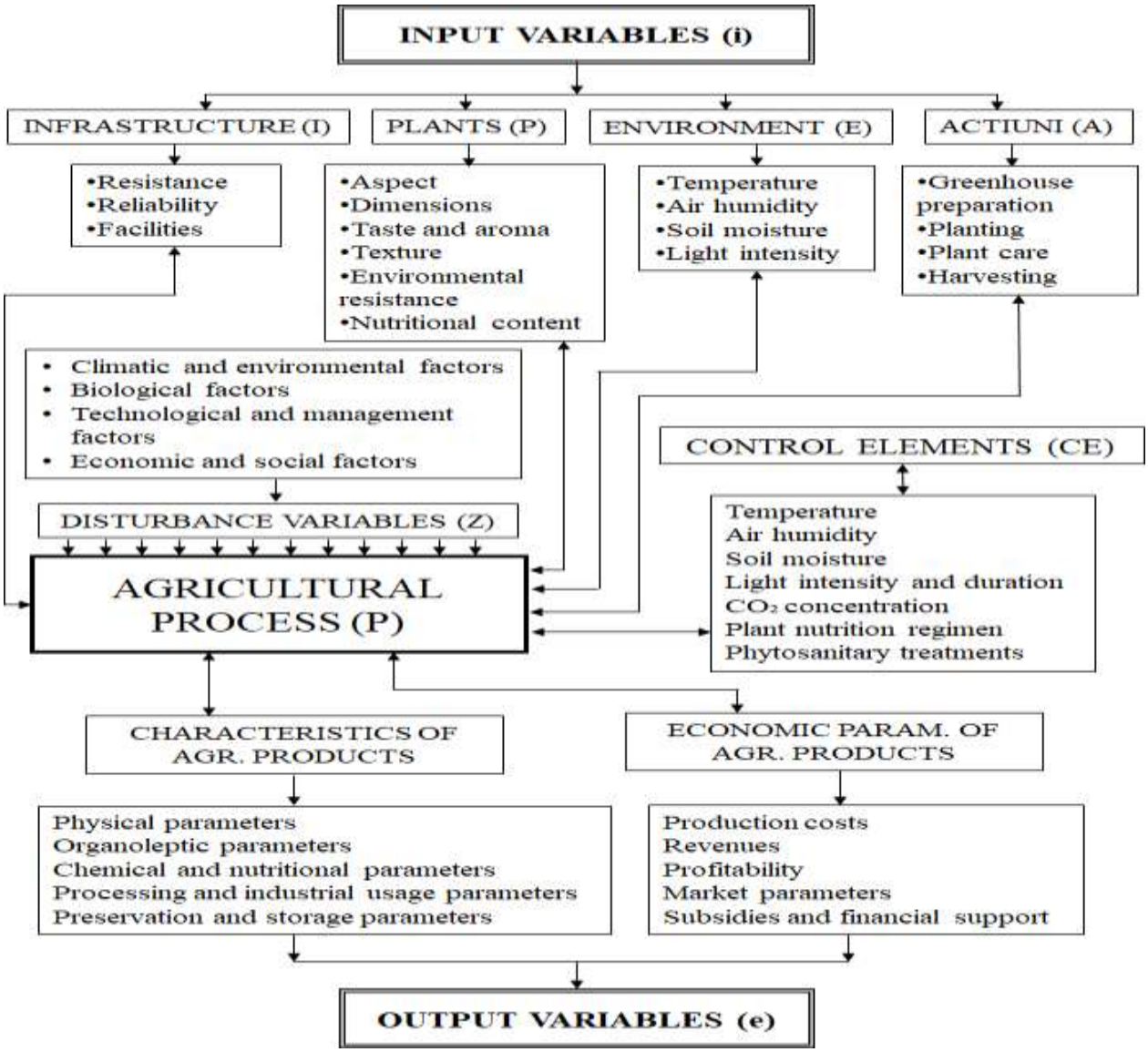

Fig. 2. Generalized input-output model for the greenhouse plant cultivation process
Source: Own contribution.

II.Output variables that characterize the state of the agricultural process, depending on the changes in the input variables, also known as state variables.

III. Control elements (CE) are the equipment through which the measurement, control, and command of the input-output variables in the agricultural process within a greenhouse are carried out. The regulation of variables is done through mathematical relationships that form the feedback component of the system, allowing the adjustment of environmental conditions and cultivation technologies to optimize production.

The variables that can be controlled include:

-*Temperature* – regulation is achieved through automated heating, cooling, or ventilation systems, which adjust the temperature based on plant requirements and external conditions.

-*Atmospheric humidity* – controlled through humidification and dehumidification systems, to maintain an optimal level, preventing fungal diseases or plant dehydration.

-*Soil moisture* – managed by irrigation systems based on moisture sensors, ensuring balanced water distribution, avoiding excess or water deficit.

-*Light intensity and duration* – controlled through the use of blinds/shutters or artificial lighting, to supplement natural deficiencies, optimizing photosynthesis.

-*CO_2 concentration* – controlled by carbon dioxide dosing systems, maintaining an optimal level for plant growth stimulation.

-*Plant nutrition regime* – controlled by controlled fertilization systems, ensuring the necessary nutrient supply based on plant needs and growth stage.

-*Phytosanitary protection* – achieved through monitoring and applying treatments against diseases and pests.

These control variables ensure an integrated management of the agricultural process, contributing to the system's stability and maximizing the yield of greenhouse crops.

IV.Disturbance variables or disturbances (z) are other factors that can negatively influence the system, such as:

-*Climatic and environmental factors* play a crucial role in plant development. Sudden temperature variations can cause thermal stress, while improper atmospheric humidity either favours fungal diseases or leads to plant dehydration. Soil humidity must also be maintained at an optimal level, avoiding both excess water, which can cause root suffocation, and deficiency, which affects nutrient absorption. Light intensity and duration influence photosynthesis, and fluctuations in CO_2 concentration can limit plant growth.

-*Biological factors* can be a constant threat to crops. Pests, such as insects and mites, along with diseases caused by fungi, bacteria, or viruses, can damage plant health and significantly reduce production. Additionally, overcrowding in the greenhouse can create excessive competition for light, water, and nutrients, affecting the uniform development of the crops.

-*Technological and management factors* directly influence the efficiency of the agricultural process. Equipment malfunctions, such as issues with irrigation, heating, or ventilation systems, can compromise optimal growing conditions. Moreover, errors in applying fertilizers and pesticides can affect plant health and even pollute the soil. Delays in performing essential agricultural tasks, such as planting, fertilizing, or harvesting, can reduce yield and quality.

-*Economic and social factors* influence the sustainability of agricultural production. Fluctuations in the prices of seeds, fertilizers, energy, and labour can increase production costs and affect profitability. Furthermore, market demand and supply play an important role, and overproduction or a decrease in demand can negatively influence prices and the profitability of the business.

Therefore, proper management of these factors is essential for maintaining an efficient agricultural process and ensuring the production of high-quality crops in a protected system (Perju et. al., 1998) [22].

V.The characteristics of the agricultural product influence both its quality and its market destination. These properties are analyzed from multiple perspectives, each playing a crucial role in determining the product's value and use.

1. Physical parameters. The size and weight of the agricultural product are essential characteristics for handling, packaging, and transportation, influencing logistical efficiency and associated costs. The commercial appearance, including colour, shape, and uniformity, plays an important role in the product's attractiveness to consumers. Additionally, texture and firmness are decisive factors for both direct consumption and industrial processing.

2. Organoleptic parameters. Taste and aroma are key elements that determine consumer acceptance of the product. Consistency and juiciness are also relevant, especially for products used in gastronomy and the food industry, influencing quality perception and consumer experience.

3. Chemical and nutritional parameters.

The water content of an agricultural product affects both its shelf life and the applicable preservation methods. Nutritional value, expressed through the concentration of proteins, carbohydrates, lipids, vitamins, and minerals, influences health benefits and

demand in the food market. The level of sugars and acidity determines the final taste of the product and processing possibilities, being essential factors in the juice and jam industries.

4. Processing and industrial use parameters.

The processing capacity of the agricultural product determines its adaptability to industrial processes such as peeling, chopping, or drying. Extraction yield is an important economic factor, indicating the proportion of usable product after processing, which is crucial for industries such as oil and juice production.

5.Preservation and storage parameters. Shelf life defines the period during which the product maintains its quality without degradation. Resistance to transportation and handling is a crucial aspect for efficient distribution, especially for products intended for export or long-distance sales.

These parameters are essential for determining the commercial value of the agricultural product and for adapting it to market and consumer requirements, thereby contributing to the optimization of the production and distribution chain (Căta et al., 2006) [4].

VI. Economic parameters of the agricultural process are essential factors that influence the efficiency, profitability, and sustainability of agricultural activities. They enable better resource management and production optimization based on market demands and associated costs.

1. Production Costs. Production costs are key elements that influence the profitability of an agricultural enterprise. These costs are divided into fixed and variable costs. Fixed costs are expenses that do not vary with production volume, such as equipment depreciation, infrastructure costs, or land taxes. On the other hand, variable costs depend directly on production volume and include expenses such as seeds, fertilizers, water, energy, and seasonal labour. Total costs represent the sum of fixed and variable costs for a production cycle, serving as an essential indicator for the economic analysis of the farm.

2. Revenues. Revenues from agricultural activity are fundamental for evaluating economic efficiency. Gross revenue represents the total amount obtained from the sale of agricultural products, without considering production costs. Net revenue is determined by subtracting total costs from gross revenue, reflecting the farm's actual profitability. Another important parameter is productivity per unit of area, which indicates the ratio between the obtained yield and the cultivated area, expressed in kg/m² or t/ha.

3. Profitability. The profitability of the agricultural process is essential for maintaining the farm's economic viability. Profitability represents its ability to generate profit and is calculated as the ratio between profit and total costs. Return on Investment (ROI) indicates the efficiency of capital utilization by measuring the ratio between the profit obtained and investments made in infrastructure, equipment, and technologies. Another key parameter is the unit production cost, which reflects the average cost required to obtain one unit of product, expressed in cost/kg.

4. Maret Parameters. Market conditions play a decisive role in the success of an agricultural business. The selling price of an agricultural product is influenced by the relationship between supply and demand, product quality, and industry competition. Demand elasticity represents consumers' sensitivity to price changes and can directly affect sales volume. Another essential factor is market accessibility, meaning the farmer's ability to sell products through local markets, supermarkets, exports, or other distribution channels.

5.Subsidies and Financial Support. Financial support can significantly impact the economic viability of agricultural farms. Government aid and subsidies are forms of support provided by the state to reduce production costs and increase competitiveness. Additionally, access to credit and financing is crucial for farm development, enabling investments in equipment, infrastructure, and modern technologies. These economic parameters are essential for strategic decision-making, optimizing the agricultural process and ensuring the sustainability of the agricultural business. Effective management of these factors can lead to increased profitability and the development of competitive agricultural production on the market.

The main criterion for grouping the variables was determined both by the order of their

determinations and involvement in the process, as well as by the existence of implicit relationships between them.

Based on the presented variable blocks and information from the literature regarding the agricultural process of growing vegetables in greenhouses, the possible connections between these groups of variables—also referred to as direct links—are outlined.

The analysis of these connections leads to the conclusion that there are extensive possibilities for controlling the vegetable cultivation process in a protected system (through a high number of variables). At the same time, the complexity of the process is remarkable, highlighting the clear necessity for highly qualified personnel.

The analysis of the generalized interpretation system of the greenhouse cultivation process has led to the development of a generalized input-output model. This model serves as a starting point for designing an experimental framework to determine the functional relationships between different variables, aiming to establish dependency relations. These relations can later be used for optimization through mathematical models, based on one or more criteria, under various conditions. The optimization of the greenhouse cultivation process can be applied either globally or partially, integrating not only technical optimization criteria but also a set of economic-organizational and hygienic-ecological criteria (Țucu et al., 1998) [33].

The importance of such an input-output model lies in its ability to be applied and customized to any agricultural process, regardless of its nature. This facilitates a deeper understanding and analysis of the process, ultimately enabling the implementation of optimal control.

2. Smart Greenhouse Process Design

Figure 3 presents the monitoring and control scheme of a greenhouse.

The Greenhouse Monitoring and Control System is an automated system that ensures optimal growing conditions for plants by continuously monitoring environmental factors and making necessary adjustments. The flowchart outlines how the system collects data, processes information, makes decisions, and controls various actuators.

The system collects real-time data from the following sensors: Temperature Sensor – Measures air temperature inside the greenhouse; Air Humidity Sensor – Monitors the moisture level in the air; Soil Humidity Sensor – Detects the moisture level in the soil; Light Sensor – Measures the intensity of natural light; CO_2 Sensor – Checks the concentration of carbon dioxide for plant growth.

Blinds Position Sensor – Determines the state of the blinds (open/closed) to regulate light and temperature.

The collected data are compared with predefined threshold values set for each environmental parameter.

The system evaluates the readings and determines the appropriate response: If Temperature is too High → Activate Cooling System (e.g., fans, ventilation); If Temperature is too Low → Activate Heating System; If Air Humidity is too Low → Turn on the Misting System; If Soil Humidity is too Low → Activate Irrigation System; If Light Levels are Low → Turn on Artificial Grow Lights; If CO_2 Levels are Low → Activate CO_2 Enrichment System; If Blinds Need Adjustment → Open or Close Blinds accordingly.

In the next step, the system activates the corresponding devices to adjust the environment as needed. Sensor readings and system responses are logged for future analysis. The data are displayed on a dashboard, allowing real-time monitoring. If critical conditions arise (e.g., extreme temperature, equipment failure), the system sends alerts via a mobile app, email, or SMS.

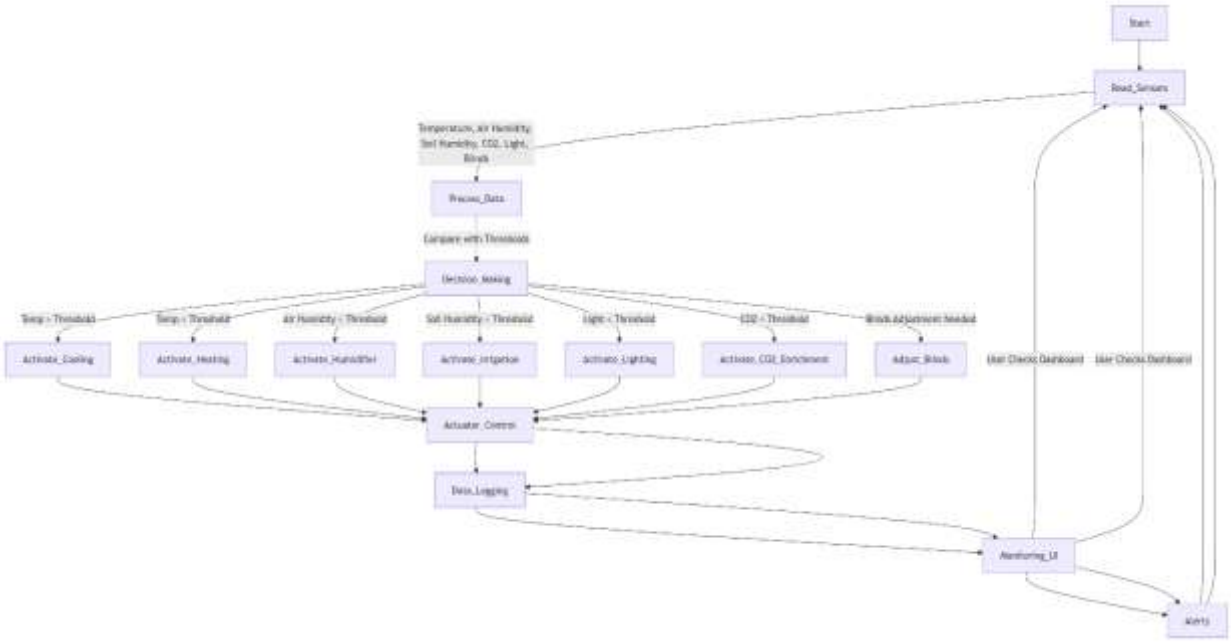

Fig. 3. The Greenhouse Monitoring and Control System
Source: Own contribution.

Users can manually check and adjust settings through the interface. The system continuously loops back to sensor readings to maintain optimal conditions.

The benefits that automation system bring are:

•Increased Crop Yield & Quality, by: maintaining optimal growing conditions, ensuring healthier plants and higher yields, preventing stress conditions (e.g., overheating, overwatering) that may damage crops.

•Efficient Resource Management, by water savings: automated irrigation ensures that plants receive just the right amount of water; energy efficiency: grow lights, fans, and heaters only activate when needed, reducing electricity consumption; CO_2 optimization: the CO_2 enrichment system boosts plant growth without excess waste.

•Reduced Labor Costs & Human Error: the system works automatically, reducing the need for manual monitoring and intervention and preventing mistakes such as overwatering, which can lead to root rot.

•Remote Monitoring & Control: cloud connectivity allows farmers to monitor conditions via a smartphone or computer. Alerts notify users about critical conditions, enabling quick intervention.

•Data Logging & Predictive Analysis: the storing of historical data for trend analysis and future optimizations helps farmers predict climate conditions and adjust settings accordingly.

•Scalability & Integration: the system can be expanded to multiple greenhouses or can be integrate with AI-based systems for advanced decision-making (Dorf et al., 2016; Puspitasari et al., 2018; Li et al, 2021; Visvesvaran et al., 2021; Soussi et al., 2024) [7, 23, 16, 34, 28].

3.Enhancing Greenhouse Agriculture Production through Optimization of Intervals Between Cultivation Cycles

Optimizing the cultivation cycles between two harvests and production yields in greenhouse agriculture can be achieved through a series of strategic and technological measures. First and foremost, the selection of adapted varieties is essential, with the recommendation to choose species and cultivars with shorter growth cycles, increased resistance to diseases and pests, and high productivity (Mihnea, 2011) [18]. Resource management plays a crucial role, through the use of efficient irrigation systems, such as drip irrigation or soil moisture monitoring technologies, and through the precise application of fertilizers, tailored to the crops' needs and soil analyses.

Microclimate control is another important aspect, achieved by adjusting temperature, humidity, and light levels with the help of automated systems and supplementing light with LED lamps when necessary. Careful

planning of cycles and crop rotation significantly contributes to preventing soil depletion and the spread of diseases, ensuring optimal conditions for each crop.

Advanced technologies, such as precision agriculture, sensors, and artificial intelligence, enable real-time monitoring and adjustment of critical variables, thereby optimizing growing conditions. In addition, reducing unproductive intervals between cycles can be achieved by automating processes such as harvesting, soil preparation, and planting, as well as using modern substrates, such as coconut fiber or perlite, which facilitate rapid transitions between crops.

By applying these measures, greenhouse agriculture can become more efficient and sustainable, maximizing the use of space and resources while ensuring increased productivity in the long term.

The cultivation cycles between two harvests and production yields in greenhouse agriculture are essential factors in optimizing agricultural systems. Optimizing these cycles involves careful management of the duration of each cycle, crop rotation, and resources used, such as water, fertilizers, and energy. By implementing modern technologies and adapting agricultural practices to the specifics of each crop, maximum productivity per unit of area can be achieved, while simultaneously reducing costs and environmental impact.

In vegetable farming, the use of greenhouses allows for obtaining two, three, or even more annual harvests through early, main, and successive crops. Between harvest cycles, there are short intervals dedicated to activities such as harvesting the previous crop, soil preparation, applying fertilizers, checking soils, and ensuring an adequate water supply to support the next harvest.

Case study.

In an agricultural farm, a greenhouse is designed to support a cultivation cycle between two harvests, with a duration of t = 110 days, of which the actual cultivation cycle is t_{fi} = 100 days. To shorten the soil preparation period between two crops, a new method of harvesting, soil processing, and seeding is proposed, which reduces the preparation time to t_{r1} = 5 days. The fixed costs for the greenhouse in question are 9,000 lei/day, while the costs for soil preparation will increase from R_0 = 200,000 lei to R_1 = 263,000 lei. To calculate the minimum effective operating duration of the agricultural greenhouse that justifies the increase in soil preparation costs by 63,000 lei, we proceed with the following steps.

$$t_{fi} = \frac{(R_1 - R_0 + c_k \cdot t_{r1}) \cdot t_{f0}}{c_k \cdot (t_0 - t_{f0})} \text{ [days]}$$

$$t_{fi} = \frac{(263{,}000 - 200{,}000 + 9{,}000 \cdot 5) \cdot 100}{9{,}000 \cdot (110 - 100)}$$

$$t_{fi} = 120 \text{ days}$$

$$t_1 = t_{fi} + t_r = 120 + 5 = 125 \text{ days}$$

where:

t_{fi} – effective operating duration of the greenhouse, in days;

R – soil preparation costs;

C – fixed costs per greenhouse, in lei/day;

t_r – duration of soil preparation work, in days;

t_f – duration of the actual cultivation cycle, in days.

Therefore, the introduction of the new method of harvesting, soil processing, and seeding will be profitable if the operational intervals between two cultivation cycles increase from 100 days to at least 120 days. In the end, the cultivation cycle between two harvests is extended to 125 days. The extended growth period can provide the plants with more time to accumulate biomass and develop fruits or seeds, leading to increased productivity.

CONCLUSIONS

An automated agricultural greenhouse is safer, consumes less energy, and ensures high productivity. It provides complete control over the facilities: electrical installation, heating, humidity, ventilation, CO_2, and is easy to control remotely.

The Greenhouse Monitoring and Control System is a highly efficient, automated solution for maintaining optimal environmental conditions. It enhances productivity, reduces resource wastage, and allows remote monitoring. By integrating IoT,

automation, and data logging, this system is essential for modern precision agriculture.

The integration of automated systems for monitoring and control, along with the optimization of cultivation cycles and resource management, leads to increased efficiency, reduced energy consumption, and enhanced productivity. Ultimately, this research contribute to maximizing the economic and environmental benefits of greenhouse farming.

REFERENCES

[1]Akpenpuun, T. D., Ogunlowo, Q. O., Na, W-H., Rabiu, A., Adesanya, M. A., Dutta, P., Zakir, E., Ogundele, O. M., Kim, H-T., Lee, H-W., 2023, Review of Temperature Management Strategies and Techniques in the Greenhouse Microenvironment. Adeleke University Journal of Engineering and Technology, 6(2), 2023.

[2]Al-Qudah, R., Almuhajri, M., Suen, C.Y., 2025, Unveiling the potential of sustainable agriculture: A comprehensive survey on the advancement of AI and sensory data for smart greenhouses, Computers and Electronics in Agriculture, 229, 109721.

[3]Çakmakçı, R., Salık, M.A., Çakmakçı, S., 2023, Assessment and Principles of Environmentally Sustainable Food and Agriculture Systems. Agriculture, 13, 1073.

[4]Căta, A., Glevitzky, M., Moldovan, R., Calisevici, M., Perju, D., 2006, Optimisation of Heat Exchangers Ensemble Operation in order to improve the technological indicators. Buletinul Universităţii Petrol – Gaze din Ploieşti, LVIII(1), 122 – 125.

[5]Dhanaraju, M., Chenniappan, P., Ramalingam, K., Pazhanivelan, S., Kaliaperumal, R., 2022, Smart Farming: Internet of Things (IoT)-Based Sustainable Agriculture. Agriculture, 12, 1745.

[6]Directive EU 2018/2002 of the European Parliament and of the Council of 11 December 2018 amending Directive 2012/27/EU on energy efficiency. PE/54/2018/REV/1, OJ L 328, 21.12.2018. pp. 210–230.https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0210.01.ENG . Accessed on February 20, 2025.

[7]Dorf, R. C., Bishop, R. H., 2016, Modern Control Systems, 13th Edition, Boston: Pearson.

[8]Eigbrett, B., 2015, Effect of a Window Shade on Home Energy Use, Environmental Studies Undergraduate Student Theses, University of Nebraska, Lincoln, 164.

[9]Ganandran, G. S., Mahlia, T. M., Ong, H. C., Rismanchi, B., Chong, W. T., 2014, Cost-benefit analysis and emission reduction of energy efficient lighting at the Universiti Tenaga Nasional. The Scientific World Journal, 745894.

[10]Jerca, I.O., Smedescu, C., 2023, a decade of change in europe's tomato greenhouses: insights and trends. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 23(4), 431-436.

[11]Knez, S., Štrbac, S., Podbregar, I., 2022, Climate change in the Western Balkans and EU Green Deal: status, mitigation and challenges. Energy, Sustainability and Society, 12, 1.

[12]KNX Romania, KNX - open standard for commercial and residential building automation. https://knxromania.ro/ . Accessed on February 20, 2025.

[13]Krishnan, P., Prabu, A. V., Loganathan, S., Routray, S., Ghosh, U., & AL-Numay, M., 2023, Analyzing and Managing Various Energy-Related Environmental Factors for Providing Personalized IoT Services for Smart Buildings in Smart Environment. Sustainability, 15(8), 6548.

[14]Kusz, D., 2014, Modernization of agriculture vs sustainable agriculture. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 14(1), 171-178.

[15]Lee, S.H., Oh, S. T., Lim, J. H., 2024, Lighting control method based on RIIL to reduce building energy consumption, Energy Reports, 11, 2090-2098.

[16]Li, H., Guo, Y., Zhao, H., Wang, Y., Chow, D., 2021, Towards automated greenhouse: A state of the art review on greenhouse monitoring methods and technologies based on internet of things, Computers and Electronics in Agriculture, 191, 106558.

[17]Maraveas, C., Karavas, C.-S., Loukatos, D., Bartzanas, T., Arvanitis, K.G., Symeonaki, E., 2023, Agricultural Greenhouses: Resource Management Technologies and Perspectives for Zero Greenhouse Gas Emissions. Agriculture, 13, 1464.

[18]Mihnea, N., 2011, Tomiş – soi nou de tomate pentru cultivare în câmp deschis neprotejat, Genetica şi fiziologia rezistenţei plantelor, (Tomis - a new tomato variety for cultivation in an open unprotected field. Genetics and physiology of plant resistance), Chişinău, 105p.

[19]Ministry of Energy of Romania – ME-RO, 2020, Integrated National Energy and Climate Change Plan for 2021 – 2030. https://energie.gov.ro/wp-content/uploads/2019/02/NECP_EN_COM-1.pdf. Accessed on February 20, 2025.

[20]Morgan, L., 2022, Greenhouses and Protected Cultivation, CABI Compendium, 13765263.

[21]Muñoz-Liesa, J., Royapoor, M., Cuerva, E., Gassó-Domingo, S., Gabarrell, X., Josa, A., 2022, Building-integrated greenhouses raise energy co-benefits through active ventilation systems, Building and Environment, 208, 108585.

[22]Perju, D., Şuta, M., Geantă, M., Rusnac, C., 1998, Automatizarea proceselor chimice I (Automatisation of chemical processes I), Timişoara, RO: Mirton.

[23]Puspitasari, W., Perdana R, H. Y., 2018, Real-Time Monitoring and Automated Control of Greenhouse Using Wireless Sensor Network: Design and Implementation. 2018 International Seminar on Research of Information Technology and Intelligent Systems (ISRITI), Yogyakarta, Indonesia, 362-366.

[24]Ray, S., Majumder, S., 2024, Water Management in Agriculture: Innovations for Efficient Irrigation, pp.

169-185. In book: Modern Agronomy, Delhi, India: Satish Serial Publishing House.
[25]Romania's Parliament, 2014, Law no.121 from July 18, 2014, regarding energetical efficiency.
[26]Singh, D., Basu, C., Meinhardt-Wollweber, M., Roth, B.W., 2014, LEDs for Energy Efficient Greenhouse Lighting. arXiv, 1406.3016.
[27]Sorrell, S., 2015, Reducing energy demand: A review of issues, challenges and approaches, Renewable and Sustainable Energy Reviews, 47, 74-82.
[28]Soussi, A., Zero, E., Sacile, R., Trinchero, D., Fossa, M., 2024, Smart Sensors and Smart Data for Precision Agriculture: A Review. Sensors, 24, 2647.
[29]Sulewski, P., Wąs, A., 2024, Agriculture as Energy Prosumer: Review of Problems, Challenges, and Opportunities. Energies, 17, 6447.
[30]Tayefeh, A., Aslani, A., Zahedi, R., Yousefi, H., 2024, Reducing energy consumption in a factory and providing an upgraded energy system to improve energy performance, Cleaner Energy Systems, 8, 100124.
[31]Toma (Diaconu), E., Vochin, I., 2024, Peculiarities of the management process in the hydroponic greenhouse sector in the context of ensuring sustainability: A critical review . Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 24(3), 889-902.
[32]Trépanier, M.P., Gosselin, L., Jørgensen, B.N., 2025, Best combinations of energy-efficiency measures in greenhouses considering energy consumption, yield, and costs: Comparison between two cold climate cities, Applied Energy, 382, 125163.
[33]Ţucu, D., Mnerie, D., 1998, Sisteme integrate pentru producţia agroalimentară (Integrated sustems for agri-food production), Timişoara, Orizonturi Universitare.
[34]Visvesvaran, C., Kumar, K., Murugananda, S., Vasan, S. G., Sundaram, K. M., Jafrrin, S., 2021, Smart Greenhouse Monitoring System using Wireless Sensor Networks. 2nd International Conference on Smart Electronics and Communication (ICOSEC), 96-101.
[35]Yoomak, S., Jettanasen, C., Ngaopitakkul, A., Bunjongjit, S., Leelajindakrairerk, M., 2018, Comparative study of lighting quality and power quality for LED and HPS luminaires in a roadway lighting system, Energy and Buildings, 159, 542-557.
[36]Zbancă A., Negritu G., 2013, Feasibility of investments in cultivation of tomatoes in protected areas. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 13(3), 327-331.

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SOYBEAN IN THE EUROPEAN UNION - AN UPWARD TREND FOR CULTIVATION AND PRODUCTION

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Abstract

The research investigated the trends in soybean crop cultivated area, production and yields in the EU and in its major producing countries: Italy, France and Romania in the period 2015-2024. The data were picked up from European Commission and USDA. Growth rate, trend line regressions, R square, comparisons and forecast, illustrative and tabular methods were used for processing data and commenting the results. The global context was presented first, showing that, in 2024, soybean was cultivated on 146.7 million ha (+22% versus 2015). In Brazil, USA and Argentina are sown the largest areas, accounting for 33.9%, 24.9% and 12.8% summing 71.6%. The world seeds harvest reached 420.8 million tonnes, (+33.12% vs. 2015) to whom Brazil, USA and Argentina contributed by 39.8%, 28.9%, 12.9%, totaling 81.6%. The yield reached 2.87 tonnes/ha (+9.5%) being higher in Brazil 3.4 tonnes/ha, USA 3.09 and Argentina 2.90. In 2024, the EU soybean harvested area was 1,115 thousand ha, (+26.56% vs 2015). The share of Italy, France and Romania in the EU area with this crop was: 30.2%, 13.7%, 13%, summing 56.9%. Production reached 2,992 tonnes (+27.76%), to which Italy, France and Romania contributed with 36.1%, 13.3% and 9.9%, summing 59.3%. The EU yield attained 2,682 kg/ha (+0.9%). In 2024, the yields were: Italy 3,208 kg/ha (-11.29%), France 2,594 kg/ha (- 5.3%), Romania 2,034 kg/ha (-0.64%). The worst year for soybean was 2022 when all the EU producers registered the lowest yield. In the EU, smaller surfaces are sown and productions are achieved in Croatia, Hungary, Austria, Slovakia and Germany. Climate change in terms of high temperatures and droughts was the main cause which led to a smaller performance in soybean culture in the Central and Eastern Europe and also in the Mediterranean region. Soybean area, gross output and yield will continue to grow in the EU and at the global level, as soybean plays has a crucial role in assuring high quality protein for human diets and animal feed, oil for biofuel and industrial purposes, Nitrogen capture into the soil, fertility improvement, reduction of chemical fertilizers, environment protection and biodiversity preservation. To diminish the negative effect of climate change, farmers must adopt adapted technologies regarding: early cultivation, high production potential and resistant to drought varieties, irrigation systems, plant protection etc Only in this way, they could sustain yield and also they could extend the cultivated area to increase seeds gross output.

Key words**:** *soybean, importance, trends, harvested area, gross output, yield, EU*

INTRODUCTION

Soybean is one of the crops of high interest at present, being an important source of protein and like peas, chickpea, lentils, broad bean and also of oil like rape, sunflower and linseed [36].

Soybean chemical composition includes high quality protein (36%), oil (20%), carbohydrates (30%), fiber (13%), vitamins, minerals, enzymes.

Protein production is destined to improve human diet, diminish hunger and nourish the global population [14].

In addition, soybean is lacked of cholesterol, which is beneficial for health assuring protection against cardiovascular diseases [17, 37].From crushed soybean oilseeds it results meal used as feed for animals (poultry, pigs, cattle, fishes, shrims) [2, 18, 25].

Also, soybean oil is utilized as a source of renewable energy for producing biodiesel reducing pollution and protecting environment. Oil is also used in processing industry for obtaining a large range of useful products.

Soybean has a large range of utilizations, which could be grouped into two categories: food, including various products and industrial products for various destinations as shown in Figure 1.

Fig.1. Soybean utilizations for food worldwide
Source: Own conception based on [36].

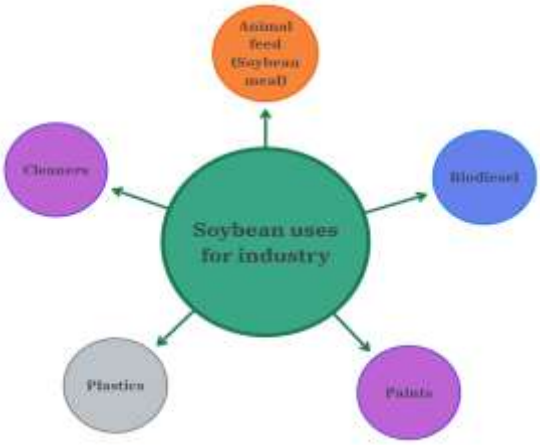

Fig. 2. Soybean utilizations for industry.
Source: Own conception based on [36].

Soybean uses for industry are also of a large diversity as presented in (Figure 2).

Soybean cultivation could assure important income and profit for farmers and a higher living standard for their families [29].

Soybean is largely cultivated in Brazil, USA and Argentina which are the main producing countries and also at a smaller scale in a few European countries like Italy, France, Romania, Austria, Hungary, Croatia and Germany [28].

In 2023/2024, soybean was cultivated on over 137.10 million ha at the global level, of which in Brazil 33.4%, in the USA 24.3% and in Argentina 12.1%, all together summing 70%. In the EU, soybean is grown on a much smaller area accounting for 1.12 million ha (0.8%). For the years 2024/2025, the projection is 145.81 million ha [34].

Soya cultivation is suitable to temperate climate zones and fertile soils and needs a corresponding amount of precipitations or irrigations. The agricultural technology requires modern machinery and an integrated weed management to assure high yields.

Soybean has a high production potential giving yields which could vary between 1.6 and 2.8 t/ha and even more than 3 t/ha, depending on soil fertility and climate conditions.

Soybean cultivated area and production increased as mentioned by [19, 24].

In 2024, soybean production at the global level accounted for 420.8 million tonnes, of which Brazil 40%, USA 28% and Argentina 12%, summing 80% [33, 35].

In the EU, both the cultivated area and soybean gross output increased across the time [4, 20, 26].

In 2024, the EU-27 soybean gross output reached 2.99 million tonnes, representing 0.71% of the world production. The weight of main producing countries was: Italy 36.1%, France 13.2% and Romania 9.9%, totaling 60% of the EU production [8, 9, 13].

Soybean is recognized as a crop able to capture atmospheric Nitrogen grace to the nodules existing on the roots system of the plant, and in this way soil fertility could be improved, with less chemical fertilizers favoring environment protection. For this reason, soybean could be included in crop rotation [5, 27].

Soybean consumption has increased and continue to grow. In 2021, it accounted for 1.77kg/capita at the world level compared to 1.29 kg in the year 2010 [32].

The higher and higher consumption, generated by the protein and oil need, determines to cultivate soybean on a larger acreage which in the tropical countries has led to deforestation, biodiversity loss, increased CO_2 emissions, water pollution and displacement of indigenous population [3, 6].

In the EU, soybean is cultivated for food, feed, fuel and industrial purposes. Soybean is ranked the 3rd after rape and sunflower for producing oil.

The EU crude protein coming from crops is not enough to cover consumption and for this reason imports are required. In 2024, the EU produced 64 million tonnes of crop crude protein and imported 19 million tonnes especially from Brazil and USA, which are the main suppliers.

Protein is needed in animal diets for growing and fattening and animal farming is the largest consumer of plant protein as feed.

The EU livestock requires 72 million protein as feed, of which 27% comes from soybean and the rest from roughage (42%), cereals (21%), and oilseeds meals (10%). Soybean meal and other sorts of meals account for 35% in the EU livestock protein intake. Soybean as feed is used 67% for poultry, 21% for pigs and 10% for beef and dairy cattle, and the remaining of 2% fishes and shrimps [11].

Starting from 2023, the EU issued a Deforestation Regulation (EUDR) which provides that the imported soybeans to have zero risk of deforestation, promoting a sustainable agriculture [7].

Therefore, the EU reviewed its policy and priorities to ensure o more resilient food system. In this respect, it issued measures of interventions of the CAP sustaining the expand of the cultivated area, increase yields and production of plant-based crude protein to balance the supply and demand [10].

In the EU, it is cultivated GM-free soybean, but GM soybean can be used under a *"complete and rigorous procedure, which guarantees a high level of protection of human and animal health, as well as for the environment"* [31].

The market request for organic soybean has encouraged the farmers to extend the cultivated surface and grow the output, using new cultivars with a high genetic value and even adapted to the climate conditions existing in the Northern Europe like in Germany, Poland and Netherlands.

Due to the discrepancy in the impact of climate between Western and Northern Europe and Eastern European countries, North of Italy and the Balkan regions, it is still an yield gap, which oblige the members states to look for climate resilient solutions [16, 30].

Organic soybean is produced especially in France, Austria, Romania, Germany and Italy, all together weighting for 90% in total soybean output [1].

Therefore, in the EU internal production of soybean will cover the needs for food, but the

requirements of feed will be still covered by imports.

However, the EU soybean output is deeply affected by the climate factors mainly by higher temperatures and droughts which in the recent years increased the gap of production among the member states with favorable and the ones with non favorable climate conditions. And this aspect will still impose the dependence of external supply of soybeans to cover the deficit.

In the EU, soybean is utilized as food, and also for animal feed, crushing and other purposes. From the crushed soybeans it is obtained 80% soymeal for feeding poultry, pigs and cattle and 20% oil. From the total EU meal consumption, soymeal comes on the top position with 55%, while rape, sunflower and other meal sources have smaller percentages (Figure 3).

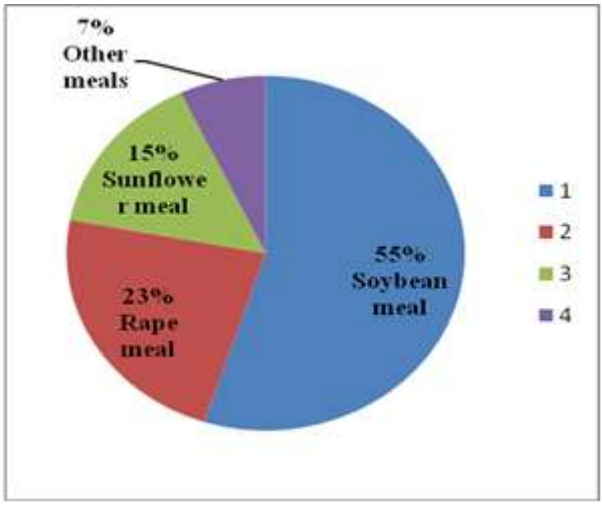

Fig. 3. Share of soybean meal in the EU meal consumption in 2023 (%).
Source: Own design and calculations based on the data from [15].

Soybean meal is largely utilized in the countries where animal farming is well developed like Spain, France, Italy, Germany, Poland, Netherlands, Denmark, Portugal, Belgium and Romania [18].

The use of soybean oil for various purposes in the EU is mentioned in Figure 4.

Taking into account the aspects presented above, the goal of this research is to analyze the status and evolution of soybean crop regarding the cultivated area, production, yield in the EU in the global context, in the period 2015-2024, highlighting the performance in the main producing countries Italy, France and Romania for identifying the new tendencies in the EU policy for the future of this important protein and oilseed plant.

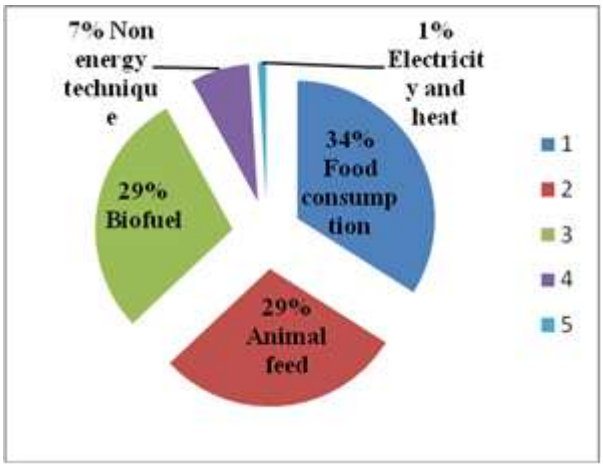

Fig. 4. The uses of soybean oil in the EU (%).
Source: Own design based on the data from [15].

MATERIALS AND METHODS

This research work required a deep documentation regarding the role of soybean crop in assuring food for the population, feed for animals and raw material for industry, studying the published scientific literature, official reports of recognized agricultural organizations such as: European Commission, FAO, USDA, FEDIOL and other source from which the needed empirical data have been picked up.

The data have been structured by the selected items and processed using various procedures and methods including:

- the dynamic analysis in the period 2015-2024 for the key economic indicators: cultivated area, production and yield;
- the growth rate registered in the whole interval;
- regression equations for identifying the trend line;
- coefficient of determination, R square, for reflecting the determinants of the changes across the time;
- descriptive statistics for each indicator in terms of mean, standard deviation, maximum and minimum level and coefficient of variation;

-market share of the selected countries in the total level of the studied indicator;
-comparison method for establishing the similarities and differences among the countries.
-forecast for the year 2025 based on the regression equations.
Graphical illustrations were used for a better understanding of the obtained results and tables summarized the essential data and results, being followed by corresponding discussions.
Finally, the main conclusions were emphasized.
The study consists of two parts:
(a) A brief statistics of the international context of soybean at the global level in terms of cultivated area, production and yield an in the main producing countries Brazil, USA and Argentina.
(b) The EU analysis of the same indicators both the community level and also in the three main producing member states: Italy, France and Romania.

RESULTS AND DISCUSSIONS

A brief statistics on soybean at the global level

The cultivated area with soybean worldwide has registered an upward trend from 120.7 million ha in the year 2015 to 146.7 million ha in the year 2024, accounting for a surplus of 26 million ha, or +22.1%. the value of R square = 0.890 reflects that 89% of the variation of the cultivated area with this crop depended on time and farmers higher interest to cultivate a larger acreage taking into consideration its advantages in terms of income and profit. More than this, looking at the regression equation and the shape of the graphic it is clear the tendency to increase the surface (Fig. 5). Therefore, in 2025, it is expected as the cultivated area with soybean to reach 149.26 million ha.
The main countries cultivating soybean are Brazil, USA and Argentina whose share in the global cultivated surface in the year 2024 was: 33.9%, 24.9% and 12.8% summing 71.6%. Smaller surfaces are cultivated in India and China.

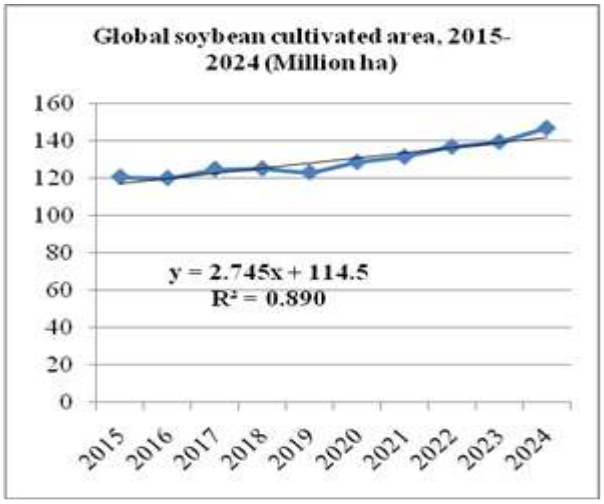

Fig. 5. Cultivated area with soybean worldwide (Million ha)
Source: Own design and calculation based on the data from [35].

The soybean production at the global level had an ascending trend from 316.1 million tonnes in the year 2015 to 420.8 million tonnes in 2024, meaning by 33.12% more than in the first year.
The R square value = 0.809 shows that production varied in time having an increasing trend (Figure 6). This growth was determined by the increased soybean harvested surface and also due to other factors contributing to a higher production in terms of more productive varieties and new technologies applied etc.
Taking into account the regression equation, it is easy to estimate the forecast of seeds production for the year 2025 which is expected to rich 429.66 million tonnes.

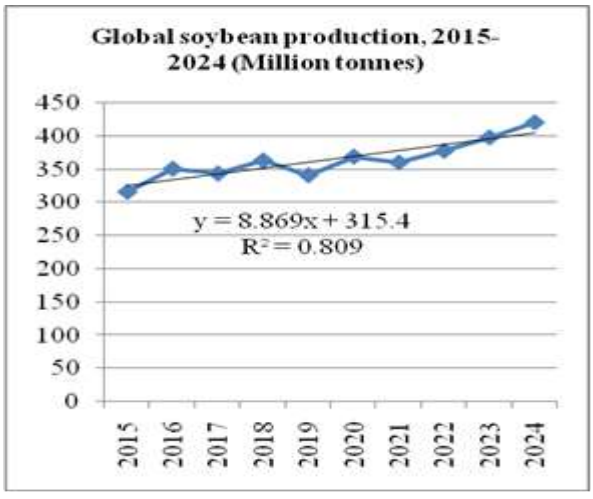

Fig.6. Soybean production worldwide (Million tonnes)
Source: Own design and calculation based on the data from [35].

The production carried out by the main soybean producing countries in the year 2024 had the following contribution to in the global production: 39.8% Brazil, 28.9% USA and 12.9% Argentina, totaling 81.6%.

Soybean yield at the global level increased from 2.62 tonnes/ha in 2015 to 2.87 tonnes/ha in 2024, showing a surplus of +9.5% in the last decade. It does not look to be too much.

The factors responsible of such a situation with a deep impact on the results have been the productive potential the varieties, the zone and its soil and climate conditions, soil fertility, precipitations and temperatures, technologies applied, farmer experience and climate change, which did not allow as average production to reach the desired results (Figure 7).

The value of R square= 0.113 very small shows exactly that the variation of yield was caused by other factors.

In 2025, the mean of global soybean production is expected to be only 2.90 tonnes/ha.

In the main countries producing soybean seeds, yield level was in the year 2024: Brazil 3.4 tonnes/ha, USA 3.09 tonnes/ha and Argentina 2.90 tonnes/ha.

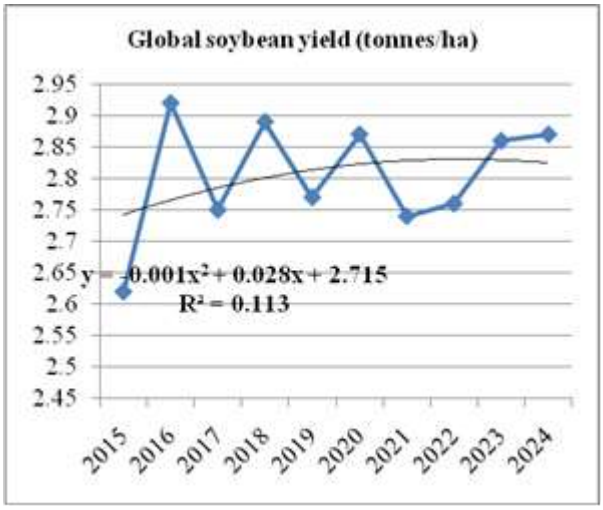

Fig.7. Soybean yield at the global level (Tonnes/ha)
Source: Own design and calculation based on the data from [35].

The increased production of soybean seeds at the world level was influenced by the growth of consumption and especially in China, USA, Brazil, the EU and Argentina whose requirements 31.5%, 17.2%, 15%, 14.2 % and 11.2 % totalize 90% in total consumption.

The descriptive statistics for the three soybean economic indicators at the global level is shown in Table 1.

Table 1. Descriptive statistics for soybean cultivated area, production and yield at the global level in the period 2015-2024

	Cultivated area (Million ha)	Soybean seeds production (Million tonnes)	Soybean yield (Tonnes/ha)
Mean	129.68	364.24	2.80
Standard Deviation	8.80	29.84	0.092
Kurtosis	-0.238	0.458	0.101
Skewness	0.836	0.461	-0.716
Minimum	120.1	316.1	2.62
Maximum	146.7	420.8	2.92
Coefficient of variation (%)	6.78	8.19	3.28

Source: Own calculations.

At the global level, the cultivated area in the period 2015-2024 had an average of 129.68 million ha. The average production accounted for 364.24 million tonnes and the average yield for 2.8 tonnes/ha.

The coefficient of variation for each studied indicator is very small, more exactly lower than 10% (Table 1).

Soybean in the European Union

Cultivated area

In the EU, soybean registered an increased cultivated are from a year to a year from 881 thousand ha in 2015 to 1,115 thousand ha in 2024, therefore by 26.56%. This was a consequence of the attention paid by the European Commission for agriculture to apply a policy favorable to this protein and oil crop in order to stimulate the internal production and diminish the dependence on import. In the EU is cultivated only the GO-free soybean (Figure 8).

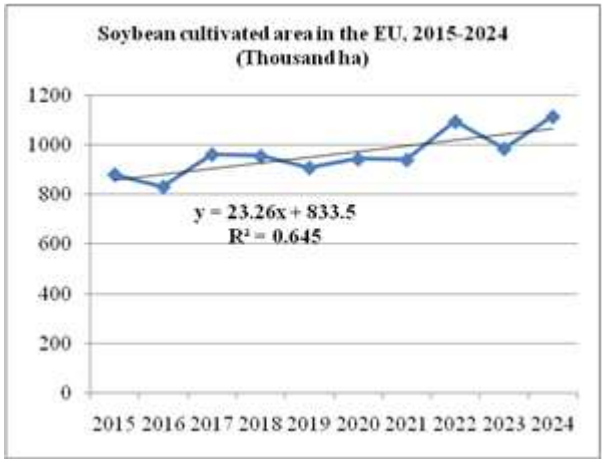

Fig. 8. The cultivated area with soybean in the EU, 2015-2024 (Thousand ha)
Source: Own design and calculations based on the data from [12].

The R square reflect that the variation of the cultivated surface was determined 64.5% by time an also the remaining of 35% variation was caused by other factors.
The regression equation allows to calculate the forecast of the cultivated area for the year 2025 which is expected to be 1,136 thousand ha.
The surface increased in the member states which have good soil and climate conditions for this crop.
The main countries dealing cultivating soybean are Italy, France and Romania with a share in the EU total cultivated surface with this crop in the year 2024 of: 30.2%, 13.7%, and, respectively, 13%, all these three countries totalling 56.9%.
But, in the EU, there are also other counties which cultivated smaller surfaces, therefore having a smaller percentage as follows: Croatia 9.2%, Hungary 10%, Austria 8%, Slovakia 6% and Germany 3.7%. All these eight member states together account for 93.8% in the EU cultivated area with soybean in 2024 (Figure 9).
In case of Italy, the surface variation depended on time only in a small proportion accounting for 27.2%, as shown by R square and the remaining of 62.8% is determined by the change of other factors, probably the intervention policy to stimulate farmers to grow the cultivated area and climate change.
In case of France, R square tells us that 36.8% of the variation in cultivated area with soybean was influenced by time, and 64.2% variation was caused by other factors.
In Romania, R square is 0.731 showing that 73.1% of area variation was determined by time, and the remaining of 26.9% by other factors of influence like incentives offered to cultivated soybean on larger surfaces.
Based on the regression equations, the forecast for 2025 is that in Italy the cultivated area will decline from 337 thousand ha to 323.24 thousand ha.

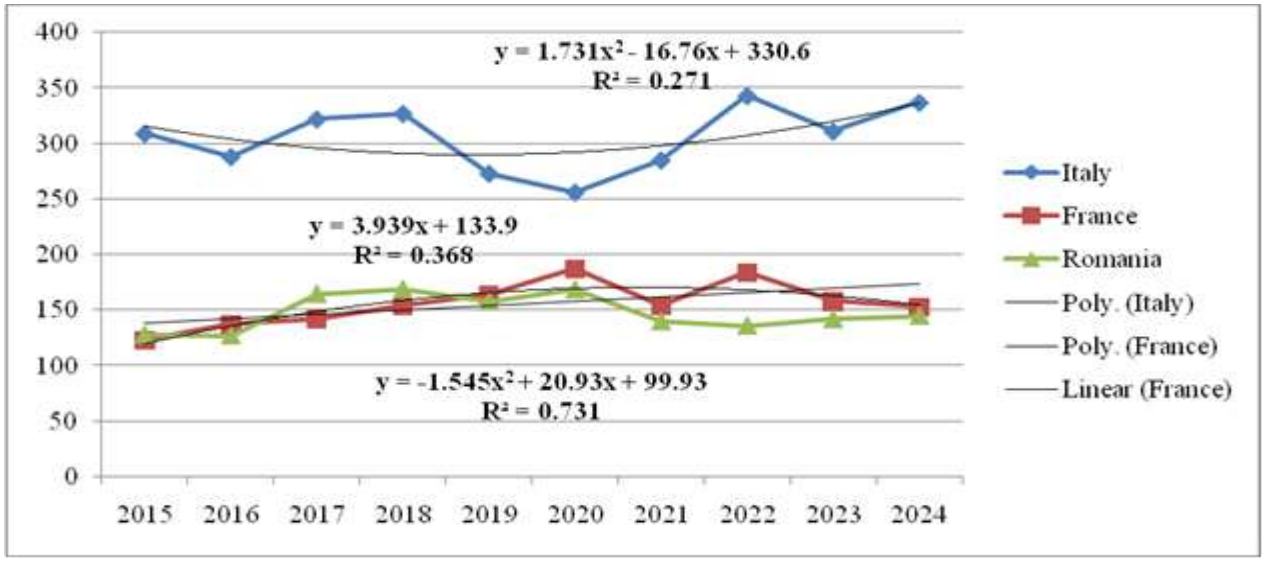

Fig. 9. The cultivated area with soybean in Italy, France and Romania, 2015-2024 (Thousand ha)
Source: Own design and calculations based on the data from [12].

Table 2. The description statistics for the EU cultivated area with soybean and also in the main producing countries Italy, France and Romania, 2015-2024

	EU	Italy	France	Romania
Mean	961.5	305.1	155.6	147.9
Standard Deviation	87.65	28.68	19.64	16.21
Kurtosis	0.146	-0.944	-0.076	-1.604
Skewness	0.638	-0.365	0.198	0.176
Minimum	831	256	123	127
Maximum	1,115	343	187	169
Coefficient of variation (%)	9.11	9.4	12.62	10.9

Source: Own calculations.

In France, it is expected that in 2025, the soybean to be sown on 156.9 thousand ha and in Romania the forecast is 164.38 thousand ha. The description statistics for the cultivated area in the EU is presented in Table 2.

At the EU level, the average cultivated area in the period 2015-2024 accounted for 961.5 thousand ha.

In the main cultivating countries the mean surface with soybean is 305.1 thousand ha in Italy, 155.6 thousand ha in France and 147.9 thousand ha in Romania.

The variation coefficient is small at the EU level and in Italy being below 10%, while in France and Romania is a little over 10%.

Soybean production

In the EU soybean gross output increased by 27.76% from 2,341 tonnes in the year 2015 to 2,992 tonnes in the year 2024. This growth was stimulated by the ascending cultivated surface and also by the improved implemented technologies based on high performance potential varieties, fertile soil and favorable climate conditions in general, except the year 2022 which was not so favorable for soybean (Figure 10).

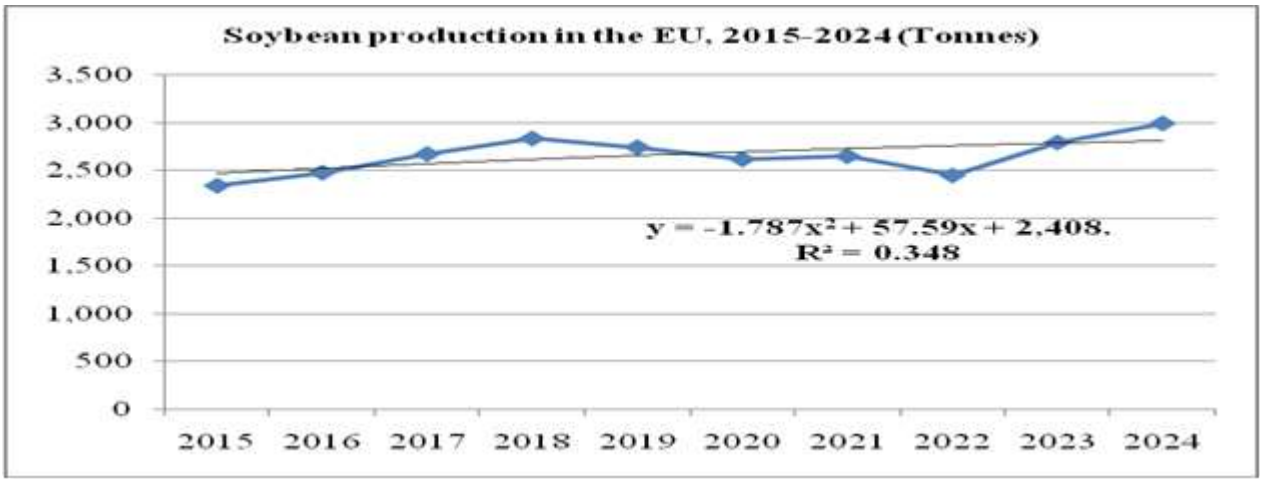

Fig. 10. The EU soybean gross output, 2015-2024 (Tonnes)
Source: Own design and calculations based on the data from [12].

R square = 0.348 reflects that 34.8% of the production variation is caused by time and 65.2% by other factors such as technologies applied and climate change.

The regression equation allows to estimate the forecast for soybean production in the EU which is expected as in 2025 to reach 3,045.39 tonnes.

In the year 2024, the contribution of the main soybean producing countries to the EU output was: Italy 36.1%, France 13.3% and Romania 9.9%, summing 59.3%. Other EU countries also contributed by in smaller proportions as follows: Croatia 8.5%, Hungary 8.3%, Austria 8.2%, Slovakia 5.5% and Germany 4.4%.

The dynamics of soybean production in Italy, France and Romania is presented in Figure 11.

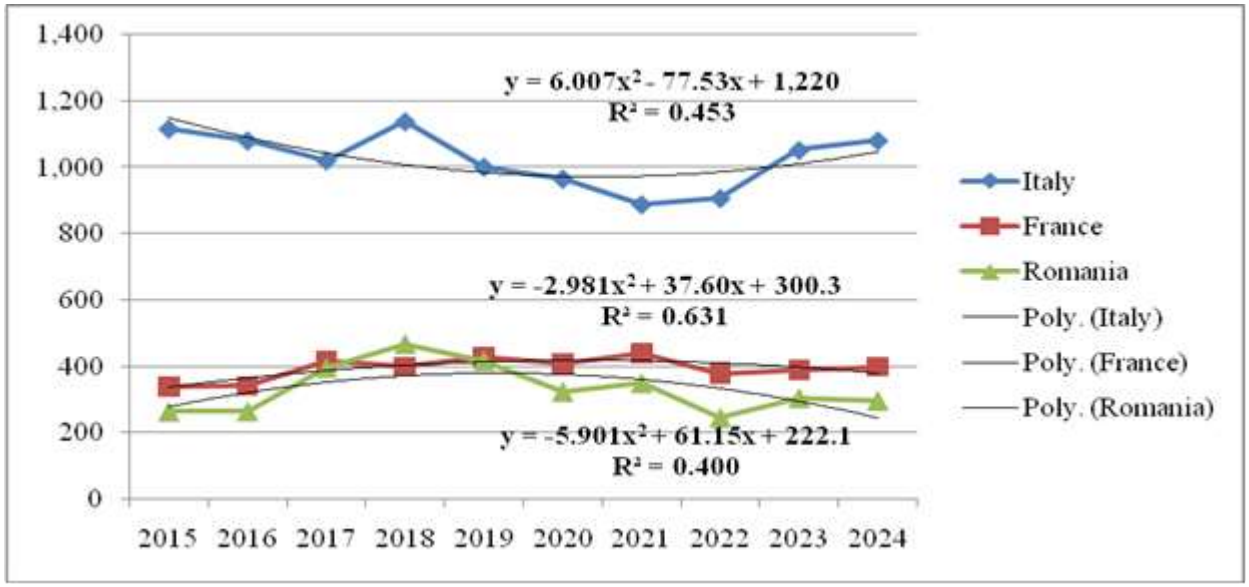

Fig. 11. The soybean gross output in the main producing countries in the EU: Italy, France and Romania, 2015-2024 (Tonnes)
Source: Own design and calculations based on the data from [12].

In Italy, soybean production had a sinuous evolution from 1,117 tonnes in 2015 to 1,081 tonnes in 2024, meaning a decline by 3.3%. The lowest productions were registered in the years 2021, the lowest level of only 887 tonnes, and also in 2020, 2022. Later, production started to recover to 1,081 tonnes in the last year of the analysis. This variation was caused mainly by the climate change bringing high temperatures and lower rainfalls which disadvantage the crop.

R square = 0.453 reflects that 45.3% of the production variation was caused by time and 54.7 % by other factors, mainly climate change.

The regression equation provides information to estimate than in the year 2025, Italy will obtain a soybean production of 1,043.7 tonnes/ha.

In case of France, soybean production also had a sinuous dynamics. But, if in 2015, France recorded the lowest soybean seeds production of only 337 tonnes, in 2024, production was by 17.8% higher, accounting for 397 tonnes. The worst climate years for France were 2015, 2016 and then 2022.

R square shows that 63.1% of the production variation was caused by time and 36.9% by other factors. The regression equation furnished useful information to determine the production forecast for 2025 which will account for 425.71 tonnes.

In case of Romania, soybean output increased from 262 tonnes in 2015 to 295 tonnes in 2024, showing a surplus of 12.59%. After a good start from 2015 to 2018 when it achieved a peak of 466 tonnes, since 2020 soybean production declined in Romania due to the higher and higher temperatures, hot air waves and severe droughts as it happened in Eastern Europe and Balkan region. However, oil seeds crops and soybean will continue to be cultivated for their productivity and fast net return to farmers [21].

R square = 0.400 reflects that the variation of production by time accounted for 40%, while 60% of variation was caused by other factors as specified above.

Based on the regression equation, it was established the forecast for the year 2024 which is expected as Romania to carry out 321.33 tonnes soybean seeds.

The description statistics for the EU soybean seeds production and also in the main producing countries Italy, France and Romania is shown in Table 3.

The EU average soybean seeds production in the interval 2015-2024 was 2,656.1 tonnes, ranging between the minimum 2,341 tonnes and maximum 2,991 tonnes, having a small coefficient of variation of 7.57%.

Table 3. The description statistics for the EU soybean production and also in the main producing countries Italy, France and Romania, 2015-2024

	EU	Italy	France	Romania
Mean	2,656.1	1,024.9	392.4	331.3
Standard Deviation	196.01	85.54	34.07	73.65
Kurtosis	-0.389	-0.930	-0.391	-0.619
Skewness	0.0007	-0.419	-0.572	0.665
Minimum	2,341	887	337	244
Maximum	2,991	1,139	439	466
Coefficient of variation (%)	7.37	8.34	8.68	22.23

Source: Own calculations.

In Italy, the average soybean production in the last decade accounted for 1,024.9 tonnes, varying between the minimum 887 tonnes and the peak of 1,139 tonnes. The coefficient of variation is small accounting for 8.34%.

In case of France, the average production on the whole analyzed period is 392.4 tonnes varying between the lowest level 337 and the highest level 439 tonnes. The variation is 8.38%, a reasonable value.

In Romania, soybean seeds output registered a mean of 331 tonnes in the last 10 years, and ranging between 244 tonnes, the smallest level and 466 tonnes, the top production. The coefficient of variation has a value of 22.23 % reflecting that standard deviation is 22.23% of the mean, and, compared to the coefficient of variation got by Italy and France, in Romania it has a higher level.

Soybean is an important oil plant in Romania and for this reason the utilized land for this crop has grown and production increased despite that the climate change could affect productivity and farmers income in the years with high temperatures and droughts [22, 23].

Soybean seeds yield in the EU and in the main producing countries

Soybean seeds yield in the EU varied between 2,657 kg/ha in the year 2015 and 2,682 kg/ha in the year 2024, a year in which it looked to be a little higher by 0.9% than in the year at the beginning of the studied interval. Its level was determined by the gross output level and also by the cultivated area. The top average yield accounted for 3,020 kg/ha and was recorded in the year 2019. The lowest performance of 2,230 kg/ha was carried out in the year 2022, which was the worst year for soybean crop (Figure 12).

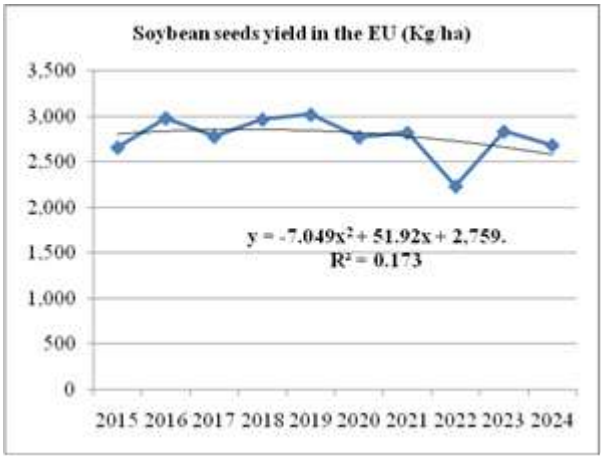

Fig. 12. The soybean seeds average yield in the EU, 2015-2024 (kg/ha)

Source: Own design and calculation based on the data from [12].

The R square value reflects that 82.7% of the yield variation is caused by other factors than time. The regression equation was used to calculate the forecast for the year 2025 and the result is 2,684.24 kg/ha with 0.02 kg more than it was in the year 2024. Practically, a neglecting difference.

The evolution of the soybean seeds yield in the main producing countries of the EU in the studied period is presented in Figure 13.

In Italy, average yield varied between 3,615 kg/ha in 2015 and 3,208 kg/ha in 2024, when it was by 11.29% smaller. The best years for soybean yield in Italy were 2020 when yield recorded the highest level of 3,769 kg/ha and also in 2016, when it was 3,753 kg/ha.

The smallest yield was registered in the year 2022, only 2,641 kg/ha.

R square = 0.251 reflects that other factors are responsible of yield variation and not time. According to the regression equation, the forecast for the year 2025 is 3,174.31 kg/ha

smaller than in the year 2024, when it accounted for 3,208 kg/ha.

In France, soybean seeds yield registered the top level of 2,915 kg/ha in the year 2017 and the smallest level of 2,043 kg/ha in the year 2022, the worst year for soybean in all the selected countries. In this case, also the yield variation was caused by the changes of other factors.

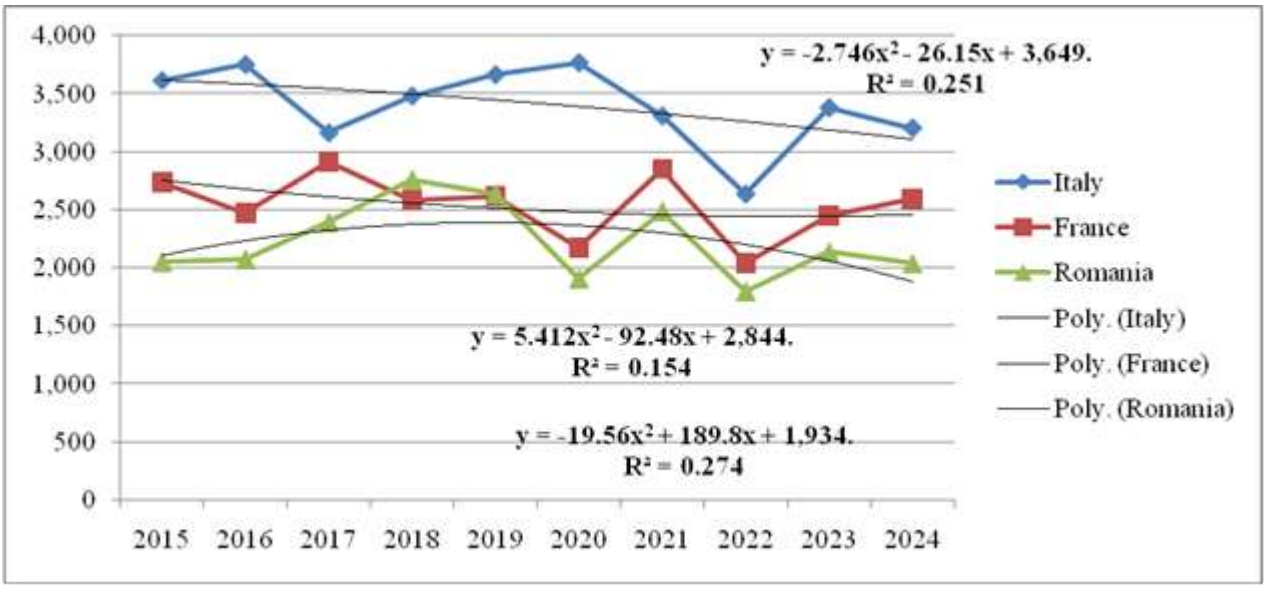

Fig. 13. The soybean seeds average yield in Italy, France and Romania, 2015-2024 (kg/ha)
Source: Own design and calculations based on the data from [12].

The forecast for 2025 is 2,528.8 kg/ha by 2.5% smaller than 2,594 in the year 2024.

In Romania, soybean seeds yield accounted for 2,047 kg/ha in 2015 and for 2,034 kg/ha in 2024 (-0.64%). Like in Italy and France, the yield variation was determined by other factors. In the year 2022, Romania registered the lowest yield, 1,794 kg/ha and in 2020 also a very low level, 2,176 kg/ha.

In 2022, per surface unit, it was obtained the lowest yield of 1,448 kg in Slovakia, 2,030 kg in Hungary, 2,143 kg in Croatia, 2,327 kg in Germany and 2,617 kg in Austria.

The main cause was climate change which had a negative impact on agriculture in the Central and Eastern Europe and also in the Mediterranean region.

Based on the regression equation, the yield forecast for the year 2025 is 1,841.21 kg/ha, by 9.5% smaller than in 2024.

The descriptive statistics for soybean seeds yield in the EU and Italy, France and Romania is shown in Table 4.

Table 4 reflects that the mean of soybean yield at the EU level in the period 2015-2024 is 2,773.7 kg/ha, with a low variation as shown by the coefficient of variation.

Italy registered a soybean average yield in the last decade of 3,399.6 kg/ha, by 22.56% higher than the EU average yield. The variation was also small, CV being 10.09%.

Table 4. The description statistics for the soybean seeds yield in the EU, Italy, France and Romania , 2015-2024

	EU	Italy	France	Romania
Mean	2,773.7	3,399.6	2,544.6	2,224.7
Standard Deviation	227.07	343.17	274.52	321.82
Kurtosis	3,428	1.5924	-0.076	-1.059
Skewness	-1.563	-1.143	-0.603	0.464
Minimum	2,230	2,641	2,043	1,794
Maximum	3,020	3,769	2,915	2,757
Coefficient of variation (%)	8.18	10.09	10.78	14.46

Source: Own calculations.

France performed an average yield of 2,544.6 kg/ha, by 9.3% smaller than the EU average.
Romania recorded an average yield of 2,224.7 kg/ha by 19.8% smaller than the EU average, by 34.6% smaller than the soybean average yield of Italy, by 12.6% lower than the average in France.
In case of Italy and France, the CV is around 10%, while in Romania is closer to 15%, reflecting a variation a little higher than the other two countries.

CONCLUSIONS

This research was destined to investigate the trends in soybean crop cultivated area, seeds production and yields and in the EU and in its major producing countries Italy, France and Romania.
First, it was presented the global status of the crop.
In 2024, soybean was cultivated on 146.7 million ha, by +22% more than in 2015. The largest areas are sown in Brazil, USA and Argentina whose share was 33.9%, 24.9% and 12.8% summing 71.6% .
The global soybean seeds gross harvest reached 420.8 million tonnes in 2024, meaning by 33.12% than in 2015. The contribution of the main producing countries was: 39.8% Brazil, 28.9% USA and 12.9% Argentina, totaling 81.6%.
In 2024, the yield accounted for 2.87 tonnes/ha, showing a surplus of +9.5% compared to 2015.
The yield level in Brazil was 3.4 tonnes/ha, while in USA 3.09 tonnes/ha and Argentina 2.90 tonnes/ha.
The EU does not cultivate a large surface with soybean, but it has also registered an increased acreage being interested to produce more seeds for internal market and reduce the dependence of imports, which is still necessary for meals.
In 2024, the EU soybean harvest area was 1,115 thousand ha, by 26.56% higher than in 2015. Italy, France and Romania had a weight in the EU cultivated area with this crop of: 30.2%, 13.7%, and, respectively, 13%, totaling 56.9%. Smaller surfaces are cultivated in other member states as follows: Croatia 9.2%, Hungary 10%, Austria 8%, Slovakia 6% and Germany 3.7%.
Soybean seeds production reached 2,992 tonnes in the year 2024, being by 27.76% higher than in 2015. Italy, France and Romania contributed with 36.1%, 13.3% and 9.9%, summing 59.3%. Other EU countries had a smaller proportions: Croatia 8.5%, Hungary 8.3%, Austria 8.2%, Slovakia 5.5% and Germany 4.4%.
Soybean seeds yield in the EU varied has slightly grown by only 0.9% attaining 2,682 kg/ha in the year 2024 compared to 2,657 kg/ha in 2015. The best year for soybean was 2019, when yield had a peak of 3,020 kg/ha. The worst year was 2022 when, the EU recorded only 2,230 kg/ha.
Italy registered 3,208 kg/ha in 2024, by 11.29% less than in 2015. The best yield in Italy was 3,769 kg/ha in 2020 and also 3,753 kg/ha in 2016. The worst year for Italy was 2022, when yield was only 2,641 kg/ha.
In 2024, France attained 2,594 kg/ha seeds by 5.3% less than in 2015. The top level was 2,915 kg/ha in 2017 and, the worst year was 2022 when per ha there were produced only 2,043 kg.
Romania registered 2,034 kg/ha in 2024 by 0.64% less than in 2015. In 2022, it was carried out the lowest yield of 1,794 kg/ha. But, the best yield 2,757 kg/ha was achieved in 2018.
Therefore, the highest yield is produced in Italy, followed by France and Romania.
All these three countries had the smallest yield level in the year 2022 which was not favorable for soybean neither in the major producers or in the other EU countries.
The main cause was climate change which had a negative impact on agriculture in the Central and Eastern Europe and also in the Mediterranean region.
Soybean acreage, production and yield will continue to grow in the future due to the role of soybean crop in assuring high protein for human diets and animal feed, oil for biofuel and industrial purposes. More than this the plant ability to capture Nitrogen into the soil and increase its fertility leading to lower amounts of chemical fertilizers will have a beneficial effect of environment protection and

biodiversity conservation. Also, its importance in crop rotation must not be neglected.

Having in mind the effects of climate change, farmers have to adopt adapted technologies concerning: early cultivation, varieties of high production potential and resistant to drought, irrigation systems, plant protection etc in order to sustain yield, but also they could grow the cultivated area to increase seeds gross output.

REFERENCES

[1]AgenceBio.org., 2024, Study of the organic soybean sector in the EU and in the main non-EU countries, https://www.agencebio.org/wp-content/uploads/2024/09/Soja-bio_synthese-resultats-EN.pdf, Accessed on 5 May, 2025.

[2]Anderson International Corp, 2025, Why soybean meal dominates the animal food market, https://www.andersonintl.com/why-soybean-meal-dominates-the-animal-feed-market/, Accessed on 5 May 2025.

[3]Anonymous, 2025, The growth in soy production is mainly driven by the world's increasing meat consumption, https://www.forestsoftheworld.org/forest-clearing/soy/, Accessed on 5 May, 2025.

[4]Bertheau, Y, Davison, J., 2011, Soybean in the European Union, status and perspective. Recent trends for enhancing the diversity and quality of soybean products, InTech - Open Access Publisher, https://hal.inrae.fr/hal-02810708/document, Accessed on May 10, 2025.

[5]Ciampitti, A.I., de Borja Reis, A.F., Cordova, C.S., Castellano, J.M., Archontoulis, V.S., Correndo, A.A., De Almeida, L.F.A., Moro Roso, L.H., 2021, Revisiting biological Nitrogen fixation dynamics in soybeans, Front. Plant Sci., 07 October 2021, Sec. Crop and Product Physiology, Volume 12 - 2021 | https://doi.org/10.3389/fpls.2021.727021.

[6]Dreoni, I., Mathews, Z., Schaafsma, M., 2022, The impacts of soy production on multi-dimensional well-being and ecosystem services: A systematic review, Journal of Cleaner Production, Vol.335, 130182. https://doi.org/10.1016/j.jclepro.2021.130182

[7]European Commission, Regulation on deforestation free-products, https://environment.ec.europa.eu/topics/forests/deforestation/regulation-deforestation-free-products_en#:~:text=The%20main%20driver%20of%20deforestation,for%20micro%20and%20small%20enterprises. Accessed on 5 May 2025.

[8]European Commission, Oilseeds and protein crops production, 2025, https://agridata.ec.europa.eu/extensions/DashboardCereals/OilseedProduction.html, Accessed on May 10, 2025.

[9]European Commission, Cereals, oilseeds, protein crops and rice, https://agriculture.ec.europa.eu/farming/crop-productions-and-plant-based-products/cereals_en, Accessed on May 10, 2025.

[10]European Commission, Agriculture and Rural Development, Reducing the plant protein deficit of the European Union, https://agriculture.ec.europa.eu/farming/crop-productions-and-plant-based-products/cereals/reducing-plan-protein-deficit-eu_en, Accessed on May 10, 2025.

[11]European Commission, Protein supply and demand ,https://agriculture.ec.europa.eu/document/download/96cc3458-64d8-4ad0-adb3-40ab63358685_en?filename=protein-supply-demand_en.pdf, Accessed on May 10, 2025.

[12]European Commission, 2025, Oilseeds and Protein Crops market situation. Expert Group for Agricultural Markets, 24 April 2025, https://circabc.europa.eu/rest/download/d5db7f03-9cfb-4c3e-a206-33073dfa1101, Accessed on May 10, 2025.

[13]European Commission, 2025, Crops market observatory, https://agriculture.ec.europa.eu/data-and-analysis/markets/overviews/market-observatories/crops_en, Accessed on May 10, 2025.

[14]FAO, The role of soybean in fighting world hunger, https://openknowledge.fao.org/server/api/core/bitstreams/c239502b-efef-4448-9fe0-2af1db6dffaa/content, Accessed on Oct.10, 2024.

[15]FEDIOL.eu, 2023, Soybean consumption on the EU, https://www.fediol.eu/data/soy-consumption%2023nov20.pdf, Accessed on May 10, 2025.

[16]Fogelberg, F., Recknagel, J., Developing soy production in Central and Northern Europe. Chapter. In Legumes in cropping systems, pp.109-124. https://doi.org/10.1079/9781780644981.0109

[17]Galben, R.D., Urda, C., Rezi, R., Gheorghieş, V., Negrea, A., Russu, F., Balaş, S., Varga, I.A., Duda, M.M., 2021,
Seed Composition Of Soybean And Its Significance For Human Health, Hop and Medicinal Plants, Year XXIX, No. 1-2, 2021, 157-163.

[18]Kuepper, B., Stravens, M., 2022, Embedded Soy in Animal Products Consumed in the EU27+UK, https://wwfeu.awsassets.panda.org/downloads/2021_106_european_soy_supply_wnf_2201_final.pdf, Accessed on May 10, 2025.

[19]Pirvutoiu, I., Popescu, A., 2012, Considerations regarding the trends on the soy bean seeds world and Romania, Annals of University of Craiova, Series Agriculture, Montanology, Cadastre, Vol. XLII(2)/2012, p.396-401.

[20]Popescu, A., 2012, Research regarding oilseeds crops development in Romania in the EU context, Journal of Agricultural Economics, Ekonomika Poljoprivrede, Vol.1/2012 Institute for Agricultural Economics, Belgrade, Serbia, 129-138.

[21]Popescu, A., 2012, Research on Romania's oilseeds biodiesel production potential, Annals of the Academy of the Romanian Scientists, Series on Agriculture, Silviculture and Veterinary Medicine Sciences, Vol. 1, No.2, pp. 70-81.

[22]Popescu, A., 2020a, Oil seeds crops: sunflower, rape and soybean cultivated surface and production in Romania in the period 2010-2019 and the forecast for 2020-2024 horizon, Scientific Papers Series

Management, Economic Engineering in Agriculture and Rural Development, Vol.20, Issue 3/2020, pp.467-477.
[23]Popescu, A., 2020b, Soybean Production - Actual Statement and 2020-2024 Forecast in Romania, Proceedings of 36th IBIMA International Conference on Vision 2025: Education Excellence and Management of Innovations through Sustainable Economic Competitive Advantage, November 4-5, 2020, Granada, Spain, pp.2196-2206.
[24]Popescu, A. 2024, Soybean production trends in the world, European Union and Romania. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 24(3), 695-708.
[25]Popescu, A., Criste, R., 2003, Using full fat soybean in broiler diets and its effect on the production and economic efficiency of fattening, Journal of Central European Agriculture, Vol. 4(2), 167-174.
[26]Popescu, A., Stoian, E., Șerban, V., 2019, Oil seeds crops cultivated area and production in the EU28-trends and correlations, 2008-2018, Scientific Papers Series ‘’Management, Economic Engineering in Agriculture and Rural Development, Vol. 19(4), 265- 272.
[27]Radu, A., 2023, Importanta culturii de soia in Europa (Importance of soybean crop in Europe, Agrointel.ro, https://agrointel.ro/248159/importantaculturii-de-soia-in-europa/, Accessed on 10 May 2025.
[28]Rittler, L., Pugachov, V., 2023, Soy production in Europe, Austrian Development Agency. https://thecollaborativesoyinitiative.info/storage/files/donau-soja-for-csi-webinar-european-soy-2023-23-03-2023.pdf, Accessed on 10 May 2025.
[29]Roger, C. B., Pocoun, D. K. & Jacob, A. Y. (2021). Profitability and technical efficiency of soybean producers in the Municipality of Tanguiéta in Benin. Agricultural Science, 3 (2), 1-17.
[30]Rotundo, J.L., Marshall, R., McCormick, R., Trung, K.S., Styles, D., Gerde, A.J., Gonzales-Escobar, E., Carmo-Silva, E., Janes-Bassett, V., Logue, J., Annicchiarico, P., De Visser, C., Dind, A., Dodd, C.I., Dye, L., Long, P.S., Lopez, M.S., Pannecoucque, J., Reckling, M., Rushton, J., Schmid, N., Shield, I., Signor, M., Messina, D.C., Rufino, C.M., 2024, European soybean to benefit people and the environment, Scientific Reports, Vol.14, Art.no. 7612.
[31]Safefoodadvocacy.eu, 2024, The EU Commission authorized two genetically modified crops as food and animal feed, https://www.safefoodadvocacy.eu/eu-commission-authorises-two-genetically-modified-crops-as-food-and-animal-feed/#:~:text=The%20European%20Commission%20has%20authorised,allow%20cultivation%20in%20the%20EU, Accessed on 5 May 2025.
[32]SNI, Sustainable Nutritional Innitiative.com, 2025, Soybeans for global nutrition: A numbers story, https://sustainablenutritioninitiative.com/soybeans-for-global-nutrition-a-numbers-story/, Accessed on 5 May 2025.
[33]USDA Foreign Agricultural Service, US Department for Agriculture, 2025, Production Soybeans, https://www.fas.usda.gov/data/production/commodity/2222000, Accessed on 20 May 2025.
[34]USDA, 2024, World Agricultural Production, 2024, https://apps.fas.usda.gov/psdonline/circulars/production.pdf, Accessed on 5 May 2025.
[35]USDA, 2025, World Agricultural Production, 2025, https://apps.fas.usda.gov/psdonline/circulars/production.pdf, Accessed on 20 May 2025.
[36]Wikipedia, Soybean. https://en.wikipedia.org/wiki/Soybean, Accessed on 10 May 2025.
[37]Zampelas, A., 2019, The Effects of Soy and its Components on Risk Factors and End Points of Cardiovascular Diseases, Nutrients, 11(11), 2621. doi: 10.3390/nu11112621

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LAND USE FOR CEREALS, OILSEEDS AND PROTEIN CROPS IN THE EUROPEAN UNION

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Abstract

Land use in the EU for cereals, oilseeds and protein crops was studied in the period 2018-2025 based on Eurostat data aiming to identify the trends, similarities and differences among the member states as a reflection how cultivated areas are involved by structure and orientation to stimulate agricultural production. Growth rate, structural index, trend equations, R square, comparison and graphical illustration represent the methodological approach. The results pointed out that the utilized agricultural land (UAA) increased by 0.82% reaching 160.56 Mill. ha, of which six countries keep 68.2%: France, Spain, Germany, Poland, Italy and Romania in which UAA is over 10 Mill. ha. The EU arable land accounts for 99.01 Mill. ha, by 1.81% smaller and having a share of 60.5% in UAA. France, Spain, Germany and Poland account for 52.9% in arable land, having each more than 10 Mill. ha. In 2025, the EU arable land is destined for two groups of crops: cereals 50.2 Mill. ha (52.5%) and oilseeds and protein crops 13.1 Mill. ha (13.9), summing 66.5%. In case of cereals, the largest arable land is allotted to soft wheat (42.1%), barley (20.5%) and grain maize (17.4%) totaling 80%. In case of oilseeds and protein crops, the highest share in arable land is kept by rape (45.1%), sunflower (35.3%) and soybean (7.9%), summing 88.3%. Smaller land surfaces are covered by other crops from these two groups in order to sustain the diversity of domestic production, to cover market needs and stimulate export. All these reflect the role of these crops in the EU vision for developing a sustainable agriculture assuring food security, animal feeding, renewable energy, industry processing and environment protection.

Key words**:** *land use, UAA, arable land, cereals, oilseeds and protein crops, EU*

INTRODUCTION

Land is our most precious capital because is our home, provides food for sustaining our life and also other useful resources, offers habitat for various plant and animal species, stores water and carbon and their cycle in nature, regulates climate, assures wealth, has an economic, social, historical and cultural importance in the development of each nation [15]. Land use is limited by its surface and for this reason its objectives must be balanced between the most beneficial utilizations under the maintenance of environment quality and preservation of land resources and biodiversity [40]. The primary purposes of the land use regard establishing settlements, attaining commercial aims, industrial goals, agricultural products, transportation and recreation tourism.

In consequence, the primary category of land use are: crop land for agriculture, grassland for animals, wetlands, forests land, terrain for setting up settlements and other types [42].

The utilization of land by humans could lead to soil alteration, to the change its destination to another, as it happens in case of the expansion of the urban and semi-urban areas diminishing the agriculture land in the rural areas by crop land abandonment, deforestation, reforestation, investments in transport infrastructure etc. Even farmers could change the land destination from a grassland to a crop land. The changes made by humans have a

negative impact on carbon cycle, climate change and biodiversity [17, 24].

Land use is very important for agriculture because it could offer space for cultivating crops and other plants and breeding animals for assuring food for humans and forages for animal feeding. More than this it provides raw materials for industrial purposes [16].

All these have shown the influence of land use on ecosystems, environment sustainability and biodiversity maintenance, and also the derived challenges and opportunities in adopting land use beneficial practices [1]. The agricultural land-use system is centered on land use including all the activities that humans make and the results of their efforts not only in the field of food security but also on mitigating climate change [2]. The EU is an important "player" in the world's land use for agriculture and not only. Of its total area accounting for 4,225,104 km^2, 4,101,431 km^2, that is 97.07% is land [14]. Agricultural land in the EU covers 160.55 million ha, representing 39% of the EU surface. Because agriculture is very important for assuring food security, sustainable development and environment protection, land use is a key factor in planning the cultivated areas with various crops and production management. Therefore, land use plays a specific social, economic and environment role in connection to soil protection and productivity, nature and biodiversity preservation and the prevention and mitigation of climate change influence.

Having in mind these aspects presented above, and continuing the previous researches, the study aimed to analyze the EU land use for cereals and oilseeds and protein crops in the period 2018-2025 based on Eurostat data for identifying the tendencies, differences and similarities among the member states to further understand how cultivated areas are involved in the future orientation to stimulate agricultural production in accordance with the change in consumer's demand.

MATERIALS AND METHODS

First of all, this paper started with the study of the literature in the field in order to have an image on the scientific knowledge framework on the topic especially in the last decade.

The main data source was Eurostat including various websites to identify and collect the information necessary to build a statistical presentation on the topic in the period 2018-2025. In a few cases, Eurostat displayed updated data only till 2022.

The following land indicators have been taken into account:

-Utilized agricultural land (UAA) at the EU level and in the main member states with the largest UAA for which the share was calculated in total EU utilized land;

-Arable land at the EU level and in the main countries which have the largest arable surface, and for which it was determined the corresponding share;

-Arable land destined for two groups of crops:

(a) Cereals as a whole and also by category of cereals: soft wheat, durum, rye, barley, oat, grain maize, triticale and other cereals;

(b) Oilseeds and protein crops as a whole and by category: field peas, broad bean, lupins, rapeseeds, sunflower seeds, linseeds, soybean.

-Forecast of land use for Cereals in the year 2026 and forecast of land use for Oilseeds and protein crops for the years 2025 and 2026.

The countries utilizing the largest land surface have been identified for each crop.

The applied methodology included: dynamic analysis, growth rate, structural index, trend line and regression equations, R square, forecast, descriptive statistics, comparison and graphical illustration. The results were accompanied by comments and the main conclusions were drawn and synthesized at the end.

RESULTS AND DISCUSSIONS

EU land surface and its primary land uses

Of its land surface accounting for 4,101,431 km^2, the EU has the following primary land uses: agricultural land 39.1%, forestry area 35.9%, unused and abandoned terrains 14.8%, services and residential surfaces 5.7%, areas with a deep environmental impact 3.9% and fishing 0.6%.

EU agricultural land

The EU agricultural land accounts for 160.55 million ha representing 3.4% of the global agricultural area, 7% of the global crop land and 1.61% of grasslands [39].

The EU countries with the largest agricultural land are: France 17.58 million ha, Spain 16.09 million ha, Germany 10.18 million ha, Poland 8.9 million ha, Romania 8.02 million and Italy 7.61 million ha [41].

The agricultural land per inhabitant in the EU is 0.37 ha [39].

EU -Utilized agricultural land (UAA)

The UAA in the EU 27 was 157.2 million ha in the year 2024. This figure reflects a slight decline of 0.64% compared to 159.24 million ha in the year 2018 (Figure 1).

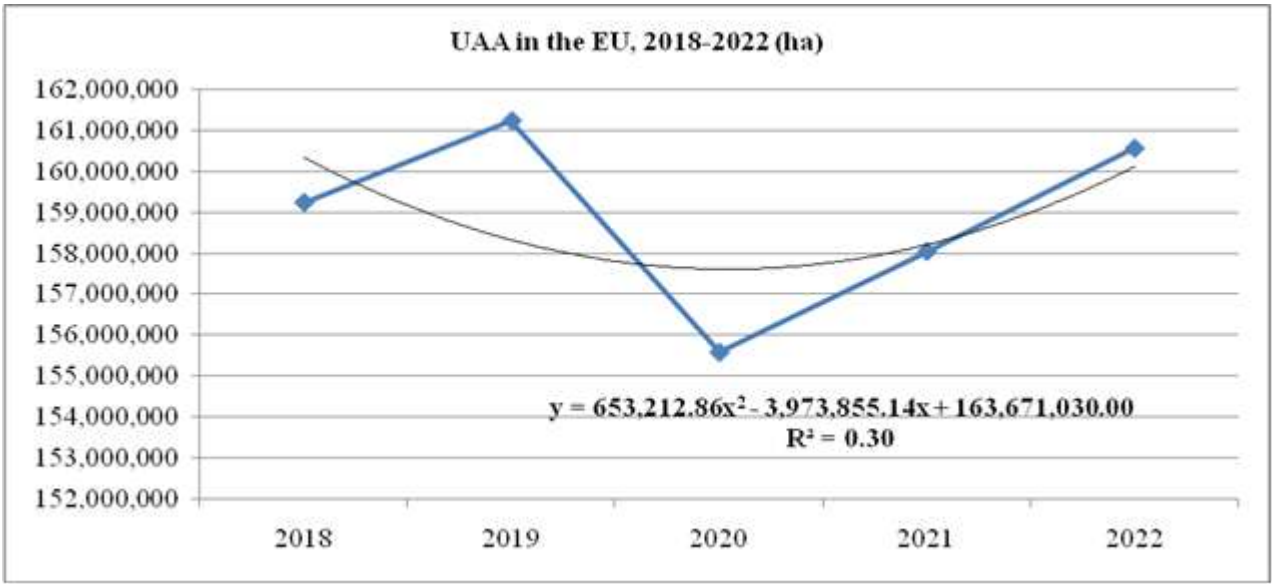

Fig.1. The dynamics of utilized agricultural land UAA at the EU level, 2018-2022 (ha)
Source: Own design and calculation based on the data from Eurostat [13].

The R square shows that 30% of the variation of UAA was determined by time and the remaining of by other factors. The downward variation in the year 2020, accounting for - 5.64 million ha compared to 2019 when the UAA was 161.23 million ha, was caused by climate change. Then, UAA restarted to grow.

The UAA varies from a member state to another depending on the local peculiarities and characteristics of land in relationship with its use in agriculture and crop type, the surface of the territory of each country, the relief forms, soil type, quality and fertility and climate conditions.

In the year 2022, the countries with the largest UAA, in the decreasing order of their share in the EU UAA were: France 17.80%, Spain 15.37%, Germany 10.33%, Poland 8.835, Italy 9.06% and Romania 7.89%. All these six countries accounts for 68.28% in the EU UAA and each utilizes more than 12. million ha.

However, it deserves to be specified that these six countries are followed by other three member states with a lower weight: Greece 3.34%, Hungary 3.16% and Bulgaria 3.12% (Figure 2).

Taking into account the UAA in each country, it was proceeded to a classification of the EU countries in four categories: over 10 Million ha, 5 to 10 Million ha, 1 to 5 Million ha and below 1 Million ha. The results are presented in Table 1.

The land utilization include: "arable land, permanent crops and grasslands and kitchen gardens"[13].

In the EU, these categories represent: arable land 62.4%, permanent grasslands 30.5%, and permanent crops 7.1% (Fig. 3).

The land use by category is deeply influenced by geographical region, soil type, structure, quality and fertility and climate conditions which are very different from a country to another and from a region to another of the EU member states, but this affirmation is also available at the global level.

In addition, land use is closely connected to its efficiency which depends of a large range of factors such as: number of farms and their specialization, farms size (physical in ha and economic in standard output-euro), labor force and its productivity, farmers' age, training level and experience, technical equipment for working land and technologies applied [23].

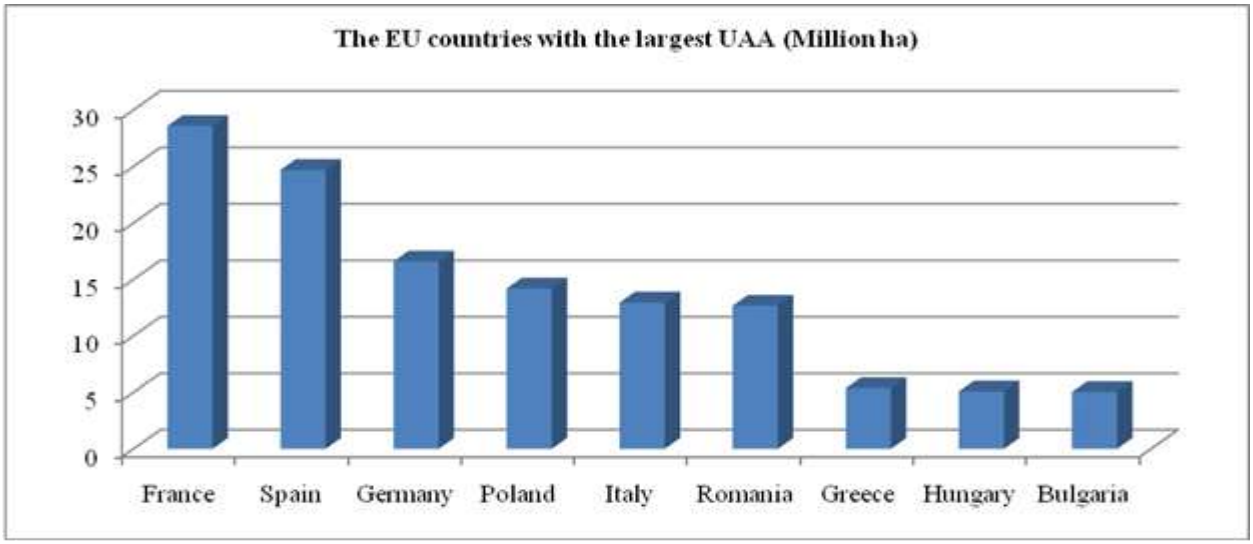

Fig. 2. The EU countries with the largest UAA in 2022 (Million ha)
Source: Own design based on the data from Eurostat [13].

Table 1. Classification of the EU member states based on UAA in 2022 (Million ha)

Over 10 Million ha		5 - 10 Million ha		1 -5 Million ha				Below 1 Million ha	
1.France	28.58	1.Greece	5.37	1.Ireland	4.34	7.Finland	2.26	1.Estonia	0.98
2.Spain	24.69	2.Hungary	5.08	2.Portugal	3.95	8.Latvia	1.97	2.Slovenia	0.47
3.Germany	16.59	3.Bulgaria	5.02	3.Czechia	3.53	9.Slovakia	1.84	3.Luxemburg	0.13
4.Poland	14.19			4.Sweden	2.99	10.Netherlands	1.80	4.Cyprus	0.12
5.Italy	12.95			5.Lithuania	2.91	11.Croatia	1.44	5.Malta	0.10
6.Romania	12.67			6.Denmark	2.62	12.Austria	1.36		
						13.Belgium	1.36		

Source: Own conception based on the data from Eurostat [13].

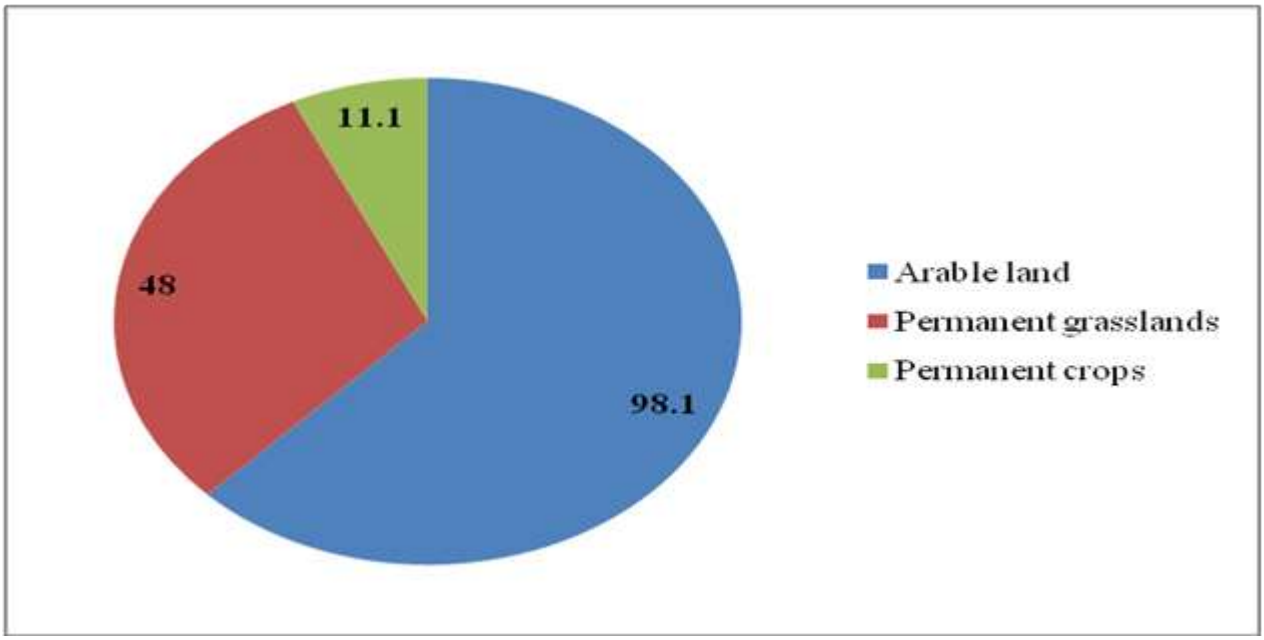

Fig. 3. The land use in the EU agriculture by category (million ha)
Source: Own design based on the data from Eurostat, [13].

The largest UAA is in the following countries: France, Spain, Germany, Poland, Romania, Italy, many of them having the largest surface area [27].

In a few countries such as: France, Austria, Hungary, Poland, Greece, Netherlands, Italy, Portugal, the UAA registered a slight declining trend on the reason that the new technologies applied using precision agriculture are more efficient assuring higher yields [37].

Another important aspect is how much of the surface of a country is utilized for agriculture. From this point of view, from the 27 EU member states, only 10 have an UAA accounting for more than 50% of the country area. In the decreasing order, it is about: Denmark, Ireland, Hungary, Romania, Netherlands, France, Luxembourg, Belgium, Poland and Lithuania [39].

Arable land

Agricultural land in the EU is utilized as follows: arable land for agricultural multi-crops, permanents crops (orchards and vineyards), permanent grasslands (meadows and pastures), kitchen gardens and temporarily fallow.

In the year 2022, the EU arable land accounted for 97,226,840 ha , being by 1.81% smaller than in the year 2018 when it was 99,017,780 ha (Figure 4).

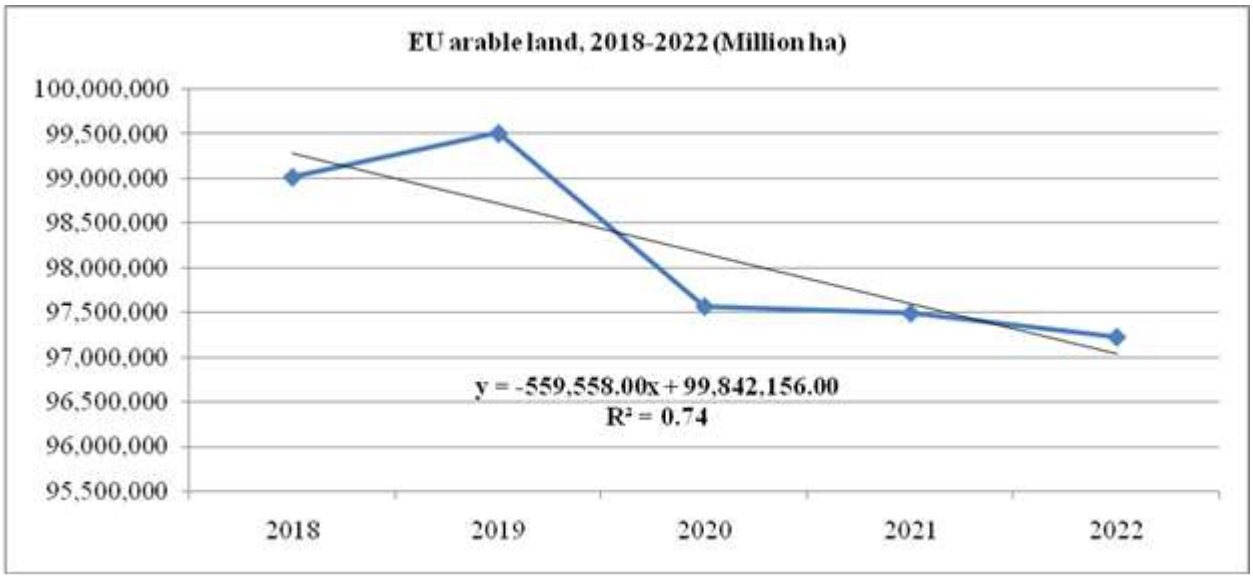

Fig. 4. The dynamics of utilized agricultural land UAA at the EU level, 2018-2022 (ha)
Source: Own design and calculation based on the data from Eurostat [12, 13].

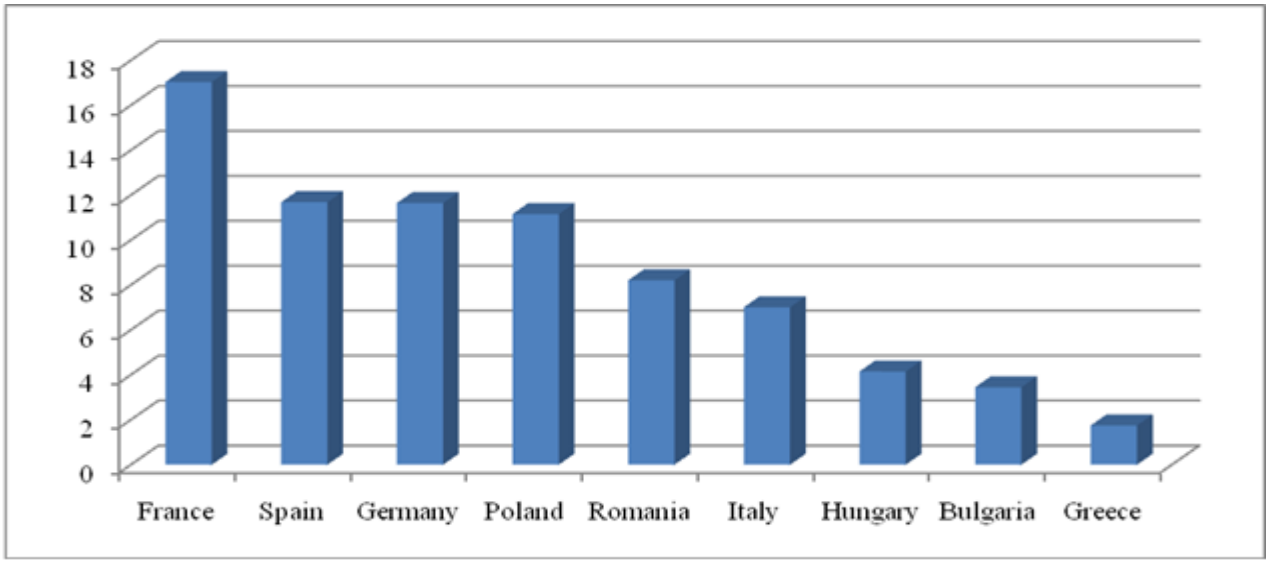

Fig. 5. The EU countries with the largest arable land in 2022 (Million ha)
Source: Own design based on the data from Eurostat [12, 13].

The R square value reflects that 74% of the variation of the EU arable land depended on time and 26% was caused by the variation of other factors.

In the decreasing order of their share in the EU level, the main countries having the largest arable land are: France 17.53%, Spain 12.02%, Germany 11.98% and Poland 11.48%, each country having more than 11 million ha arable land. Summing their shares, it resulted 41.53% These countries are followed by other five countries whose share is the following one: Romania 8.44%, Italy 7.21%, Hungary 4.27%, Bulgaria 3.55%, Greece 1.80%, summing 25.27%, and if we add this percentage to the one achieved by the 5 countries mentioned above, it results that nine EU countries keep 66.8% of the EU arable land, and each has over 1.75 million ha (Figure 5).

The arable land in the EU UAA decreased from 62.18% in 2018 to 60.5% in 2022, reflecting less 1.68 percentage points.

Based on their arable land surface, the EU countries were classified into four groups as shown in Table 2.

Table 2. Classification of the EU member states based on arable land in 2022 (Million ha)

Over 10 Million ha		5 - 10 Million ha		1 -5 Million ha				Below 1 Million ha	
1.France	17.04	1.Hungary	4.15	1.Czechia	2.38	7.Austria	1.32	1. Portugal	0.93
2.Spain	11.69	2.Bulgaria	3.45	2.Denmark	2.99	8.Slovakia	1.32	2.Belgium	0.86
3.Germany	11.65	3.Greece	1.75	3.Lithuania	2.29	9.Netherlands	1.00	3. Croatia	0.85
4.Poland	11.11			4.Finland	2.24			4.Estonia	0.69
5.Romania	8.21			5. Sweden	2.24			5.Ireland	0.44
6.Italy	7.01			6.Latvia	1.35			6. Slovenia	0.17
								7.Cyprus	0.09
								8.Luxemburg	0.06
								9.Malta	0.007

Source: Own conception based on the data from Eurostat [12].

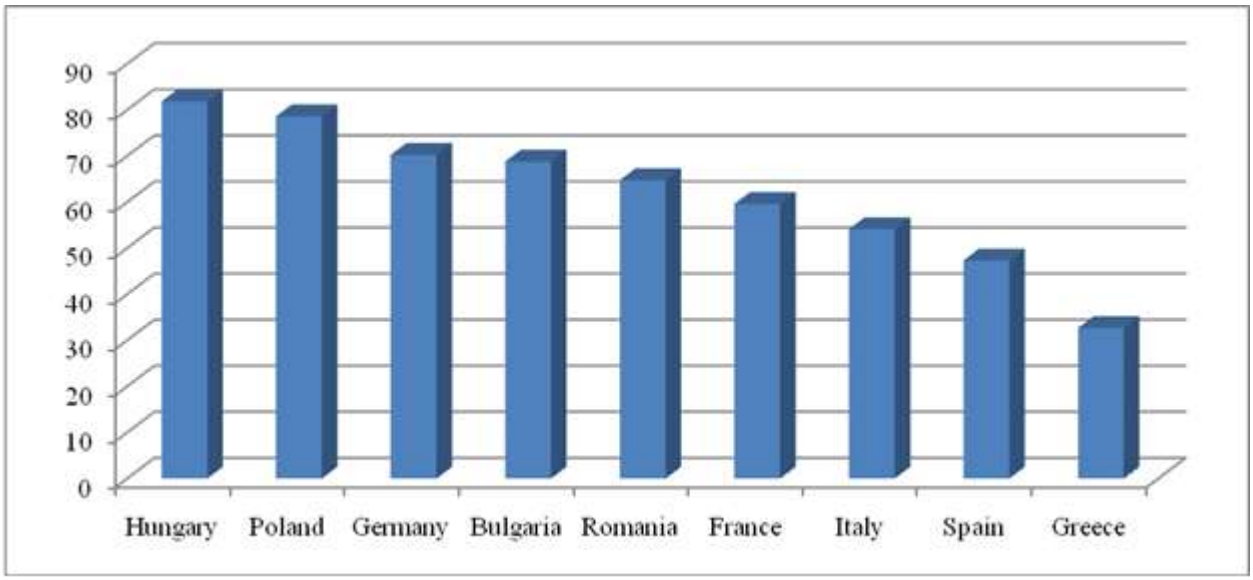

Fig. 6. The share in UAA of EU countries with the largest arable land in 2022 (%)
Source: Own design based on the data from Eurostat [12, 13].

The share of arable land in UAA

The weight of arable land in UAA is a very important aspect regarding the crop cultivation and depends on the relief of each countries, soil type, its fertility and climate factors. Figure 6 presents the share of arable land in the nine EU countries with the largest arable surface.

Based on this criterion, we may observe important changes regarding their ranking, as follows: Hungary 81.85%, Poland 78.63%, Germany 70.24%, Bulgaria 68.81%, Romania 64.76%, France 59.60%, Italy 54.13%, Spain 47.34%, Greece 32.67%. The figures show how much of arable land of UAA could be used

for crop cultivation and how much remain from the UAA for other purposes.

EU Land use for the main groups of crops

The crop land in the EU accounted for 110.78 million ha in the year 2021 and in 2024, it measured 94 million ha, being by 15.15% smaller.

The largest cropland is in the following countries: France, Spain, Germany, Poland, Italy, Romania, and also in Hungary, Bulgaria, Greece and Sweden, all these member states summing 92% of the EU cropland.

Two important groups of crops are cultivated in the EU: Cereals and Oilseeds and protein crops for which is reserved an important part of arable land [7, 8].

Land use for cereals

In the year 2025, arable land for cultivating cereals registered 50,247 thousand ha compared to 51,914 thousand ha in 2018, meaning a decrease by 3.3% [5]. As a result, the share of the land used for cereals in arable land declined from 52.42% in 2018 to 52.57% in 2025, reflecting -0.89 pp less (Figure 7).

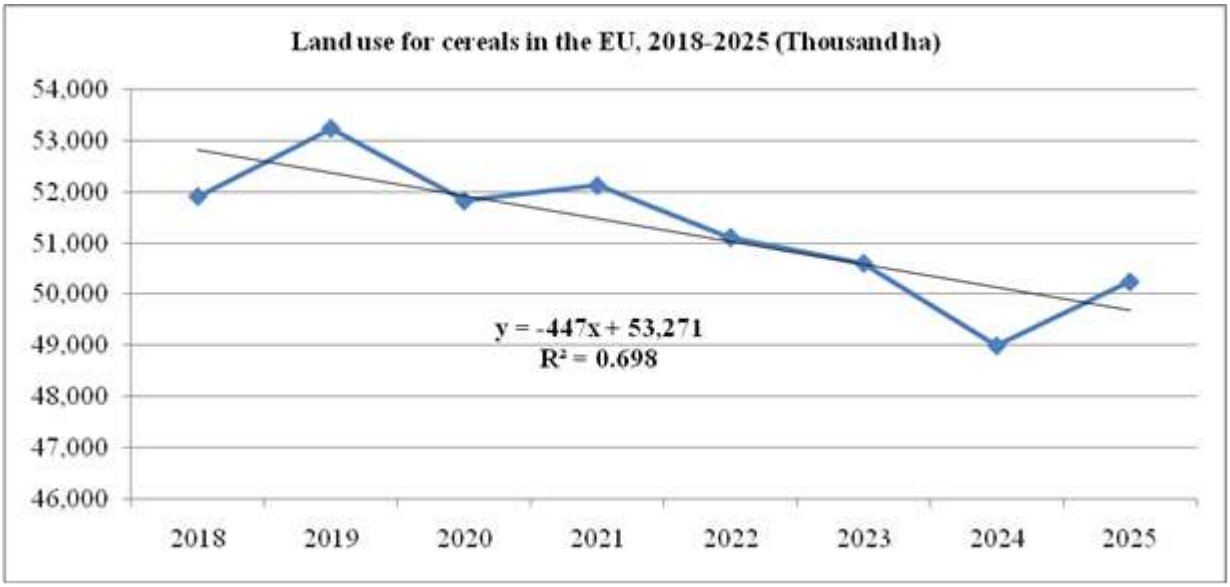

Fig. 7. The dynamics of the land use for cereals in the EU, 2018-2025 (Thousand ha)
Source: Own design based on the data from Eurostat [7, 8].

Figure 7 reflects a downward trend starting from 2020 and a slight increase starting from 2024 to 2025. The value of R square shows that 69.8% of the variation depended on time and 30.1% depended of other factors.

Based on the regression equation, the forecast for 2026 is 49,800 thousand ha, a surface which will be by 0.9% smaller than the level attained in 2025.

Land used for oilseeds and protein crops increased from 11,774 thousand ha in 2018 to 13,096 thousand ha in 2024. For the year 2025, there were not available data yet in Eurostat data base. In 2022, this share accounted for 11.89% in arable land compared to 11.89% in 2018, which means +2.06 pp (Figure 8).

This reflects the importance given by the EU to oilseeds crops and protein crops which have the role to produce protein for improving the diets for humans and partially replace the meat, to assure meal for animal feeding, for producing renewable energy (biofuels) and for protecting environment. All these will increase the domestic production and decrease the EU's imports.

In this case, the coefficient of determination, R^2, reflected that 65.7% of the land used for Oilseeds and protein crops was influence by time and 34.3% of the variation was caused by other factors.

Keeping in mind the regression equation, it was calculated the forecast of 13,375 thousand ha for the year 2025 and 13,653 for the year 2026.

Summing the arable land used for Cereals with the arable land utilized for Oilseeds and protein crops in each year of the analyzed period 2018-2026, the results reflect that while the land used for cereals will decline to 49,800 thousand ha in the year 2026, the land utilized for oilseeds

and protein crops will grow and reach 13,653 thousand ha.

But, summing the shares of the land use in the arable land for each group of crops and in every year till 2022, for which we had available data, we will notice an increased share to 66.51% in 2022 compared to 64.31% in 2018, meaning a surplus of +2.2pp (Fig. 9).

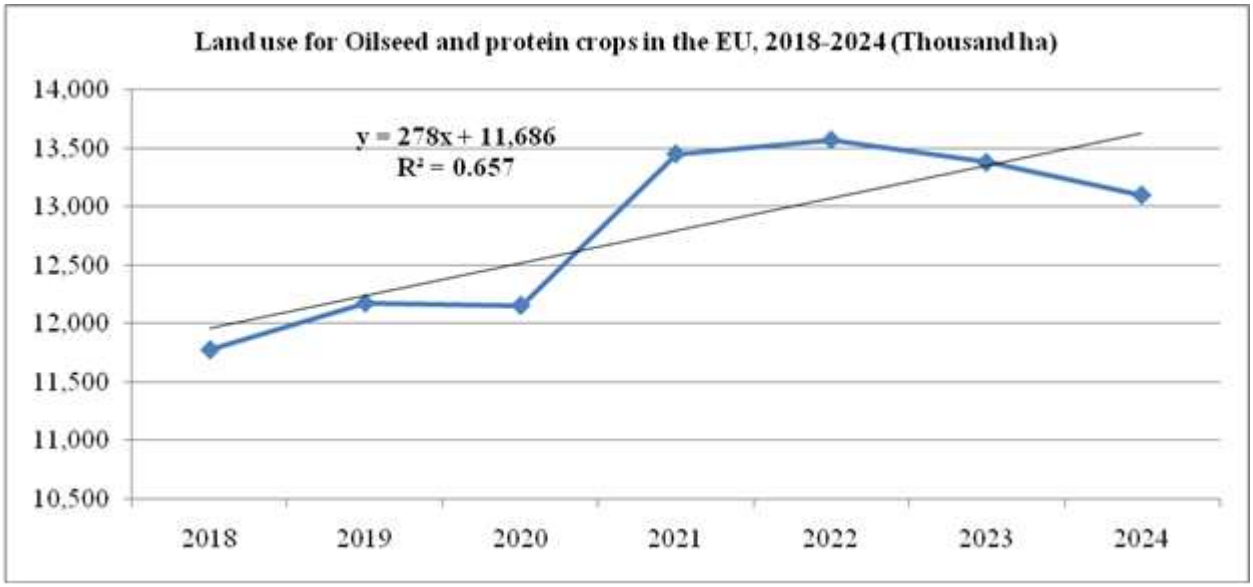

Fig. 8. The dynamics of the land use for oilseeds and protein crops in the EU, 2018-2025 (Thousand ha)
Source: Own design based on the data from Eurostat [9, 10, 11].
Note: For the year 2025-No available data.

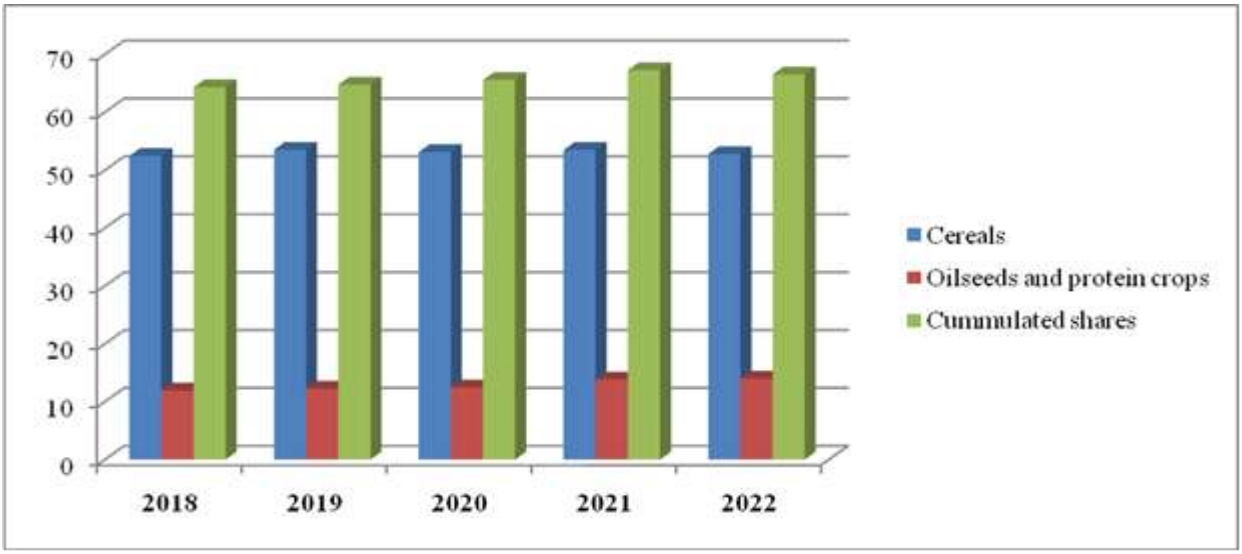

Fig. 9. The shares of land use for cereals and the shares for land use for oilseeds and protein crops, and the cumulated shares in the EU's arable land, 2018-2022 (%)
Source: Own calculations.

Land use by cereals type

In the EU**,** the land use for the cereals group differs from a cereal to another depending on its importance in relation to the market demand. Three cereals occupy the largest cultivated area: soft wheat, barley and grain maize. In case of soft wheat, the land use accounted for 21,173 thousand ha in 2025, being by 0.5% smaller than in the year 2018 when it was 21,277 thousand ha. In case of barley, the land utilized in 2025 was 10,286 thousand ha by 7.8% smaller than 11,145 thousand ha in the year 2018. Grain maize was cultivated on 8,767 thousand ha in 2025, by 6.26% larger area than 8,252 thousand ha in the year 2018 (Figure 10).

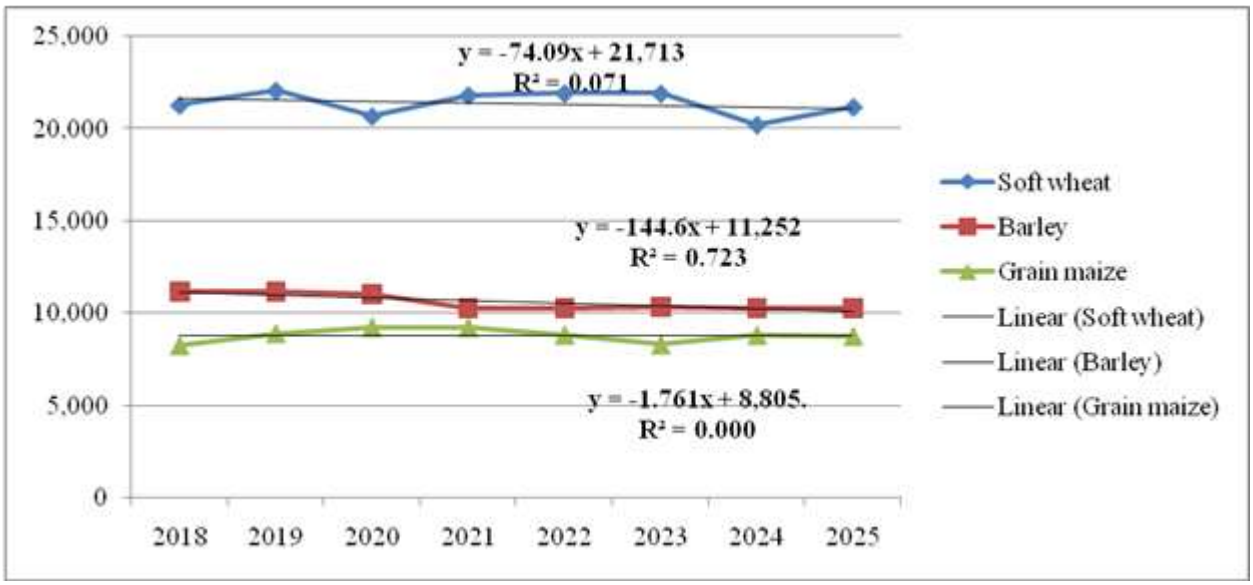

Fig. 10. Dynamics of the EU land use for the main cereals: soft wheat, barley and grain maize, 2018-2025 (Thousand ha)
Source: Own design based on the data from Eurostat [7, 8].

Figure 10 shows relative variations regarding land use for the three cereals and R square value is practically insignificant for soft wheat and grain maize, but only in case of barley it reflects that the variations depended 72% on time and 28% on the change of other factors.
Based on the regression equations, it was established that in the year 2026, the land use for soft wheat will be 21,098.91 thousand ha, for barley 10,141.4 thousand ha and for grain maize 8,765.23 thousand ha.
For the total land covered with all the cereals the forecast for 2026 is 49,800 thousand ha.
The description statistics for the EU land utilized by cereal crop in the period 2018-2025 is presented in Table 3.

Table 3. Description statistics for the EU land utilized by cereal crop in the period 2018-2025 (Thousand ha)

	Mean	St. Dev.	Kurtosis	Skewness	Minimum	Maximum	CV %
Soft wheat	21,379.75	678.49	-0.582	-0.799	20,195	22,068	3.17
Durum	2,230.8	131.76	0.492	0.880	2,082	2,481	5.90
Rye	1,905.87	155.67	0.105	0.967	1,750	2,191	8.16
Barley	10,601.5	416,39	-2.112	0.056	10,268	11,145	3.92
Oat	2,460.5	104.73	-1.606	-0.390	2,305	2,570	4.24
Grain maize	8,798	372.70	-0.725	-0.368	8,252	9,254	4.23
Sorghum	170.25	32.33	-0.001	0.655	127	228	18.78
Triticale	2,594	131.93	0.113	-0.455	2,360	2,754	5.08
Other cereals	1,130.62	273.65	-1.369	0.388	813	1,541	24.20
Total cereals	51,529	1,309.86	0.182	-0.335	48,999	53,242	2.54

Source: Own calculations.

The coefficient of variation is very low for almost all the cereals, except Sorghum where CV is 18.78% reflecting a greater dispersion of the data around the mean and also in case of other cereals, CV is equal to 24.20% showing a high variation, therefore a lower precision of the estimate.
Studying the land use by type of cereals in the period 2018-2025, it is found that the weight of the largest surfaces is allotted to three cereals in 2025: 42.1% for soft wheat, 20.5% for barley and 17.4% for grain maize, summing 80%. The difference of 20% of land being utilized for durum, triticale, oat, rye and sorghum etc. The land use for cereals compiles with the cereals utilizations for animal feed,

human consumption and for biofuel and other purposes (Table 4).

Table 4. The share of land use by type of cereal in the EU surface used for cereals, 2018-2025 (%)

	Soft wheat	Durum	Rye	Barley	Oat	Grain maize	Sorghum	Triticale	Others
2018	**40.9**	4.8	3.7	**21.5**	4.9	**15.9**	0.3	5.0	3.0
2019	**41.4**	4.0	4.1	**20.9**	4.5	**15.7**	0.4	5.2	2.7
2020	**39.8**	4.1	4.0	**21.2**	5.0	**17.9**	0.4	5.3	2.3
2021	**41.8**	4.3	3.7	**20.0**	4.9	**17.7**	0.3	5.1	2.2
2022	**42.9**	4.5	3.4	**20.1**	4.6	**17.3**	0.3	5.2	2.2
2023	**43.3**	4.6	3.7	**20.5**	4.6	**16.4**	0.3	5.0	1.6
2024	**41.2**	4.2	3.5	**21.1**	5.1	**18.0**	0.5	4.8	1.6
2025	**42.1**	4.3	3.5	**20.5**	4.9	**17.4**	0.3	5.0	2.0

Source: Own calculations based on the data from Eurostat [9].

However, a relative decline was notice for soft wheat and barley, and a slight increase for grain maize.

Durum is in a slight decline, rye as well and all the other cereals oat, sorghum and triticale look to maintain their shares.

Maize and wheat are among the most cultivated cereals in the world. The EU is placed on the 4th position for the cultivated land with these two crops. The top rank in the EU for the area covered by maize is kept by Romania [28].

Barley is another important cereal in the EU because its multi-purposes such as feed-stuffs for animal raising (pigs, poultry, horses) especially in France, Netherlands, Germany and Romania. It is also used for manufacturing industry for producing beer and alcohol and other food products. Also, farmers cultivate it because it is harvested before wheat and brings the first net return from winter crops [29].

Sorghum is the 5th cereal in the world, after maize, wheat, rice and barley grace to its role in animal feeding, but also for food consumption and industrial purposes, a special attention being given to biomass for biofuel. It is suitable for arid zones and it production costs per ha are much smaller than in case of maize. It is also friendly with the environment [32, 33, 35, 36].

Sorghum is considered a miracle cereal crop for the geographic zones with specific conditions in terms of low precipitations and high temperatures and droughts as it happened in many EU countries during the last decade and especially in Romania. In Dobrogea region, year by year agriculture was affected by high heat waves, lack of rainfalls and snows, long and severe droughts. Under these conditions, sorghum could be successfully used as a complementary crop for maize, farmers adopting adapted technologies like: early sowing, resistant varieties to drought and of high potential production [18, 20, 21].

In 2025, the EU countries with the largest land use by cereal type, in the decreasing order, are:

-***Soft wheat*** (thousand ha): France (4,632), Germany (2,839), Poland (2,453), Romania (2,042), Spain (1,773);

-***Durum:*** Italy (1,289).

-***Barley:*** Spain (2,313), France (1,744), Germany (1,577), Poland (756), Romania (529);

-***Rye:*** Poland (700), Germany (550).

-***Triticale***: Poland (1,216), France (302), Spain (253).

-***Oat:*** Poland (508), Spain (492), Finland (321);

-***Grain maize***: Romania (2,259, (France (1,535), Poland (1,150), Hungary (893),Bulgaria (543), Germany (451);

-***Sorghum***: France (72), Italy (41), Romania (8).

Land use by oilseeds and protein crops type

The oilseeds crops are cultivated for seeds, oil and for producing food and biofuel and other industrial products, and also meals for animal feeding [34].

They have special agronomical qualities in the sense that: they are good precursor plants for winter cereals and hoeing crops, being successfully utilized in crop rotation for weed control. They also have a high profitability bringing high net return to farmers. They respond very well as a feed-back to the increased demand for bioenergy and biofuels.

For this reason, the EU sustains the cultivation of these crops and also for their protein content which is so much requested coming from plants and less from animal origin [31, 9, 11].
According to the European Commission renewable Energy Directive 28/2009/, these crops are suitable for producing biofuels (bioethanol and biodiesel). They emit less than 35-40% greenhouse emissions with a positive effect on the environment and on the reduction of imports.
Biodiesel is mainly produced from rape oil, 84%, then 13% from sunflower oil and 3 % from soybean oil [26].
Rape, sunflower and soybean are suitable to be cultivated in Romania where they achieved good productions in the favorable years and also using adapted technologies to high temperatures and droughts in the non favorable climatic years [25, 30, 22].
The decision to cultivate a crop of another belongs to the farmer as an expression of knowledge, soil acreage, technologies applied and climate conditions, experience in agribusiness, financial resources, awareness of risks and opportunities, expectations of the decision drawn in terms of income and profit and subsidies to improve the financial results in close relationship with the market demand [3].
In the EU**,** the land use for the oilseeds and protein crops differs from a plant to another depending on its importance in relation to the market demand. Three oilseeds and protein crops which cover the largest cultivated area are rapeseed, sunflower and soybean.
In the year 2024, the land use for rapeseed accounted for 5,911 thousand ha, being by15.47% higher than 5,119 thousand ha in the year 2018.
In case of sunflower, the land utilized in 2024 was 4,619 thousand ha by 6.47 higher than 4,338 thousand ha in the year 2018. Soybean was cultivated on 1,024 thousand ha thousand ha in 2024, by 12.77% larger than 908 thousand ha in the year 2018 (Figure 11).

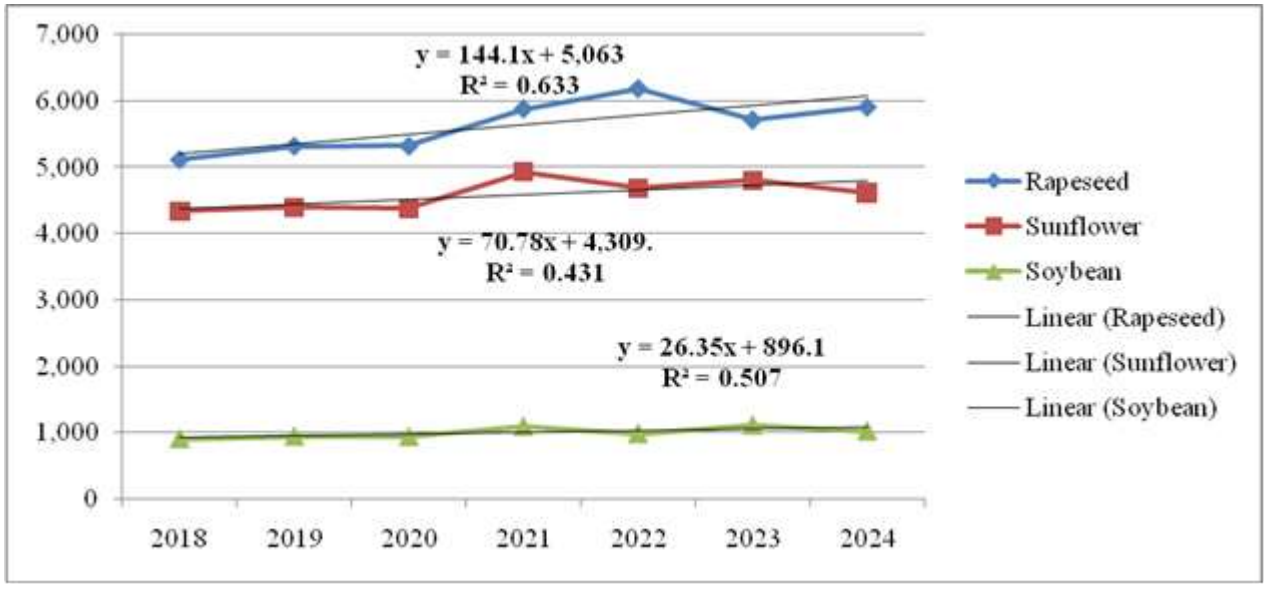

Fig.11. The dynamics of the EU land use for the main oilseeds and protein crops, 2018-2024 (Thousand ha)
Source: Own calculations based on the data from Eurostat [4].

From Figure 11, R square reflects that the variation in land use was determined by time in a higher proportion in case of rape seed 63.3%, in 50.7% in case of soybean and in 43.1% in case of sunflower, the difference of variation being caused by other factors.
The regression equations provided the necessary information to estimate the forecast for the year 2025, for which in Eurostat the data are missing. Therefore, in 2025, it expected as land use to be
6,055.1 thousand ha for rapeseed, 4,689.78 thousand ha for sunflower and 1,050.35 thousand ha for soybean. Also, for the next year 2026, the forecast is: 6,199.2 thousand ha for rapeseed, 4,760.56 thousand ha for sunflower and 1,076.70 thousand ha for soybean.

The description statistics for the land utilization in the EU for the oilseeds and protein crops in the period 2018-2024 is shown in Table 5.

Table 5. Description statistics for the land utilization in the EU for the oilseeds and protein crops in the period 2018-2024 (Thousand ha)

	Mean	St. Dev.	Kurtosis	Skewness	Minimum	Maximum	CV %
Field peas	845.42	99.50	-0.833	1.186	776	998	11.76
Broad bean	459.14	30.44	-0.181	-0.502	409	500	6.60
Lupins	214.42	26.90	0.947	0.281	174	260	12.54
Rapeseed	5,639.42	391.04	-1.482	0.0062	5,119	6,193	7.75
Sunflower	4,592.85	232.86	-1.603	0.274	4,338	4,934	5.07
Linseed	48.42	7.43	0.895	0.907	40	62	15.34
Soybean	1,001.42	79.94	-1.453	0.476	908	1,115	7.98
Total oilseed and protein crops	12,796.85	739.42	-2.183	-0.367	11,774	13,567	5.77

Source: Own calculation.

The coefficient of variation reflects a small share of standard deviation in the mean level, therefore it is a precise distribution of the estimates around the mean.

In the studied period, 2018-2024, it was noticed that the share of land use for oilseeds and proteins crops increased. By crop type, the situation is a little different. The highest share of land use in arable land belongs to rape 45.1% in 2024 compared to 43.5% in 2018 (+1.6 pp), with a slight ascending trend in the period. Sunflower recorded a slight decline from 36.8% in 2018 to 35,3% in 2024 meaning by - 1.15 pp. Finally, soybean registered a slight growth of 0.5 pp from 7.4% in 2018 to 7.9% in 2024. The other crops have the following status: broad bean remain constant for 3.5%, lupins increased its share from 1.5% to 1.7% (+0.2 pp), and linseed stagnated on 0.3%. The structure of the land utilized for these crops is in accordance with the EU policy for assuring more protein of vegetal origin and reduce meat, more feed for animals and raw materials for industry [38] (Table 6).

Table 6. The share of land use by type of oilseeds and protein crops in the EU surface used for these crops, 2018-2024 (%)

	Field peas	Broad bean	Lupins	Rapeseed	Sunflower seeds	Linseed	Soybean
2018	7.0	3.5	1.5	**43.5**	**36.8**	0.3	**7.4**
2019	6.5	3.7	1.9	**43.7**	**36.1**	0.4	**7.7**
2020	6.4	3.9	1.7	**43.8**	**35.9**	0.5	**7.8**
2021	5.8	3.2	1.9	**43.8**	**36.7**	0.4	**8.2**
2022	7.2	3.5	1.5	**45.6**	**34.5**	0.4	**7.2**
2023	7.5	3.7	1.5	**42.7**	**35.9**	0.3	**8.4**
2024	6.2	3.5	1.7	**45.1**	**35.3**	0.3	**7.9**

Source: Own calculations based on the data from Eurostat [4].

In 2025, the EU countries with the largest land use by oilseeds and protein crops, in the decreasing order, are:

-***Field peas*** (Thousand ha): Spain (145), France (112), Germany (108), Romania (88);

-***Broad bean***: France (88), Lithuania (72), Germany (60), Spain (24);

-***Lupins***: Poland (155), Germany (27), Greece (13), Romania (8);

-***Rapeseeds***: France (1,287), Germany (1,114), Poland (1,029), Romania (702);

-***Sunflower seeds***: Romania (1,120), Bulgaria (874), France (785), Spain (731), Hungary (668);

-***Linseeds:*** France (23);

-***Soybean***: Italy (330), France (165), Romania (142).

The new EU policy orientation for the future land use for cereals and oilseeds and protein crops

Being aware that land is a limited resource, consumers' demand is continuously changing and climate factors have become more aggressive, the EU has renewed its strategy orientation, as mentioned in the EU agricultural outlook 2024-35 [6], being focused on the following aspects in the future:
(i) the assurance of the population requirements for high quality food and in a sufficient amount for a healthy diet based especially on plant-based protein,
(ii) the assurance of the animals' needs for feed for growing and fattening and for carrying out and better and higher productions,
(iii) providing more raw materials for industrial processing into oil, biofuels and other useful products.
The use of the land in agriculture involves risks and uncertainties linked to climate conditions and that is why the EU policy promotes a sustainable land management.
The limited area must be compensated by a balanced structure of crops in cropland and a higher productivity under the land preservation, environment protection, diminishing meat production and consumption by replacing the protein of animal origin with plant-based protein which could provide a healthier green food for the population.
In this context, the actual goals of the EU agro-food strategy provides:
- to continue to assure agri-food self-sufficiency;
-to decrease meat production especially beef and pork;
- to encourage poultry sector;
-to sustain the protein production provided by protein crops for a healthier green diet for the population;
-to continue to be a net agro-food exporter contributing to the global food security.
To attain these objectives, agriculture should be sustained to grow its performance in close relationship with environment sustainability.
In the perspective of the year 2035, land use will be oriented to the following directions:
- the expand of surfaces cultivated with soybean, other oilseeds and pulses;
-to diminish the areas covered by cereals for feed;
-to reduce the land use for rapeseeds for biofuel;
-to maintain the land surface with permanent grasslands and fallow;
-to extend the land use for permanent crops.
These changes in the EU land use management is justified by the fact that in the year 2035, it is expected as yields of cereals, oilseeds plants and protein crops to grow grace to the development of precision agriculture, digitalization, improved soil fertility and quality and reduced farm inputs [6].

CONCLUSIONS

The aim of this study was to research the land use in the EU for cereals, oilseeds and protein crops in the period 2018-2025 using the data provided by Eurostat data. In fact, there were identified the trends, similarities and differences among the member states as a reflection how cultivated areas are involved by structure and orientation to stimulate agricultural production. The methodological approach consisted of: growth rate, structural index, trend equations, R square, forecast, comparison, tabular presentation and graphical illustration.
The results pointed out that the utilized agricultural land (UAA) increased by 0.82% reaching 160.56 Mill. ha, of which six countries: France, Spain, Germany, Poland, Italy and Romania keep 68.2%, in which UAA is over 10 Million ha.
The EU arable land accounts for 99.01 Million ha, by 1.81% smaller and having a share of 60.5% in UAA.
France, Spain, Germany and Poland account for 52.9% in arable land, having more than 10 Million ha each.
In 2025, the EU arable land distributed for two groups of crops looked as follows: cereals 50.2 Million ha (52.5%) and oilseeds and protein crops 13.1 Million ha (13.9%), summing 66.5%.
In case of cereals, the largest arable land belongs to soft wheat (42.1%), barley (20.5%) and grain maize (17.4%) totaling 80%.

In case of oilseeds and protein crops, the highest share in arable land is kept by rape (45.1%), sunflower (35.3%) and soybean (7.9%), summing 88.3%.

Other crops from these two groups used smaller land surfaces in order to sustain the diversity of domestic production, to cover market needs and stimulate export.

All these reflect the EU vision concerning the role of these crops for developing a sustainable agriculture assuring food security, animal feeding, renewable energy, industry processing and environment protection.

To attain its goals by the year 2035, the EU new land use management provides that soybean, other oilseeds and pulses to be cultivated on larger land areas, while the land allotted for cereals for feed and rapeseeds for biofuel to decrease; land with permanent grasslands and fallow to be maintained at the actual level, but permanents crops to benefit of a larger land surface.

REFERENCES

[1]Ali, M.A., Kamraju, M., 2023, Land use and agriculture, In: Natural Resources and Society: Understanding the Complex Relationship Between Humans and the Environment. Earth and Environmental Sciences Library. Springer, Cham. https://doi.org/10.1007/978-3-031-46720-2_8

[2]Deng, X., Gibson, J., Song, M., Li, Z., Han, Z., Zhang, F., Chang, W., 2024, Agricultural land-use system management: research progress and perspectives, Fundamental research, In Print.

[3]Dinu, T., Badiu, A.-F., Stoian, E., Vlad, I.M., Popescu, A., Stefan, M., 2017, Rapeseed market in Romania. The determinant regarding the decision to cultivate rapeseed. AgroLife Scientific Journal, Vol.6(1), 92-97.[4]European Commission, 2020, Oilseeds and Protein crops market situation, Committee for the Common Organization of Agricultural Markets.[5]European Commisison, 2025, Cereals, oilseeds, protein crops and rice, https://agriculture.ec.europa.eu/farming/crop-productions-and-plant-based-products/cereals_en, Accessed on 10 May 2025.

[6]European Commisison, 11 Dec. 2024, EU agricultural outlook 2024-35: A resilient sector adapts to climate change, sustainability concerns, and shifting consumer demand, https://agriculture.ec.europa.eu/media/news/eu-agricultural-outlook-2024-35-resilient-sector-adapts-climate-change-sustainability-concerns-and-2024-12-11_en#:~:text=EU%20agricultural%20outlook%202024%2D35:%20A%20resilient%20sector,change%2C%20sustainability%20concerns%2C%20and%20shifting%20consumer%20demand.&text=According%20to%20the%20report%2C%20the%20EU%20agricultural,as%20climate%20change%20and%20changing%20consumer%20demand., Accessed on 10 May 2025.

[7]European Commission, Cereals statistics, https://agriculture.ec.europa.eu/data-and-analysis/markets/overviews/market-observatories/crops/cereals-statistics_en, Accessed on 10 May 2025.

[9]European Commission, Cereals EU Dashboard, https://agridata.ec.europa.eu/Reports/Cereals_Dashboard.pdf, Accessed on 10 May 2025.

[9]European Commission, Oilseeds and protein crops production, 2025, https://agridata.ec.europa.eu/extensions/DashboardCereals/OilseedProduction.html, Accessed on May 10, 2025.

[10]European Commission, Cereals, oilseeds, protein crops and rice, https://agriculture.ec.europa.eu/farming/crop-productions-and-plant-based-products/cereals_en, Accessed on May 10, 2025.

[11]European Commission, 2025, Oilseeds and Protein Crops market situation. Expert Group for Agricultural Markets, 24 April 2025, https://circabc.europa.eu/rest/download/d5db7f03-9cfb-4c3e-a206-33073dfa1101, Accessed on May 10, 2025.

[12]Eurostat, Land use Statistics, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Land_use_statistics, Accessed on May 10, 2025.

[13]Eurostat, Utilised agricultural area by categories, 2019, UAA, https://ec.europa.eu/eurostat/web/products-datasets/-/tag00025, Accessed on Sept.20, 2019.

[14]Eurostat, 2024, Area by NUTS 3 region, https://ec.europa.eu/eurostat/databrowser/view/reg_area3__custom_13249664/default/table?lang=en, Accessed on 5 May 2025.

[15]FAO, Land Resources and People: Dependence and Interaction, https://www.fao.org/4/x3810e/x3810e04.htm#g, Accessed on 5 May 2025.

[16]García-Álvarez, D., Hinojosa, J.L., Jurado Pérez, F.J., Quintero Villaraso, J., 2022, General Land Use Cover Datasets for Europe. In: García-Álvarez, D., Camacho Olmedo, M.T., Paegelow, M., Mas, J.F. (eds) Land Use Cover Datasets and Validation Tools. Springer, Cham. https://doi.org/10.1007/978-3-030-90998-7_16

[17]Gibas, P., Majorek, A., 2020, Analysis of Land-Use Change between 2012–2018 in Europe in Terms of Sustainable Development, Land, *9*(2), 46; https://doi.org/10.3390/land9020046

[18]Jinga, V., Vlăduț, V., Marin, E., Manole, D., 2018, Sorghum culture a solution for Dobrogean agriculture. International Symposium, ISB-INMA TEH' 2018, Agricultural and mechanical engineering, Bucharest, Romania, 1-3 November 2018 , pp. 951- 954. ref.7.

[19]Krantgartner, R., Nenard, M. C., Lieberz, S., Boshnakova, M., Flach, B., Wilson, J., Wideback, A., Bettini, O., Guerrero, M., Bendz, K., 2011, EU-27 Oil

seeds and products Annual modest rebound in EU-27, Oils seeds Products, GAIN Report No. E 60016, USDA.
[20]Manole D., Jinga V., Giumba Ana Maria, Dudoiu R., 2018, Sorghum crop, an alternative for Dobrogea farmers in the context of climate changes, Proceeding Book Agrobiol, International Agricultural, Biological & Life Science Conference, Edirne, Turkey, pp.415- 419
[21]Manole, D., Giumba, M., Ganea, L., 2020, Research and contributions to plant sorghum crop in the conditions of climate change, Annals of the Academy of the Romanian Scientists, Series on Agriculture, Silviculture and Veterinary Medicine Sciences, Vol.9, No.1, 37-48.
[22]Manole, D., Jinga, V., Gradila, M., Raduz, I., Iordache, S., Soare, S., 2019, New edition on sunflower crop - Romanian technology under climate change conditions in Dobrogea, Scientific Papers. Series A. Agronomy, Vol. LXII, No. 1, 348-354.
[23]Mathews, A., 2018, EU farm incomes in 2017, CAP reform, Jan.2018, http://capreform.eu/eu-farm-incomes-in-2017/, Accessed on Sept.20, 2019
[24]Olafson, B., 2022, What is land use change and what causes it? https://sentientmedia.org/land-use-change/, Accessed on 5 May 2025.
[25]Popescu, A., 2012a, Research regarding the oilseeds crops development in Romania in the EU context, Economics of Agriculture Vol.59(1), 129-137.
[26]Popescu, A., 2012b, Research on Romania's oilseeds biodiesel production potential, Annals of the Academy of the Romanian Scientists, Series on Agriculture, Silviculture and Veterinary Medicine Sciences, Vol. 1, No.2, pp. 70-81.
[27]Popescu, A., 2013, Considerations on utilized agricultural land and farm structure in the European Union, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Vol.13(4):221-226.
[28]Popescu, A., 2015, Analysis of the evolution and distribution of maize cultivated area and production in Romania, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.15(3), 243-259.
[29]Popescu, A., 2018a, Barley market development in Romania in the period 2007-2017, Annals of the Academy of the Romanian Scientists, Series on Agriculture, Silviculture and Veterinary Medicine Sciences, Vol. 7, No.2, pp. 5-14.
[30]Popescu, A., 2018b, Soybean market development in Romania in the period 2007-2017, Annals of the Academy of the Romanian Scientists, Series on Agriculture, Silviculture and Veterinary Medicine Sciences, Vol. 7, No.2, pp. 14-21.
[31]Popescu, A., 2020a, Oil seeds crops: sunflower, rape and soybean cultivated surface and production in Romania in the period 2010-2019 and the forecast for 2020-2024 horizon, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.20(3), 467-477.
[32]Popescu, A., 2020b, Sorghum production in the EU-28 in the period 2008-2019 and its forecast for 2020-2024 horizon, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.20(3), 479-488.
[33]Popescu, A., 2020c, Sorghum production in Romania in the period 2010-2019 -Trends and determinant factors, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol. 20(3), 455-466.
[34]Popescu, A., Criste, R., 2003, Using full fat soybean in broiler diets and its effect on the production and economic efficiency of fattening, Journal of Central European Agriculture, Vol. 4(2), 167-174.
[35]Popescu, A., Condei, R., 2014, Some considerations on the prospects of sorghum crop, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.14(3), 295-304
[36]Popescu Agatha, Dinu, T.A., Stoian, E., 2018, Sorghum-An important cereal in the world, in the European Union and Romania, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.18(4): 271-284.
[37]Popescu, A., Dinu, T.A., Stoian, E., 2019, Efficiency of the agricultural land use in the European Union . Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 19(3), 475-486.
[38]Popescu, A., Stoian, E., Șerban, V., 2019, Oil seeds crops cultivated area and production in the EU28-trends and correlations, 2008-2018, Scientific Papers Series ‘’Management, Economic Engineering in Agriculture and Rural Development, Vol. 19(4), 265- 272.
[39]Popescu, A., Dinu, T.A., Stoian, E., Ciocan, H.N., Șerban, V., 2024, Land use -at the global and European Union level in the period 2000-2021, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol. 24(1),761-774.
[40]Savini, F., Aalbers, M. B., 2016, The de-contextualisation of land use planning through financialisation: Urban redevelopment in Milan. European Urban and Regional Studies. 23 (4): 878–894
[41]The World Bank, 2024, Agricultural land (% of land area), http://data.worldbank.org/indicator/AG.LND.AGRI.ZS, Accessed on May 5, 2025.
[42]Wikipedia, 2024, Land use, https://en.wikipedia.org/wiki/Land_use, Accessed on 5 May 2025.

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IMPACT OF M19 LEADER FUNDING ON RURAL AREAS IN THE NORTH-EAST REGION OF ROMANIA

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Abstract

The objective of this paper is to analyze the effects of funding provided through Measure 19 – LEADER on rural development, with particular emphasis on the North East region. By supporting Local Action Groups, the LEADER approach plays a key role in carrying out Local Development Strategies, fostering economic diversification in rural areas, enhancing infrastructure, and safeguarding cultural heritage. The study compares the performance of the measure between the 2007-2013 and 2014-2020 periods, highlighting the increased efficiency of resource allocation in the recent phase due to the introduction of additional sub-measures (19.1, 19.3). The results show that the funding provided has generated jobs, stimulated entrepreneurship and strengthened social cohesion. The study emphasizes the necessity of consistent monitoring and ongoing support for enhancing the operational capacity of Local Action Groups (LAGs). The findings suggest that Measure 19 – LEADER acts as a driving force for sustainable rural development by encouraging active participation of local communities and promoting solutions adapted to local needs, thereby making a substantial contribution to the goals of the Common Agricultural Policy and to the broader sustainable development of rural areas.

Key words**:** *LEADER, M 19, rural development, Local Action Groups, North East Romania*

INTRODUCTION

The LEADER approach represents a key instrument for Romania, fostering both economic and social progress in rural regions, while helping to bridge the gap between urban and rural areas and advancing social inclusion (Ciobanu & Vladu, 2024) [4]. Aligned with the objectives of the Common Agricultural Policy and the National Rural Development Programme (NRDP), LEADER supports the growth of local communities by offering tailored solutions that reflect the specific needs and priorities of each territory (Turek-Rahoveanu A. & Turek-Rahoveanu M.M., 2013) [21]. Its added value stems from empowering local initiatives that address challenges identified within communities and transform them into targeted, practical actions that contribute directly to sustainable rural development (Staic & Vladu, 2021a) [18]. Moreover, LEADER has a notable influence on intervention area DI 6B, improving the quality of life in rural areas by enhancing infrastructure and boosting their overall attractiveness (Creangă et al., 2022) [5]. Its innovative approach, support for cross-cutting initiatives and encouragement of community involvement are central pillars of the measure's success, and the projects supported promote the diversification of non-agricultural economic activities, the development of local infrastructure (including broadband), increased social inclusion and the preservation of cultural heritage (Special Report LEADER, 2023) [6].
LAGs are concrete tools that turn local potential into reality, facilitating the economic, social and cultural development of LEADER territories (Turek-Rahoveanu, 2012) [20]. They ensure the active involvement of communities, the creation of partnerships, knowledge transfer and the implementation of innovative solutions to local challenges. LEADER thus becomes a catalyst for sustainable rural development with positive effects on the whole community.
The LEADER measure contributes significantly to the cross-cutting objectives by supporting local initiatives that integrate environmental, climate and innovation dimensions (Brezuleanu et al., 2024) [2]. Thus in the period 2007-2013, measure 41 focused

on the implementation of local development strategies through investments in rural infrastructure, support to SMEs and diversification of the rural economy, with a strong emphasis on the formation and functioning of LAGs (measure 431) and on cooperation (measure 421), all within a limited budgetary framework (RNDR Evaluation Study, 2022) [14].

In the 2014-2020 period, support was expanded and diversified by the introduction of sub-measures 19.1 (preparatory support), 19.2 (implementation of local strategies), 19.3 (national and transnational cooperation) and 19.4 (operating and animation expenditure), and the activities financed included public consultations, the creation of local strategies and the financing of projects proposed by the development strategies. Benefiting from a considerably increased budget, this phase signaled a shift from the initial establishment of Local Action Groups (LAGs) toward broadening the influence of the LEADER initiative in rural areas, while also encouraging innovation through transnational cooperation and integrated development projects (Ministry of Agriculture and Rural Development, 2019) [8]. In this context, the paper seeks to examine the financial impact of implementing Measure 19 – LEADER on rural development in Romania, with particular attention given to the North-East region.

The study investigates how the funding allocated to the Local Action Groups contributes to increasing the quality of life, diversifying the rural economy, preserving the cultural heritage and developing infrastructure in local communities, thus the objectives of the paper aim to:

-comparing the performance of the implementation of LEADER measures in the period 2007-2013 compared to 2014-2020, in order to identify differences in the efficiency of the use of resources;

- assessing the economic impact of the M19 LEADER measure, by analyzing the financial indicators and results achieved in the 2014-2020 programming period;

- analyze the regional distribution of approved projects and their effects on less developed areas.

MATERIALS AND METHODS

This study aims to assess the effects of funding allocated through Measure 19 – LEADER on rural development, with a particular emphasis on the North-East region of Romania. The analysis is based on several key categories of data, including financial and operational information provided by the Agency for Rural Investment Financing (AFIR), such as budget allocations, funding requests, signed contracts, and disbursed payments under sub-measures 19.1, 19.2, 19.3, and 19.4. In addition, the study considers outcome indicators reported by Local Action Groups (LAGs), including the number of approved projects, beneficiaries reached, and the measurable impact on rural communities. The research also incorporates strategic documents such as the National Rural Development Programmes (NRDP) for 2007–2013 and 2014–2020 [8], alongside relevant European regulations and rural development strategies. A mixed-methods approach combining quantitative and qualitative analysis is employed to evaluate the impact of funding under Measure 19 – LEADER (Ministry of Agriculture and Rural Development, Status of submitted projects 2007–2013 and 2014–2020) [11, 12]. The quantitative method involves descriptive statistical analysis, assessing the measure's performance through indicators such as project selection rate, completion rate, amount of payments made and financial efficiency (Brezuleanu, 2017) [3]. Data are also compared between the 2007-2013 and 2014-2020 programming periods in order to identify performance differences and evolutionary trends, while the regional distribution analysis examines how projects and funds have been distributed between less developed and more developed regions (Viziteu, 2022) [22].

RESULTS AND DISCUSSIONS

2013

In Romania, the implementation of LEADER principles and Local Action Groups started in the period 2007-2013 through the National Rural Development Program, and between 2011 and 2012, 163 LAGs were selected,

covering approximately 142,000 km², representing about 63% of the eligible territory and about 58% of the population targeted by LEADER (Alecu et al., 2015) [1]. For the next programming period, it is intended to extend the coverage of LEADER to the entire eligible territory, through a smaller number of LAGs compared to the previous period, thus this approach aims at a balanced territorial development, ensuring the critical mass necessary for the effective implementation of strategies, as well as optimizing the running costs (Staic &Vladu, 2021b) [19].

As a general principle of complementarity, the ERDF and the ESF, through the DLRC-POR instrument, will finance local development actions in urban areas with populations of more than 20,000 inhabitants. In parallel, the EAFRD will support the work of LAGs in rural areas and small towns with less than 20,000 inhabitants, thus the funding of the LEADER initiative through the PNDR will be provided from the funds allocated through the EAFRD (Staic &Vladu, 2020) [17].

In the 2007-2013 programming period, the short duration of the selection call for broadband infrastructure investments in rural areas, caused by the obligation to sign the financing contracts by June 30, 2014 and the limited time for project implementation until the end of the programming period, led to the rejection of some technical projects and applications for funding due to the failure to meet the technical requirements or eligibility criteria. In the current programming period, Local Action Groups (LAGs) are no longer constrained by the strict time limitations that characterized previous cycles, which enables them to incorporate broadband infrastructure projects into their local development strategies (Brezuleanu et al., 2024) [2]. Lessons learned from the implementation of the PNDR 2007–2013 period underscore the importance of financing initiatives that leverage local resources and emphasize territorial specificity, thereby preserving the innovative and bottom-up nature of the LEADER approach (National Network for Rural Development, 2024) [15, 16].

Measure 41, titled "Implementation of Local Development Strategies," was designed to support integrated territorial projects aimed at enhancing the competitiveness of the agriculture and forestry sectors, protecting the environment, improving rural landscapes, and fostering economic diversification and a better quality of life in rural communities.

The implementation of Measure 41 has demonstrated significant progress in rural development through the selection of 163 LAGs in two sessions (2010 and 2012), with a total value of projects of over 453 million euro, supporting integrated local strategies, however, in 2013, although 1,964 projects were contracted, they represented only 20.67% of the PNDR target of 9,502 projects, and the actual contracted value of 69.9 million euro was only 23.61% of the allocated budget (National Network for Rural Development, LEADER, 2023) [15, 16].

According to the data reported by the 163 LAGs, the results indicate a significant coverage of the territory, with 78.34% of the target area and a population covered of 72.34% of the target.

Table 1. LAGs results 2007-2013

Indicator	Result obtained	Target foreseen	Achievement percentage (%)
Total area covered (km²)	142,267 km²	181,600 km²	78.34%
Total population in the territory (persons)	6,770,589 persons	9,360,000 people	72.34%
Total number of members in LAGs	6,942 members	5,285 members	131.35%
Number of private partners and NGOs in LAGs	5,103 partners	3,213 partners	158.82%
Number of projects contracted	2,040 projects	9,502 projects	21.47%

Source: According to the Ministry of Agriculture and Rural Development (MADR, 2024), the report on the status of submitted projects for the 2007–2013 programming period [11].

The number of LAG members exceeded the target, reaching 131.35% of the target, and the private partners and NGOs involved achieved an impressive 158.82% of the target. However, the number of contracted projects represents only 21.47% of the target of 9,502 (Table 1).

By the end of 2013, 12 contracts were terminated at the request of the beneficiaries and 7 contracts were finalized (4 in measure 411,121. 2 in measure 413,312 and 1 in measure 413,322), but due to the low number of finalized projects, the outcome indicators on jobs created and beneficiaries developing innovative activities have not been calculated and will be reported in future evaluations, according to the frequency set by the CMEF.

Measure 421 "Implementation of cooperation projects", in 2013 the first 6 projects were submitted under this measure, with a total public value of 77,834 thousand euro, but by December 31, 2013 their selection or contracting had not been carried out.

Measure 431 - sub-measure 431.1 "Building public-private partnerships", phases 1 and 2 of the sub-measure involved the organization of training courses for the LEADER approach, structured in four batches, each covering two development regions:

- Lot I: North-East (Bacău, Botoșani, Iași, Neamț, Suceava, Vaslui) and South-East (Brăila, Buzău, Constanța, Galați, Vrancea, Tulcea) regions.
- Lot II: South-Muntenia (Argeș, Călărași, Dâmbovița, Giurgiu, Ialomița, Prahova, Teleorman) and Bucharest-Ilfov regions.
- Lot III: South-West (Dolj, Gorj, Mehedinți, Olt, Vâlcea) and West (Arad, Caraș-Severin, Hunedoara, Timiș).
- Lot IV: North-West (Bihor, Bistrița-Năsăud, Cluj, Sălaj, Satu-Mare, Maramureș) and Center (Alba, Brașov, Covasna, Harghita, Mureș, Sibiu).

For the implementation of these activities, the total amount allocated, including the value of the contracts, was 1,704,000 thousand euro, thus the implementation of the phases of the sub-measure on the LEADER approach demonstrates a well-defined structure and a logical progression in preparing and supporting local actors for rural development.

The regional distribution of the approved projects shows a significant concentration in region 3 South Muntenia Targoviste, which has the highest share, representing 23.76% of the total number of projects, reflecting an active involvement and a considerable volume of local initiatives in this region, and region 7 Center Alba Iulia follows with a share of 19.80%, also indicating a high level of participation and absorption of available funds. In contrast, region 8 Bucharest Ilfov registers the lowest share of only 0.99% (Table 2).

Table 2. Regional distribution of approved projects

Region	Number of approved projects (M431.1)	Public value - thousands of euro
1 North-East Iasi	16	684,933
2 South East Constanta	8	308,740
3 South MunteniaTargoviste	24	1,101,705
4 South West Oltenia Craiova	6	179,489
5 West Timișoara	7	247,737
6 North-West Satu Mare	19	820,173
7 Center Alba Iulia	20	833,238
8 Bucharest Ilfov	1	25,970
Grand total	101	4,201,985

Source: According to the Ministry of Agriculture and Rural Development (MADR, 2024), the report on the status of submitted projects for the 2007–2013 programming period [11].

By the end of 2013, for measure 431.1, phases 1, 2 and 3, total payments of 4,850.505 thousand euro were made, of which the EAFRD contribution amounted to 3,880.404 thousand euro. The largest share of payments was directed to the preparation of LAG selection dossiers, amounting to EUR 3 193.188 thousand euro (65.83% of the total public contribution), highlighting the importance of this process in selecting and preparing LAGs for the implementation of local development strategies. The EAFRD contribution for this action amounted to 2,554.550 thousand euro, and for general training, payments amounted to 1,122.834 thousand euro, representing 23.15% of the total, with an EAFRD contribution of 898.267 thousand euro, reflecting the efforts made to prepare local actors in the LEADER approach. Payments for the specialized training of LAG representatives were lower, totalling 534.483 thousand euro (11.02% of the total), with an EAFRD contribution of 427.586 thousand euro, demonstrating a support focused on strengthening the skills of the groups already formed. The regional distribution of approved projects (committed amounts) as well as payments made are presented in Table 3.

Table 3. Value of projects approved and paid per measure M431.1

Region	Amount approved (million euro)	Value paid (million euro)
North-East Iasi	1.20	0.82
South-East Constanța	0.60	0.51
South MunteniaTargoviste	0.24	0.18
South-West Oltenia Craiova	0.25	0.24
West Timișoara	0.31	0.24
North-West Satu Mare	0.68	0.60
Center Alba Iulia	0.82	0.68
Bucharest Ilfov	0.06	0.03

Source: According to the Ministry of Agriculture and Rural Development (MADR, 2024), the report on the status of submitted projects for the 2007–2013 programming period [11].

By the close of 2013, the measure had recorded substantial progress toward meeting its physical and financial objectives, despite a limited number of early terminations. Specifically, 10 contracts were cancelled at the request of beneficiaries. Nevertheless, a total of 104 contracts were successfully completed—4 during Phase 1, another 4 in Phase 2, and the remaining 96 in Phase 3—reflecting a concentrated effort on implementation and project completion during the final phase. In terms of physical targets, 181 actions (training sessions and strategies developed) were supported, representing an execution rate of 70.70% against the target of 256 actions, indicating good progress but with potential for improvement in reaching the full target. In financial terms, the execution rate was remarkable, reaching 87.69%, with payments made amounting to 4,850,505 thousand euro out of the total allocation of 5,531,676 thousand euro. This achievement reflects an efficient use of available resources. By the end of 2010, the contracts finalized under the measure have demonstrated significant progress in achieving the output indicator targets. As regards general training, a total of 1,578 persons successfully completed the training actions within the 64 sessions organized in phase 1. Compared to the NRDP target of 1,640 people, this represents an achievement rate of 96.2%, which indicates a performance close to the set target. For the specialized training of LAG representatives, 300 persons successfully completed the training during the 16 sessions organized in phase 2. This result fully reaches the NRDP target of 300 people, marking a 100% achievement.

Measure 431.2 "Local action group operation, skills acquisition and territorial animation"

By the end of 2013, Measure 431.2 demonstrated significant progress in contracting and implementing projects. In the first session, 25 contracts were signed in 2011, and the remaining 56 LAGs were contracted in 2012, reaching a total amount of 42.665,605 thousand euro for this session. In the second selection session, 6 contracts were signed in 2012 and the remaining 76 contracts were finalized in 2013, totalling a public value of 22.467,237 thousand euro. By the end of 2013, cumulative payments totalled 16,317.895 thousand euro, of which the EAFRD contribution was 14,665.384 thousand euro, representing a financial execution rate of 28.33% of the total allocation of 57,603.143 thousand euro. In the same year, payments made amounted to 12,283.715 thousand euro, with an EAFRD contribution of 10,832.913 thousand euro, reaching an execution rate of 21.32% of the allocation (Table 4).

Table 4. Payments made, by type of event

Component	Payments made (thousand euro)	Share of public contribution (%)	EAFRD contribution (thousand euro)
Component b - Studies on the areas concerned	565.35	3.46	507,344
Component b - Information provision measures	387,033	2.37	350,812
Component b - Staff training	611,405	3.75	553,431
Component b - Promotional events	558,404	3.42	504,155
Component b - Animation actions	58,654	0.36	49,483
Component a - Running the LAG - Other	14,195.7	86.99	12,749.64

Source: According to the Ministry of Agriculture and Rural Development (MADR, 2024), the report on the status of submitted projects for the 2007–2013 programming period [11].

U According to the data on the implementation of the two components, Component a - LAG operation absorbed the largest share of the funds, with total payments of 14,195.702 thousand euro, representing 86.99% of the public contribution paid, and the EAFRD contribution for this component was 12,749.644 thousand euro, emphasizing the importance of allocating resources for advances and operating expenses, essential for the LAGs' operability.

nder Component b - Training and territorial animation after LAG selection, resources were distributed among different types of activities:

- Training of staff involved in local strategies recorded the highest payments of 611.405 thousand euro, representing 3.75% of the public contribution, reflecting the emphasis on training local actors.
- promotional events, with payments of 558,404 thousand euro (3.42%), and studies on the areas concerned, with 565,350 thousand euro (3.46%), supported communication and territorial analysis activities.
- animation actions, with a smaller amount of 58,654 thousand euro (0.36%), supported local dynamization.
- measures aimed at providing information on the local development area and strategy received 387.033 thousand euro, representing 2.37% of the public contribution.

Implementation of the LEADER Axis 2014-2020

LEADER facilitates the development and implementation of local strategies tailored to the specific needs of communities, emphasizing the use of local resources and innovative approaches. Through the projects funded, LEADER supports both basic infrastructure such as broadband networks and related actions such as digital literacy or collaborative platforms, helping to better connect local needs with existing opportunities (Ministry of Agriculture and Rural Development, LEADER (2023-2027), 2023) [9, 10].

Local Action Groups (LAGs) serve a vital role as facilitators in reinforcing local governance, fostering cooperation among public institutions, private stakeholders, and community members. The distinctive value of the LEADER approach stems from its support for innovative, community-driven initiatives that address locally identified challenges while promoting integrated and sustainable development. The experience accumulated thus far highlights the importance of financing actions that harness local potential and preserve territorial uniqueness, thereby aligning with the goals of the Common Agricultural Policy and the National Rural Development Programme (NRDP) through the continuous adaptation of strategies to evolving community needs.

Measure 19 - Support for local development LEADER (DLRC), is an essential strategic instrument for the revitalization and development of rural areas, responding directly to multiple identified needs, such as poverty reduction, preservation of local heritage, improvement of infrastructure and access to ICT, increasing employment and developing collaboration between rural actors, and the implementation of the measure through the four sub-measures (sM19.1 - preparatory support, sM19.2 - implementation of strategies, sM19.3 - cooperation, sM19.4 - operation and animation) allows the adaptation of solutions to the local specificity.

Local Development Strategies (LDS) implemented through LEADER are an essential tool for the revitalization and development of rural territories. These strategies target areas with a population of between 10,000 and 100,000 inhabitants, including communes and small towns, with a specific adaptation for the Danube Delta, where a minimum threshold of 5,000 inhabitants is accepted, thus these limitations ensure a critical mass of actors involved and a balance between local needs and opportunities. Table 5 shows the allocations for measure M19 - Support for LEADER Local Development (DLRC) in the period 2014-2020.

Of the five categories presented, the major allocations are concentrated on the less developed regions, with a total planned contribution of 632,473,306 euro (about 98% of the total), in line with Art. 59 para. (3) lit. (In contrast, regions whose GDP per capita exceeds 75% of the EU average (Art. 59 para. (3) lit. (b)) received only 8,826,365 euro

(1.37% of the total) and financial instruments below EURI (Art. 59 para. (4) lit. (ea)) attracted a specific allocation of 26,168,700 euro, contributing to post-pandemic economic regeneration.

Table 5. Allocations M19 - Support for LEADER local development (DLRC)

Types of regions and allocations	Applicable rate EAFRD 2014-2022 (%)	Rate of financial contribution (%)	Financial instruments under the responsibility of the managing authority - Art. 59 para. (4) lit. (d)	Total planned Union contribution (euro)
Art. 59 para. (3) lit. (a) - Less developed regions, outermost regions and small Aegean islands	83.45%	0.00	0.00	632,473,306.00 (6B)
Art. 59 para. (4) lit. (e) - Operations financed from funds transferred to the EAFRD	100%	0.00	0.00	0.00 (6B)
Art. 59 para. (3) lit. (b) - All regions whose GDP per capita GDP exceeds 75% of the EU average GDP	74.29%	0.00	0.00	8,826,365.00 (6B)
Art. 59 para. (4) lit. (a) - LEADER local development measures	89.74%	0.00	0.00	0.00 (6B)
Art. 59 para. (4) lit. (ea) (EURI - NGEU) - Less developed regions & outermost regions	100%	0.00	26,168,700.00	26,168,700.00 (6B)

Source: European Investment Bank, SWECO, t33, University of Strathclyde – EPRC, Spatial Foresight, &infeurope, 2017 [7].

The applicable EAFRD rate varies between 74.29% and 100%, indicating flexibility in the use of funds for different types of regions, however, categories without planned contributions (e.g. Art. 59 para. (4) lit. (e)) indicate a non-existent use in some areas.
Measure M19 under LEADER 2014-2020, focusing on local development placed under community responsibility (DLRC), had a significant impact on rural development, targeting both preparatory support and implementation and cooperation through LAGs, thus 239 Local Action Groups were selected, covering a population of 9,610,132 people, reflecting a broad extension of the program in the 2014-2020 period (Table 6).

Table 6. Planned result indicator(s) 2014-2022

Title of the measure	Indicator name	Value	Of which financed by EURI
Measure 19 – Support for Local Development under the LEADER approach is aligned with Article 35 of Regulation (EU) No 1303/2013, promoting initiatives that are led by local communities (DLRC – Development Locally Led Community).	Number of Local Action Groups (LAGs) selected	239.00	0.00
Through Measure 19, LEADER supports community-based development efforts, in line with the provisions of Article 35 of Regulation (EU) No 1303/2013, under the framework of Community-led local development (CLLD).	Total population covered by the selected LAGs	9,610,132.00	0.00
The financial assistance offered via Measure 19 is rooted in the principles of participatory local development, as established in EU Regulation No 1303/2013, Article 35, and encourages active community involvement.	Total public funding allocated for preparatory support (Measure 19.1) – expressed in EUR	5,780,460.66	0
According to Article 35 of Regulation (EU) No 1303/2013, Measure 19 provides a mechanism for implementing local strategies through community-led development, placing decision-making in the hands of local actors.	Total public funding for the implementation of operations under the Community-Led Local Development (CLLD) strategy (Measure 19.2) – in EUR	582,107,743.66	26,168,700.00
Community-Led Local Development (CLLD), supported by Measure 19 of the Rural Development Programme, is based on the legal framework set out in Article 35 of Regulation (EU) No 1303/2013.	Total public funding for the planning and execution of cooperation activities by LAGs (Measure 19.3) – in EUR	10,530,274.11	0
Measure 19 reinforces participatory rural development by empowering communities to design and implement local strategies, following the guidelines established by Article 35 of Regulation (EU) No 1303/2013, which underpins the LEADER approach.	Total public funding dedicated to administrative and animation costs of LAGs (Measure 19.4) – in EUR)	142,550,547.65	0

Source: Ministry of Agriculture and Rural Development (MADR) (2023). LEADER 2023-2027 [9].

In financial terms, the total public expenditure for the whole measure was structured as follows: preparatory support (19.1):5.78 million euro (0% EURI funding), implementation of operations (19.2): 582.1 million euro, of which 26.17 million euro funded from EURI, LAG cooperation (19.3): 10.53 million euro (0% EURI), operation and animation (19.4): 142.55 million euro(0% EURI) (SWOT analysis NSP V3, 2022) [13].
The majority of funds were allocated to the implementation of local strategies (19.2), accounting for 76% of total expenditure, while the operation and animation component (19.4) absorbed 18.7% of the budget, supporting the operational work of LAGs, and preparatory assistance (19.1) and cooperation (19.3) had smaller but essential contributions to project preparation and development.
The analysis shows a strategic allocation of funds to maximize the impact on rural communities, however, only 26.17 million euro was funded through the EURI, which underlines a limited use of this mechanism under the measure. The programme has demonstrated efficiency in mobilizing resources, but monitoring the effects remains essential to maximize results. The analysis of the implementation of sub-measures 19.1, 19.2 and 19.4 in 2016 is presented in Table 7.

Table 7. Status of projects submitted for LEADER in 2016

Sub-measure			Sub-measure 19.1	Sub-measure 19.2	Sub-measure 19.4
Projects submitted		No.	180		
		Value (euro)	2,435,307		
Projects selected		No.	175		
		Value (euro)	2,379,233		
Contracted projects	Contracted projects (ongoing and completed)	No.	164		168
		Value (euro)	2,224,725		52,629,069
	Completed projects	No.	138		
		Value (euro)	1,893,401		
	Terminated projects	No.	9		
		Value (euro)	122,482		
Projects transferred through the transition procedure	Contracted projects (ongoing and completed)	No.		2,260	
		Value (euro)		40,362,948	
	Completed projects	No.		793	
		Value (euro)		21,223,172	
	Terminated projects	No.		49	
		Value (euro)		290,757	
Payments made			1,961,693		3,735,603
Payments made (transition)				22,350,804	

Source: Ministry of Agriculture and Rural Development (MADR) (2024). Status of submitted projects 2014-2020 [12].

Sub-measure 19.1, dedicated to the preparation of local development strategies, had a high success rate in 2016, out of 180 projects submitted, 175 were selected and 164 were contracted, reflecting an efficiency of over 90%. Out of these, 138 were finalized and only 9 were terminated, indicating good implementation, and the amount of payments made for this sub-measure was 1,961,693euro, highlighting an efficient use of resources.
Sub-measure 19.2, oriented towards the implementation of actions in the framework of local strategies, was implemented exclusively through the transition procedure, with 2,260 projects transferred, amounting to 40,362,948 euro, in addition, 793 finalized projects amounted to 21,223,172 euro, which denotes a significant impact on rural areas. The sub-measure 19.4, which supports the functioning and animation of Local Action Groups, recorded a total value of contracted projects of 52,629,069euro, although there were no terminated or finalized projects, payments made of 3,735,603euro indicate the start of implementation.
In 2017, the implementation of the NRDP through sub-measures 19.1, 19.2 and 19.4 made significant progress in supporting local development and rural communities (Table 8).

Table 8. Status of projects submitted for LEADER in 2017

Sub-measure			Sub-measure 19.1	Sub-measure 19.2	Sub-measure 19.4
Projects submitted		No.	180	834	
		Value (euro)	2,435,307	51,371,554	
Projects selected		No.	175	209	
		Value (euro)	2,379,233	10,281,239	
Contracted projects	Contracted projects (ongoing and completed)	No.	164	209	239
		Value (euro)	2,224,725	10,281,239	69,849,325
	Completed projects	No.	151		
		Value (euro)	2,072,523		
	Terminated projects	No.	9		
		Value (euro)	122,482		
Projects transferred through the transition procedure	Contracted projects (ongoing and completed)	No.		2,203	2
		Value (euro)		39,849,781	311,041.7
	Completed projects	No.		1,597	
		Value (euro)		32,342,609	
	Terminated projects	No.		106	
		Value (euro)		703,603.1	
Payments made			1,975,01593	2,982,700	30,957,366
Payments made (transition)				30,697,735	

Source: Ministry of Agriculture and Rural Development (MADR) (2024). Status of submitted projects 2014-2020 [12].

Under sub-measure 19.1, in 2017, 180 projects were submitted, 175 were selected and 164 contracted, representing an implementation rate of over 90%, of which 151 were finalized and only 9 were terminated, with payments made of 1,975,015euro. Submeasure 19.2, had 834 projects submitted, but only 209 were selected and contracted, with a total value of 10,281,239 euro, and through the transition procedure, 2,203 projects were transferred and 1,597 of them were finalized, worth 32,342,609 euro, however, 106 projects were finished, indicating some difficulties in implementation. Sub-measure 19.4, contracted 239 projects with a total value of 69,849,325 euro, although payments made amounted to 30,957,366euro, no project was finalized, which underlines the need for more rigorous monitoring.

Table 9. Status of projects submitted for LEADER in 2018

Sub-measure			Sub-measure 19.1	Sub-measure 19.2	Sub-measure 19.3	Sub-measure 19.4
Public allocation PNDR 2014-2020 (euro)			1,990,183	495,598,466.1	16,987,679	123,013,164
Projects submitted		No.	180	5,080	36	
		Value (euro)	2,435,307	287,480,540.8	116,559	
Selected projects		No.	175	3,828	15	
		Value (euro)	2,379,233	227,721,985.8	59,952,87	
Contracted projects	Contracted projects (ongoing and completed)	No.	164	3,818		239
		Value (euro)	2,224,725	227,170,349.5		69,970,187
	Finalized projects	No.	161	196		
		Value (euro)	2,196,372	13,154,605.46		
	Terminated projects	No.	9	10		
		Value (euro)	122,482	487,077.5		
Projects transferred through the transition procedure	Contracted projects (ongoing and completed)	No.		2,188		2
		Value (euro)		39,582,677.7		311,041.7
	Finalized projects	No.		1,831		
		Value (euro)		34,898,919.32		
	Terminated projects	No.		121		
		Value (euro)		964,929.5		
Payments made			1,975,015	72,062,431.95		50,457,524
Payments made (transition)				32,630,212.13		39,201.31

Source: Ministry of Agriculture and Rural Development (MADR) (2024). Status of submitted projects 2014-2020 [12].

In 2018, the execution of sub-measures 19.1, 19.2, 19.3, and 19.4 reflected a high level of involvement in rural development initiatives, while also revealing certain difficulties in bringing projects to completion (Table 9).

Under sub-measure 19.1, in 2018, 180 projects were submitted, 175 selected and 164 contracted, of which 161 were finalized and only 9 terminated, reflecting efficient implementation and payments made amounted to 1,975,015 euro, consolidating the progress made in previous years. Sub-measure 19.2, this sub-measure was much larger in scale, with 5,080 projects submitted and 3,828 selected, with a value of 227,721,986euro, of which 3,818 projects were contracted and 196 completed, with payments made totaling 39,582,678 euro and relatively few projects terminated (121), indicating an ongoing implementation process but with a need to accelerate towards completion.

Sub-measure 19.3, component A, focusing on cooperation activities of Local Action Groups, had only 36 projects submitted and 15 selected, none of which were contracted, and sub-measure 19.4 with 239 contracted projects amounting to 69,970,187 euro, with payments made of 50,457,524 euro, with no completed projects, which highlights an incomplete implementation and the need for improved monitoring.

The implementation of sub-measures 19.1, 19.2, 19.3 and 19.4 in 2019 reflected varied progress in rural development (Table 10).

Table 10. Status of projects submitted for LEADER in 2019

Sub-measure			Sub-measure 19.1	Sub-measure 19.2	Sub-measure 19.3 - Component A	Sub-measure 19.3 - Component B	Sub-measure 19.4
Public allocation PNDR 2014-2020 (euro)			1,990,183	495,598,466.1	16,987,679		123,013,164
Projects submitted		No.	180	7,338	57	9	
		Value (euro)	2,435,307	404,527,895.9	203,264	1,271,633	
Selected projects		No.	175	6,206	55		
		Value (euro)	2,379,233	355,652,826.8	193,297.4		
Contracted projects	Contracted projects (ongoing and completed)	No.	164	6,147	51		239
		Value (euro)	2,224,725	352,139,067.6	171,433		70,250,525.08
	Finalized projects	No.	161	1,295	38		
		Value (euro)	2,196,372	77,932,466.31	125,954		
	Terminated projects	No.	9	59			
		Value (euro)	122,482	3,217,157.31			
Projects transferred through the transition procedure	Contracted projects (ongoing and completed)	No.		2,014			2
		Value (euro)		38,826,108.01			311,041.72
	Finalized projects	No.		1,857			2
		Value (euro)		36,085,828.19			311,041.72
	Terminated projects	No.		295			
		Value (euro)		1,722,999.19			
Payments made			1,975,015	168,606,400.5	94,745.83		60,766,825.06
Payments made (transition)				32,843,278.81			39,201.31

Source: Ministry of Agriculture and Rural Development (MADR) (2024). Status of submitted projects 2014-2020 [12].

In 2019, sub-measure 19.1 demonstrated a steady performance with 180 projects submitted, 175 selected and 164 contracted, of which 161 finalized and only 9 terminated, confirming an efficient implementation, and payments made totaling 1,975,015 euro, a similar level to previous years, indicating stability in the pace of implementation. Sub-measure 19.2 had an intense activity, with 7,338 projects submitted and 6,206 selected, representing a contracted value of 355,652,827 euro, however, out of 6,147 contracted projects, only 1,295 were finalized, which highlights difficulties in implementation, despite a significant economic impact reflected by total payments of 168,606,401 euro.

Component A of sub-measure 19.3 made modest progress, with 57 projects submitted, 55 selected, 51 contracted and 38 completed, and payments made amounting to 94,746euro, while Component B did not show any notable activity, with no projects contracted or completed. Sub-measure 19.4 supported the functioning of Local Action Groups with 239 contracted projects amounting to 70,250,525 euro, but payments made of 60,766,825 euro were not associated with finalized projects, indicating delays in execution. In 2020, the implementation of the NRDP 2014-2020 demonstrated intense activity and significant utilization of available funds under sub-measures 19.1, 19.2, 19.3 and 19.4 (Table 11).

Table 11. Status of projects submitted for LEADER in 2020

Sub-measure			Sub-measure 19.1	Sub-measure 19.2	Sub-measure 19.3 - Component A	Sub-measure 19.3 - Componenta B	Sub-measure 19.4
Public allocation PNDR 2014-2020 (euro)			1,990,183	495,641,759.2	16,987,679		123,013,164
Funding applications submitted		No.	180	8,040	69	42	
		Value (euro)	2,435,307	435,681,744.9	260,439	9,095,054	
Selected funding applications		No.	175	7,132	69	30	
		Value (euro)	2,379,233	402,409,965.7	260,438.9	6,488,413	
Contracts/ Funding Decisions	Contracts/Funding Decisions (ongoing and finalized)	No.	162	6,998	62	25	478
		Value (euro)	2,209,131	393,789,990.3	222,783.4	1,013,050	99,750,304.79
	Finalized Contracts/Funding Decisions	No.	161	3,089	50		239
		Value (euro)	2,196,372	170,908,068.2	166,429		70,107,404
	Terminated contracts/financing decisions	No.	11	134	4		
		Value (euro)	138,076.3	8,189,289.44	19,966.66		
Contracts/ Funding Decisions transferred through the transition procedure	Contracts/Funding Decisions (ongoing and finalized)	No.		1,937			2
		Value (euro)		38,274,222.74			311,041.72
	Finalized Contracts/Funding Decisions	No.		1,871			2
		Value (euro)		36,745,016.04			311,041.72
	Contracte/Decizii de finanțare reziliate	No.		372			
		Value (euro)		2,271,685.05			
Payments made			1,975,015	252,084,104.8	116,988.9		77,288,330.75
Payments made (transition)				33,039,511.01			39,201.31

Source: Ministry of Agriculture and Rural Development (MADR) (2024). Status of submitted projects 2014-2020 [12].

In 2020, sub-measure 19.1 maintained steady progress with 180 applications submitted and 175 selected, of the 162 contracts signed, 161 were finalized and only 11 were terminated, reflecting efficient implementation. The payments made, amounting to 1,975,015euro, confirmed continued progress compared to previous years. Sub-measure 19.2 recorded the highest activity with 8,040 applications submitted and 7,132 selected, totaling 435,681,745 euro, and out of the 6,998 contracts signed, 3,089 were finalized and payments made amounted to 252,084,105euro, underlining a considerable economic impact on rural areas.

In sub-measure 19.3, component A had 69 applications submitted and selected, of which 62 were contracted and 50 finalized, with modest payments of 116,989 euro, while component B had less activity, with 42 applications submitted, 30 contracted and 25 ongoing, but no finalized projects. Sub-measure 19.4 supported 478 contracts amounting to 99,750,305 euro, of which 239 have been finalized and payments made of 77,288,331 euro reflect progress.

CONCLUSIONS

The research emphasizes the beneficial effects of funding provided under Measure 19 – LEADER, showing that it plays a vital role in advancing sustainable rural development. This is achieved through the implementation of Local Development Strategies that promote economic diversification, enhance infrastructure, and help safeguard cultural heritage. An important element of this approach is the strengthening of Local Action Groups' institutional capacity, particularly through the development of public-private partnerships and the encouragement of innovative projects. As a result, the process has deepened community engagement, fostered social cohesion, and contributed to improving living standards in disadvantaged rural areas. The comparative analysis of performance between the 2007-2013 and 2014-2020 periods emphasizes the increased efficiency of resource allocation in the recent phase, thanks to the introduction of additional sub-measures such as 19.1 (preparatory support) and 19.3 (cooperation), and from the economic point of view, the projects carried out have generated jobs, stimulated entrepreneurship and facilitated access to basic services.

In the North-East region, the equitable distribution of funds and the strategic selection of projects have contributed to reducing territorial disparities, however, challenges identified include slower project implementation in some sub-measures and limited use of some financial instruments, thus to maximize impact, rigorous monitoring of implementation and continued support to LAGs' operational capacity is recommended.

REFERENCES

[1]Alecu, I.N., Fîntîneru, A., Badea, A., Baciu, G.A., 2015, Local Action Groups (LAGS) and their impact on the process of rural development in Romania. Agrarian Economy and Rural Development-Realities and Perspectives for Romania, 6th Edition of the International Symposium, November 2015, Bucharest: The Research Institute for Agricultural Economy and Rural, 373–376.

[2]Brezuleanu, C.-O., Brezuleanu, M.-M., Mihalache, R., Susanu, I., Creanga, D.E., Ungureanu, E., 2024, Aspects of the contribution of the LEADER approach to rural development in Romania. Case study: North-East Development Region. Journal of Applied Life Sciences and Environment, 57(1), 37–68. https://doi.org/10.46909/alse-571123

[3]Brezuleanu, S., Viziteu, Ș., Robu, Al. D., Brezuleanu, C.O., 2017, Leadership versus management in design and business consultancy companies 2017-, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Vol. 17(3), 79-83.

[4]Ciobanu, F.B., Vladu, M., 2024, The LEADER programme evolution in the European Union and Romania. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 24(1), 247–252.

[5]Creangă, D.E., Cristea, M.G., Staic, L.G., 2022, Evaluation of LEADER programme efficiency in Romania. Sustainable Agriculture Review, 11(2), 56–78.

[6]European Court of Auditors, Special Report 10/2022-LEADER and community-led local development facilitates local engagement but additional benefits still not sufficiently demonstrated. https://www.eca.europa.eu/en.Accessed on August 25, 2023.

[7]European Investment Bank, SWECO, t33, University of Strathclyde – EPRC, Spatial Foresight, & infeurope, 2017, EAFRD Financial Instruments in 2014-2020 Rural Development Programmes: Final Report. Directorate-General for Agriculture and Rural Development (DG AGRI), European Commission. https://www.fi-compass.eu/sites/default/files/publications/eafrd-financial-Instruments-in-2014-20.pdf Accessed on 12 February 2025.

[8]Ministry of Agriculture and Rural Development (MADR), 2019, National Programme for Rural Development 2014-2020, version IX, approved on 23 January 2019. Authority of Management for NPRD, https://www.madr.ro/. Accessed on 27 January 2025.

[9]Ministry of Agriculture and Rural Development, (MADR), 2023, LEADER 2023-2027, https://www.madr.ro/axa-leader/leader-2023-2027.html Accessed on 17 March 2025.

[10]Ministry of Agriculture and Rural Development (MADR), 2023, Ghidul Solicitantului pentru accesarea submăsurii 19.1 – „Sprijin pregătitor" sesiunea 2023. Programul Național de Dezvoltare Rurală 2014-2020. Agenția pentru Finanțarea Investițiilor Rurale. https://stportalafirprod.blob.core.windows.net/media/media/ppcfhz32/ghidul_solicitantului_pentru_sm_191_2023.pdf Accessed on 02 March 2025.

[11]Ministry of Agriculture and Rural Development (MADR), 2024, Situația proiectelor depuse 2007-2013, https://madr.ro/pndr-2007-2013/situatia-proiectelor-depuse.html. Accessed on 11 January 2025.

[12]Ministry of Agriculture and Rural Development (MADR), 2024, Situația proiectelor depuse 2014-2020, https://madr.ro/pndr-2014-2020/implementare-pndr-2014-2020/situatia-proiectelor-depuse-2014-2020.html. Accessed on 15 January 2025.

[13]Ministry of Agriculture and Rural Development (MADR), Analiza SWOT PNS V3, 2022, Analiza SWOT PLANUL NAȚIONAL STRATEGIC 2021-2027, https://www.madr.ro/docs/dezvoltare-rurala/PAC_dupa_2020/2020/DRAFT-Analiza-SWOT-Plan-National-Strategic-2021-2027.pdf Accessed on 07 March 2025

[14]Ministry of Agriculture and Rural Development (MADR), Studiu de Evaluare RNDR, 2022, Evaluarea RNDR pentru Programarea 2014-2020, https://www.madr.ro/docs/dezvoltare-rurala/programare-2014-2020/evaluari/2022/Studiu-de-Evaluare_RNDR_RO.pdf. Accessed on 15 January 2025.

[15]National Network for Rural Development (RNDR), LEADER. https://www.rndr.ro/leader.html. Accessed on August 25, 2023.

[16]National Network for Rural Development (RNDR), (n.d.). Informații generale LEADER, https://www.rndr.ro/leader/informatii-generale-leader.html Accessed on August 25, 2023.

[17]Staic, L.G.,Vladu, M., 2020, Studies concerning the evolution of the LEADER approach, part of the common agricultural policy, as a support for sustainable development of the rural area. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 20(4), 495-500.

[18]Staic, L.G., Vladu, M., 2021a, Aspects regarding the impact of Local Action Groups (LAG) financing through LEADER on rural development of the eligible territory in Romania. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 21(4), 541-548.

[19]Staic, L.G., Vladu, M., 2021b, Aspects regarding the implementation of local development strategies in

Romania. Journal of European Rural Studies, 14(1), 84–96.
[20]Turek-Rahoveanu, A., 2012, "LEADER approach" - an opportunity for rural development. Proceedings of the Agrarian Economy and Rural Development - Realities and Perspectives for Romania Conference (AERD'12), Vol. 3, Issue 2012.
[21]Turek-Rahoveanu, A.T., Turek-Rahoveanu, M.M., 2013, Socio-economic development prospects of rural areas in the context of application of LEADER program in Romania. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 13(4), 295-302.
[22]Viziteu, S**.,** Brezuleanu, S., Leonte, E., Vîntu C., Micu M.M., 2022. Digitalization in farm management, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.22(1), 687-693.

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VARIABILITY OF WINTER WHEAT AGRICULTURAL YIELDS UNDER THE INFLUENCE OF THERMAL RESOURCES. CASE STUDY: CONTINENTAL DOBROGEA, ROMANIA

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Abstract

The study aims to focus on the analysis of winter wheat yields obtained in the context of the thermal resources available in the continental Dobrogea Region. The thermal resources play a crucial role in determining the length of the growing season, the sowing time, as well as the physiological processes of the plant and last but not least, in the production obtained at the end of the growing season. In achieving this study, there have been used the average production data per hectare from the National Institute of Statistics and the monthly meteo-climatic data on air temperature and spring index from six representative meteorological stations belonging to the National Meteorological Administration, for the period 1991 – 2023. The results of the study has highlighted the importance of the thermal factor in the development of the phenological stages of winter wheat in the study area, with agricultural yields varying between 296 kg/ha (2003) and 5,133kg/ha (2018), for the analyzed period. Knowing the requirements of the winter wheat crop in relation to the thermal resources offers farmers the possibility to maximize its production.

Key words**:** *agricultural yields, thermal resources, winter wheat, variability, Dobrogea Region*

INTRODUCTION

Winter wheat is one of the most important cultivated plants, for about 40% of the global population [9]. Grown in Romania, it is used for both domestic and foreign consumption throughout Europe. The yield and productivity of winter wheat crop are particularly influenced by climatic factors (light, air temperature, soil temperature, precipitation etc.) [7; 15]. Like other crops, winter wheat has certain bio-climatic requirements which have a significant influence on the growth and development processes of the plants and their productivity [14].

The aim of this analysis is to highlight the variability of winter wheat crop yields in relation to the influence of thermal resources. Air temperature plays a particularly important role in the growth and development of the winter wheat. The phenological phases of winter wheat are optimally produced when a certain amount of effective temperatures are accumulated, which influence the plants ability to develop and not least impact on the final crop yield. Production, like the areas cultivated with cereals, greatly depends on the agroclimatic resources, which play an extremely important role in the quality of the crops.The analysis of the thermal regime in an area highlights the ability to factually estimate the thermal resources needed for a crop, especially in the current context of climate change. The study region for which the analysis of the variability of winter wheat crop yields in relation to the influence of thermal resources is carried out is the Continental Dobrogea (Fig 1). Located in the South-Eastern Romania, the Continental Dobrogea is a region recognized for its economic importance in the field of agriculture, a large part of which is made up of arable land.The

relief is represented by varied, slightly undulating plateaus, with average altitudes of 100 – 300m [12]. Climatically, the study area is characterized by a temperate continental transitional climate with arid climatic influences.

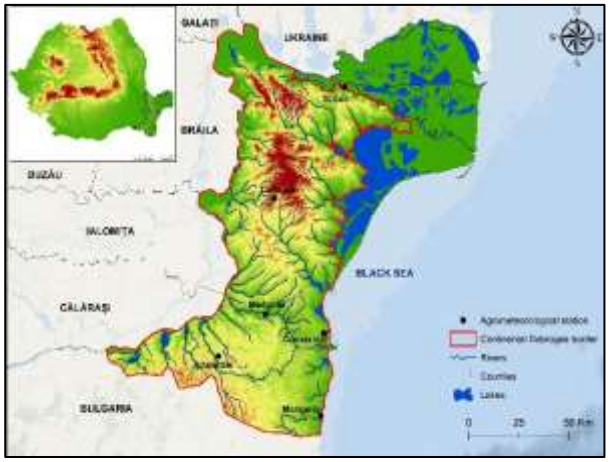

Fig. 1. The location of the study area and of the analyzed agrometeorological stations.
Source: own processing from GIS open sources.

MATERIALS AND METHODS

For the study of the variability of autumn wheat yield in relation to the influence of thermal resources, data on average production per hectare from the National Institute of Statistics (NIS) for the period 1991–2023 were analyzed and processed.These data reflect the variability of productions in relation to the analyzed thermal resources. In order to highlight the influence of thermal resources on winter wheat production, meteorological and agrometeorological data were used from six meteorological stations with agrometeorological programs within the network of the National Meteorological Administration (NMA), for the period 1991–2023. The analyzed agrometeorological stations are considered representative for the area of the Continental Dobrogea and have altitudes ranging between 4 m (Tulcea) and 219 m (Corugea) (Fig 1). From a meteorological perspective, data on the annual regime of the monthly average temperature (°C), the averages of the maximum and minimum monthly temperatures (°C) were used.

The agrometeorological indicator analyzed, which complements the study of thermalresources is the spring index.This index is expressed in 'heat units' and represents the sum of the average air temperatures greater than 0°C ($\sum T_{med.}$ >0°C).The spring index is a specific agrometeorological parameter that characterizes the thermal potential of the transition period from winter to spring for agricultural plants in the growing season [3]. These data have been processed, centralized and represented in graphical and tabular form, in Microsoft Excel and with the help of GIS techniques.

RESULTS AND DISCUSSIONS

Agricultural yields are influenced by thermal indicators, which play a significant role in the growth and development phases of winter wheat crops [5]. The rhythms of biological processes in agricultural crops vary depending on their thermal resource requirements, with the intensity of physiological processes, being directly related to the thermal fluctuations within specific limits for each genotype [10].
Depending on the plant species, whether thermophilic or mesophilic and the biological phases (germination, first leaf through coleoptile, 3 leaves unfolded etc.), the temperature requirements of agricultural crops vary.
Agricultural plants need to reach specific thermal thresholds (temperature sums) to successfully progress through each phenological phase. For example, during the October-December period, winter wheat undergoes the vernalization process, which is essential for its transition to the generative stage. This stage includes beginning of stem elongation, beginning of heading, flowering, fertilization, grain formation and ripening [5]. This process takes place from the beginning of autumn until the end of December. Depending on the sowing date, winter wheat requires a minimum accumulated temperature sum of 500°C during this period. This threshold is considered optimal for the requirements of winter wheat crops [4; 5].

Agricultural production

The productivity of winter wheat is predominantly influenced by changes in the thermal regime, leading to significant annual yield fluctuations. Table 1 presents the annual average production per hectare recorded in the Continental Dobrogea during the period 1991–2023.

Table 1. The average production per hectare (kg/ha) of the winter wheat in the study area (1991–2023)

Year	Average of production (kg/ha)
1991	2,676
1992	1,693
1993	2,129
1994	1,152
1995	2,564
1996	1,991
1997	2,948
1998	2,229
1999	2,622
2000	1,917
2001	1,831
2002	1,977
2003	**296**
2004	3,145
2005	3,024
2006	3,069
2007	1,154
2008	3,477
2009	1,770
2010	2,519
2011	3,860
2012	2,133
2013	2,946
2014	3,468
2015	3,752
2016	4,037
2017	5,060
2018	**5,133**
2019	4,230
2020	1,282
2021	4,912
2022	4,101
2023	3,521
1991-2023	**2,806**

Source: processed data from NIS, 2025 [13].
Note: light yellow – the lowest average production per hectare; dark yellow – the highest average production per hectare.

Environmental factors, especially the climatic ones, cause the yields of winter wheat crops in the analyzed region to vary from year to year. Winter wheat yields have varied between 296 kg/ha in 2003 and 5,133 kg/ha in 2018. The average production recorded during the period 1991-2023 is 2,806kg/ha.The average yields recorded in 2003 began to decline, mainly due to the meteorological phenomena (extreme temperatures, low precipitation), which impact the crop while it is in the vegetation stage.The year 2003 was considered one of the driest years recorded in the decade 2001-2010, from a meteorological perspective. The year 2018 was a normal year in terms of both precipitation and temperature. The agrometeorological conditions of the 2017-2018 agricultural year were generally favorable in terms of temperature and precipitation for winter wheat cultivation compared to previous years, which led to high yields in the analyzed region [2].

Air Temperature Regime

Air temperature is an important meteorological factor in agriculture, as it triggers certain processes in plants, such as the advancement or delay of phenological phases in agricultural crops [8]. At the same time, this parameter is essential for ensuring the yield of winter wheat crops at the end of the vegetative season.

From the analysis of the six meteorological stations with agrometeorological programs, the multiannual average temperature (Fig. 2) ranges between 11.1°C at Corugea and 12.6°C at Constanța. The achievement of this multiannual average temperature is largely influenced by the fact that at most meteorological stations analyzed with agrometeorological programs, negative monthly average air temperatures were recorded only in January. The average monthly temperature in February increases significantly, by more than 1°C compared to January, due to the intensification of global radiation as well as the strengthening of cyclogenesis processes in the Mediterranean Sea [6].

Atmospheric circulation determines the movement of air masses with different thermal characteristics, leading to a distinct evolution of temperature values depending on the season. Air temperature fluctuates monthly across most of the area, as confirmed by the values of the monthly maximum temperature averages, ranging between 27.0°C (Constanța) and 29.8°C (Tulcea) in July (Table 2).

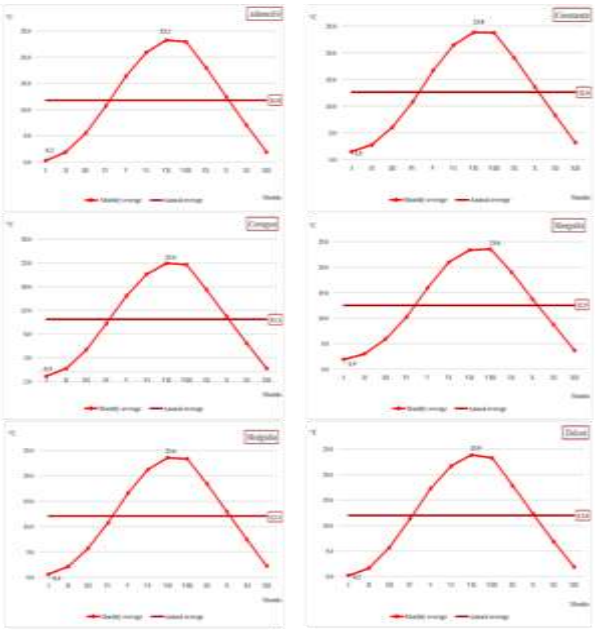

Fig. 2. The annual regime of air temperature (°C) at the agrometeorological stations analyzed for the period 1991–2023: Adamclisi (top left), Constanța (top right), Corugea (middle left), Mangalia (middle right), Medgidia (bottom left) and Tulcea (bottom right).
Source: processed data according to NMA, 2025 [1].

Table 2. Average monthly maximum and minimum temperatures (°C) at the agrometeorological stations analyzed for the period 1991–2023

Agrometeorological station	Average monthly minimum temperature (°C)												
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual average
Adamclisi	-2.7	-1.5	1.6	6.1	11.2	15.5	17.5	17.4	13.0	8.4	3.7	-1.0	7.4
Corugea	-3.9	-2.5	0.7	5.3	10.3	14.0	16.9	17.0	12.3	7.5	-9	-2.	6.6
Constanța	-1.3	-0.2	2.8	7.3	12.6	17.0	19.1	18.3	13.0	10.3	5.4	0.4	9.0
Mangalia	-0.9	0.1	3.0	7.2	12.5	16.9	19.0	18.3	15.1	10.6	5.9	0.9	9.1
Medgidia	-2.3	-1.2	1.9	6.3	11.3	15.8	17.9	17.9	13.5	8.9	4.2	-0.7	7.8
Tulcea	-2.9	-1.8	1.7	6.3	11.8	16.1	18.0	17.2	12.3	7.8	3.3	-1.3	7.4
Continental Dobrogea average	**-2.5**	**-1.2**	**2.0**	**6.5**	**11.7**	**16.0**	**18.1**	**18.0**	**13.6**	**8.9**	**3.9**	**-0.6**	**7.9**
Agrometeorological station	**Average monthly maximum temperature (°C)**												
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual average
Adamclisi	3.9	6.3	10.9	16.7	22.0	26.8	29.5	28.6	24.4	18.8	11.3	5.6	17.2
Corugea	2.7	5.2	10.1	16.1	22.3	26.5	29.1	28.1	23.6	17.2	10.5	4.3	16.4
Constanța	5.8	5.5	8.3	13.9	19.7	24.6	27.0	27.0	22.2	16.7	11.6	5.6	15.5
Mangalia	5.3	6.7	9.3	13.9	19.6	24.7	27.1	27.1	22.5	17.4	12.2	7.1	16.1
Medgidia	4.2	6.5	10.9	16.1	22.3	26.9	29.5	28.5	24.3	18.2	11.7	5.9	17.2
Tulcea	5.9	6.3	10.9	16.9	23.1	27.3	29.8	28.8	24.1	17.9	11.2	5.6	17.2
Continental Dobrogea average	**4.0**	**6.1**	**10.3**	**15.7**	**21.6**	**26.2**	**28.7**	**28.7**	**23.5**	**17.8**	**11.4**	**5.7**	**16.6**

Source: processed data according to NMA, 2025 [1].

Typically, these monthly maximum temperatures are recorded across almost the entire studied agricultural area, influenced by the Western circulation and the intrusion of the Southern and continental air masses. Additionally, in terms of maximum air temperatures, a thermal uniformity is observed in July and August across the six analyzed agrometeorological stations.

The averages of monthly minimum temperatures show low values, below 0°C, during the three winter months, ranging from -3.9°C (Corugea) to -0.9°C (Mangalia), which are typical limits for this period (Table 2). The temperature factor plays a particularly important role in the physiological processes of plant organisms. Thus, the maximum and minimum average air temperatures have a significant impact on the proper development of plants.

During the winter season, due to unfavorable temperatures, winter crops can suffer frost damage caused by low temperatures and the absence of a snow cover. If the plant's tillering node is damaged, when the air temperature rises after a period of very low temperatures, a false resumption of vegetation occurs. In addition to the frost damage to plants, seedling heaving can also occur, caused by the alternation of positive and negative temperatures, which leads to repeated freezing and thawing cycles [5]. Subsequently, due to these phenomena, plant death may occur, leading to a decrease in the agricultural production at the end of the season. Maximum air temperatures exceeding the critical biological resistance threshold of winter wheat lead to the occurrence of the shriveling phenomenon. This phenomenon represents the process by which the transport of substances assimilated in the leaves to the grain is prevented. As a result of this phenomenon, winter wheat stops growing, also suffering the yield of the crop.

Spring index

Between February 1st and April 10th, the thermal regime fluctuations occur, with variations from year to year, impacting both the resumption of vegetation and the execution of agricultural fieldwork.In general, the temperature increases at the end of winter (February),being beneficial forthewinter wheat, leading to the vegetation resumption, phenological advancement and an accelerated rate of dry matter accumulation in the grain [11].

The spring index represents the thermal potential of the transition period from winter to spring and is calculated for the period between February 1st to April 10th [1]. This index characterizes the thermal conditions required for the winter crops.For the period 1991–2023 (Fig. 3), the multiannual average of the spring index has recorded normal values, ranging from 307.6 (Corugea) to 382.1 (Tulcea), the'heat units'

indicating a normal spring transition (301–400 'heat units'). The exception was the Constanța agrometeorological station, where 403.2 'heat units' were recorded, classifying the spring transition as early (401–500 'heat units'). Although the multiannual average remained within normal limits, the variability of the spring index revealed years in which the threshold of 500 'heat units' was exceeded, indicating a very early spring transition (> 500 'heat units').

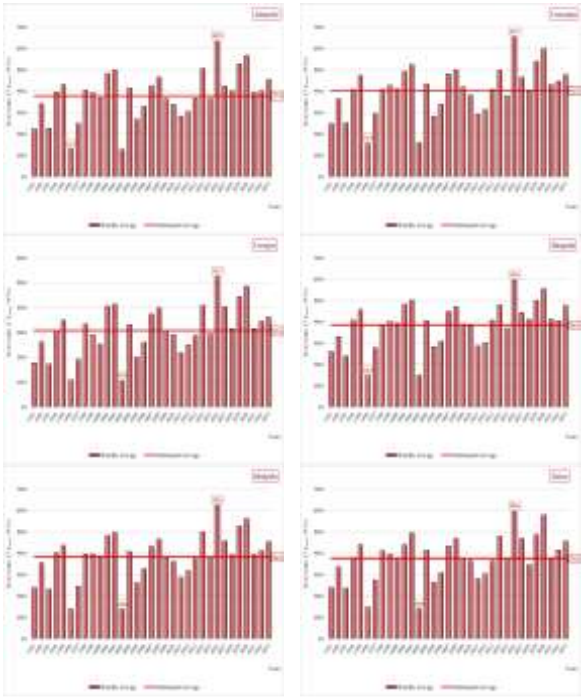

Fig. 3. Heat units ($\Sigma T_{med.} > 0°C$) at the agrometeorological stations analyzed for the period1991 – 2023: Adamclisi (top left), Constanța (top right), Corugea (middle left), Mangalia (middle right), Medgidia (bottom left) and Tulcea (bottom right).
Source:processed data according to NMA, Agrometeorological Service, 2025 [3].

The maximum values of the spring index were recorded in 2016, ranging from 522.7 'heat units' (Corugea) to 651.7 'heat units' (Constanța).
These maximum values, recorded between February 1st and April 10th, 2016, reflect higher-than-usual daily average temperatures for this period, which led to a phenological advancement of winter wheat crops in the analyzed region, intensifying the vegetative growth rates. In the case of a very early spring transition, when the phenological phase of stem elongation occurs earlier, the period of dry matter accumulation in the grain is extended, leading to a higher yield [14]. In 2016, due to the intensified biological rhythms, the recorded yield in the studied region was 4,037 kg/ha, a significantly higher production compared to 2003 (296 kg/ha). The lowest values of the spring index were recorded in the years 1996 and 2003.The lowest value of the spring index in the period 1991–2023 was recorded in 2003 (103 'heat units') at the Corugea agrometeorological station, indicating a late spring transition.Thus, in this year, a slow evolution of vegetative rhythms was recorded due to lower-than-usual temperatures, which was reflected in the low yields of 2003 (296 kg/ha).

CONCLUSIONS

This study has analyzed the evolution of the productions obtained at the end of the growing season of winter wheat, in relation to the influence of air temperature on winter wheat crops.
The variability of winter wheat yields, in terms of the thermal regime, in the Continental Dobrogea region was significant.The low values of winter wheat productions in 2003 (296 kg/ha) were due to the unfavorableair temperatures recorded during the critical periods of winter wheat, which was also reflected in the values of the spring index (late spring). Thus, this year, there was a slow evolution of the biological rhythms of plants, due to lower temperatures than usual. Depending on the variability of thermal resources and the failure to meet optimal air temperature requirements in the critical May-June period, winter wheat yields in 2003 decreased compared to those recorded in the period 1991–2002.
The year 2018 was characterized by the highest productions obtained in the entire region (5,133 kg/ha). This was due to moderate temperatures during the winter and a thermally favorable spring, which was also reflected in the spring index values of this year.To maximize the agricultural yields, a detailed analysis of the available thermal resources is necessary. This process is essential for the proper management of crops, based on the climatic conditions characteristic of each period.

REFERENCES

[1]Administrația Națională de Meteorologie (National Meteorological Administration–NMA), 2023, Agrometeorological characterization, 01 September 2022 – 31 August 2023 (Caracterizarea agrometeorologică, 01 Septembrie 2022 – 31 August 2023), https://www.meteoromania.ro/wp-content/uploads/comunicate/Caracterizare-agrometeorologica-2022-2023.pdf, Accessed on January 5th 2025.
[2]Administrația Națională de Meteorologie (National Meteorological Administration–NMA), 2018, Annual report 2018, https://www.meteoromania.ro/despre-noi/raport-anual/raport-anual-2018/, Accessed on December 30th 2024.
[3]Administrația Națională de Meteorologie (National Meteorological Administration–NMA), 2024, Heat units (Indicele de împrimăvărare), https://www.meteoromania.ro/Upload-Produse/agro/indiceledeimprimavarare.pdf, Accessed on December 20th 2024.
[4]Berbecel, O., Stancu, M., 1970, Agrometeorology (Agrometeorologie), Ceres Publishing House, București.
[5]Bîlteanu Gh., 1998, Fitotehnie, Vol I - Cereale și leguminoase pentru boabe (Phytotechniques-Cereals and leguminous plants for grains, 2nd Ed., Ceres Publishing House, București.
[6]Constantin (Oprea), D. M., 2013, The relationship between climate and environmental pollution in the area of the municipality of Slatina (Relația climă – poluarea mediului înconjurător în arealul municipiului Slatina), University Publishing House, București.
[7]Constantin (Oprea), D.M., Ionac N., Grigore E., Luftner G.D., Ilea R.G. 2023, The variability and influence of precipitation on the winter wheat in the Extra-carpathian area of the Meridional and Curvature Carpathians (Romania). Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 23(2) 181-186.
[8]Enache, L., 2009, Agrometeorology (Agrometeorologie), University of Agronomic Sciences and Veterinary Medicine, București.
[9]Ion, V., 2010, Phytotechnics (Fitotehnie), University Course, Faculty of Horticulture, București.
[10]Mateescu, E., Alexandru, D., Oprea, O. A., Manea, A., 2016, Agrometeorological Guide, Instructions for Weather Stations (Îndrumar agrometeorologic, Instrucțiuni pentru stațiile meteorologice), National Meteorological Administration, București.
[11]Mihail, A., Roman, G. V., Borcean, I., Muntean, L. S., 2006, Phytotechnics (Fitotehnie). 4th Edition, Ion Ionescu Publishing House from Brad, Iași.
[12]National Institute of Geography, 2005, Geography of Romania (Geografia României), vol V., Romanian Academy Publishing House, București.
[13]National Institute of Statistics, 2025, www.insse.ro, Accessed on January 23th 2025.
[14]Povară, R., 2000, The meteorological risk in agriculture. Winter wheat. (Riscul meteorologic în agricultură. Grâul de toamnă.), Economic Publishing House, București.
[15]Sandu, I., Mateescu, E., Vătămanu, V.V., 2010, Climate change in Romania and their effects on agriculture (Schimbări climatice în România și efectele asupra agriculturii). Sitech Publishing House, Craiova.

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THE IMPACT OF TAXES ON THE ACTIVITIES OF AGRICULTURAL ENTERPRISES: UKRAINIAN AND EUROPEAN PRACTICE

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Abstract

The study of the impact of taxes on the activities of agricultural enterprises is important in the context of ensuring the financial sustainability of the agricultural sector, increasing its competitiveness, and harmonizing the tax policy of Ukraine with European standards. The purpose of the article is to identify the features and state of taxation of agricultural enterprises in Ukraine, compare them with European practice, and substantiate recommendations for optimizing tax policy to stimulate the development of the Ukrainian agricultural sector. The study is based on official statistical data of the State Statistics Service of Ukraine, as well as on regulatory legal acts, analytical reports, and scientific publications devoted to issues of tax regulation of agriculture. The article uses a set of scientific research methods, in particular: methods of analysis and synthesis, deduction and induction, comparative method, statistical method, SWOT analysis method, and generalization method. The main results of the study are: identification of key features of taxation of the agricultural sector, in particular special taxation regimes and tax benefits, as well as assessment of their impact on the financial stability and competitiveness of agricultural producers; conducting a comparative analysis of the positive and negative aspects of existing taxation systems of agricultural enterprises in Ukraine; establishing the state, challenges, and opportunities that farmers face in modern conditions; consideration of the European experience of taxation of the agricultural sector and ways of its application in Ukraine to create a favorable tax environment for the development of agriculture. The study concluded that tax regimes and benefits significantly affect the financial sustainability and competitiveness of agricultural enterprises, while there are several challenges, in particular, regarding the significant tax burden and complex tax administration. Borrowing European experience and optimizing tax policy in Ukraine will contribute to creating a more favorable environment for the development of the agricultural sector and its effective integration into the market economy.

Key words**:** *taxes, agricultural enterprises, tax benefits, tax policy, tax burden*

INTRODUCTION

Taxes are crucial to the growth of agricultural enterprises, influencing their financial stability, competitiveness, and ability to attract investments. The taxation of the agricultural sector remains a highly sensitive issue for both domestic economies and global trade, as it shapes production incentives, the extent of government support, and the sector's adaptability to international market dynamics. Different countries apply different models of tax regulation of agricultural business, which necessitates a comparative analysis of Ukrainian and European practices.

The relevance of the study is due to a several factors. First, in Ukraine, the tax burden on agricultural producers is subject to constant changes, which complicates their long-term financial strategy, as discussed in the studies of Dehtiarova (2017) [3], Lutsenko and Polyantseva (2021) [11], Berezhenna and Kulakivska (2020) [2] and others. Secondly, the European Union demonstrates stable and predictable approaches to taxation of the agricultural sector, which contributes to its sustainable development, as reflected in the studies of Gruziel and Raczkowska (2018) [7]. Thirdly, the war in Ukraine has caused

additional challenges in the field of tax policy, which requires optimization of the tax burden and adaptation of the system to new realities Parfeniuk and Yastrubskyi (2022) [15].

The significance of this work in the scientific discourse lies in the comprehensive analysis of the impact of taxes on the functioning of agricultural enterprises in Ukraine, in particular in the context of general and simplified taxation systems, which complements the research of Koba and Shynkar (2019) [9], Lysenko (2017) [12], Kononenko and Nazarova (2022) [10] and others. The article, based on OECD materials (2020) [14] and research by Détang-Dessendre and Guyomard (2023) [4], compares the effectiveness of tax mechanisms in Ukraine and EU countries, which allows identifying the strengths and weaknesses of the domestic tax system. In addition, the impact of tax benefits on the investment activity of agricultural businesses is analyzed and recommendations are formulated for improving budget and tax policy based on the authors' research under the leadership of Rudenko et al. (2023 and 2024) [16; 17].

The purpose of this study is to analyze the impact of tax policy on the activities of agricultural enterprises in Ukraine and European countries, analyze the features of taxation of the agricultural sector, assess its impact on the financial stability and competitiveness of agricultural enterprises, and formulate recommendations for improving Ukraine's tax policy, taking into account European experience.

The scientific novelty of this study lies in expanding the understanding of tax approaches to regulating the agricultural sector in Ukraine, taking into account European experience. The study's findings can serve as a basis for formulating recommendations to enhance Ukraine's tax policy, aiming to strengthen the agricultural sector's competitiveness and align it with international standards.

MATERIALS AND METHODS

The study utilized a diverse range of scientific and regulatory sources, including legislative acts of Ukraine and the European Union governing agricultural taxation, official statistical data, analytical reports from international organizations, scholarly works of domestic and foreign researchers, as well as materials from the Ministry of Finance of Ukraine, the State Statistics Service of Ukraine, and specialized agricultural associations.

A variety of research methods were employed, including comparative analysis to evaluate the taxation of agricultural enterprises in Ukraine and the EU, identifying similarities and differences; the statistical method to examine the dynamics of the tax burden on Ukraine's agricultural sector; SWOT analysis to identify strengths, weaknesses, opportunities, and threats within the current tax system; system analysis to explore the relationship between tax incentives, financial stability, and competitiveness of agricultural enterprises; and the generalization method to synthesize taxation approaches in Ukraine and the EU, forming conclusions on optimizing Ukraine's agricultural tax policy.

The use of these methods provided an objective assessment of the impact of taxation on agricultural enterprises, enabled an evaluation of the effectiveness of existing tax regulations, and facilitated the development of recommendations for improving Ukraine's tax system, incorporating European best practices.

RESULTS AND DISCUSSIONS

Agriculture plays a key role in economic development, ensuring food security, employment, and foreign exchange earnings from agricultural exports. At the same time, the agricultural sector is significantly affected by external and internal factors, including fluctuations in product prices, changes in climatic conditions, market instability, and rising production costs. In such conditions, effective state regulation becomes a necessary tool to support agricultural enterprises and ensure their stable operation.

As noted by Odintsov et al. (2020) [13], the development of agricultural production depends on key reproduction factors such as labor, capital, and land. However, the state plays a crucial role in managing these factors

through tax and financial support, land regulation, the adoption of innovative technologies, and the creation of favorable conditions for product exports.

From our perspective, taxation serves as a fundamental tool for state intervention in the economy, particularly in shaping the growth of agricultural enterprises. A well-designed tax policy not only ensures budget revenues but also fosters the development of the agricultural sector by enhancing its competitiveness and financial resilience.

Taxes significantly influence the operations of agricultural enterprises, as they impact not only financial expenditures but also strategic decision-making. Various tax instruments directly affect the sector's profitability, investment potential, competitiveness, and long-term stability. In this context, scholars, in particular Durst and Monke (2001) [5], J. Beckman et al. (2018) [1], Berezhenna and Kulakivska (2020) [2], identify several main aspects through which taxes affect the activities of agricultural enterprises:

1. ***Impact on profitability***. Taxes paid by agricultural enterprises are part of the total costs and directly affect their profitability. A high level of tax burden can reduce net profit, which limits the enterprise's ability to reinvest in development, modernization of production, or cover financial needs in crisis. Therefore, an excessive tax burden can lead to a reduction in profit, which reduces the ability of enterprises to invest in new technologies and equipment or improve the skills of employees. At the same time, a low tax burden, on the contrary, allows agricultural enterprises to receive more profit from the sale of products, which contributes to their development and modernization.

2. ***Impact on investment activity***. Tax incentives or a simplified taxation system can be an important factor in deciding on investments in the agricultural sector. Nations that offer advantageous tax policies can encourage both local and foreign investments, fostering economic growth in the agricultural sector. A simplified tax system helps minimize administrative complexities, making it easier for small and medium-sized farmers to operate efficiently. Additionally, tax incentives for agricultural producers—such as preferential loans, tax deductions for purchasing farming equipment, or subsidies for implementing eco-friendly innovations—can drive modernization efforts and enhance productivity.

3. ***Impact on pricing***. Tax rates play a crucial role in shaping price dynamics within the agricultural market, directly impacting production costs and overall market competitiveness. In particular, increasing taxes on fuel, land, or real estate increases the cost of production, which in turn can lead to higher prices. If taxes on wheat, milk, or other products increase, an agricultural enterprise will be forced to increase the prices of its products to maintain profitability. In conditions of economic instability or lack of liquidity, agricultural enterprises may also be forced to compensate for costs by reducing profits, which can lead to an increase in the level of debt burden.

4. ***Environmental impact***. In EU member states and other developed countries, environmental taxes are increasingly being used to encourage sustainable agriculture. These taxes can have both positive and negative effects on farmers. For instance, levies on carbon dioxide emissions or charges for using pesticides and fertilizers may raise operational expenses for agricultural businesses. However, these measures can also encourage farmers to adopt more sustainable technologies, potentially leading to long-term financial benefits. At the same time, tax benefits for ecological agriculture (organic farming, renewable energy sources, water conservation) can compensate for additional costs, providing enterprises with an incentive to implement the latest environmental technologies.

5. ***Impact on the social sphere***. Taxes on wages (social security contributions) can significantly affect the employment and social conditions of workers in agricultural enterprises. For example, high rates of social contributions can lead to increased costs of maintaining the workforce, which forces agricultural enterprises to look for ways to optimize work processes (for example, through automation). Similarly, reduced tax rates on wages or employee benefits can encourage

businesses to expand their workforce and enhance social protections for employees.

Overall, taxation plays a crucial role in shaping the financial stability, investment potential, adaptability, and competitiveness of agricultural enterprises. A well-structured tax policy that aligns with the unique characteristics of the agricultural sector can serve as a catalyst for growth, whereas overly complex or high tax burdens may impose additional challenges for efficient business operations. Streamlining the tax system is essential for fostering long-term stability and sustainable development in agriculture.

In Ukraine, agricultural enterprises have the option to operate under either the general or simplified taxation system, depending on factors such as production volume, revenue structure, and workforce size.

Under the general taxation system, as outlined in the Tax Code of Ukraine (TCU) [20], businesses are subject to standard tax regulations unless they opt for a simplified system.

The main tax is the corporate income tax (18%), which is levied on net financial results (revenues minus expenses). Additionally, enterprises are required to pay a value-added tax (VAT) at a standard rate of 20%, or 14% for specific agricultural products, which enables them to obtain tax credits and partially offset costs.

Also, **agricultural enterprises under the general taxation system pay a single social contribution of 22% of the payroll**, property tax (real estate tax, land tax), and in the case of the sale of excisable goods, it is an excise tax. It should be noted that from 1998 to 2016, agricultural enterprises paid VAT under a special regime, which allowed business entities to accumulate funds to meet their own targeted needs. The abolition of VAT benefits in the taxation of agricultural producers since 2017, according to A. Lysenko, led to an increase in tax revenues to the budget. However, existing approaches do not contribute to the creation of equal taxation conditions for business entities of different sizes, forms of ownership, and types of activity [12].

The simplified system of taxation of agricultural enterprises in accordance with the TCU is a special tax regime that allows for reducing the tax burden and simplifying accounting for agricultural producers. A key characteristic is the option to pay a single tax under the fourth group, which serves as a substitute for corporate income tax and certain other general taxes. This tax is calculated based on the size of agricultural land holdings and their normative monetary valuation rather than the enterprise's income. As a result, farmers can predict their tax obligations independently of their financial performance. To use this regime, an enterprise must meet certain criteria, in particular, at least 75% of its income must come from agricultural production. In addition to the single tax, enterprises pay VAT according to general rules (20% or 14% for certain types of agricultural products), and also deduct a single social contribution (SSC) in the amount of 22% of the minimum or actual wage. It is worth mentioning that Ukraine implemented a simplified taxation system for agricultural enterprises in 1998 with the introduction of a fixed agricultural tax, which consolidated multiple state taxes and fees into a single payment. In 2015, as part of the tax reform, the fixed agricultural tax was abolished, and agro-industrial enterprises were allowed to switch to the fourth group of the single tax, which is calculated based on the area of agricultural land. According to Sarapina and Yeremian (2021) [18] , the reforms carried out in 2015 allowed to reduce the tax pressure, stabilize the costs of enterprises, and simplify accounting, which is especially important for small and medium-sized farms. At the same time, an unfair distribution of the tax burden between large and small enterprises arose, there was a lack of incentives for the modernization of production, and there was a risk of abuse through the use of tax optimization schemes [18].

Comparison of key characteristics of the general and simplified taxation systems for agricultural enterprises is an important tool for choosing the most optimal tax regime that meets the specifics of the activities of a particular enterprise. Since the agricultural sector is characterized by seasonality, fluctuations in product prices, and high production risks, the choice of taxation system

has a direct impact on the financial stability, competitiveness, and investment attractiveness of the economy.

Ukrainian scientists have paid much attention to the issues of comparing the general and simplified taxation systems for agricultural enterprises, in particular, Koba et al.(2019) [9], Parfeniuk and Yastrubskyi (2022), [15], Husiev (2021) [8].

Based on their research and our own conclusions, we have formed key differences between taxation systems in agriculture (Table 1).

Table 1. Comparison regarding the key characteristics of the general and simplified taxation systems for agricultural enterprises

Criterion	General taxation system	Simplified taxation system
Taxpayer category	All agricultural enterprises	Only agricultural enterprises (≥75% of income from the sale of agricultural products)
Accounting for income and expenses	Full accounting, expenses reduce the tax base	Simplified accounting, expenses do not affect the amount of tax
Tax incentives	Possible tax benefits and VAT refunds	Exemption from land tax, predictability of rates
Tax burden	High, depends on the enterprise's profit	Fixed, depends on the area of land and its regulatory assessment
Tax administration	Complex: involves registering as a VAT payer, submitting tax reports monthly	Simple: tax reports are submitted once a year
Control by tax authorities	High frequency of tax audits	Lower frequency of tax audits as taxation is fixed

Source: Compiled based on research Husiev (2021) [8], Koba et al. (2019) [9], Parfeniuk and Yastrubskyi (2022), [15]

To select the most suitable tax regime that supports the financial stability of an agricultural business, it is essential **to evaluate the advantages and disadvantages of both the general and simplified taxation systems**.

The general system imposes a full tax burden, which may be challenging for small and medium-sized farmers, yet it offers benefits such as access to a tax credit and the ability to deduct expenses.

In contrast, the simplified system allows for a reduction in tax and administrative complexity but may have limitations in the development and attraction of investments.

These advantages and disadvantages are reflected in Table 2.

Table 2. Comparative table of advantages and disadvantages of the general and simplified taxation systems for agricultural enterprises

Criterion	General taxation system	Simplified taxation system
Advantages	Possibility of taking into account expenses and depreciation to reduce the tax base; unlimited list of activities; possibility of using tax incentives; VAT refund in case of export.	Simplified tax administration and reporting; lower tax burden compared to the general system; no land tax (included in the single tax); predictability of the tax burden, as the single tax rates do not depend on market fluctuations.
Disadvantages	Complex accounting and tax reporting; high tax burden (income tax, VAT, land tax); mandatory payment of land tax; high level of tax audits and financial control; large amounts of income tax if the company has high revenues and significant profits.	Activities are limited to agricultural production (≥75% of income); single tax is charged regardless of actual income; no possibility of VAT refund (if not a VAT payer); not all expenses can be taken into account in the tax base; fixed amounts of single tax can be burdensome in years with low harvests or losses.

Source: Compiled based on research Husiev (2021) [8], Koba et al. (2019) [9], Parfeniuk and Yastrubskyi (2022), [15]

The tax burden is a key indicator that allows us to assess the impact of taxes on the functioning of agricultural enterprises. By determining the share of taxes in the income or expenses of an agricultural business, the tax burden helps to analyze the level of fiscal pressure and its consequences for the financial stability, profitability, and competitiveness of agricultural enterprises. Excessive tax burden can reduce profitability, and limit opportunities for investment and technological development, while a balanced tax system helps stimulate production, and modernization and attract capital. In addition, the analysis of the tax burden allows us to assess the effectiveness of tax incentives and support for the agricultural sector by the state, as well as identify the need to adjust tax policy to create a more favorable environment for the development of agriculture.

In Ukraine, despite the tax reforms carried out, the level of the tax burden on agricultural enterprises in 2014-2023 constantly increased, which is reflected in Fig. 1.

The tax burden on agricultural enterprise income in Ukraine increased during 2014-2019, decreased in 2020 and 2021, and

stabilized again at 6.7% in 2022 and 2023. The increase from 3.2% in 2014 to 6.7% in 2023 indicates an increase in the share of taxes paid by agricultural enterprises from their income, which is associated with tax reforms and changing market conditions. The tax burden on agricultural enterprise expenses in Ukraine also showed a growing trend, from 3.7% in 2014 to 10% in 2021, and then stabilized at 7.6% in 2022 and 2023. Such dynamics indicate an increase in production costs and a greater impact of taxes on such expenses.

In the European Union countries, tax mechanisms aimed at supporting the agricultural sector are in place, including simplified taxation systems, tax incentives for investments, flexible VAT systems, and a combination of tax and budget support. Taking this experience into account in Ukraine is important for improving tax policy, reducing the tax burden on agricultural business, stimulating its development, and adapting to modern economic challenges.

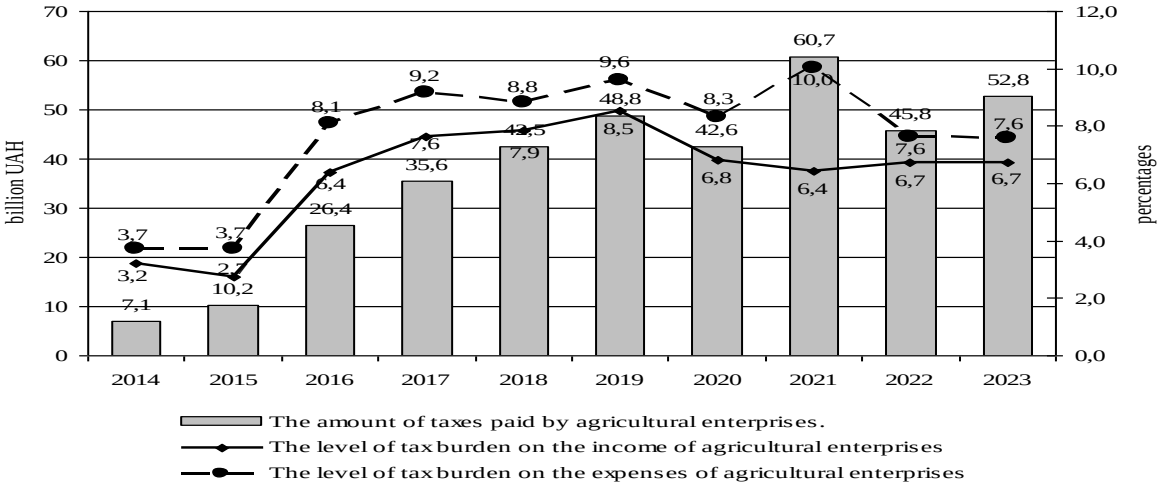

Fig. 1. Dynamics of the tax burden on agricultural enterprises in Ukraine in 2014-2023
Source: Compiled based on data from the State Statistics Service of Ukraine [SSSU] [19].

recent years, the tax burden on agricultural enterprises in Ukraine has remained relatively stable at approximately 6-8%, which is considered high compared to other nations. In contrast, the average tax burden on agricultural businesses across European countries varies depending on specific national tax policies and regulations. According to Gruziel and Raczkowska (2018) [7], in general, in EU member states, the average tax burden on agricultural enterprises usually ranges between 5% and 10%. In some countries, such as Germany, France, and Poland, this level may be even lower due to support in the form of subsidies, and in countries with less developed agriculture it may be higher [7].

To assess the impact of tax factors on the activities of agricultural enterprises in Ukraine, it is important to conduct a **SWOT analysis**. It allows for a comprehensive assessment of both positive and negative aspects of the national tax policy and to develop effective strategies for improving the tax conditions for doing business in the agricultural sector. Drawing on the research of Ukrainian scholars examining the taxation of agricultural enterprises, including Dehtiarova (2017) [3], Lutsenko and Polyantseva (2021) [11], as well as Kononenko and Nazarova (2022) [10], we carried out a SWOT analysis of the taxation system for agricultural enterprises in Ukraine, which is presented in Table 3.

The results of the SWOT analysis indicate that the taxation system for agricultural enterprises in Ukraine has several key advantages that facilitate the growth of the agricultural sector. Among the most significant are a comparatively low tax burden, the option to apply a simplified taxation system, and access to specific state support programs. This allows agricultural enterprises to reduce administrative costs and plan financial activities more effectively. However, there are also significant shortcomings that limit the

development of the industry. These include, in particular, the instability of tax legislation, the abolition of preferential regimes (in particular, the special VAT regime in 2017, as well as problems with VAT refunds for exporters. In addition, tax pressure is gradually increasing, which is especially noticeable for small and medium-sized farms.

Table 3. SWOT analysis of the taxation of agricultural enterprises in Ukraine

Factors	Strengths	Weaknesses
Taxation system	A simplified taxation system makes it possible to reduce the administrative burden and predict tax liabilities.	High dependence on changes in legislation, in particular regarding value-added tax.
Level of tax burden	Relatively low tax burden compared to other sectors of the economy.	The growing tax burden (especially after the 2016 reforms) and the abolition of benefits make it difficult to do business.
Financial support	State support programs (VAT refunds, grants) contribute to the development of agribusiness.	Inconsistent and inadequate state support, along with challenges in VAT reimbursement.
Flexibility in paying taxes	The presence of tax incentives, especially for small agricultural enterprises.	Absence of a well-defined long-term governmental strategy for agricultural sector taxation.
	Opportunities	Threats
Investment attraction	Simplifying tax administration can help attract investors and develop agribusiness.	Tax pressure and the unpredictability of tax policy can scare away investors.
Harmonization with the EU	Adapting the tax system to EU standards will expand export opportunities.	Partial abolition of tax benefits is possible within the framework of harmonization of legislation with the EU.
Technological development	The introduction of agricultural technologies allows for reducing costs and optimizing tax obligations.	Increasing taxes on agricultural land use and raising environmental standards.
State support	Implementing government support programs, such as loans and subsidies, can enhance the financial stability of agricultural enterprises.	Macroeconomic instability, ongoing military conflicts, and political uncertainties can restrict the ability to provide support for the agricultural sector.

Source: Compiled based on research Dehtiarova (2017) [3], Kononenko and Nazarova (2022) [10], Lutsenko and Polyantseva (2021) [11]

The evaluation of opportunities and challenges highlights Ukraine's considerable potential for enhancing tax policy in the agricultural sector. Aligning the tax system with European standards could create new prospects for sectoral growth, including expanding export markets, improving business conditions, and attracting investment. Notably, the taxation of agricultural enterprises in European countries incorporates specific features aimed at supporting the industry, meeting environmental standards, and promoting sustainable development and competitiveness. All European countries, as Détang-Dessendre and Guyomard (2023) argue, have common principles of taxation, but the details may vary depending on each country, its economic situation, agricultural sector policies, and environmental standards [4].

As reported by the Organisation for Economic Co-operation and Development, agricultural enterprises in European countries are subject to a range of taxes, encompassing both general taxation and sector-specific levies aimed at fostering agricultural development and promoting sustainability [14]. One of the main taxes is VAT, and agricultural products are often subject to reduced rates or preferential regimes, which helps to reduce the financial burden on farmers. In addition, agricultural enterprises may be exempt from VAT on exports to other EU member states or outside the EU. Farmers also pay land tax, although in many countries preferential rates or discounts are set for agricultural land. Fuel taxes, which apply to fuel and lubricants for agricultural machinery, are important, and farmers often have preferential rates or tax refunds. Income taxes for agricultural enterprises may have reduced rates, especially for small farms, for which simplified taxation is often provided. Environmental taxes are also an important aspect, which includes fees for the use of pesticides, fertilizers, and carbon dioxide emissions, incentivizing farmers to switch to more environmentally friendly technologies. In addition, exemptions are applied to excise duty on fuel, and tax discounts may be provided for enterprises engaged in organic farming or applying sustainable agricultural practices. The taxation system for agricultural enterprises in European countries is presented in Table 4.

Table 4. Taxes paid by agricultural enterprises in European countries

State	Income taxation		Property taxation		Tax on goods and services		Fuel Tax	Environmental taxes	Social security contributions
	Capital Gains Tax	Corporate Income Tax	Property and land tax	Transfers Acquisitions and Stamp Duties	Outputs	Inputs			
Austria	+	+	+	+	+	+			+
Belgium		+	+	+	+		+	+	+
Croatia		+			+	+	+		
Czech Republic	+	+	+		+		+	+	
Denmark			+				+	+	
Estonia			+				+	+	
Finland			+	+	+	+	+	+	+
France			+	+	+		+	+	+
Germany					+		+	+	+
Greece		+	+	+	+	+			
Hungary	+	+	+	+	+		+		
Ireland	+			+	+	+	+		
Italy		+	+	+	+	+	+		+
Latvia	+	+	+		+	+	+	+	+
Lithuania		+	+		+		+	+	+
Netherlands	+	+	+	+	+		+		
Norway	+		+				+	+	
Poland		+	+	+	+		+	+	+
Romania		+	+		+	+	+	+	+
Slovak Republic			+				+		
Slovenia			+	+	+	+	+	+	+
Spain			+	+	+	+	+	+	+
Sweden	+		+		+		+	+	
Switzerland	+		+		+	+	+		+
United Kingdom			+		+		+		

Source: Compiled based on data from the Organisation for Economic Co-operation and Development [OECD] [14].

In the European Union countries, tax mechanisms aimed at supporting the agricultural sector are in place, including simplified taxation systems, tax incentives for investments, flexible VAT systems, and a combination of tax and budget support. Incorporating this experience in Ukraine is crucial for enhancing tax policy, alleviating the tax burden on agricultural businesses, fostering their growth, and addressing contemporary economic challenges.

Adopting European practices in implementing simplified taxation systems for agricultural enterprises could play a key role in refining Ukraine's tax framework. The experience of EU countries demonstrates that such systems can greatly ease the operational burden on small and medium-sized agricultural enterprises, minimize administrative complexities, and support sectoral development. Various models of simplified taxation are successfully applied across EU nations and can be adapted to fit Ukraine's specific conditions. Thus, according to the Organisation for Economic Co-operation and Development, in France, the simplified taxation system for agricultural enterprises is called the "régime du forfeit".

This system allows farmers to pay a fixed tax based on established income, which significantly simplifies tax administration and reduces the accounting burden. In addition, enterprises with small incomes can take advantage of the "micro-fiscal" system, which provides an even more simplified form of taxation. In Germany, for agricultural enterprises, there is a simplified form of accounting and taxation for small farms. This is the "Landwirtschaftliche Buchführung" system, which allows farmers with small incomes to keep simplified accounting and submit shortened reports. At the same time, there are also options for small businesses to choose a simplified taxation system, where taxes are paid based on a fixed rate. In Italy, for farms with income up to a certain limit, there is the "regime deiminimi" system, which allows farmers to pay taxes based on a fixed rate. This allows small farms to simplify accounting and reduce the administrative burden. In Poland, there is the "ryczałt" system, which allows small farms to pay taxes on the basis of a chosen fixed rate depending on the type of activity and income. This approach enables small farmers to concentrate on production without having to spend time on complex tax reporting [14].

While European countries generally apply a simplified taxation system that primarily considers the income level of agricultural producers, in Ukraine, the simplified taxation system is based on the classification as agricultural commodity production. In particular, the share of such production obtained in the previous tax (reporting) year must be at least 75%. Moreover, the calculation of the single tax in Ukraine does not depend on the income of agricultural enterprises but

rather on the size of agricultural land and/or water fund lands, taking into account the land category (type) and its location. Considering European standards, it is advisable to introduce a mechanism for calculating the single tax based on the income of agricultural producers, which will make the taxation system fairer, since enterprises with lower incomes will not pay excessive taxes, regardless of the size of land use.

European countries implement a range of preferential VAT taxation mechanisms for agricultural producers, aimed at enhancing their competitiveness, alleviating the financial burden, and promoting the development of the agricultural sector. Taking into account the specific characteristics of agricultural production in Ukraine, adopting this experience could be a significant step toward optimizing the tax system.

According to Eurofiscalis (2025), many EU member states apply reduced VAT rates to agricultural products [6]. For example, Spain, Slovenia, Italy, Ireland, Greece, Croatia, and Belgium apply reduced or zero input VAT rates for purchases of inputs by agricultural enterprises. In Finland, a reduced VAT rate is applied to the purchase of animal feed. In Ireland, there is an option to refund VAT paid on the construction of agricultural buildings, structures, and land reclamation. Additionally, basic food products are often either exempt from VAT or taxed at lower rates. Furthermore, while a reduction in agricultural prices can positively impact farmers by boosting demand, consumers are the primary beneficiaries of this policy measure.

In Ukraine, a reduced VAT rate of 14 percent has also been introduced since 2021 for transactions on supplies to the customs territory of Ukraine and imports of certain types of agricultural products into the customs territory of Ukraine. Simultaneously, broadening the application of reduced VAT in line with European practices could help alleviate the tax burden on agricultural producers and enhance their competitiveness. Furthermore, it would be prudent to introduce clear timelines for verification and automatic VAT refunds, similar to the practices adopted by EU member states such as Sweden and Denmark; use modern digital technologies to control the VAT refund process and avoid corruption risks; introduce effective monitoring to identify schemes to minimize tax liabilities; create a single database of agricultural sector transactions, which will allow more effective tracking of suspicious transactions, etc.

Reforming the VAT administration in agriculture will increase the efficiency of the tax system, reduce administrative pressure on agricultural producers, and stimulate their development. The introduction of European practices, in particular, automation of the refund process, reduction of the VAT rate, and support for small farmers will contribute to increasing the competitiveness of the Ukrainian agricultural sector.

Investment tax incentives are an important tool for stimulating the modernization and development of agricultural enterprises in European countries. They are aimed at supporting investments in the latest equipment, technologies, environmentally friendly production, and increasing productivity. Ukraine, having significant agricultural potential, can adapt European experience in this area to increase the competitiveness of its farmers.

Thus, as evidenced by the research of Rudenko et al (2024) [17], France has a system of tax credits for innovative investments (Crédit d'impôt recherche), which allows enterprises to reduce tax liabilities when investing in technology, automation, and digital solutions. In Germany, special depreciation mechanisms are used that allow for the faster write-off of costs for agricultural equipment and machinery, which reduces the tax burden on producers. In the Netherlands, the Energy Investment Allowance (EIA) tax incentive is in place, offering additional benefits to businesses that invest in energy-efficient and environmentally friendly technologies. In Poland, small and medium-sized agricultural producers can take advantage of special investment deductions, which enable them to reduce their tax base by the amount spent on modernizing their technical equipment (Rudenko et al., 2023) [16].

Considering European practices, Ukraine should implement the following measures to stimulate investment activity among agricultural enterprises:

1) introduction of a tax credit for innovations – providing agricultural enterprises with the opportunity to reduce tax liabilities when investing in new technologies, irrigation systems, bioenergy, and production automation;

2) accelerated depreciation of fixed assets for enterprises that are on the general taxation system – creating mechanisms that allow agricultural enterprises to write off the cost of equipment more quickly and reduce the tax burden in the first years after investment;

3) tax breaks for environmental initiatives – introduction of profit tax reduction mechanisms for enterprises investing in CO_2 emission reduction, energy efficiency, and renewable energy sources (analogous to the EIA program in the Netherlands);

4) creation of special conditions for small farms – expanding access to investment tax breaks for small agricultural enterprises that do not have significant financial resources for modernization.

The introduction of investment tax incentives based on European experience will allow Ukrainian agricultural enterprises to accelerate technical re-equipment, increase competitiveness, and meet modern environmental standards. Providing credits, implementing accelerated depreciation, and lowering the tax burden for investment projects will foster the development of Ukraine's agricultural sector, bringing it closer to European agricultural production standards.

It is important to note that in European countries, support for the agricultural sector is based on a comprehensive approach that combines tax incentives with direct budget subsidies. Such a model contributes to the financial sustainability of farmers, stimulates innovation, and allows them to adapt to market challenges and climate change. Tax incentives are supplemented by budget support in the form of direct subsidies through the Common Agricultural Policy (EU countries receive subsidies to support farmers, depending on the area of land and environmental standards); investment grants for the modernization of agricultural machinery and the construction of processing plants; financing of ecological farming (countries such as the Netherlands and Sweden provide additional funds to farmers who adhere to sustainable development standards); compensation mechanisms in times of crisis, in particular during droughts, floods, market fluctuations (in Germany and France, farmers receive budget support in case of emergencies).

Ukraine can adapt to the European experience by implementing the following measures:

1) combining tax breaks with budget subsidies – providing state financial assistance to farmers in combination with reduced income taxes and VAT;

2) introducing a single tax-budgetary mechanism to support agricultural producers, which will provide for a reduced tax burden for environmentally responsible enterprises and direct budget assistance for eco-technologies;

3) support through state guarantees – state subsidization of loans, as in Poland and the Czech Republic, will allow small agricultural producers to attract financing for development;

4) introducing special tax holidays for young farmers, similar to Austria and Italy, which will stimulate new agricultural startups.

According to Rudenko et al. (2024) [17], the integration of tax and budgetary instruments will enable Ukraine, particularly in the context of post-war reconstruction, to implement priority state investment projects in agriculture, fostering economic growth and social well-being.

Therefore, adopting the taxation practices of European countries in the agricultural sector represents a crucial step towards enhancing Ukraine's tax system, boosting its efficiency, and creating a favorable environment for agricultural businesses. European countries frequently employ flexible taxation mechanisms that reflect the actual income of agricultural producers, encourage investment, offer preferential VAT regimes, and effectively combine tax and budgetary support measures. The implementation of these approaches in Ukraine will not only reduce the tax pressure on the agricultural sector but will also stimulate its development, contribute to

the modernization of enterprises, attract investment, and increase the competitiveness of domestic agricultural products in international markets.

CONCLUSIONS

Thus, taxes play a key role in the activities of agricultural enterprises, affecting their profitability, investment attractiveness, competitiveness, and financial stability. A high level of tax burden can limit the possibilities of agricultural business to modernize, introduce innovations, and expand production, while a well-thought-out system of tax benefits can promote its development. In addition, tax policy affects pricing, the social sphere, and the environmental sustainability of the agricultural sector. Therefore, a balanced tax system is an important tool of state regulation that contributes to the sustainable development of agriculture.

Agricultural enterprises in Ukraine have the opportunity to choose between the general and simplified taxation systems depending on the specifics of their activities, financial conditions, and income structure. The general taxation system involves paying income tax, VAT, a single social contribution, and property tax, making it more advantageous for large agricultural enterprises with stable incomes, as they can benefit from tax credits and cost optimization. In contrast, the simplified taxation system, which entails paying a single tax under the fourth group, enables small and medium-sized agricultural producers to decrease their tax burden since the tax amount is based on land area rather than income. This approach ensures predictable expenses but simultaneously limits flexibility in tax planning.

Taxation of agricultural enterprises in European countries is based on supporting the agricultural sector, ensuring sustainable development, and considering the environmental requirements. The general principles are reduced VAT rates, preferential regimes for small farms, special taxes on fuel, and environmental taxes that stimulate the use of environmentally friendly technologies. Different countries implement their own simplified taxation mechanisms aimed at easing the administrative burden on farmers. In Ukraine, the current simplified taxation system for the agricultural sector is determined by land size rather than the actual income of enterprises, which may lead to an imbalance in the tax burden. The introduction of European experience, in particular the calculation of taxes based on income, would make the system fairer and more efficient. In addition, expanding the practice of reduced VAT rates for agricultural products, automating VAT refund processes, and simplifying tax reporting will help increase the competitiveness of the Ukrainian agricultural sector. In general, the implementation of European approaches to the taxation of agricultural businesses can become an effective mechanism for stimulating the development of agricultural production, reducing the tax burden on farmers, and supporting their economic stability.

REFERENCES

[1]Beckman, J., Estrades, C., Flores, M., Aguiar, A., 2018, The impacts of export taxes on agricultural trade. Cambridge: National Bureau of Economic Research.

[2]Berezhenna, O., Kulakivska, T., 2020, Tax regulation of the agro-industrial complex in Ukraine. Entrepreneurship, Economy and Law, 4, 202-206.

[3]Dehtiarova, S. V., 2017, On the problem of improving taxation of agricultural enterprises. Scientific Journal of Public and Private Law, 2(2), 154-158.

[4]Détang-Dessendre, C., Guyomard, H., 2023, Evolving the Common Agricultural Policy for Tomorrow's Challenges. Versailles: Éditions Quæ.

[5]Durst, R., Monke, J., 2001, Effects of Federal Tax Policy on Agriculture. Agricultural Economic Report No. 800. Washington DC: Food and Rural Economics Division, Economic Research Service, U.S. Department of Agriculture.

[6]Eurofiscalis, 2025, EU VAT Rates for 2025: The Complete Overview. https://www.eurofiscalis.com/en/vat-rates-in-ue/., Accessed on January 27, 2025.

[7]Gruziel, K., Raczkowska, M., 2018, The Taxation of Agriculture in the European Union Countries. Scientific Journal Warsaw University of Life Sciences – SGGW. Series: Problems of World Agriculture, 18(4), 162-174.

[8]Husiev, A., 2021, Unified tax in Ukraine: economic nature and accounting features. Efektyvn aekonomika, 10. https://doi.org/10.32702/2307-2105-2021.10.201.

[9]Koba, O., Shynkar, Yu., 2019, Comparative analysis of the general and simplified system of taxation: features of use, problems and directions of their solution. Scientific Bulletin of Uzhhorod National University.

Series: International Economic Relations and World Economy, 25(1), 116-120.
[10]Kononenko, L., Nazarova, H., 2022, Taxation of agricultural producers in Ukraine: problems, prospects, directions of optimization. Economic Scope, 181, 213-217.
[11]Lutsenko, I., Polyantseva, A., 2021, Current state of taxation of agricultural activities. Efektyvn aekonomika, 12. https://doi.org/ 10.32702/2307-2105-2021.12.100.
[12]Lysenko, A. M., 2017, Assessment of the tax burden on the agricultural enterprise: a practical aspect. Scientific Papers of Kirovograd National Technical University. Series: Economic Sciences, 32, 152-160.
[13]Odintsov, O., Yevtukhova, T., Vasylkonova, E., Kunchenko-Kharchenko, V., 2020, Influence of tax burden on economic development of agricultural enterprises in Ukraine. Journal of Eastern European and Central Asian research, 7(1), 150-162.
[14]OECD, 2020, Taxation in Agriculture. Paris: OECD Publishing. https://doi.org/10.1787/073bdf99-en.
[15]Parfeniuk, T., Yastrubskyi, M., 2022, Peculiarities of application of the simplified taxation system in Ukraine in wartime. Economy and Society, 22. https://doi.org/10.32782/2524-0072/2022-44-27.
[16]Rudenko, V., Pohrishchuk, H., Moskvichova, O., Hryhoruk, I., 2023, The impact of preferential taxation on the stimulation of investment processes in Ukraine in the context of the experience of EU member states. Academic review, 2(59), 155-172.
[17]Rudenko, V., Pohrishchuk, H., Moskvichova, O., Bei, S., Smahlo, O., 2024, Prospects for reforming the budget investments management in Ukraine in the context of international experience. Financial and Credit Activity Problems of Theory and Practice, 3(56), 97-117.
[18]Sarapina, O., Yeremian, O., 2021, Taxation of domestic agricultural goods manufacturers: features, problems and prospects. Financial and Credit Activity Problems of Theory and Practice, 2(37), 116-122.
[19]State Statistics Service of Ukraine (n.d.). Economic statistics/ Economic activity/ Enterprise activity. https://www.ukrstat.gov.ua/. Accessed on January 28, 2025.
[20]Verkhovna Rada of Ukraine, 2010, Tax Code of Ukraine dated December 2, 2010, No. 2755-VI. https://zakon.rada.gov.ua/laws/show/2755-17/conv#top, Accessed on January 28, 2025.

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ENHANCING THE EFFECTIVENESS OF VILLAGE AUTONOMY: A SOFT SYSTEMS METHODOLOGY (SSM) APPROACH TO IDENTIFYING CHALLENGES AND POLICY REFORM IN RURAL DEVELOPMENT IN INDONESIA

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Abstract

Village autonomy aims to improve community welfare through independent and participatory governance. However, its implementation still faces challenges. This study analyzes the dynamics of village autonomy implementation, identifies gaps between ideal conceptual models and practices on the ground, and proposes systematic and culturally feasible changes. Using Soft Systems Methodology (SSM), this study collected data through observation, interviews, and focus group discussions (FGDs). Results show that village planning lacks participation, implementation is constrained by bureaucracy, and monitoring and accountability are weak. Key recommendations include increasing community participation, digitizing reporting, strengthening the capacity of village officials, and diversifying funding sources for more effective and transparent governance.

Key words**:** *village autonomy, governance, Soft Systems Methodology, transparency, participation*

INTRODUCTION

Since the 1980s, strategies for rural development have evolved to encompass not only enhancements in productivity and income but also improvements in quality of life factors such as health, education, gender issues, environmental concerns, and physical infrastructure (Sutiyo& Maharjan, 2017) [68]. Subsequently, these methods began to emphasize the involvement of marginalized groups by integrating political aspects into rural development efforts (Fernando, 2008) [18]. Among the various strategies, decentralization—shifting authority from central governments to local governments or NGOs (Rondinelli and Cheema, 1983) [59]. — has become increasingly favored in developing nations.

Decentralization in village level, often referred to as village autonomy, is a notable phenomenon across Asia and Africa, including Indonesia. The Panchayati Raj system in India empowers local councils with significant administrative and financial responsibilities (Das, 2022; Bukhari, 2019) [12, 7]. In China, village autonomy has been explored through the "Village Committee" system (Shen et al., 2019; Zhong, 2015) [62, 74]. The governance structure in the Philippines involves Barangay systems, where elected officials operate at the village level (Flores, 2019; Floranza, 2021) [20, 19]. Similarly, Thailand's Village Fund program offers financial resources and decision-making authority to villages (Boonperm et al., 2013; Menkhoff & Rungruxsirivorn, 2011) [6, 40]. Other countries, such as South Korea, Japan, Tanzania, Uganda, and Kenya, also exhibit comparable local governance structures that empower villages (Hwang et al., 2018; Song et al., 2018; Denpaiboon & Amatasawatdee, 2012; Onitsuka & Hoshino, 2018; Mercer & Green, 2013; Mketo et al., 2022; Okello & Mwesigwa, 2022; Singh et al., 2014; Hussein & Wanyoike, 2015; Mogoi et al., 2012) [30, 67, 13, 50, 41, 43, 49, 64, 29, 44].

In Indonesia, the process of decentralization, initiated in 2001, has granted local governments increased autonomy. In 2014, President Jokowi enacted Village Law 6/2014 [37], which further enhanced village autonomy by transitioning from top-down initiatives to a model of community-driven development.

This law classifies villages as autonomous micro-regional governments within regencies, empowering them with greater control over budgets and decision-making processes to effectively address local needs and conditions. The objective of this autonomy is to tackle economic disparities, particularly as rural areas faced higher poverty rates (12.36%) compared to urban areas (7.53%) in 2022, according to the National Statistics Bureau of Indonesia.

While there is a substantial body of research on village autonomy in Indonesian governance (Phahlevy, 2016; Indartuti et al., 2020; Pratolo et al., 2020; Zuliyah, 2020; Kadir & Idris, 2021) [53, 31, 56, 76, 32], limited attention has been given to the extent to which village autonomy impacts development in rural areas. This research aims to fill that gap by investigating the effectiveness of village autonomy in addressing rural underdevelopment. It seeks to enhance our understanding of the relationship between grassroots autonomy and rural development in Indonesia. Ultimately, this study holds the potential to inform policies that improve the quality of life for individuals in rural areas and promote more equitable and just outcomes.

The novelty of this research lies in the application of Soft System Methodology (SSM) to analyze the village autonomy phenomena. SSM, which was developed by Peter Checkland, is a powerful method for addressing complex and unclear problems by integrating various perspectives and encouraging teamwork in problem-solving. Its emphasis on understanding and improving real-life situations through ongoing learning and the involvement of stakeholders makes it particularly suitable for examining and enhancing rural governance (Checkland & Poulter, 2006) [10]. However, there is a significant lack of application of SSM in studies related to rural contexts. While it has been effectively used in multiple fields, its potential to tackle the complexities of rural governance and contexts has not been thoroughly explored (Bell et al., 2016) [4].

Through this endeavor, the research is expected to answer the following research questions:

(1)What are the dynamics influencing the implementation of village autonomy in Indonesia, particularly regarding the challenges encountered by rural key stakeholders?

(2)In what ways do the current practices of village autonomy implementation in Indonesia diverge from the ideal conceptual frameworks established, and what specific gaps can be identified?

(3)What changes are both desirable and feasible to enhance the effectiveness of village autonomy implementation in Indonesia, and how might these changes be operationalized?

Theoretical Framework

Decentralization

Decentralization generally refers to transferring power from a central government to lower levels of government or organizations. Rondinelli and Cheema (1983) [59] define it as transferring planning, decision-making, or administrative authority to local administrative units, semi-autonomous organizations, local government, or NGOs. The enactment of Village Law 6/2014 [37] in Indonesia marks a critical stage for rural development by implementing decentralization, known as village autonomy (Sutoro et al., 2014; Widjaja, 2003; Ndraha, 1991) [69, 72, 46].

Decentralization includes three main types: political, administrative, and fiscal (Sutiyo and Maharjan, 2017) [68]. Political decentralization involves transferring political power to lower government levels, enabling local decision-making. Administrative decentralization redistributes authority and resources for public services across government levels. Fiscal decentralization transfers fiscal authority for revenue generation, transfers, and expenditure decisions. Successful decentralization requires coordinated implementation of these dimensions (Falleti, 2004; Goel et al., 2017; Martinez-Vazquez et al., 2017; Sutiyo& Maharjan, 2017) [17, 22, 39, 68]. This paper analyzes village autonomy using these typologies.

Decentralization enhances rural development by bringing governance closer to communities, increasing participation, and addressing disparities. It improves service delivery,

reduces poverty, and promotes rural development (Drobnjaković, 2024; Khisa, 2020; Somanje et al., 2020) [15, 34, 66]. It boosts financial capacity, investment attractiveness, and living conditions in rural areas (Sokolova, 2023) [65]. Decentralization fosters community participation, accountability, and resource mobilization, essential for sustainable development (Somanje et al., 2020; Kakumba, 2010) [66, 33].

However, the impact of decentralization varies based on context and strategies. While some argue it can lead to regional economic disparities (Rodríguez-Pose &Ezcurra, 2009) [58], others highlight its potential to reduce poverty and enhance rural vitality (Wang et al., 2019) [70]. Effective decentralization requires mechanisms for marginalized households to engage with government and participate in decision-making (Agrawal & Gupta, 2005) [1]. Balancing decentralization efforts is crucial to prevent misallocation and ensure balanced urban-rural development (Zhou & Fan, 2023) [75].

Village Autonomy

Village autonomy refers to villages' ability to self-govern, often rooted in local customs, allowing unique local identities and reducing dependence on higher government levels (Goldsmith, 1995; Pratkett, 2004; Sutoro al., 2014) [23, 55, 69]. It emphasizes community participation, involving residents in decision-making to maximize village potential (Saragi, 2004; Silubun et al., 2020) [61, 63]. In Indonesia, the Village Law (Law Number 6/2014) [37] enhances village autonomy through a community-driven development approach, empowering villages with broader authority over budgets and decision-making for social, economic, and administrative development (Wong & Guggenheim, 2018; Dongier et al., 2003) [73, 14]. Village governments, led by village heads and councils, receive significant budget transfers, 'Dana Desa,' for locally determined programs (Salim et al., 2017; Arifin et al., 2020; Hartojo et al., 2022) [60, 3, 27].

Village autonomy is assessed through five dimensions: resource allocation, access to essential services, participation and inclusion, social cohesion, and economic opportunities. Resource allocation evaluates the fairness and transparency of distributing resources. Access to essential services examines the availability of education, healthcare, and connectivity (Ho, 2022; Wei & Zhou, 2022) [28, 71]. Participation and inclusion assess residents' involvement in decision-making. Social cohesion measures unity and cooperation, while economic opportunities evaluate employment and market access.

Effective village autonomy relies on responsive, transparent leadership fostering community participation and democratic governance (Chromý et al., 2011; Giddens, 1995; Nye, 1990; Mansuri & Rao, 2004) [11, 21, 48, 38]. Strong social capital in rural life helps overcome poverty and improve social standing, although strong ties can hinder information dissemination, highlighting the importance of both strong and weak ties (Berki et al., 2020; Granovetter, 1973; Elvy, 2019) [5, 24, 16]. Transparency and accountability in managing village budgets (APBDes) are crucial. Strong social ties can create informal power structures, posing challenges to transparency and accountability. Effective regional financial management upholds these principles to enhance village autonomy (Khotimah et al., 2018; Niswah et al., 2018; Pane, 2019) [35, 47, 51].

MATERIALS AND METHODS

Research Methodology

This study takes a qualitative approach using Soft System Methodology (SSM), which is great for tackling complex and poorly defined problems. Rural governance includes complex problems that require a holistic or systemic way of thinking, we noticed the need for a system thinking perspective (Checkland, 1985; Mingers& White, 2010; Pollack, 2006; Muhammaditya et al., 2021; Akhyar et al. 2023) [8, 42, 54, 45, 2]. SSM shines when it comes to bringing together different viewpoints and creating solutions that involve all stakeholders. Since the focus of the research is on understanding village autonomy, it’s crucial to grasp the various processes, relationships, and context at play—something

that qualitative methods do best. SSM fits perfectly here, as it provides a structured way to identify and solve broader issues within the system, helping to develop practical solutions that are specifically tailored to the rural context.

Soft System Methodology (SSM)

SSM is a qualitative approach rooted in systems thinking that seeks to comprehend issues and create a conceptual framework to address complex and poorly defined challenges. It consists of seven stages, depicted in Figure 1 (Checkland, 2000; Checkland& Poulter, 2006) [9, 10], which are categorized into two types of reasoning: thinking about the real world and thinking systemically about that real world.

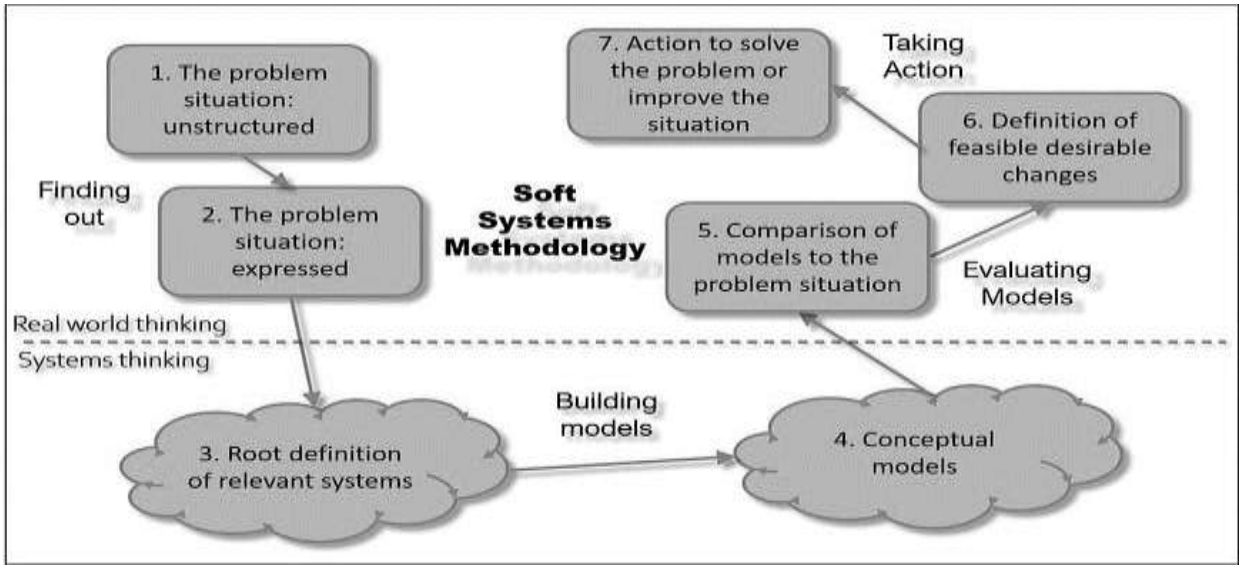

Fig. 1. Checkland's seven-stage Soft Systems
Source: Checkland, 2000; Checkland& Poulter, 2006 [9, 10].

First, we identified problematic situations on the implementation of village autonomy by conducting in-depth interviews with five village heads, three village facilitators, two regional government officers and some village communities. To achieve research aims optimally, the selection of five villages heads for interview is based on the status of Village Development Index (VDI) which comprising all five categories: Very under-developed, under-developed, developing, advanced, and independent village. Each village head will represent each VDI. VDI is an indicator of village development progress that is determined based on Law Number 6 of 2014 [37] concerning Villages and Minister of Villages, Development of Disadvantaged Regions and Transmigration Regulation Number 2 of 2016 concerning Village Development Index [57].

In the second stage, the information collected in the first stage of Soft Systems Methodology (SSM) was depicted in a rich picture. The third stage focused on crafting a root definition using the CATWOE framework, which includes Customer, Actors, Transformation, Weltanschauung (Worldview), Owners, and Environmental Constraints. This was followed by the fourth stage, where a conceptual model was developed and assessed based on criteria of efficacy, efficiency, and effectiveness. In the fifth stage, the model was compared to real-world scenarios to validate and refine it, highlighting any discrepancies and insights. The sixth stage consisted of formulating recommendations for changes, while the seventh stage was dedicated to implementing these recommendations to address the problems or enhance the situations.

RESULTS AND DISCUSSIONS

Identifying unstructured problems

Before identifying unstructured problems, it is essential to establish the Client, Practitioner, and Owner (CPO) associated with the issue (Table 1).

Table 1. CPO Components

Client/s	**Department of Social Geography and Regional Development, Charles University, Village Community**
Practitioner/s	Robert Saputra (Researcher and SSM Practitioner) Tomas Havlicek (Supervisor)
Owner	Village Community, Village Government, Regional Government, and Central Government

Source: Own presentation.

Observations and interviews with various parties revealed that the implementation of village autonomy involves many actors with diverse roles and interests, often creating complex dynamics. Village governments as the main implementers often face pressure from local and central governments regarding policies and reporting, while village communities, who should be the main beneficiaries, often feel inadequately involved in the decision-making process. In addition, external stakeholders such as NGOs and the private sector often bring their own agendas that are not always aligned with local needs. The lack of effective coordination between these actors often leads to overlapping authority, conflicts of interest, and inefficiencies in the management of village authority. Observations also noted that communication between parties tends to be one-way, with the central or local government dominating, while the role of the community as a watchdog and partner in village development has not been well accommodated.

Interviews and field observations also revealed significant capacity gaps at the village apparatus level in managing the authority granted by village autonomy. Many village heads and their officials admitted that they have difficulty understanding the various regulations that often change, so that the implementation process often runs not in accordance with the applicable rules. Interviews with village facilitators also revealed that the technical training and mentoring provided is insufficient to build the necessary competencies, particularly in terms of data-driven planning, budget management, and accountability reporting. These limitations are exacerbated by village officials' low access to supporting resources such as information technology and adequate monitoring tools. As a result, many decisions are made intuitively or based on old habits, which are often inconsistent with good governance principles.

The results of observations and interviews also showed that the level of community participation in the management of village authority is still not optimal. Village deliberations, which should be the main forum for designing development programs based on local needs, are often only attended by a handful of specific groups, such as traditional leaders, village officials, and pre-determined representatives. The general public, especially women, youth, and marginalized groups, feel uninvited or have no meaningful voice in the process. Several interviewees attributed this lack of participation to a lack of transparent information regarding the schedule and agenda of village meetings, as well as a strong hierarchical culture, where decisions tend to be dominated by those deemed to have authority. In addition, observations also noted the apathy of some communities, who felt that their opinions would not affect the final outcome, so they chose not to get involved.

The implementation of village autonomy in Kepulauan Meranti has faced challenges, particularly in transparency and accountability of village governments. While autonomy grants villages significant authority and resources, the lack of robust accountability mechanisms risks corruption and unfair practices. Since the policy's inception in 2015, at least eight village heads and officials have been detained for misappropriating village funds, resulting in state losses exceeding 2 billion Rupiah (134,000 USD). This undermines rural development efforts despite the potential benefits of village autonomy. Several villagers interviewed revealed that information on the use of village authority and budgets is often not published openly, leading to suspicion among the community of potential abuse of authority. In addition, oversight

mechanisms, both by the Village Consultative Body (BPD) and the community, have not been effective due to a lack of understanding of the role of oversight and limited access to relevant data

Developing a Rich Picture

Based on the information gathered from the first stage of SSM, we transformed them into a rich picture (Figure 2) from which it helps authors to visually communicate the problem situation.

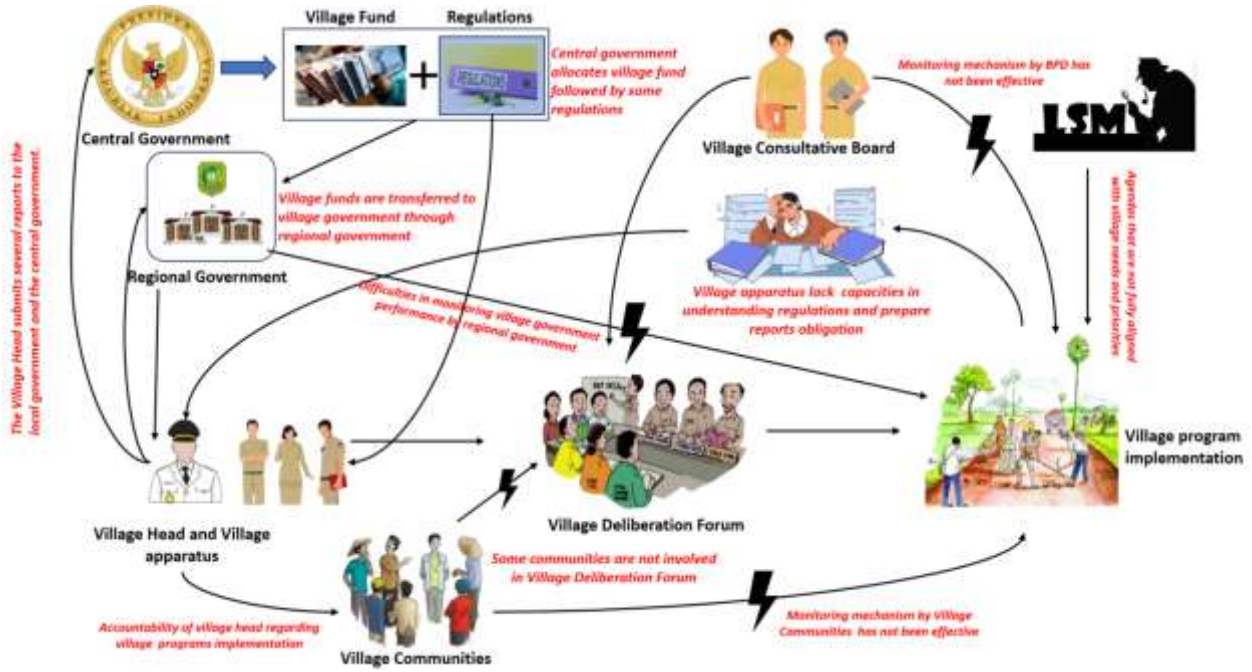

Fig. 2. Rich Picture from the Problematic Situations
Source: The visualization of the unstructured problems (Step 1 of SSM) by the author (2024).

The rich picture that has been developed illustrates the complexity of village autonomy implementation in Indonesia by mapping key actors, processes and challenges in several important aspects: planning, implementation, evaluation and accountability. In planning, village officials face the challenge of understanding and adjusting to frequently changing policies from central and regional governments. Village meetings, which are supposed to be participatory forums, are often dominated by certain groups, so the needs of the wider community are not always accommodated. The limited capacity of village officials to use data and modern planning tools also affects the quality of development plans produced.

On implementation, the complexity of the multi-actor system creates obstacles to coordination between village governments, communities, and external parties such as NGOs and the private sector. There are often overlapping authorities or conflicts of interest that hamper program implementation. In evaluation, oversight by the community and BPD has not been optimal due to the lack of access to transparent information and the lack of skills to critically evaluate the program. This has a direct impact on accountability, where reports on the management of village authority are not always open and in accordance with the principles of good governance, leading to community distrust.

Root Definition

The third stage is to determine the root definition (RD). The technique applied is to answer the questions about what is done (P), how to do it (Q), and why it is done as an objective (R) (Checkland & Poulter, 2006) [10]. The root definition for this study are as follows:

(P) A system for managing village authorities within the framework of village autonomy, (Q) implemented through participatory, transparent, and accountable processes involving the community, village officials,

local government, and external stakeholders, (R) to support needs-based local development and enhance the welfare of village communities.

The Root Definition (RD) is created through direct observations, discussions with stakeholders, and the conceptual frameworks used in this research. To verify the choice and designation of the Human Activity System, the CATWOE analysis method was employed, evaluating the components of Customers, Actors, Transformation, Weltanschauung (Worldview), Owners, and Environment (Hardjosoekarto 2012; Hardjosoekarto et al. 2013; Permatasari et al. 2019; Muhammaditya et al., 2021; Akhyar et al., 2023) [25, 26, 52, 45, 2]. Detailed information on the CATWOE components can be found in Table 2.

Table 2. CATWOE analysis

Customers	**-The village community is the main beneficiary of the implementation of village autonomy** **- Regional and central government as parties who want to ensure the success of the program.**
Actors	- Village government (village head, village officials). - Village Consultative Board (BPD). - Village community groups (farmers, youth, women, traditional leaders) - Regional government and external parties (NGOs, private sector).
Transformation	Village authority is transformed into local needs-based development programs through village consultative meetings, with participatory implementation, monitoring, and evaluation.
Weltanschauung (Worldview)	Village autonomy is the key to improving community welfare through participation, transparency, and accountability in village development management.
Owners	- The central and regional governments provide direction and supervision. - Village communities as beneficial owners and supervisors.
Environment	- Changing government regulations. - Limited capacity of village apparatus. - Suboptimal community participation. - Conflict of interest and corruption.

Source: Author's analysis.

Formulating Conceptual Model (CM)

The fourth stage of SSM is to formulate a conceptual model (CM) to identify required activities for the optimization of village autonomy implementation (Figures 7). This adaptive process involves executor activities and feedback. The model must align with five criteria: efficacy, efficiency, effectiveness, elegance, and ethicality (Hardjosoekarto 2012; Hardjosoekarto et al. 2013; Permatasari et al. 2019) [25, 26, 52]. This study focuses on three: efficacy (benefits of changes), efficiency (minimal resource use), and effectiveness (optimal time use). Ethicality and elegance are not explicitly addressed, focusing instead on functional aspects within a morally sound organization (Kotiadis et al. 2013, Muhammaditya et al., 2021; Akhyar et al. 2023) [36, 45, 2]. Testing criteria is detailed in Table 3. The root definition of each component serves as the foundation for developing a crucial conceptual model (Figure 3) aimed at fulfilling an ideal objective. This model outlines the human activities system, reflecting the results of the problem situation. It functions as an adaptive process, allowing for feedback between the modeling activities and the representation of the problem situation. The conceptual model includes all elements used in CATWOE.

The planning stage in the implementation of village autonomy begins with a needs assessment of the village society, where various data and information are collected to identify and analyze development issues and opportunities. The results of this assessment form the basis of the village deliberation, which serves as a deliberative forum for the community and stakeholders to set development priorities that are appropriate to local conditions.

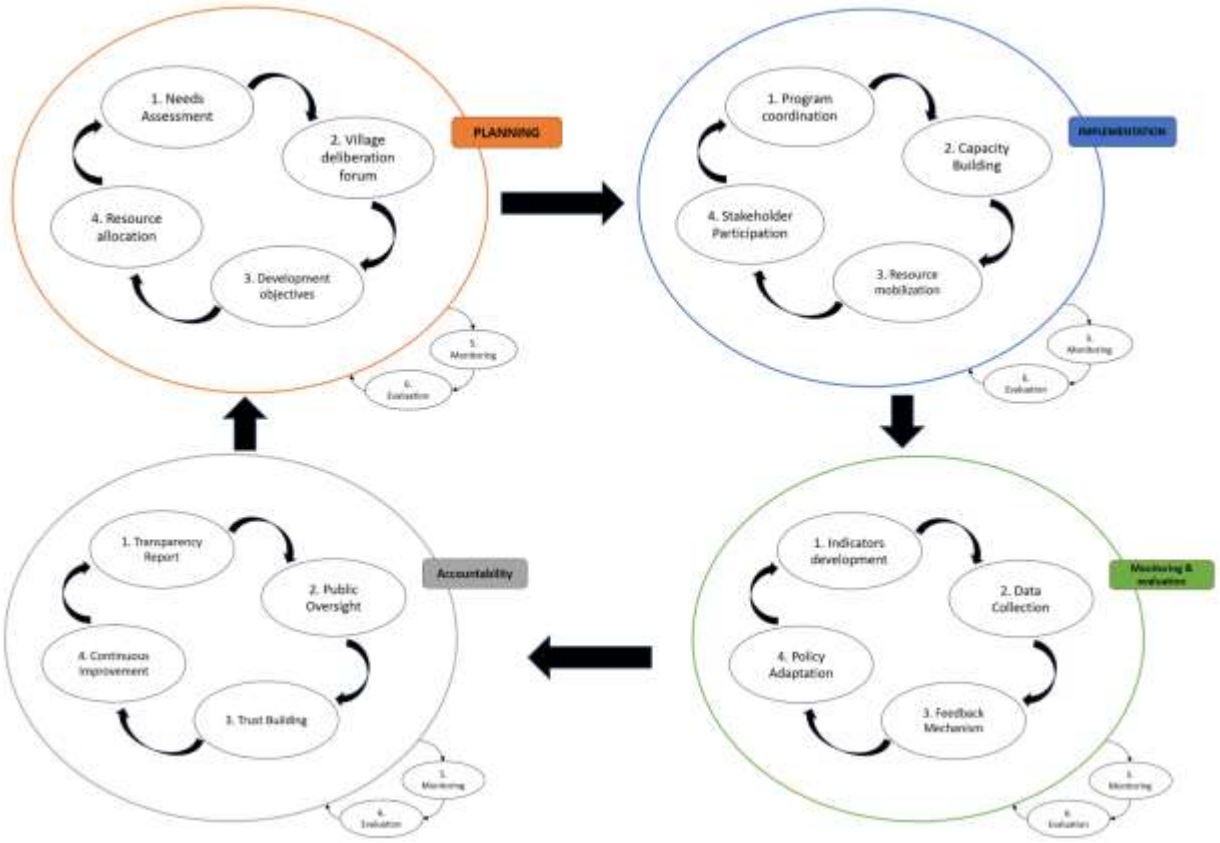

Fig. 3. Conceptual Model of Relevant System
Source: Own conception.

Furthermore, the results of the deliberation are formulated into the *RKPDes* (Village Government Work Plan), which contains strategic programs, indicators of success, and a systematic implementation mechanism. Finally, to ensure the effectiveness of planning, needs-based resource allocation is carried out, which includes the distribution of budget, manpower, and infrastructure so that development programs can run optimally in accordance with the priorities that have been set.

The implementation stage emphasizes implementing the policies and programs in the *RKPDes*. The initial step is coordination of program implementation, where the village officials works closely with relevant institutions to ensure synergy in policy execution. To improve the effectiveness of implementation, capacity building of village officials is carried out, including administrative, technical, and managerial training to ensure the readiness of human resources. Furthermore, resource mobilization and distribution are important element in ensuring smooth program implementation, both in terms of funding, logistics, and manpower.

In addition, community involvement and participation are highly emphasized so that the program truly responds to the needs of the community, creates a sense of ownership, and increases the sustainability of development at the village level.

To make sure the village program works effectively, we carry out the Monitoring & Evaluation (M&E) stage in a structured way through several key steps. It begins with creating performance indicators that act as benchmarks to gauge the program's success against set targets.

After that, we gather and analyze data from different sources, including reports from the field, direct observations, and community feedback.

The insights we gain from the analysis feed into our reporting and feedback systems, promoting transparency in our evaluations and laying the groundwork for future policy improvements.

To foster continuous improvement, we adapt our policies based on these evaluations, enabling the village to refine its strategies and programs to better meet the changing needs of the community.

Accountability in the implementation of village autonomy is a crucial aspect to ensure public trust and transparency in the management of village authority. One of the main elements in this stage is transparency in reporting the use of authority, where the village government is obliged to submit information related to programs, budget use, and development achievements to the community.

To ensure effective oversight, a monitoring mechanism is implemented by the community and the BPD (Village Consultative Body), which serves as a social control over the operation of the village government. In addition, increasing public trust through the publication of results is an important strategy in building the legitimacy of the village government and encouraging active participation of citizens.

Finally, the accountability process also includes continuous learning and improvement, where evaluation results are used to identify best practices and correct weaknesses in the next village development cycle.

Table 3. Testing Criteria 3E

3E Criteria	Explanation
Efficacy (1E)	This conceptual model ensures that village policies are more participatory, data-driven, and responsive to community needs. Continuous monitoring and evaluation allow ineffective policies to be corrected immediately.
Efficiency (2E)	Efficiency is achieved through needs-based resource allocation, good coordination, and strengthening the capacity of village officials. Transparency and oversight mechanisms prevent budget misuse and increase productivity.
Effectiveness (3E)	Clear strategic planning and regular monitoring ensure that each stage of development is on target. Transparent accountability accelerates decision-making and village responsiveness to change.

Source: Author's analysis.

The comparison of model and real world

The conceptual model helps in achieving the epistemological model (Hardjosoekarto, 2012; Hardjosoekarto et al. 2013; Permatasari et al. 2019; Muhammaditya et al. 2021) [25, 26, 52, 45].

Aligning the model's structure with one's worldview improves comprehension of reality. Checkland (2000) [9] outlines four comparative methods, which are created using a matrix based on the conceptual model (Table 4).

The comparison of a conceptual model (human activity system) with the reality produces several recommendation formulas that are utilized to prevent the problems that have been happening recently. Recommendations are grouped into four parts, namely planning, implementation, monitoring and evaluation, and accountability.

Recommendations for Further Actions

In the Soft Systems Methodology (SSM), stages 6 and 7 focus on proposing changes and taking actions to tackle issues identified through comparisons and discussions. As noted by Checkland (2000) and Checkland and Poulter (2006) [9, 10], Stage 6 involves validating the conceptual model to confirm that it is both systematically desirable and culturally acceptable. In this stage, the researcher engaged with rural stakeholders and problem owners through consultations. These consultations employed a participatory approach, utilizing Focused Group Discussions (FGDs) and in-depth interviews to ensure the model's systematic desirability and cultural feasibility. Detailed notes and audio recordings were made with participants' consent to capture all pertinent insights. The qualitative data collected was analyzed to extract key themes, and the results were formally documented. Based on the feedback received, the conceptual model was modified as necessary to better reflect the local cultural context, ensuring its practical applicability and alignment with SSM principles. After discussions with various rural stakeholders regarding the study results, it was concluded

that the developed system meets the standards of systematic desirability and cultural feasibility, with several key factors to consider. Village planning should involve all elements of the community to ensure that the policies adopted truly reflect local needs. Village deliberations (*musdes*) need to be strengthened with an inclusive approach, ensuring that women, youth, and vulnerable groups participate in decision-making. Focus group discussions (FGDs) can be conducted before the *musdes* to dig deeper into the aspirations of the community, so that every decision is data-based and not just dominated by a few parties. In this way, community participation increases, transparency is maintained, and village development policies become more relevant and sustainable.

Table 4. The comparison of model and reality

Activity	**Real Condition**	**Recommendation**
Planning	Village planning often lacks comprehensive community participation, with dominant influence from village elites and local political interests. Needs assessments are sometimes superficial, and *RKPDes* preparation may not align well with real community needs. Resource allocation can be inefficient due to bureaucratic constraints and misalignment with long-term goals.	Strengthen participatory planning by ensuring all community groups are involved in needs assessments and village meetings. Implement data-driven decision-making for RKPDes and improve transparency in budget allocation. Capacity building for village officials should be prioritized to enhance strategic planning skills.
Implementation	Execution of programs often faces delays due to administrative inefficiencies, lack of coordination, and resource mismanagement. Village apparatus may lack technical knowledge, and community involvement in implementation is often minimal. Some projects suffer from poor execution quality due to inadequate supervision	Improve coordination mechanisms among stakeholders, including government, private sector, and local communities. Provide continuous training for village officials on project management and technical aspects. Enhance community engagement by promoting local ownership and volunteerism in project execution.
Monitoring & Evaluation	Monitoring is often weak due to a lack of clear performance indicators and structured evaluation mechanisms. Data collection is inconsistent, and feedback from the community is rarely integrated into policy improvements. Evaluation tends to be reactive rather than proactive, leading to repeated issues in project implementation.	Develop standardized key performance indicators (KPIs) and ensure systematic data collection for continuous evaluation. Establish independent monitoring teams involving civil society organizations (CSOs), community representatives coordinated by Village Consultative Body or *BPD*. Institutionalize feedback loops where community input is actively considered for policy revisions.
Accountability	Transparency in financial and program accountability remains a major issue, with limited public access to financial reports. Community oversight mechanisms such as BPD (Village Consultative Body) exist but are often ineffective due to lack of authority or political influence. Corruption and misuse of village funds still occur in some areas due to weak governance structures.	Enhance transparency by mandating regular public financial reporting through accessible platforms. Strengthen the role and authority of BPD and other oversight bodies to conduct independent audits. Implement digital governance tools to track fund allocations and project progress in real-time.

Source: Comparison of developed Conceptual Model (CM) with real world by using secondary data, FGD and interview with rural stakeholders.

In addition to involving the community in planning, transparency in village financial management is also an important factor in improving accountability. One of the main challenges in village governance is the transparency of the use of village funds, which is often still managed manually and less open to the community. Digitalization of financial recording and reporting can be a solution by utilizing simple technology, such as mobile-

based applications or village social media. With this mechanism, village financial reports can be accessed by the public on a regular basis, reducing the risk of misuse of funds and increasing public trust in the village government. This approach is also in line with the increasing penetration of technology in rural areas, enabling digitization to be implemented effectively without creating cultural barriers.

However, transparency alone is not enough without improving the capacity of village officials and oversight institutions. Village officials often face obstacles in carrying out administrative and technical tasks due to limited capacity and resources. To overcome this, regular training is needed for village officials in governance, project management, and evaluation and monitoring of development programs. This training can be conducted in collaboration with universities, NGOs, or relevant government agencies. In addition, the Village Consultative Body (BPD) as a supervisory institution must also be strengthened so that it can optimally perform its functions, without creating tension with the village government. With this capacity building, villages will be better able to carry out professional and accountable governance.

In addition, a responsive complaints mechanism is also needed so that the community can directly provide input or submit complaints related to village policies. To improve accountability in village governance, a complaint mechanism that is easily accessible and can be followed up immediately is required. Effective communication channels, such as suggestion boxes at the village hall, weekly citizen forums, or village WhatsApp groups, can be a suitable solution for rural communities. These mechanisms ensure that residents have a means to submit complaints or suggestions related to village programs, so that the village government can respond and make improvements in real-time. This approach also reflects the principles of transparency and openness in village governance, while strengthening the relationship between the government and the community.

Furthermore, to ensure the effectiveness of village policies and programs, village officials who perform well should be rewarded, while those who perform less optimally should receive further evaluation and mentoring. Providing merit-based incentives, such as additional bonuses or public recognition in village events, can motivate village officials to perform better. In addition, the community also needs to be given access to information related to village government performance so that they can participate in assessing the effectiveness of the policies implemented. With this incentive system, the quality of village government services can improve and be more in line with community expectations.

In addition to the internal aspects of village governance, the sustainability of village development also depends on more diverse funding sources. The village's dependence on funds from the central government is often an obstacle to sustainable village development. Therefore, villages need to develop partnerships with the private sector, cooperatives, and social organizations to obtain alternative funding sources.

This cooperation pattern can be adapted by considering local norms and traditions, for example through Village-owned Enterprises (*BUMDes*) or cooperation with religious social institutions that have great influence in the community.

With more diverse funding sources, villages can be more flexible in implementing development programs that suit the needs of the community.

Finally, for village development to be more effective and sustainable, community empowerment programs must be based on local potential and wisdom.

Village development programs must be structured by considering local potential in order to provide sustainable benefits to the community.

This approach can be done by developing businesses based on agriculture, fisheries, and creative industries typical of the village that are in accordance with the traditions of the local community. In addition, traditional and religious leaders can be involved in policy

socialization to ensure wider acceptance by the community.

By tailoring empowerment programs to the values and customs of village communities, development can be more effective, while maintaining local identity and culture.

CONCLUSIONS

This research aims to analyze the effectiveness of Village Autonomy policy by using Soft System Methodology (SSM). Furthermore, this paper is also intended to address the following research questions:

(1) What are the dynamics influencing the implementation of village autonomy in Indonesia, particularly regarding the challenges encountered by rural key stakeholders?

(2) In what ways do the current practices of village autonomy implementation in Indonesia diverge from the ideal conceptual frameworks established, and what specific gaps can be identified?

(3) What changes are both desirable and feasible to enhance the effectiveness of village autonomy implementation in Indonesia, and how might these changes be operationalized?

For the first research question, it was found that the main dynamics and challenges in village autonomy include governance complexity, elite dominance in decision-making, limited community participation, and transparency issues.

Although village autonomy aims to empower local governance, its implementation still faces obstacles in bureaucracy, unequal distribution of resources, and weak institutional capacity.

Answering the second research question, there is a gap between the ideal conceptual model and the practice in the field. In the planning aspect, participatory mechanisms have not been effective, while in implementation, there are many bureaucratic obstacles and inefficiencies in resource management. In addition, monitoring and accountability mechanisms remain underdeveloped, with minimal public oversight and weak enforcement of village governance standards. These gaps suggest that while the regulations and structures for village autonomy are in place, their implementation on the ground still requires improvements in coordination, oversight, and community engagement.

For the last research question, several systematically desirable and culturally feasible changes are recommended to improve the effectiveness of village autonomy. These changes include strengthening participatory governance through more inclusive planning, increasing financial transparency through digital reporting, and building the capacity of village officials through structured training. In addition, there is a need to establish responsive feedback mechanisms, incentivize good governance practices, and diversify funding sources through partnerships with external parties.

By ensuring that these recommendations are systematically desired and culturally applicable, village autonomy in Indonesia can be optimized to achieve more transparent, efficient, and community participation-based governance.

REFERENCES

[1]Agrawal, A., Gupta, K., 2005, Decentralization and participation: The governance of common pool resources in Nepal's Terai. World Development, 33(7), 1101-1114. https://doi.org/10.1016/j.worlddev.2005.04.009

[2]Akhyar, D., Hendriyani, H., Hardjosoekarto, S., 2023, Crisis communication in non-tectonic tsunami disaster management policy in Indonesia: the application of soft systems methodology based multi-method. Jurnal Komunikasi Indonesia, 12(1), 2.

[3]Arifin, B., Wicaksono, E., Tenrini, R. H., Wardhana, I. W., Setiawan, H., Damayanty, S. A., Solikin, A., Suhendra, M., Saputra, A. H., Ariutama, G. A., Djunedi, P., Rahman, A. B., Handoko, R., 2020, Village Fund, Village-Owned-Enterprises, And Employment: Evidence from Indonesia, Journal of Rural Studies. Vol. 79, pp 382-394. https://doi.org/10.1016/j.jrurstud.2020.08.052.

[4]Bell, S., Berg, T., Morse, S., 2016, Rich pictures: Sustainable development and stakeholders–The benefits of content analysis. Sustainable Development, 24 (2), 136-148.

[5]Berki, B., Málovics, G., Tóth, J., Creţan, R., 2020, The Role of Social Capital and Interpersonal Relations in the Alleviation of Extreme Poverty and Spatial Segregation of Romani People in Szeged. Jura - Juristische Ausbildung, 9, 33.

[6]Boonperm, J., Haughton, J., Khandker, S. R., 2013, Does the Village Fund matter in Thailand? Evaluating

the impact on incomes and spending. Journal of Asian Economics, 25, 3-16.
[7]Bukhari, M., 2019, Panchayati raj system of Jammu and Kashmir: Issues and challenges. Think India Journal, 22(10), 4622-4634.
[8]Checkland, P., 1985, From optimizing to learning: A development of systems thinking for the 1990s. The Journal of the Operational Research Society, 36 (9), 757-767.
[9]Checkland, P., 2000, Soft systems methodology: A thirty year retrospective. Systems Research and Behavioral Science, 17 (1), 11-58. https://doi.org/10.1002/1099-1743(200011)17:1+<::aid-sres374>3.0.co;2-o
[10]Checkland, P., Poulter, J., 2006, Learning for Action: A Short Definitive Account of Soft Systems Methodology and Its Use for Practitioners . John Wiley & Sons Ltd.
[11]Chromý, P., Jančák, V., Marada, M., Havlíček, T., 2011, Venkov – žitýprostor: regionální diferenciace percepce venkova představiteli venkovskýchobcí v Česku (Countryside-living space: regional differentiation of the perception of the countryside by representatives of rural communities in the Czech Republic), In Czech. Geografie, 116 (1), 23–45.
[12]Das, M., 2022, Panchayati Raj Institutions in India. Galore International Journal of Applied Sciences and Humanities, 6(2), 6-14.
[13]Denpaiboon, C., Amatasawatdee, C., 2012, Similarity and difference of one village one product (OVOP) for rural development strategy in Japan and Thailand. Japanese Studies Journal Special Issue: Regional Cooperation for Sustainable Future in Asia (Thammasat, 2012).
[14]Dongier, P., Van Domelen, J., Ostrom, E., Ryan, A., Wakeman, W., Bebbington, A., ... & Polski, M., 2003, Community driven development. World Bank Poverty Reduction Strategy Paper, 1, 303-327.
[15]Drobnjaković, M., 2024, Introduction of the approach for reviving the sub-municipal level as a spatial aspect of decentralization in Serbia. Land, 13(6), 752. https://doi.org/10.3390/land13060752
[16]Elvy, J., 2019, Towards socially inclusive sustainable mobility: the role of social capital in participatory transport planning processes.
[17]Falleti, T. G., 2004, A sequential theory of decentralization and its effects on the intergovernmental balance of power: Latin American cases in comparative perspective. Cambridge University Press.
[18]Fernando, N.A., 2008, Rural development outcomes and drivers: an overview and some lesson. Asian Development Bank, Philippines.
[19]Floranza, J. M., 2021, Barangay Governance in Northeast of Catanduanes, Philippines: Basis for Catanduanes State University Panganiban Campus Extension Program. European Journal of Social Impact and Circular Economy, 2(1), 100-123.
[20]Flores, R. R., 2019 (November), Assessment of Selected Barangays in Makati City Towards Improved Barangay Governance. In Iapa Proceedings Conference, pp. 141-167.
[21]Giddens, A., 1995, The Constitution of Society: The Outline of the Theory of Structuration, Cambridge: Polity Press.
[22]Goel, R. K., Mazhar, U., Nelson, M. A., Ram, R., 2017, Different forms of decentralization and their impact on government performance: Micro-level evidence from 113 countries. Economic Modelling, 62, 171-183.
[23]Goldsmith, M., 1995, Autonomy and City Limits. In Theories of Urban Politics, edited by David Judge, Gerry Stoker, and Harold Wolman, 228–52. SAGE.
[24]Granovetter, M. S., 1973, The Strength of Weak Ties. American Journal of Sociology, 78(6), 1360-1380.
[25]Hardjosoekarto, S., 2012, Construction of social development index as a theoretical research practice in action research by using soft systems methodology. Systemic Practice and Action Research, 25 (6), 493-509. https://doi.org/10.1007/s11213-012-9237-9
[26]Hardjosoekarto, S., Yovani, N., Santiar, L., 2013, Institutional strengthening for the role of mass media in disaster risk reduction in Japan and Indonesia: An application of SSM-based action research. Systemic Practice and Action Research, 27 (3), 227-246. https://doi.org/10.1007/s11213-013-9282-z
[27]Hartojo, N., Ikhsan, M., Dartanto, T., Sumarto, S., 2022, A Growing Light in the Lagging Region in Indonesia: The Impact of Village Fund on Rural Economic Growth. Economies 10: 217.https://doi.org/10.3390/economies10090217
[28]Ho, E.L., 2022, Social geography II: Space and Sociality. Progress in Human Geography, 46, 1252 - 1260.
[29]Hussein, F. H., Wanyoike, D., 2015, Challenges in service delivery within the procurement function of county governments in Kenya: A case of Nakuru Sub-County, Kenya. International Journal of Research in Business Management, 3(11), 1-14.
[30]Hwang, J., Park, J., Lee, S., 2018, The impact of the comprehensive rural village development program on rural sustainability in Korea. Sustainability, 10(7), 2436.
[31]Indartuti, E., Handoko, I. V. R., Wirawan, I. B., Nasution, U. C., 2020, Evaluation of Village Autonomy in Indonesia (An Analysis Study of Village Autonomy in Pekarungan Village, Sukodono Sub-District, Sidoarjo District). Evaluation, 10(6).
[32]Kadir, A., Idris, I., 2021, Village autonomy and participatory democracy in Indonesia: the problem of community participation in Post-Village autonomy in the Southeast Sulawesi Province. Public Policy and Administration, 20(4), 514-529.
[33]Kakumba, U., 2010, Local government citizen participation and rural development: Reflections on Uganda's decentralization system. International Review of Administrative Sciences, 76(1), 171-186. https://doi.org/10.1177/0020852309359049
[34]Khisa, M., 2020, Decentralization of public services and the role of local government in rural development: Findings from Bangladesh. Journal of Public Administration and Governance, 10(1), 249. https://doi.org/10.5296/jpag.v10i1.16612

[35]Khotimah, H., Kustono, A.S., Martiana, N., 2018, Transparency and Accountability in Management of Village Administration Revenue and Expenditure Budget (APBDES). Muhammadiyah International Journal of Economics and Business.

[36]Kotiadis, K., Tako, A. A., Rouwette, E. A. J. A., Vasilakis, C., Brennan, J., Gandhi, P., Wegstapel, H., Sagias, F., Webb, P., 2013, Using a model of the performance measures in soft systems methodology (SSM) to take action: A case study in health care. Journal of the Operational Research Society, 64 (1), 125-137. https://doi.org/10.1057/jors.2012.21

[37]Law No. 6 of 2014 concerning Villages: https://peraturan.bpk.go.id/Details/38582/uu-no-6-tahun-2014, Accessed on Friday, April 5th 2024.

[38]Mansuri, G., Rao, V., 2004, Community-based and driven Development: a Critical Review. World Bank Research Observer 19(1), pp.1–39.

[39]Martínez-Vázquez, J., Lago-Peñas, S., Sacchi, A., 2017, The impact of fiscal decentralization: A survey. Journal of Economic Surveys, 31(4), 1095-1129.

[40]Menkhoff, L., Rungruxsirivorn, O., 2011, Do village funds improve access to finance? Evidence from Thailand. World development, 39(1), 110-122.

[41]Mercer, C., Green, M., 2013, Making civil society work: Contracting, cosmopolitanism and community development in Tanzania. Geoforum, 45, 106-115.

[42]Mingers, J., White, L., 2010, A review of the recent contribution of systems thinking to operational research and management science. European Journal of Operational Research, 207 (3), 1147-1161. https://doi.org/10.1016/j.ejor.2009.12.019

[43]Mketo, A. R., Ringo, C. J., Nuhu, S., Mpambije, C. J., 2022, Enhancing community participation for environmental health improvement in rural Tanzania: Evidence from Bukombe district. Evaluation and Program Planning, 94, 102152.

[44]Mogoi, J., Obonyo, E., Ongugo, P., Oeba, V., Mwangi, E., 2012, Communities, property rights and forest decentralisation in Kenya: Early lessons from participatory forestry management. Conservation and Society, 10(2), 182-194.

[45]Muhammaditya, N., Hardjosoekarto, S., Herwantoko, O., Fany, Y. G., Subangun, M. I., 2021, Institutional divergence of digital item bank management in bureaucratic hybridization: An application of SSM based multi-method. Systemic Practice and Action Research. https://doi.org/10.1007/s11213-021-09579-4

[46]Ndraha, T., 1991, Dimensi-Dimensi Pemerintahan Desa. Jakarta: BumiAksara.

[47]Niswah, F., Tumbel, G.H., Aslinda, 2018, Village Finance System (SISKEUDES): Transparency of Village Asset Management Toward Open Government Partnership.

[48]Nye, J.,1990, Bound to Lead: The Changing Nature of American Power, New York: Basic Books.

[49]Okello, T., Mwesigwa, D., 2022, Analysing the significance of village savings and loan association (VSLA) to community development in Uganda.

[50]Onitsuka, K., Hoshino, S., 2018, Inter-community networks of rural leaders and key people: Case study on a rural revitalization program in Kyoto Prefecture, Japan. Journal of Rural Studies, 61, 123-136.

[51]Pane, E., 2019, The Reconstruction of Village Governance Towards Good Governance (Study in Kalianda District, South Lampung Regency). FIAT JUSTISIA: Jurnal Ilmu Hukum.

[52]Permatasari, Y. I., Hardjosoekarto, S., Salomo, R. V., 2019, Institutional transformation of public private partnership to ensure low transaction costs: Case study of infrastructure provision at the Ministry of Public Works and Housing of the Republic of Indonesia. Systemic Practice and Action Research, 33 (2), 149-165. https://doi.org/10.1007/s11213-019-09485-w

[53]Phahlevy, R. R., 2016, The Concept of Village Autonomy in Indonesia (Indonesian Constitution Perspective). Rechtsidee, 3 (1), 27–40.

[54]Pollack, J., 2006, Pyramids or silos: Alternative representations of the systems thinking paradigms. Systemic Practice and Action Research, 19 (4), 383-398. https://doi.org/10.1007/s11213-006-9025-5

[55]Pratchett, L., 2004, Local Autonomy, Local Democracy and the 'New Localism. Political Studies 52 (2): 358–75. https://doi.org/10.1111/j.1467-9248.2004.00484.x.

[56]Pratolo, S., Atmaja, N. R. S., Sofyani, H., 2020, What Determines Village Autonomy in Indonesia? A Case of Villages in Sleman Regency. Jurnal Dinamika Akuntansi dan Bisnis, 7(1), 15-32.

[57]Regulation of the Minister of Villages, Development of Disadvantaged Regions and Transmigration No.2, 2016, concerning Village Development Index: https://peraturan.bpk.go.id/Download/142786/Permendesa%20Nomor%202%20Tahun%202016.pdf, Accessed on Friday, April 5th 2024.

[58]Rodríguez-Pose, A., Ezcurra, R., 2009, Does decentralization matter for regional disparities? A cross-country analysis. Journal of Economic Geography, 10(5), 619-644. https://doi.org/10.1093/jeg/lbp049

[59]Rondinelli, D.A., Cheema, G.S., 1983, Implementing decentralization policy: an introduction. In: Cheema, G.S., Rondinelli, D.A. (eds) Decentralization and development: policy implementation in developing countries. Sage Publication Inc, Beverly Hills, pp. 9–34.

[60]Salim, A., Bulan, W.R., Untung, B., Laksono, I., Brock, K., 2017, Indonesia's village law: enabler or constraint for more accountable governance? Brighton: IDS.

[61]Saragi, T. P., 2004, Mewujudkanotonomimasyarakatdesa: alternatifpemberdayaandesa (Diterbitkanataskerjasama Yayasan Adikarya IKAPI dengan Ford Foundation)

[62]Shen, C., Zhao, X., Zou, H. F., 2014, Fiscal decentralization and public services provision in China. Annals of Economics and Finance, 15(1), 135-160.

[63]Silubun, A. J., Kalalo, J. J. J., Inggit, A. B., Kalalo, C. N., Rahail, E. B., 2020, (March), Village authority

and position in realizing village autonomy. In IOP Conference Series: Earth and Environmental Science, Vol. 473(1), p. 012032). IOP Publishing.
[64]Singh, D., Lample, M., Jones, M., Earnest, J., 2014, Capacity building and community development: A community dialogue on equality in rural Uganda. M² Models and Methodologies for Community Engagement, 41-52.
[65]Sokolova, A., 2023, Features and prospects of the development of social sphere of the village under conditions of decentralization: Regional aspects. Journal of Innovations and Sustainability, 7(1), 04. https://doi.org/10.51599/is.2023.07.01.04
[66]Somanje, A., Mohan, G., Lopes, J., Mensah, A., Gordon, C., Zhou, X., ... & Takeuchi, K., 2020, Challenges and potential solutions for sustainable urban-rural linkages in a Ghanaian context. Sustainability, 12(2), 507. https://doi.org/10.3390/su12020507
[67]Song, H., Cheong, H. Y., Jun, B., Lee, M. H., 2018, The process of building community resilience in residential regeneration activities in Jangsu Village, Seoul, Korea. Journal of Asian Architecture and Building Engineering, 17(3), 457-464.
[68]Sutiyo, S., Maharjan, K. L., 2017, Decentralization and rural development in Indonesia. Springer.
[69]Sutoro, E., Titik, I.K., Dyah, W., Suci, H., Ninik, H., Puji, Q., Sahrul, A., Harto, W., Suharyanto, and Borni, K., 2014, Desa Membangun Indonesia. Cetakan Pertama. Yogyakarta: Forum Pengembangan Pembaharuan Desa (FPPD).
[70]Wang, R., Eisenack, K., Tan, R., 2019, Sustainable rural renewal in China: Archetypical patterns. Ecology and Society, 24(3). https://doi.org/10.5751/es-11069-240332
[71]Wei, M., Zhou, C., 2022, Spatial Relationship between Environmental Justice and Tier II Facilities in Massachusetts. Academic Journal of Environment & Earth Science.
[72]Widjaja, H.A.W., 2003, Otonomi Desa Merupakan Otononi yang Asli, Bulat, dan Utuh. Jakarta: Raja Grafindo Persada.
[73]Wong, S., Guggenheim, S., 2018, Community-driven development: myths and realities. World Bank Policy Research Working Paper, (8435).
[74]Zhong, Y., 2015, Local government and politics in China: Challenges from below. Routledge.
[75]Zhou, J., Fan, Y., 2023, Impact of Chinese-style fiscal decentralization on urban–rural integration: Based on factor allocation. Sustainability, 15(2), 1542. https://doi.org/10.3390/su15021542
[76]Zuliyah, S., 2020, Policy To Develop Independent Village Government in Regional Autonomy Design in Indonesia. Pal Arch's Journal of Archaeology of Egypt/Egyptology, 17(7), 16360-16371.

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ROMANIA`S COMMON OBJECTIVES FOR A SUSTAINABLE FUTURE WITHIN THE 2030 AGENDA. GREEN TRANSITION TO A CIRCULAR ECONOMY

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Abstract

The paper aims to present the actual framework, legislation and steps that should be taken by each country to mitigate climate change and its impacts in order to build a sustainable future. It also focuses on Romania and the way in which the objectives proposed by the European Union are being met. The basis for this paper is the information gathered over the years during the events organized by The Ecological Initiative and Sustainable Development Group, which is deeply involved and gives its contribution to the realization of the concept of sustainable development and environmental protection in Romania. "The Ecological Initiatives and Sustainable Development Group" Foundation has set up the first national and international forums on sustainable development, sustainability and environmental protection. We have set up a tool called responsible citizenship after hundreds of meetings in the Forum for Sustainable Development and Environmental Protection, bringing together leading figures in sustainable development and environmental protection from around the world. All these meetings led to raising awareness, rebirth of the civil spirit, information, creating working groups in order to contribute for fulfilling the Green Deal Agenda.

Key words**:** *climate changes, sustainable development, policies, European Union*

INTRODUCTION

The concept of sustainable development has been defined over the decades in various international scientific debates and has taken on precise political implications in the context of globalization.

In recent history, the first signal that the economic and social developments of the world's countries and of humanity can no longer be separated from the consequences of human activity on the natural environment was given in the 1972 Club of Rome report entitled The Limits to Growth (Meadows Report). It summarized data on the evolution of five parameters: population growth, the impact of industrialization, the effects of pollution, food production and trends in the depletion of natural resources

As part of this process of shaping sustainability, a number of international conventions have been adopted which establish precise obligations on the part of states and strict deadlines for implementation on climate change, biodiversity conservation, protection of forests and wetlands, limiting the use of certain chemicals, access to information on the state of the environment and others, which outline an international legal space for the practical application of the precepts of sustainable development.

Literature review

According to Chiritescu et al., (2013) [4] the concept of eco-economic development is the premise that human civilization is a subsystem of the ecosphere, dependent on material and energy flows within its stability and capacity for self-adjustment and is completed by Berca, M. (2020) [1] saying that life forms of the different segments of life are almost identical, although they are found in systems and subsystems of distant life, distant from an evolutionary point of view.

The green economy improves the human and social welfare, while significantly reducing environmental risks and ecological deficit mentioned R. Blaj (2013) [2] in his paper.

The concept of circular economy is not limited to the European area but rather has a global outlook given its importance. As described by the United Nations Organisation the key idea behind was “the goods of today are the

resources of tomorrow at yesterday's resource prices" Chereji et al., (2024) [3].

The development of the economy has continuously increased the demand for raw materials, while reducing the available quantities of natural resources.

The sustainable development involves the monitoring of the implementation of the environmental measures as affirmed Turtoi et al., 2014) [33].

Bioeconomy is another important aspect of a sustainable development as discussed at the International Conference in Lithuania in 2024 [35].

In addition, the impact on climate and the environment is significant, as excessive energy consumption directly affects the increase in CO_2 emissions mentions Devcic, A., 2022 [7].

The European Commission (2019) [11] defined The European Green Deal as a response to these challenges. It is a new growth strategy that aims to transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use

The European Green Deal was first presented in December 2019 as the EU's pledge to become the first climate neutral continent by 2050 and comes with an action plan to promote a cleaner environment, more affordable clean energy, smarter transport, a circular economy and new jobs in greener industries (United Nations, 2022) [34].

Global consumption of materials such as biomass, fossil fuels, metals and minerals is expected to double in the next forty years, while annual waste generation is projected to increase by 70% by 2050. This Circular Economy Action Plan provides a future-oriented agenda for achieving a cleaner and more competitive Europe in co-creation with economic actors, consumers, citizens and civil society organisations. It aims at accelerating the transformational change required by the European Green Deal, while building on circular economy. European Commission (2020) [10, 5].

Various financial tools, including taxes or incentives, can serve the purpose of internalizing external costs based on taxation of pollution or waste resulting from the manufacture and consumption of a given product as affirmed Platon et al. (2024) [22].

Recycling old equipment is a key strategy in mitigating climate change, as it reduces both direct emissions from improper waste disposal and indirect emissions from the resource extraction and manufacturing processes. Social Innovation Solutions, 2023 [28].

The European Union's taxation initiative to ensure the carbon price on imports is equivalent to the carbon price paid for domestic production (Deloitte Romania (2023) [6].

A policy of sustainable recovery is defined by its dual potential to create activities or opportunities for income, jobs and growth and, at the same time, to accelerate the process of achieving medium- and long-term environmental objectives, both at national and global level as mentioned Frone and Frone (2022) [15].

In view of a greener and circular economy, the general trend in European Union is to improve and enhance all activities related to waste management, starting with the quantities of waste generated and ending with the disposal of the waste (Frone et al. 2020) [14].

As a feature form of the green economy, circular economy proposes the re-use of resources used in products whose shelf life has come to an end or which have lost their usefulness, to construct new objects, the same quality or even better.

For the green and circular economy, eco-innovation is based on centralizing knowledge on material and energy flows as an efficient tool to foster a transition from a linear industrial system to a closed-loop system mimicking biological ecosystems (Frone and Frone, 2017; Sirbu C., 2023) [13, 27].

Between circular economy and food production systems is a close relationship tracing linkages and exploring synergies for assuring food security through agrif-food supply chains [16, 17].

As the literature reveals, the concept of circular economy is not a new one. Concerns regarding the transition to renewable energy and the fundamental change of the economic system

began to appear as early as the 1970's when the idea of a model based on the transformation of waste resulting from all activities from production to consumption (and even after this point) into inputs, began to take shape (Nicolau et al., 2024; Mihai and Ulman, 2023; Tarhini et al., 2022) [21, 18, 29].

The circular economy is a complex concept with economic, environmental, and social implications and a tool for the sustainable development in all the areas (Platon et al, 2024) [22, 8].

Romania's green economy transition needs to focus on sustainable energy. The country has signed up to the Paris Agreement and targets a 40 per cent reduction in greenhouse gas (GHG) emissions by 2030.

Romania was the first EU country to achieve the bloc's target of a 20 per cent renewables share ahead of the 2020 deadline, but investment in renewable energy has stalled in recent years due to a lack of commitment. Buildings account for the largest share of Romania's final energy consumption. The quality of its building stock falls well below the standards of EU regulation and a lot of retrofitting is required.

While the prevalence of coal has been decreasing slowly (some of it replaced by gas), it remains important. The coal industry is a significant employer, but Romania will need to decommission 100 per cent of its coal infrastructure by 2030 to meet its climate change targets. Promoting e-mobility in public transport policy is also essential. (European Bank for Reconstruction and Development, 2022) [9].

As mention by Sîrbu, C. (2016) [26] To ensure the sustainable development, it is necessary to focus on a limited number of core priorities relating to knowledge transfer and innovation, forestry and rural areas, to farm viability, to the competitiveness and promoting innovative technologies and the sustainable management, to the organization of the food chain, including the processing and marketing, to risk management, restoring, preserving and enhancing, to the promotion of resource efficiency and the shift towards a low carbon economy, and to promoting social inclusion, poverty reduction.

According to The Romanian Government, Ministry of Environment and Sustainable Development 2008 [23], for the last ten years, Romania set its goals based on the performance of the global economy and in line with EU policy. Today, both Romania and the EU need to rethink their medium and long-term priorities. Achieving the goals of the 2030 Agenda for Sustainable Development represents a guaranteed way to create a better future for the next generations.

A long-term and sustainable cooperation framework needs to be enabled which promotes decentralised but also coordinated work. A demand for professional exchange to develop ideas and to collaborate in concrete projects is clearly visible (Sîrbu, C., 2013) [25].

In this context, the purpose of the paper is to present the actual framework, legislation and steps that should be taken to mitigate climate change and its impacts in order to build a sustainable future. The focus is on Romania especially regarding the way in which the objectives proposed by the European Union are fulfilled.

MATERIALS AND METHODS

In order to provide the information in this paper, the meeting organized starting with 2005 was the main source. In the development of the paper we used the information in the official documents issued by the European Commission, European Union, European Bank for Reconstruction and Development.

Romania's green economy transition needs to focus on sustainable energy, so through our activity we have focused on developing sustainable development in Romania.

the studied literature tried to reflect how to bring the whole society as much as possible in touch with the current reality, the act of awareness of reality being a first step towards sustainable development.

The data was collected in the period of 2019-2024 and they have been logically structured and critically approached and finally summarized and interpreted in order to estimate an image on the sustainable future for all generations.

RESULTS AND DISCUSSIONS

Climate change and its impact negative impact and measures to mitigate its effects

Climate change is a challenge that requires an action-based approach at international, regional, national and local level.

The 2030 Agenda together with the Paris Agreement on climate change have become the roadmap vector for all countries in the European Union and in Europe towards a world that looks forward to a circular economy.

Problems of circular economy- causes and solutions for implementation in Romania

The circular economy is the type of economy that promotes the reuse, recycling and regeneration of goods, thereby reducing landfilling or incineration of waste, a destructive practice that affects human health and the environment.

The circular economy is the answer to the apparent contradiction between sustainable development or caring for nature and economic growth, the dynamism of which is unprecedented in the history of the European Union.

The circular economy model is the opposite of the linear economy (it is based on the extract - use - discard idea which has proven to be oblivious to the problems caused by the waste of resources and the negative effects on nature and the environment

As products, raw materials are becoming increasingly difficult to acquire, prices are in line with global resources, extremely fluctuating and ever increasing.

To avoid the extractive industry today is almost impossible, although the depletion of natural resources is clearly a reality.

The advantages of the circular economy include:

-Environmental protection;

-Reduced dependence on raw materials;

-Creating new jobs and improving the economy for consumers.

If the current rate of exploitation continues, we are expected to run out of resources by 2050, hence the need to move to a fully circular economy.

Future generations will have to choose between slowing down the pace of research development and the scarcity of natural resources.

Today, according to the data in the reports presented, Romania is still a country with natural resources (e.g. crude oil, coal deposits, tungsten, nickel, silicon, gold, silver, titanium, etc.).

Fig.1. The circular economy model
Source: Adapted after the European Parliament [12].

Financial support from the EU and Romania's Government for implementing circular economy in the country

Measures, such as financial support of each country under the climate change plan, should emphasize water conservation, crop rotation, public planning, public awareness, raising the height of dykes, increasing renewable energy, forest conservation, associated with the negative effects of climate change.

Today we have clear evidence that every country has received its climate finance contribution under the Paris Agreement. In the countless conferences which were running in many of the countries of the world, it was emphasized that the directive on renewable energy by 2030 seems to be the most ambitious with reversible results.

Contribution to Green Deal Agenda in Romania

The Foundation "The Ecological Initiative and Sustainable Development Group" of public utility under the high patronage of the General Secretariat of the Government, was established on 30 August 2005.

The aim of the "Ecological Initiative and Sustainable Development Group" Foundation is to contribute to the concept of sustainable development and environmental protection in Romania.

For this purpose, the "National Forum for Sustainable Development and Environmental Protection" was created, which had the possibility to provide an institutional framework for responsible debates on Romania's development issues before and after EU accession.

The "National Forum for Sustainable Development and Environmental Protection" has provided, during its 20 years, the motivations and tools for the rebirth of a responsible civil spirit capable of bringing together public and private institutions in the elaboration and active support for the creation of national and international programs for development, environmental protection and climate change.

Over 300 events, meetings organized over these years have built the basis for consultations at national and international level with broad participation of civil society structures and organizations, business representatives, organizations, academic and university scientific research, media representatives and last but not least with the state organizational structures responsible for carrying out activities of sustainable development and environmental protection.

On 17 May 2010, the EISDG Foundation had as its guest of honor Mr. Lester Brown, President and Founder of the World Watch Institute and the Earth Policy Institute, two global, non-profit, service-based research organizations on climate change and projects to restore natural terrestrial and marine ecosystems destroyed by massive over-industrialization and enthronization.

Lester Brown was the first person in the world to advocate the introduction of the concept of the eco-economy in 2001, according to the book "Eco-Economy: Building a future for the Earth".

In 2010, it was the first official visit to Romania, on the occasion of the 17 May forum and the first World Watch Institute and Earth Policy conference organised in a Central and South-Eastern European country. Thus, the EISDG Foundation has signed a partnership with the prestigious World Watch Institute and Earth Policy, succeeding for over 18 years to translate numerous books by Lester Brown.

In 2019, September 26, we left the forum "Towards a Sustainable Europe by 2030" [30, 31]. The 2030 Agenda for Sustainable Development and the 17 SDGs. NATO factor of geostrategic stability 2019-2030", in Bucharest, and in the week of 23-30 September 2019 at the UN during the General Debates of the 74th session of the UN General Assembly held in New York, Romania supported the acceleration of the implementation of the 2030 Agenda for Sustainable Development, as well as the regional role assumed by organizing events to promote regional partnerships, using the expertise to increase the effectiveness, accountability and participatory nature in achieving progress on the 2030 Agenda.

The Forum continued to present the 2030 Agenda for Sustainable Development and the 17 SDGs in all 8 regions of Romania. The second forum was held in Cluj-Napoca at the House of Culture of Students, on November 14, 2019 with the participation of all socio-economic actors, local bodies, guests from the Romanian Government and the Romanian Presidency.

The Forum "Towards a sustainable Europe by 2030; 2030 Agenda for Sustainable Development and the 17 SDGs; NATO Geostrategic Stability Factors 2019-2030." continued in 2020 in Craiova on January 11-12, in the electric scooter factory in Craiova, the only electric transport factory in Romania, built on the Sectoral Operational Program "Increasing Economic Competitiveness" in the financial year 2007 -2013.

The "Ecological Initiative and Sustainable Development Group" Foundation has supported the continuation of this series of forums, so on 21.12.2021, it organized an

online debate, the forum "Towards a Sustainable Europe by 2030", focusing on the most important event of the year, the UN Climate Change Conference (COP26)[31].

Based on the above affirmations, the scientific contributions of the Earth Policy Institute and the World Watch Institute, as well as part of the actions undertaken by civil society, of which the GIEDD Foundation is a part, have contributed to the foundation of the Green Deal policies and the 2020 - 2030 Agenda.

As a part of the Green Deal Agenda Goals, in June 2022 The "Ecological Initiative and Sustainable Development Group" organized the Forum dedicated to The World Food Safety Day with the theme: "Safer Food-Better Health".

On April 15th 2023 it was organized the Forum dedicated to World Earth Day "Invest In Our Planet!" and on 13 of October, The Forum dedicated to the International Day for Disaster Risk Reduction, events that were also organized in 2024, respecting the theme each year provides.

The actions of the Foundation has been always sustained by The Romanian Academy, the Academy of Agricultural and Forestry Sciences, The University of Agronomic Sciences and Veterinary Medicine of Bucharest and The National Institute for Earth Physics, which soon became partners in the events.

Important contributions have had various research and development institutes such as:

-National Institute for Research - Development in Informatics - ICI Bucharest, on the occasion of Digital Innovation Summit Bucharest (DISB), 16-18 April 2024 [19];

-Also, National Research and Development Institute for Animal Biology and Nutrition Balotesti, at the launching of the project: Climate Smart Advisors, Connecting and Mobilizing the EU Agricultural Advisory Community to Support the Transition to Climate Smart Farming, which was held on 29th March 2024 [20].

The Ministry of Research, Innovation and Digitisation played an important role in 2023 in the international event on "Danube and Black Sea Lighthouse" as part of the EU Mission "Restore our Ocean and Waters by 2030" under the Horizon Europe programme [32].

Let's not forget about the contribution of the governmental institutions, civil society together with small and medium enterprises, municipalities and county councils, as well as partnerships with some institutions of the European Union.

The debates aim to disseminate information on the UN reports of the 2030 Agenda, but also on the Climate Change Agenda.

Romania, as a member country of the European Union, but also as a member country of the United Nations Organization, is joining the two major bodies in the effort to build a safer and better world for all.

Of course, Romania supports efficient multilateralism and a rules-based international order in which the UN plays a central role. The European Union is also the successful integrator in terms of negotiating the sustainable development goals (it is a useful tool to project the values and objectives of the European Union globally, providing a useful common framework for international partnerships.

In 2019, Romania participated in the 75th UN General Assembly Conference where commitments were signed on achieving the Sustainable Development Goals -SDGs by 2030.

Sustainable Development Goals for Romania by 2030

Year after year, the "Ecological and Sustainable Development Initiative Group" Foundation advocates for better environmental protection and the fight against climate change.

In almost 20 years of activity, it carried out reforestation campaigns, forums for sustainable development with partners such as civil society, academia, the Romanian Government, the European Union, World Watch Institute, Earth Policy.

"The Ecological and Sustainable Development Initiative Group" Foundation was the first to present at the National Institute for Economic Research "I.C. Kirițescu", on the same day as the UN Forum, the commitments presented by Romania on meeting the conditions for sustainable development by 2030.

The 2030 Agenda for Sustainable Development has set 17 goals (SDGs - Sustainable Development Goals) [34].

The 17 Sustainable Development Goals (SDGs) of the 2030 Agenda have been accepted by all countries present at the UN. These objectives are related to:

(1)No Poverty - Eradicate poverty in all its forms and in all contexts;

(2)Zero Hunger - Eradicate hunger, ensure food security, improve nutrition and promote sustainable agriculture.

(3)Health and well-being - Ensuring healthy lives and promoting well-being for all at all ages.

(4)Quality education - Ensuring quality education and promoting lifelong learning opportunities for all.

(5)Gender Equality - Achieving gender equality and empowering all women everywhere;

(6)Clean water and sanitation- Ensure availability and sustainable management of water and sanitation for all;

(7)Affordable and clean energy - Ensuring access to affordable energy for all in a secure, sustainable and modern way;

(8)Decent work and growth - Promoting sustained, inclusive and sustainable economic growth;

(9)Industry, innovation and infrastructure - Building resilient infrastructure, promoting sustainable industrialization and encouraging innovation;

(10)Reduced inequalities - Reducing inequalities within and between countries;

(11)Sustainable cities and communities - Develop cities and human settlements to be inclusive, safe, resilient and sustainable.

(12)Responsible consumption and production - Ensuring sustainable consumption and production patterns;

(13)Climate action - Take urgent action to combat climate change and its impacts;

(14)Aquatic life - Conservation and sustainable use of oceans, seas and marine resources for sustainable development;

(15)Terrestrial life - Protecting, restoring and promoting the sustainable use of terrestrial ecosystems, managing forests sustainably, combating desertification, halting and repairing land degradation and halting biodiversity loss;

(16)Peace, justice and effective institutions - Promote peaceful and inclusive societies for sustainable development, access to justice for all and effective, accountable and inclusive institutions at all levels;

(17)Partnerships to achieve the goals - Strengthening the means of implementation and revitalizing the global partnership for sustainable development.

The 17 goals are commitments and actions to eradicate poverty, fight inequality and injustice and protect the planet by 2030.

Each member state is required to adopt its own National Renewable Energy Action Plan including sectoral targets.

Romania is undergoing an energy transformation, shifting from fossil fuel dependence to renewable energy sources. This transition is essential to achieve the goals of combating climate change and creating a more sustainable economy.

Romania aims to reach climate neutrality faster, aiming to reduce net greenhouse gas emissions by 85% by 2030 compared to 1990 levels and to reach climate neutrality by 2045, thus beating the previous deadline of 2050.

Romania has also increased its target for renewable energy in gross final consumption from 36.2% to 38.3% in 2030 (Romanian Government, Ministry of Energy, 2024) [24].

Romania's transition to renewable energy sources is well underway and the progress made so far is promising.

By investing in renewable technologies and promoting appropriate policies, Romania is moving towards a more sustainable and environmentally friendly energy system. It is essential that all stakeholders continue efforts to accelerate the transition and achieve a green and sustainable energy society.

The objectives and targets of the Agenda spell out the means to achieve the collective ambitions.

CONCLUSIONS

Most importantly, all world leaders have defined their commitment to poverty eradication.

Protecting the planet and ensuring that all people can enjoy peace and prosperity should become the norm.

It is international cooperation on sustainable development and the economic, social, environmental, governmental dimensions that have marked the roadmap towards a real world based on facts.

In 2024, the European Union appreciated Romania's involvement in achieving sustainable development objectives, as well as our country's cooperation with all partner countries (but also with the organizations interested in the success of this concept).

The United Nations High-Level Political Forum on Sustainable Development closely follows each country's engagement and dissemination of good practices, which are binding over time to achieve real results.

On June 5-6, 2024, the need for policy coherence for sustainable development and policies that integrate social, economic and environmental dimensions were presented in Brussels at the annual conference of the European Sustainable Development Network. The theme of the conference was one that calls for cooperation and alignment of all Member States, namely: "Modernizing Europe: developing transformative policies to achieve the Sustainable Development Goals".

The 2030 targets include bringing Romania closer to the average level of sustainable development indicators of EU member countries.

Achieving the objectives will ensure economic growth in our country and a reduction in the gap between Romania and EU member states.

Of course, peace is clearly desired. The European Commission is committed to meeting the Sustainable Development Goals for 2030 and putting the Green Pact at the heart of its recovery efforts.

With only 5 years left (until 2030) to implement the 2030 Agenda coherently, we are still a long way off, not only as a country, but also the 194 other countries globally that strongly believe that action must be taken to address the challenges of the beginning of the third millennium.

Natural disasters, climate change, wars, poverty, gender inequality, an ageing workforce and declining working capacity are really pressing issues of the 2030 Agenda.

A number of documents such as the EU Commission's Reflection Paper Towards a sustainable Europe by 2030, the EUROSTAT Monitoring Report on progress towards the Sustainable Development Goals in the EU context, the Joint Synthesis Report on supporting the Sustainable Development Goals, etc.

All these are documents and objectives in which Romania actively participates and has added value through the seriousness with which it has fulfilled the obligations of each member country of the European Union and the United Nations Organization.

Our future, Europe's and the world's, depends on a healthy planet.

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Year after year, the Foundation "Group for Ecological Initiative and Sustainable Development", a public utility organization under the auspices of the Ministry of Environment, has organized campaigns for better environmental protection and the fight against climate change.

In 20 years of activity, it carried out reforestation campaigns, forums for sustainable development with partners from civil society, academia, the Romanian Government, the European Union, World Watch Institute, Earth Policy.

The study is a sum of information collected in the many years of activity, in the events organized and events attended.

REFERENCES

[1]Berca, M., 2020, Management of the green world by photosynthesis modeling (report of thinking and comparative synthesis). Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 20(1), 89-94.

[2]Blaj R. 2013, Green economy - The economy of the future. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 13(4), 63-68.

[3]Chereji, A.I., Chiurciu, I.A., Sebe, M., 2024, Agricultural and rural development in the context of a circular economy in the European Union and francophonie states. Case study: Romania. Scientific

Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 24(2), 259-266.
[4]Chiritescu, V., Gogonea, M. R., Andrei, R. D., Kruzslicika, M., Gavrila, V.. 2013, Sustainable development through eco-economic development. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 13(4), 73-76.
[5]Croitoru, I.M., Grigoras, M.A., Popescu, A., Grigoras, B.A., 2024, Embracing the circular economy: a paradigm shift for sustainable prosperity . Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 24(2), 397-406.
[6]Deloitte Romania, 2023, Webinar: CBAM reporting and charging - what does it mean and how does it apply?
[7]Devcic, A., 2022, Economic management of rural areas: on the way from linear to circular economy. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 22(2), 257-262.
[8]Dobrota, E.M., Saracu, A.F., 2022, Public food procurement - a tool for a sustainable economy development in rural areas . Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 22(2), 301-310.
[9]European Bank for Reconstruction and Development, EBRD in Romania, 2022, Green Economy Transition, Source: https://www.ebrd.com/content/dam/ebrd_dxp/assets/pdfs/country-strategies/romania/The-EBRD-in-Romania-Results-Snapshot.pdf, Accessed on 14.01.2025.
[10]European Commission, A new Circular Economy Action Plan Communication, March 11, 2020, https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1583933814386&uri=COM:2020:98:FIN, Accessed on 16.01.2025.
[11]European Commission, 2019, Communication From The Commission, The European Green Deal, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52019DC0640, Accessed on 04.02.2025.
[12]European Parliament, Circular economy: definition, importance and benefits, https://www.europarl.europa.eu/topics/en/article/20151201STO05603/circular-economy-definition-importance-and-benefits , Accessed on 20.02.2025.
[13]Frone, D.F., Frone, S., 2017, Circular economy in Romania: an industrial synergy in the agri-food sector. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 17(2), 103-110.
[14]Frone, D.F., Frone, S., Platon, V., Constantinescu, A., 2020, Green economy prerequisites of waste management. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 20(4), 211-218.
[15]Frone, D.F, Frone, S., 2022, Green policies to increase climate resilience and water security for rural development. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 22(2), 335-344.
[16]Gkountani, V.A., Tsoulfas, G.T., 2021,Circular economy and food production systems: tracing linkages and exploring synergies. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 21(2), 281-288.
[17]Gkountani, V.A., Tsoulfas, G.T., Mouzakitis, Y., 2022, Mαpping sustainability assessment methods in agri-food supply chains: A circular economy perspective. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 22(2), 361-368.
[18]Mihai, F.C., Ulman, S.-R., 2023, Sustainable and Circular Management of Resources and Waste Towards a Green Deal, Chapter 4, Circular economy in Green Deal; strategies, pp.49-63, https://doi.org/10.1016/B978-0-323-95278-1.00029-2
[19]National Institute for Research - Development in Informatics - ICI Bucharest, Digital Innovation Summit Bucharest (DISB), 16-18 April 2024.
[20]National Research and Development Institute for Animal Biology and Nutrition (INCDBNA-IBNA Balotești), The launching in Romania of the project: CLIMATE SMART ADVISORS, Connecting and Mobilizing the EU Agricultural Advisory Community to Support the Transition to Climate Smart Farming, 29th March 2024.
[21]Nicolau, A.I., Ionitescu, S., Moagar-Poladian, S., Tilea, D.M., Dinu, A.M., 2024, Challenges in implementing circular economy strategies in Romania. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 24(1), 669-684.
[22]Platon, V., Frone, S., Constnatinescu, A., Jurist, S., Banghiore, G., Moise, O., 2024, Circular economy and economic instruments in the EU and Romania, Romanian Journal of Economics/Revista Română de Economie, 59(2), 1-19.
[23]Romanian Government, Ministry of Environment and Sustainable Development, Romania's National Strategy for Sustainable Development Horizons 2013-2020-2030, Bucharest 2008, p. 10.
[24]Romanian Government, Ministry of Energy, Romania's Energy Strategy 2025-2035, with a 2050 perspective, 2024, chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://energie.gov.ro/wp-content/uploads/2025/02/Strategia-Energetica-a-Romaniei-2025-2035-cu-perspectiva-anului-2050.pdf Accessed on 04.02.2025.
[25]Sîrbu, C., 2013, Strategy for the Danube region - Present and future in Romania. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 13(3), 271-272.
[26]Sîrbu, C., 2016, Financing programs: Horizon 2020. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 16(2), 283-286.
[27]Sirbu, C., 2023, Renewable energy, an influential factor in the development of the Danube transport corridors Romania - Bulgaria and a support mechanism

in intermodal connections. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 23(2), 585-590.
[28]Social Innovation Solutions, 2023, Climate Change Summit 2023.
[29]Tarhini, M., Turcea, V.C., Zapucioiu, L.F., Ion, R.A., 2022, Food waste status and reduction through the circular economy. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 22(4), 731-742.
[30]The Ecological Initiative and Sustainable Development Group" Foundation, 2019, Forum "Towards A Sustainable Europe By 2030. 2030 Agenda For Sustainable Development"- 26th of September, Bucharest
[31]The Ecological Initiative and Sustainable Development Group" Foundation, 2021, Forum "Towards A Sustainable Europe By 2030. 2030 Agenda For Sustainable Development"- December, 21, 2021, Bucharest.
[32]The Ministry of Research, Innovation and Digitisation, 2023 "Danube and Black Sea Lighthouse" event as part of the EU Mission "Restore our Ocean and Waters by 2030" under the Horizon Europe programme.
[33]Turtoi, C., Toma, C., Gavrilescu, C., 2014, Statistical indicators for monitoring implementation of environmental measures. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 14(2), 331-334.
[34]United Nations, 2022, Agenda for Sustainable Development, Source: https://euinasean.eu/wp-content/uploads/2022/11/Blue-Book-EU-ASEAN-2022.pdf, Accessed on 04.02.2025.
[35]Vytautas Magnus University (VMU) Lithuania, Online conference "Sustainable Bioeconomy Development 2024: Theory and Practice", 8th May, 2024

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ECONOMIC WEIGTHS OF PRODUCTION AND FUNCTIONAL TRAITS AND THEIR IMPORTANCE IN SETTING UP BREEDING PROGRAMS WITH A POSITIVE IMPACT ON DAIRY SHEEP GROWING PROFITABILITY: A REVIEW

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Abstract

This article is a review of studies carried out in relation to calculation of the economic impact of various productive and functional traits in dairy sheep in connection with setting economically reasoned breeding goals in the breeding programs. Milk yield was found to be considered the main selection trait ensuring the sustainability of dairy sheep farms, subsequently complemented by quality traits such as protein and fat content, and somatic cell score (SCS). It has been also established that improving the reproductive performance of animals, fertility, survival and growth rate of lambs are also important for modern breeding programs, given that a large part of the farm income comes from lamb sales. In Bulgaria, economic values and weights for dairy sheep have been calculated only for two separate flocks of the Bulgarian dairy synthetic population and so far they have not been taken into account in the breeding programs. Calculation of economic weights of productive and functional traits for this dairy population would provide valuable information on which traits are of greatest economic importance and which should be emphasized in the breeding programs.

Key words**:** *sheep, breeding goals, genetic progress, economic weights, bio-economic models*

INTRODUCTION

Sustainability of livestock production systems is a fundamental issue of scientific debate, especially in the last decades, in view of the global concern about climate change, the negative impact of greenhouse gas emissions, the population emigration, the declining profitability of farms, the preservation of natural resources and biodiversity etc. (Bernués et al., 2011) [7]. According to the commonly accepted understanding of „sustainability“ of livestock systems, they should be environmentally friendly, economically viable, and socially acceptable, with emphasis on animal welfare (Lebacq et al., 2013) [22]. Therefore, the concept of “sustainability” has three main aspects, defined as economic, social, and environmental. Thus, to study and analyze such a complex system, it is necessary to consider the different perspectives of the relevant stakeholders (Belanche et al., 2021) [6], This, in turn, requires cooperation and exchange of knowledge between scientists, as well as the relevant institutions that are involved in making decisions in this direction, etc. (Francis and Goodman, 2010) [12].

Sustainability of European Small Ruminant (i.e. sheep and goats) Sector (ESRS) attracts the attention of science, as it is socially, economically and environmentally beneficial in many countries, although it accounts for a small share of the total livestock production in the EU (Belanche et al., 2021; The future of the EU's sheep and goat sector, 2018) [6, 50].

According to Belanche et al. (2021) [6] the small ruminant production represents only 6% of meat production and only 3% of dairy production in the European Union (EU), based on FAOSTAT statistic database, but even so it makes a significant contribution to achieving

the sustainability goals set by the United Nation (Animal Task Force - ATF, 2019) [4].

In 2013, sheep were reared in 850,000 farms and goats – in 450,000 farms in EU, and more than 1.5 million people in rural areas, including those in marginal zones, were engaged in raising them, thereby ensuring their livelihood (The future of the EU's sheep and goat sector, 2018; Paraskevopoulou et al., 2020) [50, 33]. Additionally, the sector provides multiple ecological benefits such as forest fire protection through sheep grazing during the summer, especially in the areas characterized by a dry and hot climate, as well as maintaining of the landscape and species diversity (Rook et al., 2004; Milán et al., 2003) [39, 27]. However, economic and structural difficulties interfere with the development of the sector, which makes it one of the most vulnerable in Europe (Pulina et al., 2018) [35] and led to a steady decline in livestock number and farms (mainly in sheep farming) (FAOSTAT, 2020) [61].

Inadequate prices of production at the farm-gate and increased production costs are typical for the sector (Vouraki et al., 2020) [55], which results in working below the profitability threshold (Report on the Current Situation and Future Prospects for the Sheep and Goat Sectors in the EU, European Parliament., 2018; Paraskevopoulou et al., 2020) [38, 33]. Thus, the sheep sector was one of the first to receive public support from the Common Agricultural Policy (CAP) as a compensation for income's drop down (Milán et al., 2003) [27].

Even though sheep and goat farming are of secondary importance in comparison to other sectors in EU, CAP measures always give priority to small ruminant farms, in which a significant percentage of the EU workforce is employed (Tzouramani et al., 2019) [54].

However, regardless of direct payments, the sheep and goat sector needs to adopt sustainable practices to be more resilient and competitive in the future (Paraskevopoulou et al., 2020) [33].

In the Mediterranean countries, dairy sheep farming plays an important role in livestock sector. The milk production of the countries in this region provide 45% of total world dairy production from sheep. It also provides employment for part of the population, and income for the farmers and employees, as well as social cohesion in rural and disadvantaged areas (Papanikolopoulou et al., 2023; Tzouramani et al., 2019; Carta et al., 2009) [32, 54, 10]. In general, in the Mediterranean and Black Sea regions, dairy products are traditional for consumers and are an important component of the diet of the population, which is why dairy sheep populations have a strong concentration (Pulina et al. 2018) [35]. In Bulgaria, as a country in the Black Sea region with centuries-old traditions in raising sheep and consuming dairy products from them, dairy sheep account for about 75% of the total population (Slavova and Stancheva, 2023) [44]. In recent years however, dairy sheep sector is facing difficulties, which Papanikolopoulou et al. (2023) [32], for example, explains with the continuously increasing feedstuff and energy costs during the last decade, which strongly affected profitability of farms. However, some authors suggested that dairy sheep sector is expected to overcome them applying appropriate management practices (Pulina et al., 2018; Mazinani and Rude, 2020) [35, 25], due to the growing global demand for dairy sheep and goat products, in relation to the constant world population increase (Papanikolopoulou et al., 2023) [32].

Papanikolopoulou et al. (2023) [32] also highlighted that economic performance of dairy sheep farms and factors affecting their profitability are of great interest especially to less-favoured areas. When it comes specifically to economic sustainability of sheep enterprises economic efficiency of farms is essential for sheep industry progress (Krupova et al., 2012) [20]. An option for increasing the revenues on sheep farms and reducing production costs in order to keep sheep enterprises competitive in the future is by achieving genetic progress, set as a goal in a breeding program (Wolfová et al., 2007, 2009a; Krupova et al., 2012) [57, 58, 20]. Due to the fact that high selection can negatively impact animal robustness (Rauw et al., 1998) [37], breeding objectives must achieve a balance between production, health and welfare (Theodoridis et al., 2018) [51].

Livestock breeding programs require precisely set breeding goals, the focus of which falls on the traits with the greatest impact on farm management and economic results (Theodoridis et al., 2018) [51]. The correct determination of breeding goals is related to the estimation of the economic values of the traits that influence the profitability of the farm (Ponzoni, 1986; Tozer and Stokes, 2002) [34, 53]. Therefore, selection is aimed at improving those productive and functional traits that could ensure sustainability of sheep farms in economic aspect.

The object of this paper is to make a review of conducted research focused on calculation of economic values (weights) of traits in dairy sheep, which to be taken into account for the breeding goal as a specific tool for creating conditions for farms to stay viable and profitable in the future. The results in this review are presented on the basis of structuring the obtained data on the values of the main productive and functional characteristics under study into separate meaningful parts, with summary statements being made.

MATERIALS AND METHODS

In accordance with the aim of the current research, namely a thorough and detailed review of conducted studies related to the possibilities of increasing the sustainability of dairy sheep farms by using economic weights of traits to determine the breeding goal, we performed a selection of articles that met the criteria in relation to the title of the article. We used keywords such as “dairy sheep farms”, “profitability”, ”sustainability of sheep” “economic values”, “economic weights”, “production and functional traits in dairy sheep”. The search was carried out by accessing the databases Web of Science, Elsevier; Scopus, CAB Abstract etc., as well as an advanced search on Google platform. Since the concept of “sustainability” of livestock farming is briefly presented, planning, statistical and fundamental documents of the UN and the European Commission were also cited, as well as statistical data of the Ministry of Agriculture and Food in Bulgaria. The subject of consideration are two studies conducted in Bulgaria to calculate economic weights in dairy sheep, using one and the same methodology - a program for calculating economic weights for sheep, which is generally accepted and applied by some of the other authors whose publications are presented in this review. The results and discussion are presented on the basis of structuring the obtained data on the values of the main productive and functional characteristics under study into separate meaningful parts, with summary statements being made.

RESULTS AND DISCUSSIONS

Economic Goals of the Breeding programs

According to Islam et al. (2013) [16] modern genetic selection technologies for farm animals provide considerable opportunities for improving productive performance, profitability of farms and production quality. Genetic selection has already achieved a significant progress in increasing levels of production in livestock (Rauw et al., 1998) [37], but when it comes to increasing profitability, it is necessary to know which variables are influencing the production system and how they affect profit (Michaličková et al., 2016) [26]. The establishment of these variables is directly related to the definition of breeding objectives, which has a leading role in creating breeding programs for farm animals (Ponzoni, 1986) [34].

To a large extent, breeding goals are oriented towards increasing the economic result by increasing the volume and quality of production (Ramon et al., 2010) [36], which very often requires the simultaneous improvement of several traits (Tolone et al., 2011; Simianer et al., 2023) [52, 40]. This goal could also be interpreted as increasing the biological potential of the animals, which is a function of the additive genetic values of the traits considered, measured by economic values (Michaličková et al., 2016) [26]. Selection, being a a very important part of livestock breeding, is usually based on a traits complex, each of which is characterized by its breeding (BV) and economic value (EV) or weight (Krupova et al., 2008) [18]. Economic value of a given trait represents the change in

the profit, resulted from one unit change in the genetic merit of that trait (Charfeddine, 2000) [11].

Economic value and economic weight can be considered as the absolute and relative results of increasing the level of a certain trait (Amer et al., 2001) [3]. For a common selection index to be created, the relative share of the economic value of each trait should be estimated (Fuerst-Waltl and Baumung, 2009) [13]. Therefore, the economic weight of a given trait, which is included in the selection index, must be calculated on the basis of an overall assessment of the economic contribution of each trait (Krupová et al., 2009) [19].

Economic weights (EW) of traits have a leading role for defining of the breeding goals in the breeding programs (Groen et al., 1997) [14] to guarantee that selection focus is in accordance with the economic importance of each trait (Amer et al., 2001) [3]. According to Bytyqi et al. (2015) [8] all traits that are related to farm profit should be taken in account in the breeding programmes for farm animals.

Therefore, economic values can be defined as the net economic benefit of genetic improvement of traits that affect farm profit (Krupova et al., 2008; Krupova et al., 2012) [18, 20]. They have been calculated for many farm animal species and farming systems under specific economic circumstances (Ramon et al., 2010; Krupova et al., 2008; Krupova et al., 2012) [36, 18, 20].

Due to the many aspects of livestock that should be considered when estimating economic weights in farm animals, the most appropriate and widely applied approach is the bio-economic modeling of the production system (Michaličková et al., 2016) [26]. In addition, to achieve results from the implementation of a particular breeding program, it is important to accurately assess the economic value of those traits that have an economic impact on farm performance. (Theodoridis et al., 2018) [51]. Bio-economic models consist of a set of equations, which characterize biological relationships, simulate management and economic situations and determine profitability (Krupová et al., 2008) [18]. The main advantages of bio-economic models are related to precision, flexibility, inclusion of a number of biological data and more accurate reflection of variation in genetic values on profitability (Krupova et al., 2008) [18].

Economic values of traits in dairy sheep

Economic weights for various production and functional traits in dairy sheep have been estimated and published by a number of authors (Ramon et al., 2010) [36]. Legarra et al. (2007a) [23] calculated economic weights for the traits milk yield, prolificacy, fertility, and productive lifetime for dairy sheep of the Latxa and Manchega breeds. In addition, Legarra et al. (2007b) [24] studied the economic importance of somatic cell score (SCS) for Latxa sheep. Fuerst-Waltl and Baumung (2009) [13] presented estimation of economic weights for dairy, meat and functional traits in Austrian dairy sheep. Ramon et al. (2010) [36] calculated economic weights of fat and protein content in sheep of the Manchega dairy breed. Wolfová et al. (2009a) [58] developed a bio-economic model for dairy or dual-purpose sheep aimed to estimate the effect of variation in production and functional traits on profit. Wolfová et al. (2009b) [59] applied this bio-economic model for deriving economic values in sheep in a research for the dairy Slovakian Improved Valachian breed and calculated the economic values of 15 production and functional traits. Applying the bio-economic model approach, Krupová et al. (2009) [19] estimated the economic values - marginal (MEV) and relative (REV), of 14 important traits for two Slovak dairy sheep breeds - Improved Valachian and Tsigai. Krupová et al. (2012) and Krupová et al. (2013) [20, 21] studied the influence of various production strategies and economic parameters on the REV of most important traits in Slovak dairy sheep. Tolone et al. (2011) [52] made an estimation of economic values of production and functional traits for the Italian dairy sheep breed - Valle del Belice. Bytyqi et al. (2015) [8] presented their calculation of economic values for dairy and meat traits for 4 dual purpose sheep breeds in Kosovo – Bardhoka, Balusha, Sharri and Kosova. Theodoridis et al. (2018) [51] applied a profit function model in order to derive economic values of the following traits: milk

production, prolificacy, fertility, milking speed, longevity and mastitis occurrence. Selection in dairy sheep is primarily aimed at increasing milk yield, so over the years they have been primarily bred for large milk production, thus making animals on farms more profitable (Theodoridis et al., 2018) [51].

Economic values of traits related to milk production and quality

In dairy sheep systems, increasing the economic result through a larger volume of production mostly means increasing milk production and improving its quality characteristics (Ramon et al., 2010) [36]. A number of genetic programs for different breeds have been established with the primary, and sometimes sole objective of improving milk traits (Barillet, 1997) [5], among which milk yield has been treated as the leading trait, object of selection (Othmane et al., 2003; Carta and Ugarte, 2003; Carta et al., 2009; Smulders et al., 2007; Oravcová et al., 2005) [31, 9, 10, 45, 29]. This is most certainly due to the fact that in dairy sheep farms, milk is considered as the main source of revenues and farmer's income. Improving milk yield is still perceived as the leading breeding objective from the point of view of economic benefit (Carta et al, 2009) [10]. Consequently, researchers began to pay more attention to milk composition (Barillet, 1997; Othmane et al., 2002) [5, 30]. This is due to the fact that almost total amount of milk produced is sold to dairy industry for cheese production (Carta et al, 2009) [10], so that its composition is currently the subject of great interest (Othmane et al., 2003) [31]. In such case as for Manchega sheep, discussed in the paper of Ramon et al. (2010) [36] the importance of milk composition is even greater because the cheese is produced under the mark of origin "Manchego", which is adding value to the final product.

Since much of the milk production is used as a raw material for dairy industry, especially in the countries from the Mediterranean region, the traits related to its composition become very important. The genetic improvement of milk composition must be tailored to the characteristics determining the yield and quality of the final product (Othmane et al., 2003; Carta et al., 2009) [31, 10].

The most important traits, related to milk composition, are considered to be fat and protein content and SCS (somatic cells score). The SCS is calculated as an indicator of the ewes' health. Fuerst-Waltl and Baumung (2009) [13] found that milk yield, fat and protein content have the highest economic importance for Austrian dairy sheep. They indicated a proportion between dairy, meat and functional traits as follows: 68.8: 9.2: 22.0, where dairy traits had a significant advantage over the other studied traits.

Legarra et al. (2007a) [23] calculated economic weights for Latxa and Manchega – Spanish dairy breeds, taking in account milk yield (litres) as a major trait. The authors emphasize the need for conduction of an additional studies in which other traits - somatic cell score (SCS), milk composition and udder characteristics to be included. Regarding the economic weight of the somatic cell score in the Latxa breed, however, Legarra et al., (2007b) [24] considered it to be of low economic importance and recommended the inclusion of SCS in the breeding program of the breed only if controlling the trait is not a costly undertaking and for animal welfare considerations.

Ramon et al. (2010) [36] calculated economic weights of the major milk components - fat and protein content for the Spanish dairy sheep breed - Manchega. The estimated values were very close, giving a slight advantage to protein content. Economic weights for milk carrier were calculated negative, since an increase in carrier accompanied by no changes in fat and protein content is related to increasing animals' energy demands but the product price being constant. Given the estimated economic importance of the traits, authors recommend fat and protein content to be taken into consideration for the breeding goal in dairy sheep.

Theodoridis et al. (2018) [51] in their study of Chios sheep in Greece, besides the usual traits such as milk production, prolificacy, fertility, longevity, included the occurrence of mastitis, which is indirectly related to milk yield. Authors concluded that breeding for clinical mastitis will have an insignificant effect on farm profitability and is not recommendable, and highlighted the importance of the

calculation of economic values of traits when developing a breeding program. Furthermore, estimation of the economic importance of traits other than milk yield, will help farmers and breeders in making correct breeding decisions (Abdallah and McDaniel, 2000) [1].

Economic values of traits related to lamb production

In dairy sheep, next in importance after milk yield and milk composition traits is that of lamb production, the income from which represents a significant part (e.g. 35 to 45% in Slovakia or Austria) of the total output on farms (Krupová et al., 2009; Wolfová et al., 2009 a,b) [19, 58, 59]. In Slovakia, breeding programmes for dairy sheep breeds give priority to the traits milk production, reproduction of ewes, intensity of growth of lambs, and a simple selection index focused on milk yield and litter size is widely applied (Krupová et al., 2009) [19]. Milk production and fertility had the highest economic values for Greek Chios dairy sheep as well (Theodoridis et al., 2018) [51]. Bytyqi et al. (2015) [8] pointed out that the economic importance of two main traits - milk yield and daily gain was investigated for the breeds Bardhoka, Balusha, Sharri and Kosova in Kosovo, since the main revenues on farms came from the sale of milk and fattened lambs. Therefore, improving reproduction traits, growth abilities and survival rate of lambs until weaning occupy an important place in the modern breeding programs for dairy sheep (Legarra et al., 2007a; Fuerst-Waltl and Baumung, 2009) [23, 13]. According to the estimations of Krupová et al. (2009) [19] for the Slovak dairy sheep breeds - Improved Valachian and Tsigai, milk production has a leading role in the complex of studied traits with relative economic values of 26% and 32%, respectively, with productive lifetime of ewes and conception rate of females on second and third place of importance. Conception rate of ewes and female lambs indirectly correspond to prolificacy, which is of great importance to lamb production. Tolone et al. (2011) [52] used a deterministic model for deriving economic values of production traits, such as milk production, weight of lambs at birth, and average daily gain of lambs, as well as functional traits, including survival of adult animals and lambs, fertility rate, prolificacy and mature weight of ewes in dairy sheep of the Valle del Belice breed. In general, functional traits are increasingly important to the effectiveness of breeding programs in dairy sheep farming (Barillet, 2007) [5], and are the subject of study in a number of studies. This was confirmed by Tolone et al. (2011) [52] – conception rate of females and prolificacy have the greatest impact on profit. Authors suggested that genetic improvement of milk yield in ewes, survival of lambs and ewes, fertility rate and prolificacy will positively influence the farm profitability of Valle del Belice breed in Italy.

Legarra et al. (2007a) [23] recommended the relative share (in %) of inseminated and lambed ewes to be included in the breeding programs of the breeds Latxa and Manchega. According to Krupová et al. (2012, 2013) [20, 21] the traits milk production, fertility rate, litter size per ewe and longevity of production for ewes were of great importance for the economic results in the Improved Valachian breed in Slovakia. In authors' opinion, a calculation index of the traits that have mostly affected genetic gain and economic profitability should be used for effective selection.

As Tolone et al. (2011) [52] noted, it is important to understand that economic values and weights estimated for a breed are specific for it and for the production system considered, which means they will be different for another production system or for a breed as well.

Economic values for dairy sheep in Bulgaria

The total number of sheep in Bulgaria as of November 1, 2023 amounts to 1072.8 thousand of which 718.3 thousand dairy ewes, according to the information database of the Agrostatistics Department of the Ministry of Agriculture and Food (MAF) (Agrostatistics, Ministry of Agriculture and Food, 2024) [2]. In the annual report of MAF, the Executive Agency for Selection and Reproduction in Livestock (IASRG) provided data that in 2022, 356,926 sheep under selection control of 34 breeds were reflected in the Vetis (veterinary) database. Of them, 178,393 sheep were from the Bulgarian Dairy Synthetic Population

(BDSP). Due to their ability to adapt easily to different environment and their genetic potential for achieving high milk production and prolificacy, while providing optimal raising and feeding conditions, they are widely spread all over the country.

The number of representatives of local and imported dairy breeds is significantly smaller. Sheep from BDSP and local dairy breeds are mainly raised in low-investment, semi-intensive and extensive production systems. The average suckling period is within 55-65 days, thus limiting the amount of milk produced (Miteva, 2022; Stancheva et al. 2018; Zhelyazkova et al., 2014) [28, 47, 60]. In such production system, a high level of milk production is limited to attain (Slavova and Stancheva, 2023) [44].

Despite the long-term efforts of breeders, milk production in BDSP is still the subject of many questions. According to a number of studies, the average milk yield for a standard 120-day period varied widely within 150 to 200 l and did not correspond to the genetic capabilities of animals for milk productivity (Iliev et al., 2022; Ivanova, 2013; Slavova and Stancheva 2023; Stancheva et al., 2014; 2018, 2021, 2022; Zhelyazkova et al., 2014) [15, 17, 44, 46, 47, 48, 49, 60]. In all studies, the authors conclude that the realization of the genetic potential of BDSP sheep depends mostly on the provided conditions of nutrition, breeding, and management of the production system. The synthetic population is in a continuous process of development, improvement and genetic renewal, which is particularly pronounced in the private sector. The aspiration of the new farmers to accelerate genetic progress has increased interest in the possibilities of introducing a new genetic variance from the highly productive breeds Assaf, Lacaune, Awassi and Chios, which are successfully adapted in our country. The selection in these herds is conducted by four non-governmental breeding organizations whose activity to date, regardless of the efforts made and the breeding goals set, has not developed in the desired direction - improvement of the population and increase of milk productivity.

In the breeding programs of the breeding organizations for sheep from BDSP, the leading breeding and selection trait is milk yield. Contrary to the breeding goal, in some recent studies, it has been found that in herds of the population, farms had a greater income from lambs than from sold milk (Slavova et al., 2015 a, b) [41,42]. In Bulgaria, economic values for dairy sheep have been calculated using a bio-economic model (Wolf et al., 2011) [56] only for two separate flocks of a Bulgarian dairy synthetic population – BDSP, raised in the Agricultural institutes of Stara Zagora and Shumen (Slavova and Laleva, 2021; Slavova and Stancheva, 2023) [43, 44]. Economic values of the production and functional traits have not been taken into account in the breeding programs of the relevant breeding organizations so far. In both institute herds, object of study of Slavova and Laleva (2021) [43] and Slavova and Stancheva (2023) [44], the number of lambs born per ewe showed the highest economic importance of the trait complex – 22.27% and 28.74% (Table 1).

Although milk production is a main selection trait in the breeding programs for BDSP, the economic weights of the milk yield trait is second in economic importance. Still it should be taken into account that milk yield is a leading trait, but this is valid for situations in which nutrition is of the highest quality and ad libitum, since feeding is the most important factor as the genetic potential to be expressed.

Fertility of females and productive lifetime of ewes also had a significant contribution to profit.

The conception rate is estimated to have a REV of about 17% and 16%, and production longevity – about 10% and 11%, respectively. The complex of traits related to lamb survival from birth until weaning also showed high economic importance – about 13% and 15%. According to the authors, these traits require more in-depth evaluation in other herds of the population because so far they are not the subject of selection in breeding programs for dairy sheep in Bulgaria.

Moreover, modern methods for developing defined breeding goals, guaranteeing an increase in profitability of dairy sheep farms breeding are still not applied.

Table 1. Relative economic values (REV%) or weights of main production and functional traits in two flocks of BDSP studied by Slavova and Laleva (2021) and Slavova and Stancheva (2023)

Traits	REV% of traits in studied flock 1 of BDSP (2021)	REV% of traits in studied flock 2 of BDSP (2023)
Milk yield per standard milking period of 120 days, L/ewe	16.79	14.30
Live weight at birth, kg	1.65	1.36
Growth rate from birth to weaning, g/day	6.94	5.76
Growth rate of breeding lambs in rearing, g/day	0.64	0.87
Mature weight of ewes, kg	8.71	6.23
Wool yield, kg	3.39	2.10
Conception rate of ewe lambs, %	5.75	6.47
Conception rate of ewes, %	11.02	9.02
Number of lambs born per ewe, for 1 lamb/ewe	22.27	28.74
Survival rate of lambs from birth to 24th hour, %	7.07	7.46
Survival rate of lambs from 24th hour of birth till weaning, %	5.67	6.29
Productive lifetime of ewes, years	10.10	11.39
Sum of the absolute values	100.00	100.00

Source: Slavova and Laleva (2021); Slavova and Stancheva (2023) [43, 44].

This necessitates conducting a larger-scale study of various traits, related to production and functional characteristics in dairy sheep in Bulgaria.

It is recommendable to use a bio-economic model that covers all components of the production system (biological and economic), both the dynamics in the level of productivity for a certain period of time (extremely important for updating the breeding programs) and the profitability of the studied farms as a factor for achieving economic sustainability should be established.

The marginal (absolute) and relative economic values (weights) of a complex of traits directly related to the profit on farms should be established and the most important of them will be clarified, which will serve as a basis for economically effective selection and breeding activity.

CONCLUSIONS

Breeding programs for livestock are an important tool for improving farms' performance, and they require clearly defined breeding goals focused on the traits with leading importance to the profit. In dairy sheep milk yield is considered the main selection trait, providing great share of revenues and farmer income. It is subsequently complemented by quality traits such as protein and fat content, and somatic cell score (SCS). The improvement of the animals' reproductive characteristics, their level of fertility, the rate of survival and growth of lambs are also important for modern breeding programs, given that a large part of the income comes from lamb sales on farms. The last is particularly true for the widespread dairy synthetic population in Bulgaria, as lamb revenues predominates in milk yield, according to some research conducted. In Bulgaria, economic weights for dairy sheep have been calculated only for two separate flocks of a Bulgarian dairy synthetic population and so far, economic values of the traits have not been taken into account in breeding programs. Calculating economic weights of productive and functional traits for this dairy population would provide valuable information on which traits are of greatest economic importance and which should be emphasized in the breeding program.

This requires a larger-scale study of specific economic indicators, related to farm profit, as well as estimation of economic values of production and functional traits, which may lead to adjustments to the breeding programs if necessary.

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REFERENCES

[1]Abdallah, J. M., McDaniel, B. T., 2000, Genetic parameters and trends of milk, fat, days open, and body weight after calving in North Carolina experimental herds. Journal of Dairy Science, 83 (6), 1364–1370.https://doi.org/10.3168/jds.s0022-302(00)75004-1

[2]Agrostatistics, Ministry of Agriculture and Food (2024), dated April, 2024.
chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.mzh.government.bg/media/filer_public/2024/04/

30/ra440_livestock_nov2023.pdf, Accessed on 17 February, 2025.
[3]Amer, P. R., Simm, G., Keane, M. G., Diskin, M. G., Wickham, B. W., 2001, Breeding objectives for beef cattle in Ireland. Livestock Production Science, 67 (3), 223–239. https://doi.org/10.1016/S0301-6226(00)00201-3
[4]Animal Task Force (ATF), 2019, Vision paper towards European Research and Innovation for a sustainable and competitive livestock production sector in Europe. http://animaltaskforce.eu/Portals/0/ATF_Vision_Paper_2019.pdf, Accessed on 17 Februaryl, 2025.
[5]Barillet, F., 1997, Genetics of milk production. The Genetics of Sheep, 539–564. L. Piper and A. Ruvinsky, ed. CAB International, Wallingford, UK.
[6]Belanche, A., Martín-Collado, D., Rose, G., Yáñez-Ruiz, D. R., 2021, A multi-stakeholder participatory study identifies the priorities for the sustainability of the small ruminants farming sector in Europe. Animal, 15 (2), 100131. https://doi.org/10.1016/j.animal.2020.100131
[7]Bernués, A., Ruiz, R., Olaizola, A., Villalba, D., Casasús, I., 2011, Sustainability of pasture-based livestock farming systems in the European Mediterranean context: Synergies and trade-offs. Livestock Science, 139 (1–2), 44-57. https://doi.org/10.1016/j.livsci.2011.03.018
[8]Bytyqi, H., Fuerst-Waltl, B., Mehmeti, H., and Baumung, R., 2015, Economic Values for Production Traits for different Sheep Breeds in Kosovo. Italian Journal of Animal Science, 14 (4), 603-609. DOI:10.4081/ijas.2015.3808
[9]Carta, A., Ugarte, E., 2003, Breeding goals and new perspectives in dairy sheep programs. Page 89 in Proc. 54th Annual Meet. EAAP, Roma, Italy.
[10]Carta, A., Casu, S., Salaris, S., 2009, Invited review: Current state of genetic improvement in dairy sheep. Journal of Dairy Science, 92 (12), 5814-5833. https://doi.org/10.3168/jds.2009-2479
[11]Charfeddine, N., 2000, Economic aspects of defining breeding objectives in selection programmes (Conference paper). Proceedings of the meeting of the sub-network on genetic resources of the FAO-CIHEAM Inter-Regional Cooperative Research and Development Network on Sheep and Goats, jointly organized by CIHEAM and FAO-REU, with the support of FAO-AGA, Zaragoza (Spain), 18-20 November 1999. Published in: Options Méditerranéennes. Série A, Séminaires Méditerranéens, 2000, No. 43, 9-17, ref. 29. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://om2.iamm.fr/ressources/om/pdf/a43/00600461.pdf, Accessed on 17 February, 2025.
[12]Francis, R. A., Goodman, M. K., 2010, Post-normal science and the art of nature conservation. Journal for Nature Conservation, 18 (2), 89-105. http://dx.doi.org/10.1016/j.jnc.2009.04.002
[13]Fuerst-Waltl, B., Baumung, R., 2009, Economic values for performance and functional traits in dairy sheep. Italian Journal of Animal Science, 8 (3), 341-357. http://dx.doi.org/10.4081/ijas.2009.341
[14]Groen, A. F., Steine, T., Colleau, J. J., Pedersen, J. Pribyl, J., Reinsch, N., 1997, Economic values in dairy cattle breeding, with special reference to functional traits. Report of an EAAP-working group. Livestock Production Science, 49 (1), 1-21. https://doi.org/10.1016/S0301-6226(97)00041-9
[15]Iliev, M., Staykova, G., Tsonev, T., 2022, Dynamics of the selection traits milk yield and fertility in sheep from the Bulgarian dairy synthetic population. Bulgarian Journal of Animal Husbandry, 59 (2), 3-9 (Bg). https://animalscience-bg.org/page/en/details.php?article_id=725, Accessed on 17 February, 2025.
[16]Islam, M. M., Renwick, A., Lamprinopoulou, Ch., Klerkx, L., 2013, Innovation in Livestock Genetic Improvement. EuroChoices, 12 (1), 42-47. http://dx.doi.org/10.1111/1746-692x.12019
[17]Ivanova, T., 2013, Milk productivity of sheep from the Synthetic Bulgarian Dairy Population in the herd of "IZHN-Kostinbrod". Dissertation, 139.
[18]Krupová, Z., Oravcová, M., Krupa, E., Peškovičová, D., 2008, Methods for calculating economic weights of important traits in sheep. Review article. Slovak Journal of Animal Science, 41 (1), 24-29. https://office.sjas-journal.org/index.php/sjas/article/view/419. Accessed on 17 February, 2025.
[19]Krupová, Z., Wolfová, M., Wolf, J., Oravcová, M., Margetín, M., Peskovicová, D., Krupa, E., Dano, J., 2009, Economic values for dairy sheep breeds in Slovakia. Asian-Australian Journal of Animal Science, 22 (12), 1693-1702. http://dx.doi.org/10.5713/ajas.2009.90054
[20]Krupová, Z., Wolfová, M., Krupa, E., Oravcová, M., Daňo, J., Huba, J., Polák, P., 2012, Impact of production strategies and animal performance on economic values of dairy sheep traits. Animal, 6 (3), 440-448.https://doi.org/10.1017/S1751731111001728.
[21]Krupová, Z., Krupa, E., Wolfová, M., 2013, Impact of economic parameters on economic values in dairy sheep.Czech Journal of Animal Science, 58, (1), 21–30. http://dx.doi.org/10.17221/6522-CJAS
[22]Lebacq, T., Baret, P. V., Stilmant, D., 2013, Sustainability indicators for livestock farming.A review. Agronomy for Sustainable Development, 33, 311-327. http://dx.doi.org/10.1007/s13593-012-0121-x
[23]Legarra, A., Ramón, M., Ugarte, E., Pérez-Guzmán, M.D., 2007a, Economic weights of fertility, prolificacy, milk yield and longevity in dairy sheep. Animal, 1 (2), 193-203.https://doi.org/10.1017/s1751731107657814
[24]Legarra, A., Ramón, M.,Ugarte, E., Pérez-Guzmán, M.D., Arranz, J., 2007b, Economic weights of somatic cell score in dairy sheep. Animal, 1 (2), 205-212.
[25]Mazinani, M., Rude, B., 2020, Population, world production and quality of sheep and goat products. American Journal of Animal and Veterinary Science, 15 (4), 291–299. https://doi.org/10.3844/ajavsp.2020.291.299
[26]Michaličková, M., Krupová, Z., Krupa, E., Zavadilová, L., 2016, Economic weights as a tool for

sustainable livestock farming. Conference: International Scientific days 2016: The Agri-Food Value Chain: Challenges for Natural Resources Management and Society. http://dx.doi.org/10.15414/isd2016.s2.05

[27]Milán, M. J., Arnalte, E., Caja, G., 2003, Economic profitability and typology of Ripollesa breed sheep farms in Spain. Small Ruminant Research, 49 (1), 97-105.https://doi.org/10.1016/S0921-4488(03)00058-0

[28]Miteva, D., 2022, Genetic and environmental variability of some productive traits in sheep from the Bulgarian dairy synthetic population in the herd of the Agricultural Institute - Stara Zagora. Dissertation, 143.

[29]Oravcová, M.,Groeneveld, E., Kovač, M., Peškovičová, D., Margetín, M., 2005, Estimation of genetic and environmental parameters of milk production traits in Slovak purebred sheep using test-day model. Small Ruminant Research, 56 (1-3), 113-120. http://dx.doi.org/10.1016/j.smallrumres.2004.03.002

[30]Othmane, M. H., De La Fuente, L. F., Carriedo, J. A, San Primitivo, F., 2002, Heritability and genetic correlations of test day milk yield and composition, individual laboratory cheese yield, and somatic cell count for dairy ewes. Journal of Dairy Science, 85 (10), 2692–2698. https://doi.org/10.3168/jds.S0022-0302(02)74355-5

[31]Othmane, M. H., De La Fuente, L. F, San Primitivo F., 2003, Individual cheese yield as a selection goal in milking ewes: Experiences and prospects in the Churra breed. In Gabiña D. (ed.), Sanna S. (ed.) Breeding programmes for improving the quality and safety of products. CIHEAM-IAMZ, Zaragoza, Spain.Options Méditerranéennes: Série A. Séminaires Méditerranéens; n. 55, 115-123. http://om.ciheam.org/article.php?IDPDF=3600071, Accessed on 17 February, 2025.

[32]Papanikolopoulou, V., Vouraki, S., Priskas, S., Theodoridis, A., Dimitriou, S., Arsenos, G., 2023, Economic Performance of Dairy Sheep Farms in Less-Favoured Areas of Greece: A Comparative Analysis Based on Flock Size and Farming System. Sustainability, 15 (2), 1681.http://dx.doi.org/10.3390/su15021681

[33]Paraskevopoulou, C., Theodoridis, A., Johnson, M., Ragkos, A., Arguile, L., Smith, L.G., Vlachos, D., Arsenos, G., 2020, Sustainability Assessment of Goat and Sheep Farms: A Comparison between European Countries. Sustainability, 12 (8), 3099.http://dx.doi.org/10.3390/su12083099

[34]Ponzoni, R. W., 1986, A profit equation for the definition of the breeding objective of Australian merino sheep.Journal of Animal Breeding and Genetics, 103 (1-5), 342-357.https://doi.org/10.1111/j.1439-0388.1986.tb00096.x

[35]Pulina, G., Milán, M., Lavín, M., Theodoridis, A., Morin, E., Capote, J., Thomas, D., Francesconi, A., Caja, G., 2018, Invited review: current production trends, farm structures, and economics of the dairy sheep and goat sectors. Journal of Dairy Science, 101 (8), 6715-6729. http://dx.doi.org/10.3168/jds.2017-14015

[36]Ramón, M., Legarra, A., Ugarte, E., Garde, J. J., Pérez-Guzmán, M. D., 2010, Economic weights for major milk constituents of Manchega dairy ewes. Journal of Dairy Science, 93 (7), 3303–3309. https://doi.org/10.3168/jds.2009-2787

[37]Rauw, WM, Kanis, E., Noordhuizen-Stassen, E. N., Grommers, F. J., 1998, Undesirable side effects of selection for high production efficiency in farm animals: a review. Livestock Production Science, 56 (1998), 15-33.https://doi.org/10.1016/S0301-6226(98)00147-X

[38]Report on the Current Situation and Future Prospects for the Sheep and Goat Sectors in the EU, European Parliament. (2018). https://www.europarl.europa.eu/doceo/document/A-8-2018-0064_EN.pdf , Accessed on 17 February 2020.

[39]Rook, A., Dumont, B., Isselstein, J., Osoro, K., Wallis De Vries, M., Parente, G., Mills, J., 2004, Matching type of livestock to desired biodiversity outcomes in pastures – a review. Biological Conservation, 119 (2), 137-150. https://doi.org/10.1016/j.biocon.2003.11.010

[40]Simianer, H., Heise, J., Rensing, S., Pook, T.,Geibel, J., Reimer, C., 2023, How economic weights translate into genetic and phenotypic progress, and vice versa. Genetics Selection Evolution, 55, 38.https://doi.org/10.1186/s12711-023-00807-0

[41]Slavova, S., Laleva, S., Popova, Y., Slavova, P., 2015a, Economic efficiency of the sheep flock of Bulgarian Dairy Synthetic population, raised at the Agricultural Institute - Stara Zagora (BG). Science & Technologies, Union of Scientists - Stara Zagora, Bulgaria, Volume V, Animal studies and Veterinary Medicine, 60-69. http://www.sustz.com/journal/VolumeV/Number5/Papers/StanimiraSlavova.pdf, Accessed on 17 February, 2025.

[42]Slavova, S., Stancheva, N., Laleva, S., Popova, Y., Slavova, P., 2015b, Economic efficiency of the flock of Bulgarian Dairy Synthetic population raised in EB-SE to Agricultural Institute - Shumen, TsarevBrod (Bg). Bulgarian Journal of Animal Husbandry, 5, 90-97.https://animalscience-bg.org/page/en/details.php?article_id=291, Accessed on 17 February, 2025.

[43]Slavova, S., Laleva, S., 2021, Economic values of productive and functional traits in sheep of Bulgarian dairy synthetic population. Agricultural Science and Technology, 13 (1), 99-104. http://dx.doi.org/10.15547/ast.2021.01.018

[44]Slavova, S., Stancheva, N., 2023, Profitability and economic values of productive and functional traits in sheep of Bulgarian Dairy Synthetic Population. Journal of Hygienic Engineering & Design, 43, 135-140. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://keypublishing.org/jhed/wp-content/uploads/2023/08/01.-Full-paper-Stanimira-Slavova.pdf , Accessed on 17 February, 2025.

[45]Smulders, J. P., Serrano, M., Pérez-Guzmán, M. D., Jimenez, M. A., Uribe, H., Jurado, J.J., 2007, Stochastic simulation of Manchega sheep breed selection scheme. Impact of artificial insemination, progeny testing system and nucleus size on genetic progress and inbreeding.

Livestock Science, 106 (2-3), 218-231.http://dx.doi.org/10.1016/j.livsci.2006.08.008
[46]Stancheva, N., Dimitrova, I., Georgieva, S., 2014, Biological fertility and milk yield in Bulgarian Dairy Synthetic Population sheep according to breeding line, Agricultural Science and Technology, 6 (1), 17 – 20.https://agriscitech.eu/biological-fertility-and-milk-yield-in-bulgarian-dairy-synthetic-population-sheep-according-to-breeding-line/, Accessed on 17 February, 2025.
[47]Stancheva, N., Krastanov, J., Angelova, T., Kalaydzhiev, G., Yordanova, D., 2018, Suckling period and milk productivity of the sheep from Bulgarian Dairy Synthetic Population. Macedonian Journal of Animal Science, 8 (1), 11–17.DOI: 10.54865/mjas1881011s
[48]Stancheva, N., Angelova, T., Yordanova, D., Krastanov, J., 2021, Lactation curve of the sheep from Bulgarian dairy synthetic population. Tradition and Modernity in Veterinary Medicine (TMVM), 6, 2 (11), 64–71.
https://www.researchgate.net/publication/356834269_LACTATION_CURVE_OF_THE_SHEEP_FROM_BULGARIAN_DAIRY_SYNTHETIC_POPULATION, Accessed on 17 February, 2025.
[49]Stancheva, N., Angelova, T., Yordanova, D., Krastanov, J., 2022, Effect of some factors (parity, birht type and litter size) on the milk productivity in sheep from the Bulgarian Dairy Synthetic Population. Bulgarian Journal of Animal Husbandry, 59 (6), 3-12 (Bg).https://animalscience-bg.org/page/en/details.php?article_id=805, Accessed on 17 February, 2025.
[50]The future of the EU's sheep and goat sector. (2018). European Parliamentary Research Service, Rachele Rossi.
https://www.europarl.europa.eu/RegData/etudes/ATAG/2018/620242/EPRS_ATA(2018)620242_EN.pdf, Accessed on 17 February, 2025.
[51]Theodoridis, A., Ragkos, A., Rose, G., Roustemis, D., Arsenos, G., 2018, Defining the breeding goal for a sheep breed including production and functional traits using market data. Animal, 12 (7), 1508-1515.https://doi.org/10.1017/S1751731117003007
[52]Tolone, M., Riggio, V., Maizon, D.O., Portolano, B., 2011, Economic values for production and functional traits in Valle del Belice dairy sheep using profit functions. Small Ruminant Research, 97 (1-3), 41–47.https://doi.org/10.1016/j.smallrumres.2011.01.019
[53]Tozer, P. R., Stokes, J. R., 2002, Producer breeding objectives and optimal sire selection. Journal of Dairy Science, 85 (12), 3518-3525.https://doi.org/10.3168/jds.S0022-0302(02)74441-X
[54]Tzouramani, I., Zelovitis, J., Intxaurrandieta, J. M., Eguinoa, P., 2019, Sustainability of dairy sheep farming: Examples from Greece and Spain. In: Ruiz R. (ed.), López-Francos A. (ed.), López Marco L. (ed.). Innovation for sustainability in sheep and goats. Zaragoza: CIHEAM, Options Méditerranéennes :Série A. Séminaires Méditerranéens, 123, 457-461. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://om2.iamm.fr/ressources/om/pdf/a123/00007930.pdf, Accessed on 17 February, 2025
[55]Vouraki, S., Skourtis, I., Psichos, K., Jones, W., Davis, C., Johnson, M., Riaguas, L., Theodoridis, A., Arsenos, G., 2020, A Decision Support System for Economically Sustainable Sheep and Goat Farming. Animals, 10 (12), 2421. http://dx.doi.org/10.3390/ani10122421
[56]Wolf, J., Wolfová M., Krupová Z., and Krupa E. (2011). User's manual for the program package ECOWEIGHT (C programs for calculating economic weights in livestock), version 5.1.1. Part 2: Programs EWSH2 for sheep (version 1.0.2). Institute of Animal Science, Prague, Czech Republic. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/http://www.vuzv.sk/ecoweight/5_1_1/ECOWEIGHT03A.pdf, Accessed on 17 February, 2025.
[57]Wolfová, M., Wolf, J., Kvapilik, J., Kica, J., 2007, Selection for profit in cattle: I. Economic weights for purebred dairy cattle in the Czech Republic. Journal of Dairy Science, 90 (5), 2442-2455. https://doi.org/10.3168/jds.2006-614
[58]Wolfová, M., Wolf, J., Krupová, Z., Kica, J., 2009a, Estimation of economic values for traits of dairy sheep: I. Model development. Journal of Dairy Science, 92 (5), 2183-2194.
https://www.sciencedirect.com/science/article/pii/S002203020970534X Accessed on 17 February, 2025.
[59]Wolfová, M., Wolf, J., Krupová, Z., Margetín, M., 2009b, Estimation of economic values for traits of dairy sheep: II. Model application to a production system with one lambing per year. Journal of Dairy Science, 92, 2195-2203.
https://www.researchgate.net/publication/24355457_Estimation_of_economic_values_for_traits_of_dairy_sheep_II_Model_application_to_a_production_system_with_one_lambing_per_year, Accessed on 17 February, 2025.
[60]Zhelyazkova, P., Karailanska, L., Panayotov, A., Dimov, D., 2014, Study on milk yield of Syntetic population dairy sheep around Plovdiv region of Bulgaria. Bulgarian Journal of Animal Husbandry, LI (1-2), 22-29. https://animalscience-bg.org/page/en/details.php?article_id=250, Accessed on 17 February, 2025.
[61]***FAOSTAT, https://www.fao.org/faostat/en/#home, Accessed on 17 February, 2025.

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STUDY ON THE ROMANIAN GARLIC MARKET FROM 2010 TO 2023

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Abstract

The study presents the main trends on Romanian garlic market from 2010 to 2023. The indicators analyzed were collected from domestic and international databases and they are: the cultivated area, total garlic production, average production per hectare, basic price, average growth rate of indicators and the trade balance also (import, export). Based on these data, the average of the period, standard deviation and coefficient of variation were calculated. The analysis highlighted that the area cultivated with garlic has continuously decreased, the decrease being -31.6% in 2023 compared to 2010. Also, total production of garlic decreased with 31.8% in 2023 compared to 2010. The annual growth rate was negative for all indicators, the reasons being both economic (price fluctuations, high costs with the inputs, etc) and technological (lack of planting material, temperature fluctuations, diseases and pest attack). Regarding the average price of garlic in Romania, in 2023 it reached the value of 18.8 lei/kg, registering an increase of 48.38% compared to 2010. The trade balance was negative for the entire period both in value and quantity. The results obtained from the research can contribute to the consolidation of the production and marketing strategies for the crop of garlic in Romania.

Key words**:** *Allium sativum, cultivated area, production, annual growth rate, trade, Romania*

INTRODUCTION

Garlic is a species belonging to *Liliaceae* family and has been cultivated for thousands of years for its culinary and medicinal properties. This species belongs to the genus *Allium,* it is the second most widespread after onion (*Allium* cepa L.) of the 750 known species of this genus [1]. The adaptability of garlic in agriculture, culinary uses, cosmetics, production of nutraceuticals or in biological pest control, underscores its importance as a valuable crop [24]. It is one of the most abundant sources of total phenolic compounds among frequently consumed vegetables and has been highly regarded in terms of the contribution of phenolic compounds to the human diet [14]. Garlic is also rich in vitamins (Vitamin C), antioxidants, flavonoids and minerals [8]. In addition, garlic and its bioactive components have antioxidant, antimicrobial, antifungal, anti-inflammatory properties [4, 21]. According to some studies, garlic notably decreases the risk of developing cardiovascular conditions, obesity, diabetes or cholesterol [5, 13]. Moreover, garlic and its bioactive compounds are seen as potential functional foods or nutraceuticals for preventing and treating various diseases [21]. Mainly, garlic production is used fresh, dehydrated or after processing in the form of oil, extract or powder.

Global garlic consumption grew steadily from 2009 to 2016 by +3.2% per year, reaching 26,5 million tons in 2016 and is estimated to exceed 31.1 million tons by 2025 [11]. China is the global leader in garlic consumption per capita with 14.3 kg per person per year, followed by Korea (6.2 kg/person), Bangladesh (2.6 kg/person), Russia (2.2 kg/person), Indonesia (1.8 kg/person), Brazil (1.5 kg/person) and India (1.1 kg/person) [20].

In Romania, between 2015 and 2020, the consumption of agrifood products for fruits and vegetables is in decline for potatoes, cereals and other products, reflecting the fact that the population is oriented towards a healthier diet [18]. Average annual

consumption of vegetables per capita increased by + 6.28%, from 182.9 kg in 2014 to 194.4 kg in 2020 [19].
In 2017, garlic consumption in Romania was 43,603 tons/year, respectively annual garlic consumption/capita representing 2.2 kg [3]. China is also the largest producer, exporter and consumer of garlic in the world [23]. After China, the major garlic producing countries are India, Bangladesh, South Korea, Egypt, Spain, Uzbekistan, Ukraine and Myanmar [6]. In countries like China, India, Egypt and Spain which are global garlic producers, production decreased from 67,215 t in 2010 to 27, 259.2 t in 2020 [17].
Romania holds and important place in garlic production in the European Union [10], so that according to an EC report in 2018, production in Romania was 28,770 tons, ranking third in the EU after Spain and Italy [21]. However, the national area cultivated with garlic decreased 2.46 times in 2020 compared to 2010, and garlic production decreased from 67,215 t in 2010 to 27,259 t in 2020 [17].
Spain plays a significant role as an exporter to European Union countries and the United States. This is due to the varieties protected by designations of origin which have enabled it to secure a strong position in these competitive markets, where there is a high demand for quality and traceability [25].
The Romanian garlic crop has a high economic potential, being in great demand on the market, the population preferring its taste and aroma [1]. This species occupies a special place in the traditional agricultural system in Romania due to its adaptation to climatic conditions, consumer preference in food or its medicinal properties.
In order to ensure a continuous market for garlic, the Ministry of Agriculture and Rural Development decided to grant "minimis" starting with 2019 in the amount of 1,000 euros, which was insufficient for the expenses related to the technology of obtaining garlic, which imposed an increase in value to 3,000 euros per hectare cultivated with garlic starting with 2020 [2]. From this point of view, producers' interest in this crop has increased in recent years with financial support offering higher profits. Garlic cultivation requires financial and human working capital, educating producers about the specific requirements of garlic c7ltivation for the profitability of the crop [1, 12, 5].
The general purpose of the research was to analyze the trend in the garlic market at the national level and by region in terms of area, production and trade balance during the period 2010-2023.

MATERIALS AND METHODS

In order to conduct the research, statistical data for the period 2010-2023 were collected from the National Institute of Statistics and TradeMap, based on which the following indicators were analyzed: cultivated area, total production (t), price, export (t and thousands $), import (t and thousands $) and trade balance.
The data were processed in Excel, calculating descriptive statistics (mean, standard deviation, coefficient of variation) and annual growth rate.
The results obtained are presented in tables and figures.
The standard deviation indicates how much the values are dispersed from the mean.
The codified indicators used in the presentation of the descriptive statistics are:

∂ = standard deviation;

x_i = values of the data series over a number of years;

n = number of years considered.

Coefficient of variation:
$C = \partial \bar{X} * 100$. Its values can be between 0 and 100%.
Between 0-10% indicates a higher degree of homogeneity of the series, between 10-20% is medium variation; over 20% - high variation.
Annual growth rate indicates the annual increase of the analyzed indicator:

R (%) = (Ending Value ÷ Beginning Value) ^ (1 ÷ Number of Periods) – 1.

RESULTS AND DISCUSSIONS

The evolution of garlic cultivated areas in Romania during 2010-2013 indicates a decreasing trend, recording total average figures of 12,803 ha in 2010 and just 8,713 ha in 2023, representing a decline of 31.6%. These figures show that Romania has relatively small areas dedicated to garlic cultivation compared to the leading global producers.

Analyzing the cultivated area by development regions in Romania throughout the analyzed timeframe, it is evident that in the North-East Region the indicator had higher average values (2,614.714 ha), followed by South-Muntenia with 1,747.857 ha and South-West Oltenia with 1,728.143 ha, and the opposite pole with small areas were Bucharest-Ilfov Region with 244.5 ha and Center with 763 ha (Table 1).

In 2023, it is noted that all regions recorded decreases compared to 2010, the largest decrease was recorded in Bucharest-Ilfov Region of -63.3%, and in 2023 compared to 2022 the decrease was -17.6 %, in South-East Region.

Regarding the North-East Region, it was the only one that recorded in 2023 an increase but insignificant of only 0.04% compared to 2022 (Table 2).

In 2018, the Romanian Government implemented the scheme "De minimis aid for the implementation of the garlic production support program" to cover the expenses related to the applied technology, however, no positive effects were identified regarding the cultivated areas, which have been decreasing in recent years.

Table 1. Area cultivated with garlic by development regions in the period 2010-2023 (thousand hectares)

Development regions	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
NORTH-WEST	1,087	1,135	929	939	931	924	913	918	927	932	921	928	805	783
CENTER Region	757	725	683	758	775	990	899	847	848	848	709	700	572	572
NORTH - EAST	3,119	3,013	2,984	2,738	2,698	2,618	2,464	2,467	2,660	2,502	2,494	2,444	2,202	2,203
SOUTH-EAST Region	1,232	1,171	1,292	1,021	1,007	980	1035	889	903	899	895	870	1,106	911
SOUTH-MUNTENIA	2,313	2,183	1,833	1,792	1,831	1,824	1,580	1,578	1,586	1,582	1,501	1,672	1,608	1,587
BUCHAREST – ILFOV	434	382	323	285	286	285	209	179	178	182	169	184	169	159
SOUTH-WEST OLTENIA	2,367	2,067	1,873	1,665	1,755	1,744	1,693	1,688	1,681	1,679	1,470	1,618	1,460	1,434
WEST	1,494	1,452	1,450	1,418	1,420	1,413	1,418	1,408	1,413	1,406	1,379	1,153	1,064	1,064
TOTAL	12,803	12,128	11,367	10,616	10,703	10,778	10,211	9,974	10,195	10,029	9,539	9,569	8,986	8,713

Source: NIS - TEMPO Online, Accessed on 20.01.2025, [26].

Regarding the statistical analysis of the data for the cultivated area during the period 2010-2023, it is found that the standard deviation from the average had values ranging between 88.6 in Bucharest – Ilfov and 247.0 in South-West Oltenia, and the coefficient of variability was between 9.58% and 15.3% for the majority of regions, which indicates an average variation, and a high variability of 36.2% in Bucharest – Ilfov Region.

Annual growth rate for the area cultivated registered negative values for all development regions, the values being between -1.98% in Center Region and -6.92% in București-Ilfov Region (Table 2).

Regarding the total garlic production, throughout the dynamic series, a downward evolution is observed in all regions.

Thus, during the period 2010-2023, the average total garlic production in Romania recorded values of 67,215 thousand tons in

2010 when the highest production was recorded and in 2023 it decreased to 45,801 thousand tons, when it was recorded the lowest production, representing a decrease of -31.8% (Table 3).

Table 2. Descriptive statistics regarding area cultivated with garlic in the period 2010-2023

Development regions	2023/2010 (%)	2023/2022 (%)	MIN.	MAX.	Average	Standard deviation	Coefficient of variation (%)	Annual growth rate (%)
NORTH-WEST	-27.9	-2.7	913	1135	933.7	89.5	9.58	-2.32
CENTER	-24.4	0	572	990	763.0	117.4	15.38	-1.98
NORTH -EAST	-29.3	0.04	2,202	3,119	2,614.7	279.3	10.68	-2.45
SOUTH-EAST	-26.0	-17.6	870	1,232	1,015.0	137.6	13.55	-2.13
SOUTH-MUNTENIA	-31.3	-1.3	1,501	2,313	1,747.8	240.7	13.77	-2.65
BUCHAREST – ILFOV	-63.3	-5.9	159	434	244.5	88.6	36.2	-6.92
SOUTH-WEST OLTENIA	-45.6	-1.78	1,434	2,367	1,728.1	247.0	14.29	-3.52
WEST	-28.7	0	1,064	1,494	1,353.7	144.8	10.69	-2.40
TOTAL	-31.6	-3.03	8,713	12,803	10,400.7	168.1	10.88	-2.71

Source: Own calculation.

By region, it is found that in the North-East was produced the largest quantity of garlic, the average being 14,818.8 thousand tons, and the minimum production was registered in 2023 of 11,215 thousand tons and the maximum was reached in 2011 of 17,130 thousand tons. Additionally, during the period under review, the South-Muntenia Region achieved a notable average production of 10,044.6 thousand tons followed by the South-West Oltenia Region, with 9,850.3 thousand tons. West, North-West, Center, South-East and Bucharest-Ilfov Regions had a smaller contribution, ranging between 1,368.7 and 7,543 thousand tons.

Table 3. Total garlic production by development region in the period 2010-2023 (thousand tons)

Development regions	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
NORTH-WEST	6,017	6,298	5,410	5,856	5,740	5,784	5,479	5,599	5,645	5,611	5,955	6,355	4,938	4,432
CENTER	3,614	3,798	3,751	4,142	4,035	5,248	4,617	4,520	4,544	4,378	3,956	4,025	3,124	2,895
NORTH - EAST	14,928	17,130	15,551	15,934	16,378	16,253	12,962	13,968	14,755	13,330	16,626	16,348	12,086	11,215
SOUTH-EAST	6,155	6,375	6,324	5,563	5,352	5,380	5,114	4,775	5,133	4,883	5,657	5,570	5,461	4,666
SOUTH-MUNTENIA	13,040	12,293	9,479	10,953	11,122	11,004	8,926	8,938	9,364	9,000	8,724	10,184	9,256	8,342
BUCHAREST – ILFOV	2,517	1,733	1,359	1,948	1,639	1,634	911	822	841	822	1,410	1,488	1,098	940
SOUTH-WEST OLTENIA	13,287	10,705	10,015	9,576	10,503	10,577	9,483	9,495	9,670	9,245	8,836	9,961	8,534	8,018
WEST	7,657	8,270	7,479	8,184	8,004	8,260	6,897	7,556	8,023	7,593	9,978	6,670	5,738	5,293
TOTAL	67,215	66,602	59,368	62,156	62,773	64,140	54,389	55,673	57,975	54,862	61,142	60,601	50,235	45,801

Source: NIS - TEMPO Online, Accessed on 20.01.2025, [26].

The statistical analysis of the production data for the period 2010-2023 indicates an average variability in all regions except Bucharest-Ilfov Region where a variability coefficient of 36.7% is recorded, indicating a high variation. The annual growth rate recorded negative values regarding the production for all development regions, with values between -1.57 in Center Region and -6.79 in Bucharest-Ilfov Region (Table 4).

Variations in total production can be influenced by numerous factors, such as change in cultivated area, applied technology, pedoclimatic conditions or increasing production costs, technology management, infrastructure or socio-economic conditions.

Table 4. Statistical indicators calculated for total garlic production in the period 2010-2023

Development regions	2023/2010 (%)	2023/2022 (%)	MIN.	MAX.	Average	Standard deviation	Coefficient of variation (%)	Annual growth rate (%)
NORTH-WEST	-26.3	-10.2	4,432	6,355	5,651.3	503.4	8.9	-2.16
CENTER	-19.9	-7.3	2,895	4,617	4,046.2	612.7	15.1	-1.57
NORTH - EAST	-24.8	-7.2	11,215	17,130	14,818.8	1,841.2	12.4	-2.02
SOUTH-EAST	-24.2	-14.5	4,666	6,375	5,457.7	541.0	9.9	-1.96
SOUTH-MUNTENIA	-36.0	-9.8	8,342	13,040	10,044.6	1,429.6	14.2	-3.14
BUCHAREST – ILFOV	-62.6	-14.3	822	2,517	1,368.7	503.0	36.7	-6.79
SOUTH-WEST OLTENIA	-39.6	-6.0	8,018	13,287	9,850.3	1,252.3	12.7	-3.54
WEST	-30.8	-7.6	5,293	9,978	7,543	1,155.1	15.3	-2.60
TOTAL	-31.8	-8.8	45,801	67,215	58,780.8	1,155.1	1.96	-2.70

Source: Own calculation.

Regarding the average production per hectare, there are oscillations from one year to another, the average values being between 5.22 t/ha in 2012 and 6.41 t/ha in 2020 (Table 5). The average production/ha in 2023 compared to 2010 registered a difference of 0.13%, being higher in the North-East Region by 6.36% and lower in the South-Muntenia Region -6.76% (Table 6).

Table 5. Average production/ha of garlic by development region during 2010-2023 (tons/ha)

Development regions	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
NORTH-WEST	5.54	5.55	5.82	6.24	6.17	6.26	6.00	6.10	6.09	6.02	6.47	6.85	6.13	5.66
CENTER	4.77	5.24	5.49	5.46	5.21	5.30	5.14	5.34	5.36	5.16	5.58	5.75	5.46	5.06
NORTH -EAST	4.79	5.69	5.21	5.82	6.07	6.21	5.26	5.66	5.55	5.33	6.67	6.69	5.49	5.09
SOUTH-EAST	5.00	5.44	4.89	5.45	5.31	5.49	4.94	5.37	5.68	5.43	6.32	6.40	4.94	5.12
SOUTH-MUNTENIA	5.64	5.63	5.17	6.11	6.07	6.03	5.65	5.66	5.90	5.69	5.81	6.09	5.76	5.26
BUCHAREST – ILFOV	5.80	4.54	4.21	6.84	5.73	5.73	4.36	4.59	4.72	4.52	8.34	8.09	6.50	5.91
SOUTH-WEST OLTENIA	5.61	5.18	5.35	5.75	5.98	6.06	5.60	5.63	5.75	5.51	6.01	6.16	5.85	5.59
WEST	5.13	5.70	5.16	5.77	5.64	5.85	4.86	5.37	5.68	5.40	7.24	5.78	5.39	4.97
TOTAL	5.25	5.49	5.22	5.85	5.86	5.95	5.33	5.58	5.69	5.47	6.41	6.33	5.59	5.26

Source: NIS - TEMPO Online, Accessed on 20.01.2025, [26].

Garlic production/hectare in 2023 compared to 2022 was smaller in all regions except for South-East Region where an increase of 3.73% was recorded. Regarding the analysis of the calculated statistical indicators, values between 0.24 and 1.35 were recorded for standard deviation and for the coefficient of variation, values between 0.24% and 1.35%, indicating low variability. Regarding the annual growth rate, positive increases were observed in the North-West (0.16), Center (0.42), North-East (0.44), South-East (0.18) and Bucharest-Ilfov (0.14) while negative values were recorded in regions such as South-Muntenia (-0.50) and South-West Oltenia (-0.03) and West (-0.21) (Table 6).

The demand for garlic is continuously increasing, the domestic market is expanding.

The choice of cultivars adapted to the growing conditions can contribute to significantly improving production and increasing the long-term market competitiveness of this species.

Table 6. Descriptive statistics for garlic production /hectar in 2010-2023

Development regions	2023/2010 (%)	2023/2022 (%)	MIN.	MAX.	Average	Standard deviation	Coefficient of variation (%)	Annual growth rate (%)
NORTH-WEST	2.26	-7.73	5.54	6.85	6.06	0.35	0.35	0.16
CENTER	6.01	-7.33	4.77	5.75	5.31	0.24	0.24	0.42
NORTH - EAST	6.36	-7.25	4.79	6.69	5.68	0.57	0.57	0.44
SOUTH-EAST	2.52	3.73	4.89	6.40	5.41	0.47	0.47	0.18
SOUTH-MUNTENIA	-6.76	-8.68	5.17	6.11	5.75	0.29	0.29	-0.50
BUCHAREST – ILFOV	1.94	-9.01	4.21	8.34	5.71	1.35	1.35	0.14
SOUTH-WEST OLTENIA	-0.39	-4.34	5.18	6.16	5.72	0.28	0.28	-0.03
WEST	-2.94	-7.76	4.86	5.85	5.57	0.57	0.57	-0.21
TOTAL	0.13	-5.97	5.22	6.41	5.66	0.38	0.38	0.01

Source: Own calculation.

Garlic cultivars are quite diverse and have good adaptability to the environmental conditions in traditional areas [15]. For satisfactory garlic productivity, a permanent evaluation of the planting date is also needed, depending on the climatic changes in the growing area [9].

Garlic, being an essential minor agricultural product can have a significant impact on the livelihoods of industry stakeholders and consumers due to its price volatility [23]. Regarding the average price of garlic in Romania, in the analyzed period it was 12.67 lei/kg in 2010, reaching the value of 18.8 lei/kg in 2023. Figure 1 illustrates the trend of annual average garlic production prices in Romania, having an upward trajectory reflected by an increase of 48.38%.

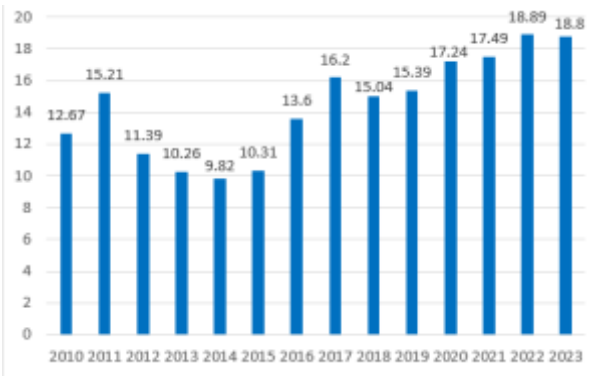


Fig. 1. Evolution of average annual prices for garlic production in Romania, 2010-2023 (lei/kg).
Source: Own design based on the data from [26].

International trade can affect all national economies, their dependence on the world market manifesting itself differently, depending on the country, both in terms of exports and imports [16]. From the data presented in Table 7, it is observed that from the total garlic quantity of 1,274,014 kg**,** the largest imported quantity of garlic in 2010 was from Netherlands **(**402,302 kg) which in the total structure of imports amounts to more than a third of total imports, followed closely by the Czech Republic with the volume being significantly lower im comparison to the Netherlands, of only 99,209 kg. Total imports in 2010 amounted 2,200,299 $, representing a quantity of 1,274,014 kg.

In 2023, imported quantities increased significantly, reaching 6,307,323 kg and totaled a value of 13,165,376 $. The main importing country was also the Netherlands, followed by Germany.

Table 7. Garlic import in Romania

Country	Trade Value(US$)	Quantity (Kg)
2010		
World	2,200,299	1,274,014
Netherlands	1,366,308	402,302
Czechia	386,853	99,209
2023		
World	13,165,376	6,307,323
Netherlands	8,192,319	3,613,302
Germany	1,575,660	425,997

Source: https://comtradeplus.un.org, [26].

The large import quantities may be due to several factors in Romania such as: climate change, inadequate technology, high prices of agricultural inputs, imbalances along the market chain and for this reason imports are necessary to cover demand, a fact also supported by other studies [19].

According to Table 8, the export had an upward trend both in value and quantity. Thus, in 2010 the total quantity exported was 367,323 kg, amounting 1,252,570 US$. From this quantity, a large part was exported to Netherlands of 266,468 kg (representing 72% of the total quantity) and to Bulgaria - 100,669 kg. In 2023, the total quantity exported of garlic was 6,307,323 kg, worth 302,829 US$, decreasing with approximately 75% compared to 2010. Of this quantity, the largest part was exported to Hungary of 3,613,302 kg, followed by Ukraine with 425,997 kg, worth 263,247 US$, respectively 24,842 US$.

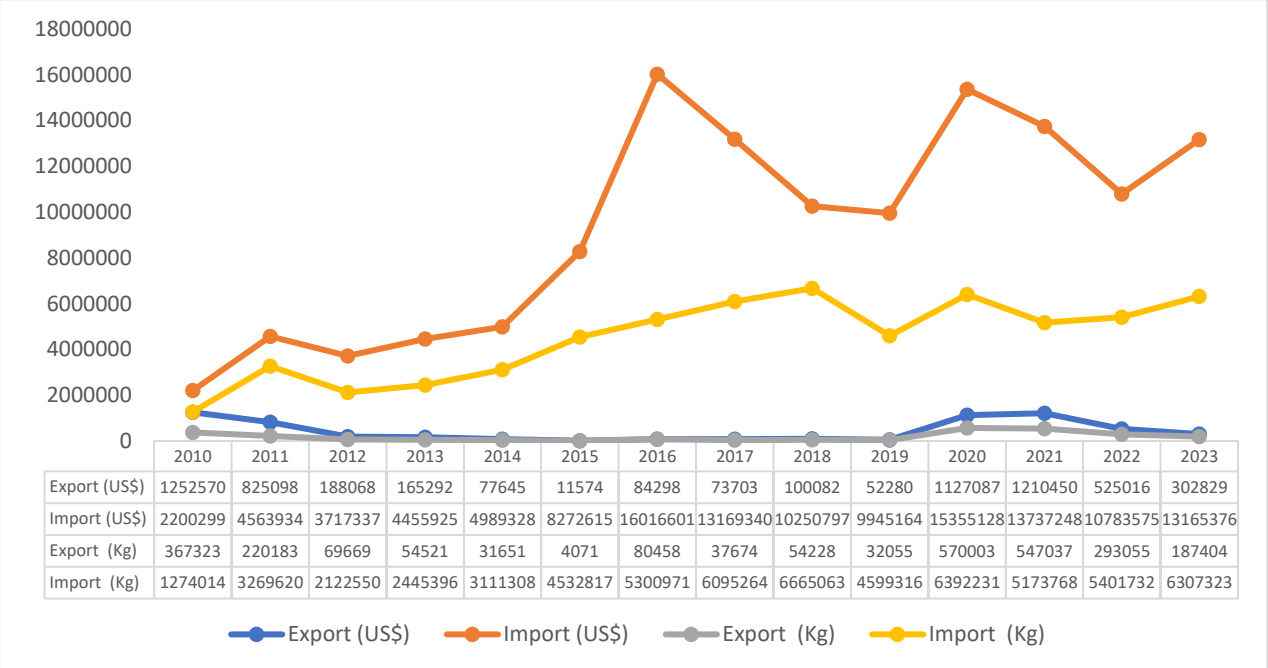
Garlic imports in Romania show an upward trend that has recorded a slight decrease since 2017 when the value of imports was 9,945,164 million dollars. It is noted that the value of garlic imports in 2023 increased significantly compared to 2010, with the total quantity imported by Romania being 6,300 tons, with approximately 400% more than in 2010. Total garlic imports in Romania ranged from 2,200,299 US$ in 2010 to approximately 16,016,601 US$ in 2016 (Figure 2). The average annual value of this indicator during the period 2010-2023 was 9,330,191 US$. Regarding quantitative imports, they varied between 1.27 thousand t and 6.66 thousand t, the average for the period being 4.47 thousand t.

Table 8. Garlic export from Romania

Country	Trade Value (US$)	Quantity (Kg)
Export - 2010		
World	1,252,570	367,323
Netherlands	956,794	266,468
Bulgaria	295,346	100,669
Export - 2023		
World	302,829	6,307,323
Hungary	263,247	3,613,302
Ukraine	24,842	425,997

Source: https://comtradeplus.un.org, [26]

Regarding the exports made by Romania, they are much lower compared to imports, both in quantity and value. The trend is an upward one, especially for quantities starting with 2020, due to the minimis aid and the increase in production during this period. The exported quantity varied between 4 t and 293 t.



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Export (US$)	1252570	825098	188068	165292	77645	11574	84298	73703	100082	52280	1127087	1210450	525016	302829
Import (US$)	2200299	4563934	3717337	4455925	4989328	8272615	16016601	13169340	10250797	9945164	15355128	13737248	10783575	13165376
Export (Kg)	367323	220183	69669	54521	31651	4071	80458	37674	54228	32055	570003	547037	293055	187404
Import (Kg)	1274014	3269620	2122550	2445396	3111308	4532817	5300971	6095264	6665063	4599316	6392231	5173768	5401732	6307323

Fig. 2. Romanian imports and export during, 2010-2023
Source: https://comtradeplus.un.org, [26]

Massive imports of garlic for Romania have negatively influenced its valorization from domestic production. According to [1], the existence of inadequate conditions regarding conditioning and storage have caused difficulties in garlic trade, favoring imports. Some authors have stated that in order to increase productivity it is necessary to expand the crop by investing in modern farms and applying new cultivation technologies [12].

The trade balance was determined as a difference between the value of exports and imports. Romania registered a deficit in its trade balance for vegetables in the period 2010-2020, and the main species were tomatoes, cucumbers, potatoes, beans and garlic [22]. Regarding the trade balance with garlic from 2010 to 2023, it can be noted that there is deficit, imports to Romania being higher than exports, resulting in a deficit of -947,729 US$ in 2010 up to -12,862,547 US$ in 2023. According to the trendline, the trade balance decreased on average by approximately 334,435 US$ per year (Figure 3).

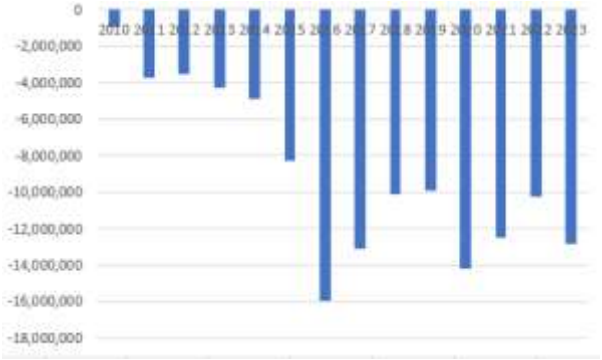


Fig. 3. Evolution of the trade balance in value with garlic in Romania, between 2010-2023 (US$)
Source: Own design based on the data from [26].

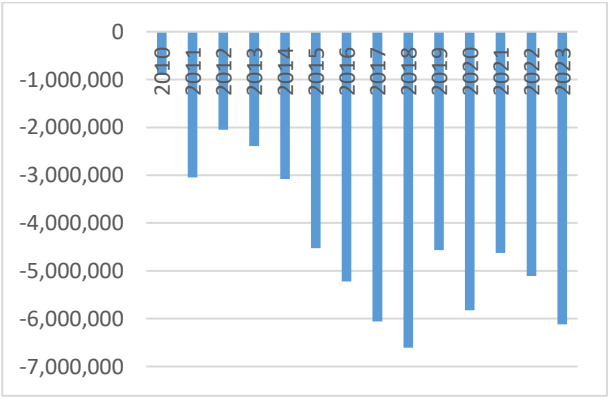


Fig. 4. Evolution of the quantitative trade balance with garlic in Romania, between 2010-2023 (Kg)
Source: Own design based on the data from [26].

According to the analysis of the quantitative trade balance, it is found that it is negative throughout the studied period. The trade deficit may also be due to the high selling price per unit of volume. Thus, the deficit increased from -906.691 kg in 2010 to -6,119,919 kg in 2023. The highest value was registered 2018, of -6,610,835 kg (Figure 4). An approach to correct the trade balance could involve enhancing yields per hectare, which may address the issues related to vegetable supply [22].

CONCLUSIONS

Throughout the analyzed period, 2010-2023, the following insights can be observed:

- The trend of garlic cultivation surfaces at national level registered a decline, with an average area of 12,803 ha in 2010 and only 8,713 ha in 2023, decreasing by approximately -31.6 %;
- The cultivated area in the development regions of Romania during the period under study was the largest in the North-East region and followed by South-Muntenia region;
- The total average garlic production in Romania recorded values between 67,215 thousand tons in 2010 when the highest production was recorded and 45,801 thousand tons in 2023, when the lowest production was recorded, which represents a decrease of -31.8%. Regarding the development regions, North-East and South-Muntenia registered greater average total yield per hectare;
- National garlic yield reached 6.41 t/ha in 2020, and at the level of development regions it was higher in the North-East and South;
- The production of garlic is also low due to the decrease of the surfaces during the period under study.
- The much negative growth rate was reflected in production instability;
-The greater instability recorded in production may also be due to the use of garlic varieties by farmers, with lower yields, inadequate cultivation practices and price volatility on the market;
- Production variability is the main component influencing price fluctuations, demand, import and export. Regarding the average price of

garlic in Romania, it indicates an upward trend, the average annual growth rate being 32.6%;
- The trade balance, both quantitative and value was in deficit throughout the analyzed period.
In order to promote garlic production as a stimulating agricultural activity, it is necessary to improve cultivation technology, use genotypes with good adaptability to pedo-climatic conditions and provide further financial support, through national legislation, to farmers for obtaining higher profits.

REFERENCES

[1]Ammarellou, A., Yousefi A.R., Heydari, M., Uberti, D., Mastinu, A., 2022, Biochemical and botanical aspects of *Allium sativum* L. sowing. BioTech (Basel), 11(2):16. doi: 10.3390/biotech11020016. PMID: 35822789; PMCID: PMC9264397.
[2]Berevoianu, R.L., Ilie, D.M., Giuca, A.D., 2024, The Economic Profitability of Garlic Cultivation through the Application of the De "Minimis" Aid Scheme, Estimates for the Year 2024 in Romania, Proceedings of the International Conference on Business Excellence, 18(1), 1552-1562.
[3]Businessmicrocredit.ro, 2025, https://businessmicrocredit.ro/importuri le-globale-de-usturoi-au-crescut-dar-exporturi le-chinezesti-record-franeaza-cresterea-preturilor, Accessed on January 5, 2025.
[4]Chanda, S., Dikshit, N., 2023, Garlic (*Allium sativum* L.): An overview of its biochemical composition, functional properties, ayurvedic, therapeutic and ethnoveterinary uses. Journal of Medicinal and Aromatic Plant Sciences, 45, 89-107.
[5]Chekol, F., Abetie, K., Sirany, T., 2023, Technical efficiency of garlic production under rain fed agriculture in Northwest Ethiopia: Stochastic frontier approach. Cogent Economics & Finance, 11(2). https://doi.org/10.1080/23322039.2023.2242177
[6]Chhetri, P., Mula, G., Sarkar, A., Ojha, S., Mondal, S., 2024, Transition in production and export potential of garlic in India. Journal of Applied Horticulture, 26(2), 148-153.
[7]Comtradeplus.un.org, 2025, Free access to detailed global trade data, https://comtradeplus.un.org/, Accessed on 20 January 2025.
[8]Dinu, M., Soare, R., Băbeanu, C., Botu, M., 2023, Evaluation of Productivity Components and Antioxidant Activity of Different Types of Garlic Depending on the Morphological Organs. Horticulturae, 9(9):1039.
[9]Draghici**,** M.E., Lagunovschi-Luchian, V., 2015, The planting period and the size of cloves influences on garlic production. AgroLife Scientific Journal, 4(2), 9-16.
[10]European Commission, Agriculture and Rural development, 2019, https://agriculture.ec.europa.eu/farming/ crop-productions-and-plant-based-products /fruit-and-vegetables/garlic_en?, Accessed on January 5, 2025.
[11]Fooddive.com, Global Garlic Market, 2018, Key Findings by IndexBox, https://www.fooddive.com/press-release/20180531-global-garlic-market-key-findings-by-indexbox/- Global Garlic Market - Key Findings by IndexBox, Accessed on January 5, 2025.
[12]Giuca, A.D., 2021, Analysis of the vegetable sector in Giurgiu county, Romania. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 21(4), 271-278.
[13]Lanzotti, V., Scala, F., Bonanomi, G., 2014, Compounds from *Allium* species with cytotoxic and antimicrobial activity. Phytochemistry Reviews, 13, 769–791.
[14]Martins, N., Petropoulos, S., Ferreira, C.F.R. I., 2016, Chemical composition and bioactive compounds of garlic (*Allium sativum* L.) as affected by pre- and post-harvest conditions: A review, Food Chemistry, 211, 41-50.
[15]Munteanu, I., 2018, Situation of garlic in Romania, Scientific Papers Series Horticulture, 61 (2), USAMV Iaşi.
[16]Pânzaru, R.L., Medelete, D.M., 2011, International trade with garlic. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.11(2), 125-128.
[17]Popa, P.M., Cosmulescu, S.N., 2024, The evolution of garlic cultivation in Romania – constraints and perspectives. Acta Horticulturae, 1391, 75-82.
[18]Popescu, A., 2022, The importance of production and import for ensuring food availability in Romania Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol. 22, (1)**,** 533-448.
[19]Popescu, A., Chiurciu, I., Soare, E., Stoicea, P., Iorga, A., 2022, Trends in average annual food consumption per inhabitant in Romania Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 22, (3), 561-580.
[20]Searle, F., 2018, Fruitnet.com, 2025, World garlic market 'set for steady growth, https://www.fruitnet.com/fresh-produce-journal/world-garlic-market-set-for-steady-growth/175368.article, Accessed on 5 January 2025.
[21]Shang, A., Cao, S.Y., Xu, X.Y., Gan, R.Y., Tang, G.Y., Corke, H., Mavumengwana, V., Li, HB., 2019, Bioactive Compounds and Biological Functions of Garlic (*Allium sativum* L.). Foods, 5;8(7):246.
[22]Stoica, G.D., Stoian, M., Nica, I.C., Jelocnik, M., Frățilă (Adam), A., 2024, Research on the Agro-Food Trade Balance of Romania. Economic Computation and Economic Cybernetics Studies and Research, 58, (1), 200-212.
[23]Sun, F., Meng, X., Zhang, H., Wang, Y., Liu, P., 2024, Prediction of Weekly Price Trend of Garlic Based on Classification Algorithm and Combined Features. Horticulturae, 10, 347.
[24]Thakur, P., Dhiman, A., Kumar, S., Suhag, R., 2024, Garlic (*Allium sativum* L.): A review on bio-

functionality, allicin's potency and drying methodologies, South African Journal of Botany, 171, 129-146.
[25]Thegarlicfactory.eu, 2025, Main Garlic Producing Countries in the World, https://thegarlicfactory.eu/main-garlic-producing-countries-in-the-world/, Accessed on 5 January, 2025.
[26]The National Institute of Statistics, Tempo online, http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table, Accessed on 20.01.2025.

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THE ROLE OF PHYSICAL SECURITY MANAGEMENT IN CONSOLIDATING THE SAFETY AND SUSTAINABILITY OF PUBLIC FOOD AND AGROTURISM UNITS IN THE RURAL ENVIRONMENT

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Abstract

The article analyses the role of physical security management in public food and agritourism units in rural areas, focusing on the challenges and particularities of this context. In rural areas, where access to advanced technologies or resources is sometimes limited, the safety of employees and customers becomes essential for strengthening the local community's trust and for the success of businesses in this sector. Practical and adaptable solutions are presented, such as implementing simple surveillance systems or organizing activities in collaboration with local authorities. At the same time, the role of staff training is highlighted, which plays a decisive factor in reducing security incidents, especially in small communities, where relationships of trust are fundamental. The main goal is to identify accessible and efficient solutions, adapted to local specifics, that contribute to economic development and to strengthening community trust. The materials used include scientific articles selected from the Web of Science database, interpreted using the VOSviewer software for bibliometric analysis. The sources of information consist of specialized works, national strategies, official statistics and relevant documents in the field of tourism, security and sustainability. The applied research methods are bibliometric analysis and systematic theoretical analysis, assuming that effective physical security management is correlated with a high level of sustainability and sustainable local development. This complex approach allowed the formulation of relevant conclusionssuggesting that, through accessible strategies and security measures adapted to rural specifics, public food and agritourism units can contribute both to local economic development and to the creation of a safe and friendly environment for the community.

Key words**:** *physical security management, safety, public food units, agritourism units*

INTRODUCTION

Security in the tourism and hospitality industry is one of the determining factors in achieving and maintaining customer and employee satisfaction and business sustainability [4].

Rural food and agritourism units face specific challenges related to physical security, including accessibility, poor infrastructure and risk management [9].

Security in food and agritourism units includes a wide range of measures and practices designed to protect employees, customers, infrastructure and sensitive business information. In a sector where human interaction is intense, the risks associated with security incidents – whether physical or digital – can have devastating consequences on operations and reputation. Implementing effective security management contributes to sustainable development, reducing the negative impact on the community and the environment [12].

Physical security management involves the protection of premises and assets, including access control by implementing access verification systems in sensitive areas, such as food warehouses or processing areas, choosing video surveillance systems for continuous monitoring to prevent theft, vandalism or other incidents, taking fire prevention measures by equipping with fire extinguishers, smoke detectors and clearly defined evacuation plans [11].

Another key element is employee and customer security, and effective management forms a safe environment for employees and customers, being an essential component of the sustainability of a business and environmental development.

Among the basic features in employee and customer security, firstly, is compliance with

health and safety regulations to prevent accidents at work and, secondly, the urgent implementation of measures for managing emergencies, to which are added regular training, to be prepared for any situation that may arise.

Because the world has undergone a drastic change in recent decades, being in the full swing of the digital age, cybersecurity has become a priority [15], especially for units that use online ordering systems and payment applications. Proper management has its say in reducing risks that include unauthorized access to customer personal data and vulnerabilities in order and inventory management systems [20],[10].

Precisely for these reasons, physical security management is an essential element for the success of public food and agritourism units, including those in rural areas, because in these areas, limited infrastructure and reduced access to advanced technologies can amplify risks, endangering the safety of both customers and employees [6].

The purpose of this article is to highlight the role of physical security management in strengthening community trust and ensuring business sustainability and to find effective physical security strategies to contribute to the development of the rural environment.

MATERIALS AND METHODS

In the analysis undertaken, to establish the role of physical security management in strengthening the safety and sustainability of public food and agritourism units in rural areas, theoretical research of specialized studies was used, which began with a bibliometric analysis in the first part of the article to identify the conceptual relationships between safety, risk management and sustainability of public food and agritourism units.

The research continued with a systematic analysis of the specialized literature, an analysis intended to respond to the following hypothesis: "The existence of an effective physical security management in public food and agritourism units in rural areas is correlated with a high level of sustainability and local economic development."

Bibliometric analysis is a quantitative research method, which in this article used the Web of Science database, from where the articles relevant to the field studied were sorted and centralized (selections are made according to several criteria such as subject, title, keywords, authors, years, countries, etc.), being used in many studies in the technical and economic fields. The aim was to find research trends in the field of physical security in public food and agritourism units. To find relevant studies in the field, the "Subject" field in the WoS platform was configured, where "Security" was added, along with two more keywords "Hospitality" and "Safety". The result of joining these keywords generated a sample of 215 publications, which was exported to a text file, which was interpreted using the VOSviewer 1.6.19 software, generating graphic representations and maps that were interpreted in the paper.

Hypothesis-based analysis by exploring the specialized literature is called theoretical analysis. The following steps were followed: formulating the hypothesis (the idea of preliminary explanation was used), studying the literature by searching and analyzing existing scientific works that refer to the hypothesis, to see if there is evidence or arguments to support or contradict it, and evaluating and drawing conclusions (based on the literature, the validity of the hypothesis was evaluated and conclusions were drawn).

This method is frequently used in scientific research to identify gaps in knowledge, being at the same time also a step to substantiate a subsequent empirical approach.

RESULTS AND DISCUSSIONS

Bibliometric analysis of key concepts

In this part of the paper, a systemic analysis of existing studies in the Web of Science (WoS) database regarding physical security in public food and agritourism units was carried out. The aim was to obtain an overview of the evolution and research directions in this field, and in the fields that converge with it.

Observing the data in Fig. 1, regarding the number of publications by year, it is observed that in 2000, the first publication on the

researched topic was recorded. Starting with 2007 (3 publications), the number of publications began to increase slightly, with significant oscillations over the years, reaching a maximum of 29 publications in 2023.

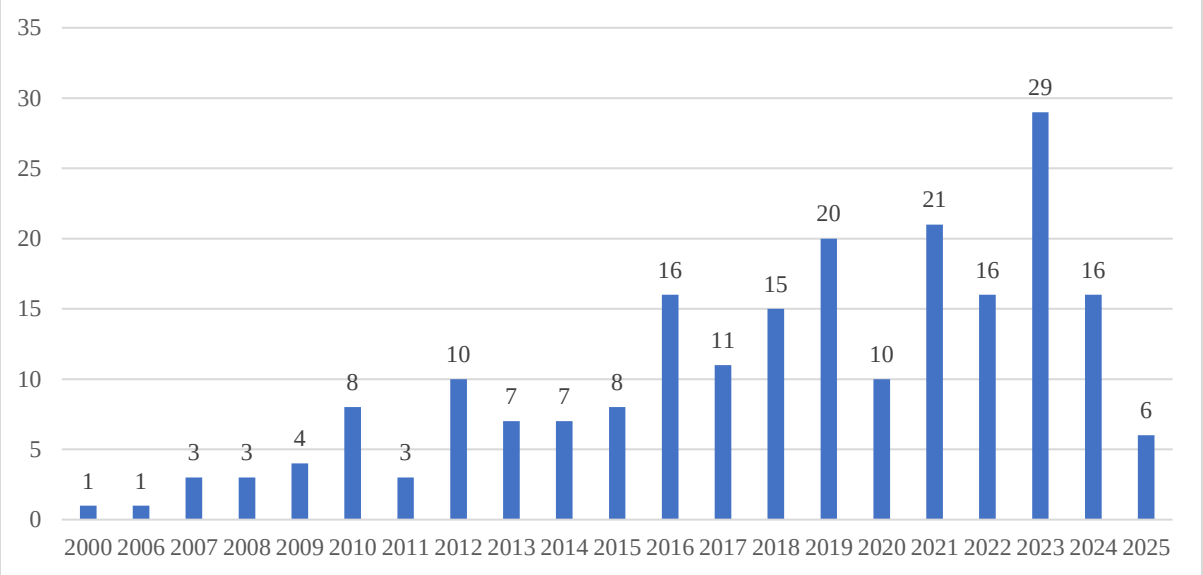

Fig. 1. Dynamics of WoS publications by keywords "security", "hospitality",& "safety" in the period 2000-2025 (number of documents/year)
Source: Own calculations based on data generated by the WoS platform [18].

In the current year, 2025, 6 publications have already been recorded, a fairly large number, considering that the year has just begun, demonstrating the growing interest in this topic.

The main correlations regarding the keywords "security", "hospitality" and "safety" were generated using the Vosviewer program, and can be seen in Figures 2 and 3, thus providing easy-to-follow maps showing the most debated topics and the correlations made by other authors using these keywords.

The maps emphasize the main terms, while the secondary terms remain in the background, forming clusters of word associations, and depending on the number of words and the strength of the association, these are larger or smaller, with the following standing out:

Cluster 1 (red) is the main cluster and is formed by 24 terms (attitudes, changing perceptions, competitive destination, crime, destination, destination risk, effect size, equity, familiarity, heritage brand equity dimensions, image, impact, international tourists, international visitors, model, perception, perceptions of safety, risk of crime, safety and security, service failure, service recovery, tourist, tourists perceptions, visitor) with a major relevance for the studied topic, as it includes fundamental concepts related to safety, security, risk perception and impact on tourism.

Analyzing the relevant key terms (safety and security, destination risk, crime, risk of crime, perceptions of safety, tourists' perceptions, service failure, service recovery) and the connections formed reflect the importance of safety measures in food and tourism locations to reduce the risks to which agritourism units and restaurants in rural areas are exposed, reflect the customer perception of the level of safety in a tourist unit and the impact of incidents on reputation and the necessary corrective measures.

The following can be deduced from the connections drawn up: a high level of safety is essential for attracting tourists and in rural areas, the perception of insecurity can affect the flow of visitors; safety incidents must be managed quickly to avoid damaging the image of the food or agritourism unit; crime and risk prevention through modern security systems and staff training is vital.

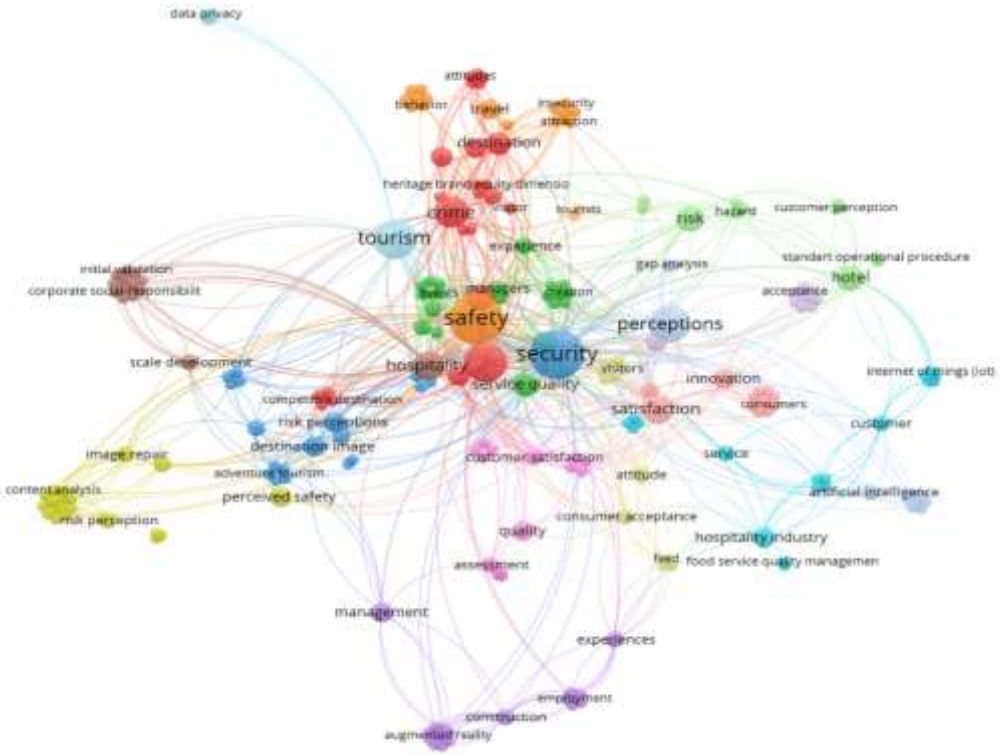

Fig. 2. Correlation map of the terms "*security", "hospitality" & "safety*"
Source: Own calculations based on data generated by the WoS platform and generated by VOSViewer[18].

Cluster 2 (green) with a focus on the hospitality industry and employee experience, consists of 21 terms (creation, economic-crisis, employees, events, experience, hospitableness, hotel management, hotels, human-resources, industry, lessons, loyalty, managers, service quality, space-to-face hospitality, spaces and places, spatial research, sport, sports mega events, tourism disaster, visual research methods) being very important for the topic studied.

This cluster is essential for human resource management and the impact of safety on personnel in the hospitality industry.

The terms that attract attention are hotel management, human-resources, managers, service quality, tourism disaster, employees, loyalty, all of which emphasize the management of personnel in the tourism and food industry, the correlation of safety with service quality and the relationship between workplace safety and employee loyalty.

It can thus be said that personnel safety directly influences productivity and service quality; staff training is crucial for preventing incidents in food and tourism units; work accidents or lack of protective measures can lead to a decrease in employee satisfaction and loyalty.

The third cluster (blue) consists of 19 terms (adventure tourism, challenges, cleanliness, crisis, critical review, destination image, everyday practice, hazard analysis, high street, information, line, man-machine-media-management (4m), personality, risk perceptions, safe places, safety system theory, security, social media, system) from the area of risk, safety and systems analysis, having a high relevance for the topic studied.

This cluster offers perspectives on risk analysis and safety systems, the most important terms being safety system theory, hazard analysis, security, risk perceptions, adventure tourism, crisis, critical review, referring to methods of risk analysis in the food and tourism industry, the relationship between risk perception and real security and the impact of risks in adventure tourism and crisis management.

Cluster 4 (yellow) also has 19 terms (bibliometric analysis, content analysis, crisis impacts, disaster management, financial crisis, global economic-crisis, globalization, image

repair, perceived hospitality, perceived risk, perceived safety, reception, regional distribution, risk perception, safety culture, security forces, synergistic factors, tourism crisis, world recession) focuses on the impact of crises on the food and tourism industry and on their management strategies with great importance for the subject of the article.

The most important terms (crisis impacts, disaster management, financial crisis, risk perception, perceived safety, safety culture) form links of crisis management in food and tourism units, the economic impact of the perception of insecurity on business and the creation of an organizational culture based on safety.

Thus, it can be argued that safety incidents can have a significant economic impact (financial losses, decrease in the number of customers); a clear crisis management strategy is essential to protect tourism and public foodunits; safety must be an integral part of the organizational culture to prevent incidents and minimize risks.

Cluster 5 (purple) consisting of 18 terms (agricultural-workers, augmented reality, conceptual-framework, construction, cyber-physical systems, employment, experiences, extent analysis method, industry 4.0, internet of things, management, meat, negative social interactions, occupational health and safety, occupational safety and health training, regulation, service innovation, virtual-reality) is very important because it focuses on modern technological solutions for physical and food security, the links between the main terms (augmented reality, internet of things (IoT), cyber-physical systems, occupational safety and health training, virtual reality, service innovation) refer to the use of advanced technologies in security, training personnel to reduce risks and finding digital solutions for security management.

These 5 clusters form a solid basis for the analysis of physical security management in public food and agritourism, with a focus on safety, risk perception, crisis management and the use of technology for protection.

After analyzing the main relevant clusters, it is important to analyze the other clusters, in order to understand how they can fit into the topic of physical security in public food and agritourism units.

Cluster 6 (light blue) consisting of 18 terms (accommodation, construct, customer, customer delight, customer value, delight grounded theory, food service quality management, HACCP principles, hospitality industry, internet of things (iot), logic, microcontroller, qualitative content analysis, sensor, service, value creation, web application, wi-fi module) has a direct link to food safety in public foodunits, an essential aspect of overall security.

The links between the main terms reflect the following: the implementation of HACCP standards is vital to prevent food contamination; IoT and smart sensors can be used to monitor the temperature and quality of ingredients; customer satisfaction is influenced by the perception of food safety, affecting the reputation of food units.

Cluster 7 (orange) includes 16 terms (attraction, behavior, event, incidents, insecurity, intention to experience, media, narratives, need-driven, pollution, predictors, preference, safety, tourism industry, transportation, travel) focuses on aspects related to tourist safety and risk factors in travel experiences.

From the analysis of the main terms and the formed links, the following can be stated: tourist behavior can influence the perceived level of safety in a destination; security incidents and lack of infrastructure can affect the attractiveness of an agritourism location; factors such as pollution and transport infrastructure are important for travel safety in rural areas.

Cluster 8 (brown) consisting of 14 terms (corporate social-responsibility, decent work, diversity management, employment quality, hospitality, hotel employees, human resource management, initial validation, job quality, micro social responsibility, performance, scale development, self-efficacy, sustainable tourism) has an indirect link with physical security, emphasizing social responsibility and work quality.

Cluster 9 (lilac) also including 14 terms (assessment, blockchain mobile payment service, consequences, corporate image,

criteria, customer, satisfaction, future, indicators, loyalty intention, physical environment, physical-environment, privacy and security, quality, rural tourism) focuses on customer experience and the impact of security on satisfaction.

From the analysis of the terms and the links between them, the following can be stated: a high level of security increases customer satisfaction and improves the company's image; rural tourism needs personalized security measures, adapted to the specifics of the region; data protection and cybersecurity are increasingly important in the hospitality industry.

Cluster 10 (pink) contains 12 specialized terms (behavioural perspective model, consumers, consumption, context, innovation, intention, liquid consumption, motivations, p2p hospitality, reasons for use, satisfaction, sharing economy) and addresses how consumers perceive safety and innovation in hospitality.

The result is that: safety influences the intention to visit a tourist destination or to return to a restaurant; business models in the collaborative economy must integrate security measures (e.g. agritourism farms).

Cluster 11 (light green) also contains 12 terms (customer perception, decision-making process, disease, emergency, employee perception, equipments of individual protection, framework, hazard, hotel, risk, standard operational procedures, tourist destinations) is closely related to emergency safety and risk management in tourism and hospitality, with high relevance for the analyzed topic.

Correlated with the first clusters, it forms links that support the following: emergency procedures are essential for the safety of customers and staff; protective equipment must be available and used properly in kitchens and serving areas; perception of safety influences tourists' decisions in choosing a destination.

Cluster 12 (blue-grey) consisting of 11 terms (adventure, artificial intelligence, comparative analysis, crisis management, disaster, gap analysis, hotel industry, information asymmetry, perceptions, risk-management, tourism safety) also has a medium relevance for the studied topic, focusing on the use of artificial intelligence for crisis management in tourism and hospitality.

Cluster 13 (light yellow) also contains 11 terms (attitude, consumer acceptance, country image, feed, food design, perspective, processed products, safety and security perception, tourists' perceptions, uncertainty, visitors) contributing to the understanding of how consumer perceptions and food safety influence the sustainability of public foodunits. Terms such as food design and processed products can be correlated with food safety standards applied in restaurants and agritourism units, and safety and security perception is an essential concept for establishing trust in public foodunits.

Cluster 14 (light purple) consisting of 9 terms (acceptance, electronic locking systems, innovations adoption, leader influence, organizational-change planners, radio frequency identification (rfid), rfid technology, technology) focuses on innovative technologies applied in security, such as RFID and electronic locking systems, which can be used for food facility security. The cluster highlights the impact of technology and innovation in physical security management, including measures such as access monitoring and theft prevention.

Cluster 15 (bleu), the penultimate in size, consisting of 5 terms (data privacy, data safety, data security, destination patronage, tourism) is more technological, referring to data protection and digital safety. Although this cluster is closer to digital security, data protection issues can influence customer trust in electronic reservation and payment systems in restaurants and guesthouses.

The last cluster 16 (light orange) consisting of only 2 terms (tourists, vulnerability) although very small, is important because it highlights the vulnerability of tourists in the context of safety. The link between safety and the perception of vulnerability is crucial in rural hospitality, where infrastructure may be less developed. The cluster highlights the fact that tourists perceive different levels of safety depending on the location, which can influence the flow of visitors and the success of public food and agritourism units.

Thus, the analysis can be summarized as follows:

- The main clusters (Cluster 1 - red and Cluster 2 - green) highlight the fact that the perception of safety is a determining factor in the choice of tourist destinations and in customer satisfaction. In rural areas, where infrastructure may be less developed, a solid risk prevention and management strategy contributes significantly to the attractiveness of public food and agritourism units.
- Cluster 5 (purple) and Cluster 14 (light purple) highlight the role of emerging technologies, such as IoT, RFID and cyber-physical systems, in strengthening safety in tourist units. The digitalization and automation of security processes not only increase protection, but also contribute to increasing consumer confidence in the services offered.
- Cluster 4 (yellow) and Cluster 8 (brown) highlight the fact that employee and customer safety must become an integral part of the organizational culture in the hospitality industry. Protective measures, continuous training of personnel and the creation of clear crisis management procedures can prevent incidents and minimize their impact on businesses.

The graphical representation of the density made with the help of VOSviewer highlights the terms or keywords that appear most frequently in the bibliographic analysis or in the specialized literature in the studied field. Through the frequency of these words, the density map shows the areas of interest or research topics considered more significant and relevant. In the context of the analyzed subject, the following representative keywords were identified: security, safety, hospitality, managers, satisfaction, tourism, satisfaction (Figure 3).

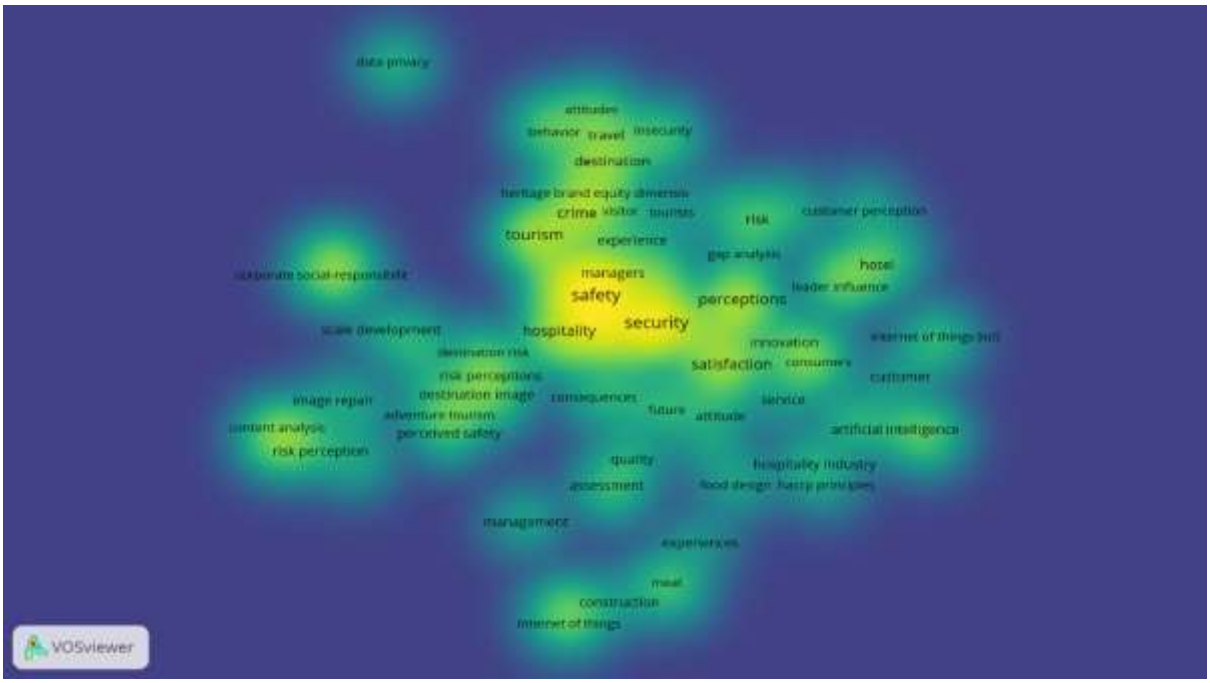

Fig. 3. Density map analysis – Physical security management in the safety and sustainability of public food and agritourism units

Source: Own calculations based on data generated by the WoS platform and generated by VOSViewer[18].

"Security and Safety" (the intense yellow area) is the most important conceptual core of the map, where the terms: security, safety, service quality, perceptions are found. This area is the densest, which suggests that the specialized literature focuses strongly on the relationship between security, safety perceptions and service quality in the hospitality and agritourism industries.

"Hospitality Industry and Risk Perception" - medium density area – this area includes terms such as hospitality industry, satisfaction, risk perceptions, customer perception. Although less dense than the central area, it

suggests that the perception of safety influences both customer decisions and the competitiveness of tourism units. Units that invest in safety measures can have a competitive advantage in the market.

"Technology, Innovation and Management" - low density areas - includes terms such as artificial intelligence, internet of things (IoT), augmented reality, management, construction and It indicates an emerging interest in the impact of technology on security management in the hospitality industry. That is, automation and digitalization contribute to improving safety and optimizing operations in public food units and rural tourism.

The bibliometric analysis highlights that physical security management is a fundamental pillar in the sustainable development of public food units and rural agritourism. Integrating safety measures, using modern technologies, and creating an organizational culture based on prevention contribute to increasing customer trust, loyalty, and competitiveness in the hospitality industry.

Analysis of the role of physical security management in public food and agritourism units for the development of the rural environment

In order to establish whether there is a correlation between effective physical security management in public food and agritourism units and rural development, the following hypothesis was formulated: **"The existence of effective physical security management in public food and agritourism units in rural areas is correlated with a high level of sustainability and local economic development."**

Physical security in rural areas, main challenges and particularities. The rural environment differs quite a lot from the urban one, having a substantial growth potential and playing a vital social role in the social and economic life of each country, but with regard to security in hospitality industry units and the services offered, the biggest challenges they face are related in particular to:

-Reduced accessibility to technology – compared to urban areas, public food and agritourism units in rural areas have more limited financial resources for investments in advanced security systems [2], [14].

-Lack of trained personnel – in many rural communities, personnel do not have access to specialized security training, which can increase associated risks [1], [16].

-Reliance on interpersonal relationships – in rural areas, social relationships are fundamental, and mutual trust plays an essential role in ensuring safety [13], [8].

-Exposure to specific risks – risks include fires, theft, vandalism, but also emergencies caused by natural factors [19].

The link between security and sustainability. Security in the hospitality industry is an essential element of sustainable development, impacting customer trust, cost optimization and corporate social responsibility.

Increasing customer trust and loyalty. Guests prefer units that offer a safe environment, which helps strengthen the brand image and attract a greater number of visitors [13].

Optimizing costs and reducing losses. Implementing preventive measures, such as video surveillance and cybersecurity, helps to reduce the risks associated with theft and incidents, thus reducing unforeseen expenses [19].

Supporting corporate social responsibility (CSR). Prioritizing safety reflects the commitment of units to employees and the community, contributing to balanced development and compliance with the principles of sustainability [17].

Research shows that safety is a key criterion in choosing tourist destinations, and emerging technologies, such as artificial intelligence and automation, are improving the security of hospitality units [2].

Effective strategies for ensuring a safe environment include:

-Implementing monitoring systems and using advanced technologies to prevent incidents [14].

-Training employees in emergency management and safety compliance [1].

-Adopting international standards, such as ISO 22000 for food safety and ISO 45001 for occupational safety [17].

By integrating these measures, hospitality units not only improve their security but also contribute to the sustainable development of the industry.

In our country, statistical data shows a clear link between security and the development of rural businesses, influencing both the increase in the number of tourists and the attraction of investments.

Increasing the number of tourists in counties with developed tourism infrastructure. According to the National Institute of Statistics (2021), counties with a well-secured tourism infrastructure, such as Sibiu, Brașov and Maramureș, have recorded a significant increase in the number of tourists in recent years [7].

Attracting investments in rural areas with low crime rates. Rural areas with a low crime rate are more attractive for investments in agritourism, thus contributing to local economic development [3]. Reports on rural tourism indicate that regions with more effective security measures benefit from more funds and development projects.

Guesthouses that have implemented security measures, such as video surveillance systems and partnerships with local authorities, have reported an increase in bookings by 15-30% [5]. Accommodation units that have invested in improving security and infrastructure have been able to attract European funds, thus facilitating the economic development of local communities [3].

Analysis of data and specialized literature confirms the hypothesis that "**The existence of effective physical security management in public food and agritourism units contributes to increasing sustainability and local economic development.**"Businesses that prioritize security have a competitive advantage, attract more tourists and ensure stable economic growth.

CONCLUSIONS

The analysis of the specialized literature confirms the importance of physical security management in the sustainable development of public food and agritourism units in rural areas. The main findings highlight:

1. Physical security plays an essential role in the perception of the quality of the services provided and in customer loyalty. Units that implement effective security measures benefit from a better reputation and attract a greater number of tourists.
2. The use of modern technologies, such as artificial intelligence and video monitoring systems, significantly contributes to preventing risks and increasing the attractiveness of rural tourist destinations. The digitalization of security measures offers effective solutions for incident management and reducing vulnerabilities.
3. The adoption of international security standards improves the sustainability and competitiveness of hospitality units. The integration of clear security protocols supports both the protection of tourists and the long-term development of businesses in the rural sector.
4. The bibliometric analysis highlights the direct correlation between physical security and the perception of service quality, demonstrating that safe and well-managed public foodunits attract more customers and ensure their loyalty. Also, the integration of modern technologies (AI, video monitoring) improves safety and reduces the risks perceived by customers. In rural areas, the adoption of clear security policies increases competitiveness and contributes to the sustainability of tourist destinations.
5. The evaluation of the hypothesis confirms that effective physical security management has a positive impact on local sustainability and economic development. Businesses that prioritize safety benefit from a competitive advantage, attract more tourists and contribute to the stable economic growth of the region.

These conclusions emphasize the need for a strategic approach to physical security management, adapted to the rural specifics, and highlight the positive impact of technologies and regulations in this area.

REFERENCES

[1]Baum, T., 2015, Human Resource Management for Tourism, Hospitality and Leisure: An International Perspective. Cengage Learning.

[2]Buhalis, D., Darcy, S., 2011, Accessible Tourism: Concepts and Issues. Channel View Publications.
[3]Camera Deputaților. Deputy Chamber, 2020, Aspecte privind turismul rural, balnear și în ariile protejate (Aspects regarding rural and balneary tourism and in the protected areas),https://www.cdep.ro/intranet/docs_dip/13445_turism%20rural_balneo_arii%20protejate%20%281%29.pdf?utm, Accessed on 5 January 2025.
[4]Epuran, G., Dovleac, L., Ivasciuc, I., Tescasiu, B., 2015, Sustenability and Organic Growth Marketing: an Exploratory Approach on Valorisation of Durable Development Principles in Tourism. Amfiteatru Economic. 17. 17-927.
[5]Guvernul României, Romania's Government, 2019, Strategia națională a României pentru dezvoltarea turismului 2019-2030 (National strategy of Romania for tourism development 2019-2030, https://sgg.gov.ro/1/wp-content/uploads/2020/09/Strategia-de-Dezvoltare-Turistic%C4%83-a-Rom%C3%A2niei-volumul-1-Raport-privind-Evaluarea-rapid%C4%83-a-sectorului-turistic.pdf?utm, Accessed on 5 January, 2025.
[6]Ilie-Ramona, 2024, Moldova Invest, https://moldovainvest.eu/romania/suceava/ce-impact-ar-avea-ai-in-transformarea-industriei-ospitalitatii-si-exemplul-de-succes-al-bucovinei-in-turismul-romanesc/, Accessed on January 5, 2025.
[7]Institutul Național de Statistică 9National Institute Of Statistics, 2021, Capacitatea de cazare turistică existentă la 31 iulie 2021. (Capacity of tourist accommodation existing at 31 July 2021), https://insse.ro/cms/sites/default/files/field/publicatii/capacitatea_de_cazare_turistica_existenta_la_31_iul_2021.Accessed on 5 January 2025.
[8]Lashley, C., 2015, Hospitality and Society. Routledge.
[9]Ministerul Antreprenoriatului și Turismului, Strategia siguranţei şi securităţii alimentare a României 2023-2035 (Ministry of Entrepreneurship and tourism, Strategy for food securirty and safety of Romania 2023-2035), SNRDT-actualizat-var-pt-HG-2023-2035, https://turism.gov.ro/web/wp-content/uploads/2022/11/SNRDT-actualizat-var-pt-HG-2023-2035.pdf, Accessed on 5 January 2025.
[10]Nafrees, A. C. M., Kariapper, A., Ponnampalam, P., Razeeth, S., 2021, Internet of Things (IoT) enabled Food Technologies: A systematic review approach. 2. 6-13.
[11]National Fire Protection Association (NFPA), Fire Prevention Standards for Commercial Buildings. https://www.nfpa.org, Accessed on 5 January 2025.
[12]Otiman, P.I., 2014,Strategia siguranţei şi securităţii alimentare a României (Strategy for food security and safety of Romania), chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://acad.ro/viataAcademica/doc2015/i0307-StrategiaAgroalimRo-PIOtiman.pdf, Accessed on 5 January 2025.
[13]Pizam, A., Mansfeld, Y., 2006, Tourism, Security, and Safety: From Theory to Practice. Butterworth-Heinemann.
[14]Sigala, M., Christou, E., Gretzel, U., 2012, Social Media in Travel, Tourism and Hospitality: Theory, Practice and Cases. Ashgate.
[15]Tariq, U., Ahmed, I., Bashir, A. K., Shaukat, K., 2023, A Critical Cybersecurity Analysis and Future Research Directions for the Internet of Things: A Comprehensive Review. Sensors, 23(8), 4117. https://doi.org/10.3390/s23084117
[16]UNWTO, 2022, Tourism and Rural Development: A Policy Perspective.
[17]UNWTO, 2022, Tourism and Safety: A Global Perspective.
[18]VOSViewer
[19]Wilks, J., Pendergast, D., 2018).Tourism Safety and Security: Research Anthology. CRC Press.
[20]YstMedia,https://ystmedia.ro/inovatie-si-excelenta-in-industria-hoteliera-strategii-esentiale-pentru-succes/, Accessed on 5 February 2025.

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OPTIMIZING MOLDOVA'S AGRI-FOOD SUPPLY CHAINS FOR THE INTEGRATION INTO THE EUROPEAN UNION

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Abstract

Moldova's agri-food sector faces significant supply chain challenges as it prepares for deeper European Union (EU) market integration. This study evaluates Moldova's logistics performance and infrastructural connectivity in a regional context, drawing on World Bank's Logistics Performance Index (LPI) data. The findings reveal that Moldova ranks low on LPI (97th out of 139 in 2023) with critical bottlenecks in customs clearance and transport infrastructure . Road and rail connectivity constraints—exacerbated by outdated infrastructure and limited port access—impede efficient trade flows. Case studies from Eastern Europe illustrate how targeted logistics optimization, digital transformation, and cooperative business models can enhance supply chain performance. Drawing on best practices from new EU member states and candidates, the analysis underscores that aligning with EU food safety and phytosanitary regulations is both a major challenge and an achievable goal. Strategic investments in infrastructure, adoption of digital logistics systems, and capacity-building for standards compliance emerge as pivotal solutions for Moldova's agri-food supply chains to compete in the EU single market.

Key words**:** *agri-food supply chain, logistics performance index, transport infrastructure, EU Integration, Food safety compliance, Digital Transformation, cooperatives, Republic of Moldova*

INTRODUCTION

Moldova's agri-food industry is a cornerstone of the national economy and a key driver of export earnings, yet its supply chains must overcome significant hurdles to integrate with the European Union (EU) market. In recent years, Moldova has pursued closer economic ties with the EU, culminating in a Deep and Comprehensive Free Trade Area (DCFTA) and candidacy for EU membership [16, 2]. These developments present both opportunities and obligations: local agri-food producers gain preferential access to a vast market, but they also face stricter logistics efficiency requirements and rigorous EU food safety and phytosanitary standards [5, 21, 13]. This research addresses the critical question of how Moldova can optimize its agri-food supply chains to meet the demands of EU integration. We combine an analysis of international logistics performance benchmarks with firm-level insights from Moldovan agri-food companies to provide a comprehensive, data-driven assessment.

Prior research highlights that Moldova's agri-food sector continues to confront substantial structural and logistical barriers, including fragmented agricultural production, limited infrastructure, and insufficient compliance with EU regulations [17, 22]. Moreover, ensuring sustainable development and food security remains a crucial objective, reinforcing the urgency to address these challenges systematically [5, 19].

Trade facilitation indicators consistently rank Moldova behind its neighbors Romania and Ukraine, reflecting chronic issues in transport infrastructure, border management, and supply chain coordination. These inefficiencies are not merely theoretical – they exact real costs on exporters. For example, preparing export documentation in Moldova takes 48 hours on average, versus less than 2 hours in the EU; consequently, the median export transaction time is nearly *12 times longer* than in neighboring EU countries [4]. Such delays undermine competitiveness and highlight the urgency of modernization. Furthermore, as an agrarian economy, Moldova depends on efficient farm-to-market logistics for high-

value produce like fruits, vegetables, and wines. Any bottleneck – whether potholed roads, scarce refrigerated storage, or slow customs clearance – can erode product quality and reliability, impeding market access.

In this context, the purpose of the paper is to evaluate Moldova's current agri-food supply chain challenges, analyze regional logistics and infrastructural gaps, and identify strategic solutions drawn from EU integration experiences of comparable Eastern European countries. The aim is to provide evidence-based recommendations for improving Moldova's logistical performance, institutional capacities, and compliance with EU standards to facilitate competitive integration into the European Union agri-food market.

MATERIALS AND METHODS

This paper is structured to first evaluate Moldova's current logistics performance and infrastructure connectivity, then examine case studies of successful supply chain enhancements in comparable contexts, and finally discuss the gaps and reforms needed for EU compliance.

Section 2 reviews Moldova's LPI rankings and pinpoints logistics bottlenecks relative to regional benchmarks.

Section 3 analyzes the state of transport routes (road, rail, and port) linking Moldovan producers to EU markets.

Section 4 discusses EU integration challenges – notably aligning with EU food safety, quality, and phytosanitary regulations – and draws on best practices from similar economies to propose solutions. The conclusions synthesize these findings, emphasizing strategic priorities for policymakers and industry stakeholders to strengthen agri-food supply chains in the lead-up to EU accession.

RESULTS AND DISCUSSIONS

Logistics performance and benchmarking

Several studies indicate that Moldova's logistical inefficiencies negatively affect its agri-food export competitiveness, especially compared to its regional peers [17, 21, 22]. These structural limitations directly translate into delays, increased transaction costs, and diminished product quality for perishable goods, highlighting the pressing need for investments in logistics infrastructure and technology [19, 22]. As emphasized by recent analyses, the underdeveloped cold-chain storage capacities and inadequate transport infrastructure substantially weaken Moldova's export potential [17, 19].

A useful starting point for assessing Moldova's supply chain readiness is the World Bank's Logistics Performance Index (LPI), a multidimensional measure of trade logistics efficiency. The LPI scores countries on a scale from 1 (lowest) to 5 (highest) across components such as customs efficiency, infrastructure quality, international shipment ease, logistics competence, tracking and tracing, and timeliness. In the latest LPI (2023), Moldova's overall score is 2.5, placing it 97th out of 139 countries. This ranking trails all EU member states and several regional peers [4]. By comparison, Romania scored 3.2 (approximately in the top 50 globally), and Ukraine scored 2.7 (rank ~79th) despite the disruptions of conflict [1].

Table 1. LPI Score (2023) – Moldova vs. Regional Peers

Country	Overall LPI	Customs	Infrastructure2015	International Shipments	Logistics Competence	Tracking & Tracing	Timeliness
Moldova (MD)	2.5	1.9	1.9	2.7	2.8	2.8	3.0
Ukraine (UA)	2.7	2.4	2.4	2.8	2.6	3.1	2.6
Georgia (GE)	2.7	2.6	2.3	2.7	2.6	3.1	2.8
Romania (RO)	3.2	2.7	2.9	3.4	3.3	3.6	3.5

Source: developed by the author based on World Bank Data, LPI [1, 26, 2].

Table 1 summarizes LPI indicators for Moldova and select regional benchmarks, highlighting Moldova's lag in key areas.

Moldova shows the lowest logistics scores, notably in Customs and Infrastructure.

Moldova's weakest points are customs clearance and infrastructure, both scoring only 1.9 out of 5 in 2023 (ranked near the bottom globally at ~132–133rd) [1]. This indicates systemic problems in border procedures –

lengthy paperwork, physical inspections, and coordination issues among border agencies – as well as inadequate transport infrastructure [14]. By contrast, Moldova's scores in logistics competence, tracking, tracing, and timeliness are somewhat higher (around 2.8–3.0), suggesting that once goods are past the border and on domestic soil, the professionalism of logistics services and ability to meet delivery schedules are closer to regional norms. Nonetheless, even these aspects significantly trail EU standards. For instance, Romania's tracking & tracing score of 3.6 far exceeds Moldova's 2.8, reflecting Romania's more advanced adoption of digital tracking systems in freight transport [26].

Notably, Moldova has made incremental progress – its LPI rank improved from 116th in 2018 to 97th in 2023– but it remains an *outlier* in Eastern Europe. Within the Europe & Central Asia region, Moldova has one of the lowest LPI scores. World Bank analysis [1] confirms that Moldova scores lower than Belarus, Georgia, and all EU neighbors on every LPI component, underscoring a broad performance gap. These data align with the lived experience of firms: according to the Enterprise Surveys, 35% of large firms in Moldova identified transportation as a major business constraint, the highest share in the sub-region [4]. The consistency between macro-level indices and firm perceptions reinforces the urgency of tackling logistics bottlenecks.

Several factors drive Moldova's underperformance. One is border management inefficiency. Despite reforms such as e-declaration systems, Moldova's customs procedures remain a serious bottleneck, with duplicate checks and long queues at checkpoints causing 2–3 day delays at busy borders. In 2018, Moldova ranked last among Eastern European peers on the LPI Customs index [4]. Another factor is the historical underinvestment in transport infrastructure. Decades of neglect and limited budgets have left roads in poor condition and railways deteriorating. Logistics infrastructure (e.g. warehouses, cold storage) is among the least developed in post-Soviet countries. Most storage facilities are outdated Soviet-era buildings repurposed as warehouses, with virtually no modern temperature-controlled logistics centers. Until recently, even basic cold chain capacity was insufficient – only 250 out of 633 cold storage facilities in the country have pre-cooling, and a mere 46 have sorting/grading equipment for produce [4]. This limits exporters' ability to maintain quality for perishables. Moreover, third-party logistics providers are scarce; many producers and retailers operate their own trucks and storage, resulting in fragmented, sub-scale logistics operations.

Overall, the LPI analysis reveals a logistics performance divide that Moldova must bridge to join the EU single market on competitive terms. Improvements in customs facilitation and infrastructure are particularly critical. The next sections delve deeper into these areas by examining Moldova's transport routes and physical connectivity, and by exploring how peer countries have tackled similar challenges.

Transportation-infrastructure and access to routes

Geography and infrastructure profoundly shape agri-food supply chains. Moldova is a small, landlocked country, bounded by Ukraine to the north and east and Romania (EU) to the west. Lacking direct sea access apart from a short Danube River segment in the far south, Moldova relies on overland corridors – road and rail – to connect to seaports and EU markets [25]. This section evaluates Moldova's principal transportation routes, identifying critical limitations and areas for improvement in road, rail, and port connectivity [7].

-Road network.

Roads carry the majority of Moldova's domestic and international freight. The country's road network handles farm-to-market transport within Moldova and links producers to border crossings and ports abroad. Key highways connect the capital Chișinău and regional centers like Bălți to Romania and Ukraine. However, road quality is a persistent concern. Many sections suffer from poor pavement, insufficient maintenance, and capacity bottlenecks (e.g. single-lane stretches) which slow down transport and raise vehicle operating costs. The freight cost for dry goods

in Moldova (non-temperature-controlled) ranges from about US$1.2 to $1.4 per truck-km, significantly higher than the regional benchmark, largely due to *bad road conditions* increasing fuel and maintenance costs [3, 4]. By contrast, in neighboring EU countries, road freight costs per km are considerably lower under better infrastructure conditions. Upgrading critical trade corridors – such as the routes from Chișinău to the Romanian border – is thus paramount. Moldova has begun addressing this through projects with international partners (e.g. rehabilitating the M1 and M2 highways), but the network remains patchy. Additionally, border crossing infrastructure on roads is problematic: limited processing lanes and lack of joint controls with neighbors lead to long queues. Trucks often wait many hours (or days, in peak season) at major border points like Leușeni–Albita (to Romania) due to congested facilities and complex procedures. Improving border infrastructure and procedures (e.g. joint customs control, more inspection bays, weight stations) would markedly reduce transit times.

-Railway connectivity

Moldova's Soviet-built railway system has deteriorated to a point where it handles only a small fraction of freight traffic today. The state rail operator Moldovan Railway ("Calea Ferată din Moldova" - CFM) oversees about 1,200 km of track, much of which is in need of rehabilitation. Nearly 45% of railway tracks are past their service life and fully depreciated, and 60% of rolling stock (locomotives and wagons) is obsolete [4]. Aging infrastructure imposes severe speed restrictions and reliability issues – there is a wagon shortage (only ~63% of needed wagons are available) and frequent locomotive breakdowns. As a result, rail transport in Moldova has fallen out of favor except for low-value bulk commodities (e.g. minerals, grain) that are less time-sensitive. This is problematic because efficient rail could otherwise be a cost-effective mode for long-haul export shipments (especially for bulky agri-food products, like grain or bottled wine, destined for seaports).

Map 1. Moldova's railway network, showing main lines and connections to Ukraine (UA) and Romania (RO). Much of the network requires rehabilitation, and links through Transnistria in the east are non-operational, limiting access to Ukrainian Black Sea ports.
Source: Railway map of Moldova. Image: Wikimedia Commons. © Maximilian Dörrbecker [6]

Moldova's rail connectivity is further complicated by geopolitics and differing rail gauges. The main Soviet-gauge lines traditionally gave access eastward to Ukrainian Black Sea ports, especially Odesa. However, the historical route from Chișinău to Odesa via Transnistria is currently closed due to the Transnistria separatist region, forcing all rail cargo to detour or switch to trucks. In practice, most Moldovan export cargo headed to Odesa port is now moved by road rather than rail. Westward, Moldova has a rail link to Romania at Ungheni (on the Iași–Chișinău line), but the break-of-gauge (former Soviet 1,520mm to EU standard 1,435mm [20]) necessitates either bogie exchange or transloading at the border, incurring delays and costs. These technical and political barriers mean that rail carries a negligible share of high-value agri-food exports. Without major investments – such as track rehabilitation, modernization of rolling stock, and perhaps installing dual-gauge segments or new interoperable rail links to Romania – Moldova's rail will remain a secondary transport option. Plans are

underway to restructure CFM and adopt a new Railway Code aligned with EU practices, which could open the sector to investments and improve service in the long run.

-Port access

Being landlocked, Moldova depends on foreign seaports for overseas trade [8]. There are three primary port options: Odessa and Chornomorsk in Ukraine, and Constanța in Romania (on the Black Sea), in addition to Moldova's small domestic Danube port at Giurgiulești. Each comes with limitations. Historically, Odessa (Ukraine) was the transit point for much of Moldova's containerized and bulk exports, due to geographic proximity (~200 km from Chișinău) and established logistics [24]. Since the outbreak of war in Ukraine, however, access to Odessa/Chornomorsk has been constrained or made risky, pushing Moldova to re-route more trade via Romania. Giurgiulești, located at the southern tip of Moldova where it touches the Danube, is the country's only seaport. While a strategic asset, Giurgiulești International Free Port is relatively small – it can handle barges and smaller seagoing vessels on the Danube, and has facilities for grains, oil products, and containers, but its throughput is limited. Moreover, Giurgiulești lacks direct rail connections to the rest of Moldova's rail system (cargo must be trucked to the port) and until recently had infrequent feeder barge services to bigger ports. Even when used, shipments via Giurgiulești often require a transshipment at Constanța (Romania) to reach ocean-going ships, adding 3–4 days transit and extra cost [4]. Constanța, on the other hand, is a large deep-sea port with direct ocean access and has become more prominent for Moldovan trade during the Ukraine conflict. The downside is distance and transit time: routing through Constanța entails a longer overland journey (whether by road or rail via Romania) and border crossings. It typically adds several days of transit compared to Odessa in peacetime.

Moldova's physical connectivity challenges include: inadequate road quality increasing transport costs and unpredictability; a moribund rail system that fails to offer a viable alternative for most exporters; and reliance on external ports with attendant political and logistical vulnerabilities. Potential areas for improvement are clear. On roads, investments in trade corridors and border facilities will yield immediate benefits by cutting delay and cost. On rail, pursuing the ongoing reform and selectively upgrading critical links (for instance, rehabilitating the north-south rail to Giurgiulești or developing intermodal hubs) could gradually shift more freight to rail. There are early positive signs – in 2023, emergency initiatives like the EU's "Solidarity Lanes" [9] have funded upgrades to rail links and Danube navigation to help Moldova and Ukraine maintain exports. Over the long term, integrating Moldova into the Trans-European Transport Network (TEN-T) – as envisaged by recent EU plans – would systematically address these connectivity gaps [15].

Case studies: logistics optimization and cooperative models

To chart a path forward, Moldova can draw lessons from other countries that have modernized agri-food supply chains under similar conditions. This section highlights a few case studies from Eastern Europe focusing on logistics optimization, digital transformation, and cooperative enterprise models. These examples demonstrate how targeted interventions can yield improvements in efficiency, market access, and compliance – outcomes highly relevant for Moldova's EU integration ambitions.

Digital transformation in agri-food Supply Chains. Across Central and Eastern Europe, agri-food companies are increasingly adopting digital technologies to streamline their supply chains. A recent multi-country study by Szegedi et al. (2022) [23] surveyed over 100 companies in the region and found that businesses expect digital transformation to significantly enhance logistics and marketing performance. The primary drivers for going digital were *quality improvement, market demand,* and *technology push*, while anticipated benefits included better sales and customer relations, followed by gains in logistics (e.g. improved inventory management, tracking) and production efficiency. This suggests that even medium-sized food processors see value in tools like

enterprise resource planning (ERP), real-time shipment tracking, and online marketplaces. In practice, some Eastern European agribusinesses have implemented digital supply chain platforms with notable success. For instance, in Serbia an EU-supported project recently established an integrated electronic food safety and traceability system that connects all inspection agencies on one platform, as mentioned by EU support for food chain in Serbia [10].

This system allows authorities and producers to instantly verify a product's origin, safety certifications, and export eligibility, greatly accelerating compliance checks. Within months of launch, Serbia reported more efficient inspections and improved confidence in export documentation, facilitated by the EU's €1.3 million investment in the underlying IT system. Moldova can take inspiration from such initiatives – indeed, the government has begun developing a National Single Window for trade and piloting digital tools in customs, but progress has been slow [4]. Accelerating digitalization (e.g. e-logistics portals, blockchain traceability for wine and organic products, mobile apps linking farmers to buyers) could leapfrog many of Moldova's legacy problems by reducing human error, increasing transparency, and integrating small producers into larger networks [3].

Logistics Hubs and cooperative storage. Another optimization approach is the development of logistics hubs or cooperatively owned storage and distribution centers. Fragmentation is a major issue in Moldova – thousands of small farms and processors, each trying to organize transport individually, cannot achieve economies of scale. In countries like Poland and Lithuania, agricultural cooperatives have transformed this landscape. Several case studies in EU new member states show that cooperatives can *improve market efficiency and bargaining power* for farmers [11]. For example, cooperative groups in Poland and Hungary have challenged monopolistic intermediaries by collectively marketing and transporting produce. In Lithuania, dairy farmer cooperatives jointly invested in milk chilling and freight services, ensuring daily collection routes reach even small farms, which solved the problem of difficult access to processing for smallholders. Similarly, cooperatives in Slovakia and Bulgaria have enabled small farmers to access markets by sharing the costs of transportation and storage. These models are instructive for Moldova, where small-scale producers dominate the horticulture and dairy subsectors. By forming producer groups or logistics cooperatives, farmers could pool resources for better trucking services, consolidate loads to fill containers bound for the EU, or jointly operate modern cold storage facilities that none could afford individually. Not only does this reduce per-unit transport costs, it also improves product quality (through proper post-harvest handling) and consistency of supply volumes – factors crucial for attracting large EU buyers. Strengthening cooperative business organization can thus be a powerful tool to optimize logistics from the bottom up.

Public-Private Partnerships in infrastructure

Upgrading national logistics often requires coordination between government and industry. A case in point is Romania's experience in the 2000s. In preparation for EU accession in 2007, Romania heavily invested in its highway network and border infrastructure, aided by EU pre-accession funds and PPP arrangements. One notable initiative was the development of the Constanța port and intermodal facilities which today serve not only Romania but also landlocked neighbors. Although Romania still faces infrastructure gaps, its LPI infrastructure score (2.9) is considerably higher than Moldova's 1.9, reflecting sustained improvements [4]. The Moldovan government, with support from international donors, is pursuing similar projects – for instance, rehabilitating the M3 road to better connect Giurgiulești port and implementing output-based contracts for road maintenance [4]. These efforts need to be scaled up and paired with logistics service development (such as encouraging modern 3PL providers to enter the Moldovan market). The creation of inland logistics centers at strategic locations (near Chișinău or Bălți) through PPPs could provide integrated services

like warehousing, consolidation, and customs brokerage, which would especially benefit agri-food exporters who often lack dedicated logistics departments. In all these cases, a common thread is capacity building – whether technological, organizational, or infrastructural. Eastern European examples demonstrate that improvements in supply chain performance are achievable through concerted action. The challenge is translating this interest into concrete projects, which often requires initial public investment or donor support to overcome coordination failures.

Integration of the Republic of Moldova into the European Union: challenges and pathways to compliance.

Meeting the stringent EU sanitary and phytosanitary (SPS) standards remains one of Moldova's most challenging tasks. Despite legislative harmonization efforts, the actual implementation and enforcement of these standards have significant shortcomings, contributing to high rejection rates of Moldovan agri-food exports at EU borders **[**5, 19, 22]. Previous research suggests that enhancing diagnostic capacities, introducing robust traceability systems, and adopting comprehensive quality management practices are essential steps towards mitigating these compliance issues [19, 22]. Moreover, successful models from other Eastern European countries demonstrate that strategic investments in infrastructure and certification processes significantly boost compliance readiness and facilitate smoother integration into the EU market [16, 21, 22].

Successfully integrating into EU agri-food markets demands more than efficient logistics; it requires meeting stringent EU regulatory standards for food safety, plant and animal health (SPS measures), and quality. For Moldovan producers and exporters, the compliance challenge is significant. Yet, several peer countries have navigated similar transitions, offering valuable lessons. In this section, we examine the main EU integration hurdles for Moldova's agri-food supply chains and discuss solutions and best practices to address them.

Sanitary and phytosanitary (SPS) standards. The EU's "farm-to-fork" regulations cover everything from pesticide residues on fruits to hygiene in dairy processing plants. Moldovan products must align with these standards to gain full access to the EU market. Currently, gaps in compliance and enforcement are evident. Many Moldovan farmers and food processors have limited knowledge of EU technical requirements. Critical elements of the safety infrastructure – such as accredited laboratories for testing and traceability systems for animal products – are still developing. The National Food Safety Agency (ANSA) has been working to harmonize Moldova's SPS regulations with EU law, adopting thousands of pages of EU directives into national legislation. However, implementation capacity remains weak: laboratory diagnostics capabilities and product traceability mechanisms *"remain low"* [4]. For example, ensuring full traceability from farm to retail (a core EU requirement) is difficult when many small farmers sell through informal channels. A telling indicator is border rejections – over 2010–2022, an increasing share of Moldovan food exports were rejected by EU border controls due to safety issues, reaching 50% of all rejections in 2022 (the rest being mostly by the US) [18]. This trend underlines that while the EU is now Moldova's main export destination, meeting its standards is an ongoing struggle.

Compliance best practices. Other Eastern European countries provide models for strengthening SPS compliance. A common strategy is to upgrade testing and certification infrastructure with EU assistance. For instance, prior to EU accession, countries like *Latvia and Bulgaria invested heavily in modern laboratories* and obtained international accreditation for their testing facilities, often through twinning projects with EU member state agencies. Moldova is following suit: new testing labs (for example, for animal health and food quality) have been established or upgraded in Chișinău, but ensuring they operate to EU-recognized protocols is key. Another best practice is implementing comprehensive on-farm quality schemes. *Poland's experience* in the dairy sector is illustrative – with government incentives, thousands of small dairy farmers adopted EU-

compliant milk handling practices (cold storage at farm, regular veterinary checks) well before accession, facilitated by dairy processors who provided training and equipment [11]. This kind of value-chain approach (lead firms mentoring their suppliers) could be replicated in Moldova's fruit and vegetable sector, where exporters help their network of growers achieve Global G.A.P. certification for orchards and fields. Notably, several Moldovan companies are already moving in this direction – e.g. a large horticultural exporter has introduced a private standard for its apple suppliers, including pesticide use monitoring and harvest handling guidelines, to ensure the entire supply meets EU norms. Scaling such initiatives would improve overall compliance readiness.

Institutional reforms and EU support. Government agencies play a critical coordinating role. Negotiating equivalence agreements (whereby the EU recognizes Moldova's control systems as equivalent) can smooth trade in sectors like dairy, meat, or eggs. A recent success story is Moldova's first authorization to export class-A eggs to the EU in 2024, achieved by the George Standard poultry factory after it implemented EU-standard biosecurity and traceability measures [12]. This milestone – the result of investments in modern facilities and close work with veterinary authorities – shows that compliance is feasible. To replicate it broadly, Moldova must continue aligning regulations (Chapter 12 of EU acquis on food safety) and improve inspection regimes. The Serbian case again offers inspiration: Serbia's introduction of an integrated food safety information system, mentioned earlier, was explicitly aimed at fulfilling EU accession Chapter 12 requirements [10]. The EU provided funding and expertise for that project, acknowledging that building such systems has high returns for both candidate country and EU (safer imports, less border friction). Moldova is receiving similar support under various EU programs and the recently launched EU Solidarity Program – for example, EU experts have been advising ANSA on risk-based inspection and residue monitoring programs, and funds have been allocated for new border inspection posts that meet EU specifications. Ensuring these initiatives are fully implemented and staffed with trained inspectors will be crucial so that, when Moldova is assessed for EU entry, its food safety control system is deemed robust.

Market access and knowledge. Beyond regulations, Moldovan producers must also adapt to market-driven standards and logistics norms in the EU. Retail chains in the EU often have strict requirements for packaging, labeling, barcoding, and delivery scheduling. Several survey respondents mentioned lack of knowledge about European market preferences as a barrier. About 80% of Moldovan agri-food firms not yet exporting said they *wish to start exporting*, but many do not know how to navigate standards and buyer expectations [4]. Bridging this knowledge gap is part of integration. Programs under EU4Business and other technical assistance have been organizing trainings for Moldovan SMEs on export marketing and certification. Expanding such capacity-building, possibly through public-private partnerships (e.g. an "Export Academy" involving successful exporters mentoring newer ones), can disseminate best practices. Also, fostering closer cooperation with neighboring Romania could help – Romanian companies that source from Moldova or have joint ventures can transfer know-how on EU compliance. This cross-border industry collaboration is already occurring to some extent (e.g. wine producers have partnerships for EU distribution), and could be incentivized further by both governments.

In tackling EU integration challenges, it is evident that logistics and compliance go hand in hand. Efficient supply chains will amplify the benefits of meeting standards, by getting certified, high-quality products to market faster and more reliably. Conversely, investing in compliance (labs, certifications, training) adds value to the improved logistics infrastructure. Therefore, Moldova's strategy should be holistic: upgrade "hard" infrastructure and "soft" infrastructure (institutional and human capacity) in parallel. Best practices from Eastern Europe underscore the importance of political will, stakeholder engagement, and external support in driving these reforms. With

sustained commitment, Moldova can transform its agri-food supply chains from a domestic bottleneck into a springboard for competitive export growth in the EU.

CONCLUSIONS

The experiences discussed in this study underscore that modernizing Moldova's agri-food supply chains requires comprehensive efforts that go beyond mere physical infrastructure upgrades. Institutional reforms, capacity building, and adopting proven logistics optimization strategies from comparable Eastern European contexts will be instrumental in Moldova's journey towards sustainable EU integration. Addressing these multifaceted challenges strategically can unlock significant growth potential in Moldova's agri-food sector, turning existing logistical bottlenecks into competitive advantages on the European market.

Moldova stands at a critical juncture in its path toward European integration. The agri-food sector, rich with potential owing to the country's fertile soils and entrepreneurial producers, can be a catalyst for prosperity if its supply chain inefficiencies are addressed. This study has shown that Moldova's current logistics performance is subpar by international standards, hampered by infrastructure deficits, cumbersome trade procedures, and fragmented coordination. The **Logistics Performance Index data** and firm-level evidence converge on a clear message: to compete in the EU market, Moldova must significantly reduce transportation delays and uncertainty, and elevate its compliance with quality and safety standards.

Key priorities emerging from our analysis include:

-**Rehabilitating infrastructure.** Modernizing roads and railways that form trade corridors to the EU is essential. Improved physical connectivity will lower freight costs and transit times. Public investment, augmented by EU and IFI funding, should target the most critical links (e.g. border highways, last-mile links to logistics hubs). Establishing intermodal facilities and upgrading the Giurgiulești port's connectivity can also enhance resilience by diversifying export routes.

-**Enhancing trade facilitation.** Moldova needs to continue overhauling its customs and border management. Completing the National Single Window for trade, streamlining customs inspections with risk-based systems, and increasing transparency will remove administrative frictions. The goal should be to approach EU "best practice" clearance times (measured in minutes or hours, not days). This also means deepening cooperation with Romanian and Ukrainian border agencies, including pursuing joint border checkpoints with the EU to simplify crossings.

-**Digital and organizational innovations.** Embracing digital logistics solutions can accelerate progress. As case studies showed, investments in IT systems for tracking, inventory, and certification management yield high returns in efficiency and trust. Moldova should leverage its growing IT sector to tailor affordable digital tools for agri-food SMEs – for example, mobile apps for farmers to coordinate truck pickups or blockchain-based platforms to document product provenance. Moreover, encouraging **cooperative models** and industry clusters will allow smaller players to achieve scale and share resources, making the supply chain more cohesive and robust.

-**Building compliance capacity.** Meeting EU standards is arguably the toughest challenge, but one where incremental gains can open significant market opportunities. Moldova should continue aligning its regulatory framework with the EU acquis, but most importantly, it must invest in the institutions and people who enforce and implement these standards. Expanding laboratory testing capabilities, training inspectors and company quality managers, and supporting firms in obtaining certifications will build a culture of quality. Engaging in regional knowledge exchange – learning from countries like Romania, Serbia, or the Baltic states that underwent similar transitions – can provide practical roadmaps for upgrading SPS controls and infrastructure.

-**Public-private collaboration.** Finally, a coordinated approach is needed. The government, private sector, and development

partners must work in concert. Initiatives such as creating an Agro-Logistics Task Force or a Supply Chain Council could facilitate regular dialogue, ensuring that policy reforms address the real constraints faced by businesses on the ground and that businesses are aware of and contribute to government plans (e.g. infrastructure projects or new regulations). Success in supply chain optimization will be measured by more Moldovan products reaching EU shelves efficiently and being recognized for their quality.

In conclusion, optimizing Moldova's agri-food supply chains is a multifaceted endeavor – one that blends hard infrastructure upgrades with soft skill enhancements and systemic reforms. The evidence and cases discussed in this paper demonstrate that while Moldova's current logistics and compliance gaps are significant, they are by no means insurmountable. With strategic focus and sustained implementation of the solutions outlined, Moldova can shorten the distance (figuratively and literally) between its farmers and European consumers. In doing so, it will not only fulfill the technical requisites of EU integration but also unlock new competitiveness and growth for one of its most important economic sectors. The road to EU membership may be long, but improving the roads (and rails, and regulations) that carry Moldova's food to market is a decisive step forward on that journey.

REFERENCES

[1]Arvis, J.-F., Ojala, L., Shepherd, B., Ulybina, D., Wiederer, C., 2023, Connecting to compete 2023: Trade logistics in an uncertain global economy. World Bank. https://lpi.worldbank.org/sites/default/files/2023-04/LPI_2023_report.pdf, Accessed on 5 January 2025.

[2]Busch, C., Giucci, R., 2023, From emergency response to reform support: medium-term development perspectives for Moldova. German Economic Team – Policy Paper Series, No. 01/2023. Berlin Economics. https://www.german-economic-team.com/wp-content/uploads/2023/10/GET_MDA_PP_01_2023_en.pdf , Accessed on 5 January 2025.

[3]Charlebois, S., Latif, N., Ilahi, I., Sarker, B., Music, J., Vezeau, J., 2024, Digital traceability in agri-food Supply Chains: a comparative analysis of OECD member countries. Foods, 13(7), 1075. https://mdpi.com, Accessed on 5 January 2025.

[4]Criscuolo, A., Hake, M. S., Cicanci, G., Castro, L., 2023, Creating markets in Moldova: Country private sector diagnostic. Washington, DC: IFC (World Bank Group). https://www.ifc.org, Accessed on 5 January 2025.

[5]Diaconu, T., 2015, Sustainable development and food security in the context of agro-food sector of Moldova's integration into the European Union. Scientific Papers Series "Management, Economic Engineering in Agriculture and Rural Development", 15(2), 99-104.

[6]EIB adds 42 million euros for railway upgrades in Moldova. RailFreight.com, 18 December 2023. https://www.railfreight.com, Accessed on 5 January 2025.

[7]European Bank for Reconstruction and Development, 2022, Moldova diagnostic: assessing progress and challenges in developing a sustainable market economy. London: EBRD.

[8]European Bank for Reconstruction and Development, 2022, Moldova infrastructure sector assessment. London: EBRD.

[9]European Commission, 2023, EU-Ukraine Solidarity Lanes: one year on. DG MOVE, Brussels.

[10]EU Delegation to Serbia, 2017, EU support for improved food safety control in Serbia. https://europa.rs, Accessed on 5 January 2025.

[11]European Union, 2012, EU support for farmers' cooperatives. Agriculture and Rural Development Directorate-General, European Commission. https://agriculture.ec.europa.eu, Accessed on 5 January 2025.

[12]Farmonaut News, 2024, Moldova's first EU-authorized egg exports. https://farmonaut.com, Accessed on 5 January 2025.

[13]German Council on Foreign Relations (DGAP), 2024, Moldova: Start of Formal Accession Negotiations with the EU. https://dgap.org, Accessed on 5 January 2025.

[14]Government of the Republic of Moldova, 2023, Aprobarea proiectului de lege pentru aprobarea Strategiei Naționale de Dezvoltare „Moldova Europeană 2030" (Approval of the law project for National Strategy of Development "European Moldova"), https://gov.md, Accessed on 5 January 2025.

[15] nfoMarket Business Daily, 2023, The EU will help Moldova modernize its transport infrastructure and facilitate its connection to the European network. https://infomarket.md, Accessed on 5 January 2025.

[16]Meister, S., 2024, Moldova: start of formal accession negotiations with the EU. German Council on Foreign Relations. https://dgap.org, Accessed on 5 January 2025.

[17]Sarban, C., 2022, The challenges of the agricultural sector of the Republic of Moldova in the year 2022. Scientific Papers Series "Management, Economic Engineering in Agriculture and Rural Development", 22(4), 645-654.

[18]Standards compliance analytics report, 2025, Border Rejections in Major Global Markets – Moldova. UNIDO. https://hub.unido.org, Accessed on 5 January 2025.

[19]Staver, L., Erhan, L., 2023, The evolving state of agri-food security in the Republic of Moldova - A

review. Scientific Papers Series "Management, Economic Engineering in Agriculture and Rural Development", 23(2), 613-620.
[20]Strategy for the EU integration of the Ukrainian and Moldovan rail system, 2023, European Commission, 11 July 2023. Integration_of_the_UAMD_railway_system_into_the_EU_transport_system.pdf, Accessed on 5 January 2025.
[21]Stratan, A., 2014, Moldovan agri-food trade under the influence of integration processes. Scientific Papers Series "Management, Economic Engineering in Agriculture and Rural Development", 14(3), 339-344.
[22]Stratan, A., Lopotenco, V., Lucasenco, E., 2023, The interconnection model between the Republic of Moldova's food security and its agricultural products export. Scientific Papers Series "Management, Economic Engineering in Agriculture and Rural Development", 23(2), 681-690.
[23]Szegedi, Z., Ulechla, G., Miskolczi-Gabriel, M., 2022, Digital transformation in food supply chains in Central and Eastern Europe. International Journal of Economics, Business and Management Studies, 9(2), 171–182. https://doi.org/10.55284/ijebms.v9i2.813
[24]USAID, Moldova's trade corridor assessment report. MSRP-TCA-Summary-EN.pdf. Accessed on 5 January 2025.
[25]World Bank, 2023, Moldova trade study: Enhancing connectivity and competitiveness. Washington, DC: World Bank Group.
[26]World Bank, Logistics Performance Index: Overall (1=low to 5=high). World Bank Data. Accessed January 2, 2022. https://data.worldbank.org, Accessed on 5 January 2025.

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REVIEW OF RESEARCH FRAMEWORKS AND METHODOLOGICAL APPROACHES ON FOOD LOSS AND WASTE

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Abstract

Food loss and waste (FLW) quantification is critical for addressing global food security and sustainability challenges. This systematic review evaluates 27 studies focusing on methods used to quantify FLW, highlighting the diversity in definitions, frameworks, and methodological approaches. Of these, five studies lacked any explicit FLW definition, while others referenced diverse frameworks, including the Food Loss and Waste Protocol, Food and Agriculture Organization, and other organizations such as United States Department of Agriculture, High Level Panel of Experts, and the United Nations. Multiple definitions were mentioned in some studies, reflecting a fragmented landscape. Methodologically, 14 studies employed quantitative approaches, three used qualitative methods, and 10 adopted mixed methods, underscoring the complexity of FLW research. The dominance of quantitative approaches reflects the need for objective, measurable data, while mixed methods offer a more comprehensive understanding by integrating contextual insights. This review highlights significant methodological variability and a lack of standardization in FLW definitions and measurement practices. These results underscore the necessity for standardized frameworks and methodologies to enhance comparability and effectively direct global efforts for the reduction of FLW.

Key words**:** *food loss and waste, quantification methods, systematic review, sustainability*

INTRODUCTION

Food loss and waste (FLW) represent paramount concerns that exert a profound influence on the environment, economy, and society on a global scale. The phenomenon of food loss predominantly occurs during the production, post-harvest, and processing stages, with a notably increased prevalence in developing countries due to inadequate infrastructure and technological capabilities (Economou et al., 2024) [12]. Conversely, food waste transpires at the retail and consumption levels, where food deemed suitable for human consumption is discarded, frequently because of inadequate planning and consumer behaviour (Vaško & Jalić, 2024) [52]. The Food and Agriculture Organization (FAO) approximates that nearly one-third of all food produced for human consumption is either lost or wasted each year, which equates to roughly 1.3 billion tonnes and incurs an economic cost of around $990 billion (Handoyo & Asri, 2023) [20]. The ramifications of FLW on the environment are considerable, as it contributes significantly to greenhouse gas emissions and the wastage of vital resources, including water and land (Economou et al., 2024) [12]. Socially, reducing FLW can enhance food security and social justice by redistributing resources to those in need (Tahmaz & Aksoy, 2024) [47]. Economically, it can lower costs for households and businesses by reducing waste disposal expenses and improving resource efficiency (Sharmila Devi & Sundareshwar, 2023) [44]. Various digital technologies, such as the Internet of Things (IoT), Blockchain Technology (BCT), and Radio Frequency Identification (RFID), are being employed to manage and reduce FLW by tracking food conditions and extending shelf life (Kusolchoo & Ueasangkomsate, 2024) [29]. Additionally, artificial intelligence and donation platforms are being developed to predict expiry dates and redistribute surplus food to the needy, respectively (Weerasooriya & Kumar, 2022) [54].

Also, the studies of dynamics of food loss and waste as well as the statistical analysis provide valuable information in this field (Nakov et al., 2020; Nijloveanu et al., 2023) [35, 37].

Bibliometric studies measure the importance of food loss and waste in literature highlighting the journals, papers, top interested countries, and authors (Ștefan, 2024) [45].

Innovative strategies are developed to reduce food loss and waste and assure a sustainable development (Moldovan, 2024) [34].

The European Union and other regulatory bodies have mandated the measurement and monitoring of FLW to align with sustainable development goals, emphasizing the need for effective waste prevention measures (Economou et al., 2024) [12]. The measurement of food loss globally is a complex issue, and currently, there is no universally standardized metric for quantifying FLW. Various studies highlight the challenges and gaps in data collection and methodology. For instance, FAO and other organizations have made significant efforts to estimate food loss, but these efforts are often hampered by inconsistent definitions, scopes, and ad-hoc data collection methods (Kitinoja et al., 2018) [27]. The Food Loss Index, developed to monitor progress towards Sustainable Development Goal (SDG) 12.3, faces challenges due to the lack of comprehensive data, which affects the robustness of the modelling approaches used to estimate annual food losses by country and commodity (Mingione et al., 2021) [33]. Additionally, the global food waste indicator, which aggregates country-wise data, suffers from variances in data collection, methodology, and presentation, with only a small percentage of data available from direct sources (Waiker et al., 2020) [53]. The literature also points out that most studies are concentrated in a few industrialized countries and often rely on secondary data, leading to high uncertainties in the global FLW database (Xue et al., 2019) [58]. Efforts to develop standardized measurement techniques are ongoing, with some studies proposing the use of robust statistical techniques and Bayesian models to improve the accuracy of food loss estimates (Mingione et al., 2021) [33]. The FOODRUS index, for example, is a recent attempt to create a sustainability index to assess the food supply chain (FSC) performance regarding FLW, incorporating expert and stakeholder feedback (Cervera et al., 2023) [8].

Varying definitions, data-collection techniques, and reporting practices make it difficult to compare results from different studies and contexts. This lack of standardization hinders the development of effective policies and interventions, particularly in the production and processing stages where substantial amounts of FLW can occur. To facilitate this extensive examination, the subsequent research inquiries are are proposed:

(1)How do existing frameworks and definitions diverge in relation to the measurement FLW during the production and processing stages of the FSC?

(2)Which methodologies (quantitative, qualitative, mixed) are most efficacious in measuring FLW, and what are their respective merits and drawbacks in diverse settings?

(3)How can emerging digital technologies contribute to the precision, scalability, and stakeholder involvement in FLW quantification methodologies?

The primary purpose of this research, therefore, is to systematically review and analyse the existing frameworks, methodologies, and tools used to measure FLW to identify the most prevalent and reliable quantification approaches and examine how inconsistencies in definitions and scope affect measurement outcomes.

MATERIALS AND METHODS

The primary objective of a systematic review is to address particular inquiries, utilizing a clearly defined, methodical, and reproducible search strategy, accompanied by criteria for inclusion and exclusion that delineate the studies to be incorporated or omitted (Gough et al., 2017) [18]. Data is subsequently encoded and extracted from the studies that are included, with the aim of synthesizing the findings and elucidating their practical applications, in addition to identifying existing gaps or discrepancies. This contribution

delineates 27 scholarly articles concerning methodologies for quantifying FLW.

The preliminary search string (Table 1) and the established criteria (Table 2) for the present systematic review encompassed peer reviewed scholarly articles published in English or Romanian, which add the methods used for quantifying FLW during the production and processing stages of the FSC, and were catalogued in two prominent international databases: Web of Science and Scopus (encompassing titles, abstracts, and keywords).

Table 1. Initial search string

Topic	Search terms
Food loss and waste	"food loss" OR "food waste" OR "FLW" OR "food loss and waste"
AND	
Quantifying method	"accounting method" OR "measurement method" OR "quantif*"
AND	
FSC stage	"production" OR "post-harvest" OR "post-production" OR "harvest"
AND	
FLW setting	"ranch" OR "farm" OR "homestead" OR "agricultural holding" OR "farmstead" OR "vineyard" OR "orchard" OR "dairy farm" OR "farmyard" OR "barnyard"

Source: Author's own elaboration

Table 2. Final inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Published 2015 – June 2024	Published before 2015
English or Romanian language	Not in English or Romanian
Empirical, primary research	Not primary research (e.g. review)
Indexed in Web of Science or Scopus	Not a journal article
Quantifying methods of FLW	No quantifying methods of FLW
Harvest, post-harvest, on-farm processing or packaging stages	Not harvest, post-harvest, on-farm processing or packaging stages
FLW occurring in farms	No FLW setting or only FLW occurring outside of farms

Source: Author's own elaboration

It was determined to restrict the selection of articles to those published in 2015 or subsequently, as this particular year marked the adoption of the 2030 Agenda for Sustainable Development by all member states of the United Nations, which established 17 global SDGs.

Furthermore, it was resolved that the corpus would be confined to articles that examine methodologies for quantifying FLW specifically during the production or post-production phases of the FSC.

Upon the completion of the established inclusion and exclusion parameters, and after the removal of redundant entries employing the statistical software R in combination with the bibliometrix package, a cumulative total of 58 potential articles were discerned for comprehensive text evaluation (Figure 1).

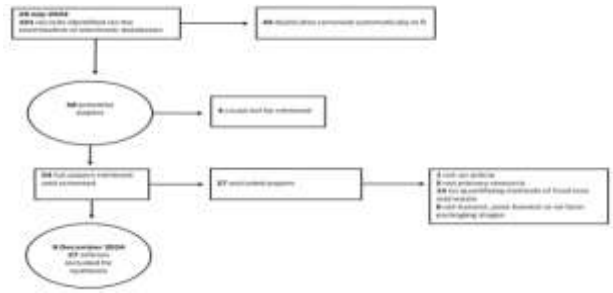

Fig. 1. PRISMA diagram
Source: modified after Brunton & Thomas (2012) [5]

Nevertheless, four articles could not be obtained via the library ordering system. Consequently, 54 articles were successfully retrieved and subjected to screening, and after the exclusion of 27 manuscripts, 27 articles were retained for synthesis.

RESULTS AND DISCUSSIONS

There was a discernible augmentation in the papers published from 2015 onwards (Figure 2). The quantity of incorporated articles expanded from none in 2015 to four in the first half of 2024, with a maximum of five articles between the years 2018 and 2022.

Fig. 2. Annual scientific production spanning from 2015 to June 2024
Source: Author's own calculation on the basis of data from Scopus and WoS.

The articles that comprised the sample were disseminated across 20 distinct academic journals (Table 3).

The highest frequency of publications was observed in Sustainability (n = 5), succeeded

by Resources, Conservation Recycling (n = 3) and Frontiers in Sustainable Food Systems (n = 2) show casing that only three journals have published two or more articles concerning methodologies for quantifying FLW during the stages of primary production, processing, or packaging from 2015 until June 2024.

Table 3. Number of included articles by journal

Rank	Journal	n
1	Sustainability	5
2	Resources, Conservation Recycling	3
3	Frontiers in Sustainable Food Systems	2
	others with one article	17

Source: Author's own calculation on the basis of data from Scopus and WoS.

For the geographical distribution analysis of scholarly articles (Table 4), the nation of origin of the first author was utilized (n = 16 nations), only four nations have contributed with two or more publications, indicating that half of the total articles are derived from merely three countries: South Africa, the United States of America and Germany.

Table 4. Distribution of articles by country

Rank	Country	n
1	South Africa	5
2	USA	4
	Germany	4
3	Brazil	2
	other	12

Source: Author's own calculation on the basis of data from Scopus and WoS.

Table 5. Affiliation of the first author

Rank	Affiliation	n
1	Agriscience	6
2	Sustainable Environment	4
	Agricultural Economics	4
3	Horticultural Sciences	3
4	Agricultural Engineering	2
	not mentioned	2
5	Bioscience Engineering	1
	Public Health	1
	Social Sciences	1
	Environmental Engineering	1
	Sustainable Agriculture	1
	Science and Technology	1

Source: Author's own calculation on the basis of data from Scopus and WoS.

The affiliation of the first author was taken into consideration, researchers predominantly hail from disciplines directly tied to agriculture and environmental sustainability (Table 5).
Among the 27 articles, most authors (n = 6) are affiliated with Agriscience departments, reflecting a strong emphasis on agricultural research. The next most common affiliations, each appearing four times, are Sustainable Environment and Agricultural Economics, suggesting that environmental impact and economic considerations play key roles in how researchers approach FLW. Horticultural Sciences (n = 3) and Agricultural Engineering (n = 2) further expand the agricultural and technical focus of FLW studies. Meanwhile, a smaller group of authors representing Bioscience Engineering, Public Health, Social Sciences, and other fields highlights the interdisciplinary nature of FLW research, encompassing health, social factors, and engineering solutions. Overall, the distribution underscores that FLW quantification research is primarily conducted by specialists in agriculture-related fields, with notable contributions from environmental, economic, and social science perspectives. This multidisciplinary backdrop reflects the complex and wide-reaching implications of FLW, from on-farm production techniques to broader sustainability and public health considerations. A plethora of references and criteria for delineating FLW were discerned, revealing considerable discrepancies in methodology and precision (Table 6). It is noteworthy that five scholarly articles failed to cite any established definitions of FLW or to propose their own conceptualizations (Kumar & Underhill, 2019; Blanckenberg et al, 2021; Blanckenberg et al, 2022; Alzubi et al., 2023; Onwude et al., 2024) [28, 2, 3, 1, 39], while others referenced more than one definition, thereby indicating a potential deficiency in coherence or cognizance concerning standardized terminologies. This absence of reference may either signify an assumption of shared comprehension or reflect a shortcoming in methodological rigor within these investigations.

Table 6. Distribution of articles by definition, multiple mentions possible

Rank	Origin of the definition	n
1	FAO	11
2	FLW Protocol	10
3	No definition	5
4	FUSIONS	4
5	USEPA	2
	Other	6

Source: Author's own calculation on the basis of data from Scopus and WoS.

FAO offers precise definitions aimed at differentiating between food loss and food waste, acknowledging the distinct factors and phases at which these phenomena manifest within the FSC.

As per the FAO's classification, food loss is defined as the reduction in the quantity of edible food during the phases of production, post-harvest management, and processing within the FSC (FAO, 2019) [14]. This phenomenon is predominantly observed in developing countries and is often attributed to technical, managerial, and infrastructural limitations. In contrast, food waste pertains to the discard of edible foods at the retail and consumer levels, primarily in developed countries (FAO, 2019) [14]. This waste is largely influenced by consumer behaviour and decisions made by retailers and food service providers.

Both food loss and food waste signify substantial inefficiencies embedded within the food system, resulting in economic detriments, environmental degradation, and detrimental consequences for food security and nutritional standards (FAO, 2019) [14]. The resolution of these challenges necessitates the implementation of targeted interventions specifically designed to address the distinct causes and phases of the supply chain where losses and waste manifest.

The definitions established by the FAO were explicitly referenced in 11 articles (Parmar, 2017; Johnson et al., 2018; Fernandez-Zamudio et al., 2020; Winans et al., 2020; Cooreman-Algoed, 2022; Hook & Soma, 2022; Tóffano Pereira et al, 2022; Herrera-Quinteros & Jara-Rojas, 2023; Lana, 2023; Canan & Uluișik, 2024; Channiyamathorn et al., 2024) [43, 25, 26, 15, 55, 10, 24, 48, 22, 30, 7, 9] rendering them the most frequently cited conceptual framework among the articles subjected to review. This predominance underscores the FAO's significant role as a preeminent authority in the domains of FLW research and policy formulation.

The recurrent invocation of FAO definitions underscores their significance in establishing a uniform comprehension of FLW. By functioning as a shared reference framework, these definitions allow scholars to contextualize their investigations within a globally acknowledged framework, thereby promoting comparability and uniformity across diverse research endeavours. This aspect is especially crucial in a domain marked by methodological and definitional inconsistencies. These definitions are particularly valued in research contexts for their alignment with global food security and sustainability priorities.

Nevertheless, the observation that the FAO definitions were cited in only 11 of the 27 studies signifies the disjointed character of FLW research, as numerous investigations depend on alternative frameworks or fail to expressly cite any definitions. This highlights the imperative for more extensive implementation and standardization to improve coherence within the discipline.

The FLW Protocol, along with its corresponding Accounting and Reporting Standard, establishes a robust framework for the measurement and reporting of food loss and waste (FLW) in a consistent manner across diverse contexts. This initiative was formulated by a collaborative partnership comprising multiple stakeholders, including the World Resources Institute (WRI), the FLW Protocol is designed to address the need for standardized methodologies in a field often characterized by fragmented and inconsistent definitions and practices. The FLW Protocol defines FLW as any food and associated inedible parts removed from the FSC that was originally intended for human consumption (WRI, 2016) [57].

The FLW Protocol enables users to delineate the parameters of their measurement endeavours (e.g., phases of the supply chain, geographical constraints, and food categories) (WRI, 2016) [57]. The framework accommodates an assortment of methodologies, including direct measurement, mass balance techniques, and surveys, thereby permitting users to identify the most suitable strategy for their specific context. Ascertaining what to incorporate within the inventory (e.g., inedible components, particular phases) can pose challenges and may differ among users. The precision of FLW quantification is significantly contingent upon the accessibility

and dependability of the foundational data, which can exhibit inconsistency across numerous regions.

In the reviewed studies, ten papers explicitly referenced the FLW Protocol (Tostivint et al., 2017; Johnson et al., 2018a, 2018b; Neff et al., 2018; Parmar et al., 2018; March et al., 2019; Caldeira et al., 2021; Opara et al., 2021a, 2021b; Dong et al., 2022) [49, 25, 26, 36, 42, 32, 6, 40, 41, 11] demonstrating its influence as a standard-setting framework in FLW research. Its comprehensive and systematic approach makes it particularly valuable for academic studies aiming for methodological rigor and comparability. The Protocol's emphasis on transparent reporting also aligns well with the scientific community's need for reproducibility and accountability.

The FLW Protocol represents a significant step toward harmonizing FLW quantification efforts, helping to bridge gaps in definitions and methodologies while fostering actionable insights for reducing FLW globally.

The Food Use for Social Innovation by Optimizing Waste Prevention Strategies (FUSIONS) initiative, which receives funding from the European Union, has established a widely acknowledged definition of FLW that has significantly impacted discourse, particularly within European frameworks. According to FUSIONS food waste consists of the disposal or alternative (non-food) utilization of both food items and inedible portions that were initially designated for human consumption (FUSIONS, 2016) [17]. This definition explicitly incorporates both edible and inedible elements, thereby underscoring a holistic methodology for FLW assessment.

The FUSIONS definition is distinguished by its focus on prevention strategies, which is congruent with the sustainability objectives delineated in EU policy frameworks. Furthermore, it facilitates harmonization among member states, thereby promoting uniformity in reporting and comparative analysis (FUSIONS, 2016) [17].

The FUSIONS definition was explicitly cited in four of these studies (Tostivint et al., 2017; March et al., 2019; Fernandez-Zamudio et al., 2020; Caldeira et al., 2021) [49, 32, 15, 6]. This comparatively modest frequency of citation implies that although the FUSIONS framework holds considerable importance in specific geographic or contextual settings, it has not attained extensive utilization in the realm of global FLW research when juxtaposed with frameworks such as those proposed by FAO.

The limited references to definitions of FUSIONS within the examined literature indicate a regional focus, given that the FUSIONS initiative is predominantly European, its definitions may be less recognized or relevant to scholars in other locales. Considering the existence of various organizations that propose definitions of FLW, such as FAO and the FLW Protocol, researchers might select frameworks that align with their specific geographical context or the objectives of their investigations.

Despite its limited use in the reviewed papers, the FUSIONS definition remains a critical contribution to the discourse on FLW, particularly in advancing strategies for prevention and harmonized reporting across European countries. Its influence is likely stronger in studies or policies with a European context or focus on sustainability and waste prevention.

The United States Environmental Protection Agency (USEPA) provides a practical and action-oriented framework for understanding and addressing FLW, focusing on waste prevention and resource recovery. According to the USEPA, FLW encompasses food products that were designated for human consumption but have been extricated from the FSC, regardless of their edibility (surplus or spoiled food) or inedibility (peels, rinds) (USEPA, 2020) [51].

The definitions provided by the USEPA are especially pertinent for research endeavours conducted within the United States or those that concentrate on waste management strategies, as they delineate a comprehensive blueprint for the reduction of waste and the enhancement of resource recovery.

The USEPA definitions were explicitly referenced in two studies (Winans et al., 2020; Dong et al., 2022) [55, 11]. This limited citation frequency indicates that while the USEPA framework is significant, its use is

geographically concentrated and primarily relevant to research or policy work within the U.S. context.

Despite its limited global adoption, the USEPA definitions are influential in the U.S. and provide valuable guidance for reducing FLW in line with environmental sustainability goals. Their hierarchical approach offers practical solutions that are often incorporated into local, state, and federal policies, as well as corporate sustainability initiatives.

A significant variety of definitions not associated with prominent frameworks such as the FAO, USEPA, or FUSIONS were employed throughout the research landscape; these alternative definitions were referenced in six distinct studies (Ludwig-Ohm et al., 2019; Winans et al., 2020; Eičaitė et al., 2022; Herrera-Quinteros & Jara-Rojas, 2023; Lana, 2023; Canan & Uluișik, 2024) [31, 55, 13, 22, 30, 7], coming from organizations such as United States Department of Agriculture (USDA, 2024) [50], Organisation for Economic Co-operation and Development (OECD, 2024) [38], The High Level Panel of Experts (HLPE, 2014) [23] and The Waste and Resources Action Programme (WRAP, 2017) [56], also from other researchers such as Franke et al. (2016), Hafner et al. (2013), Hartikainen et al. (2018), and Strid & Eriksson (2014) [16, 19, 21, 46]. This heterogeneity underscores the fragmented and contextually contingent attributes inherent in food loss and waste (FLW) research.

A multitude of academic studies have either established or refined definitions relevant to their particular research frameworks, which encompass a focus on the discrete phases of the supply chain (Winans et al., 2020; Eičaitė et al., 2022) [55, 13], geographic locales (Ludwig-Ohm et al., 2019, Winans et al., 2020; Herrera-Quinteros & Jara-Rojas, 2023) [31, 55, 22] or specific categories of food products (Ludwig-Ohm et al., 2019; Eičaitė et al., 2022) [31, 13]. Certain research endeavours have opted for streamlined, operational definitions to meet the exigent demands of their methodologies, especially in instances where comprehensive measurement frameworks were impractical (Eičaitė et al., 2022) [13].

The absence of a universally accepted definition of FLW often compels scholars to construct their own frameworks tailored to the unique objectives of their investigations. Customized definitions facilitate the adaptation of methodologies to regional, sectoral, or institutional contexts, especially when existing international frameworks, such as those articulated by FAO, are perceived as excessively broad or convoluted. In emergent domains of FLW research, including circular economy applications or urban food systems, prevailing definitions may inadequately encompass the dynamic aspects associated with FLW.

The utilization of varied, ad hoc definitions impedes the comparability of research findings, thereby complicating efforts to synthesize or generalize results across the field. In certain instances, these definitions may not be fully articulated or may lack precision, thereby undermining the replicability and credibility of the scholarly inquiry.

The widespread presence of alternative definitions underscores a significant imperative for standardization within the domain of FLW research. Although flexibility can be advantageous in addressing distinctive contexts, a more uniform application of standardized definitions, such as those established by FAO or the FLW Protocol, would augment the comparability and efficacy of FLW studies. As the body of research on FLW continues to grow, promoting dialogue and collaboration among various stakeholders may facilitate the bridging of gaps and encourage the development of more cohesive frameworks.

A clear preference for quantitative methods emerges, with 14 papers employing these techniques to address FLW quantification (Table 7). Quantitative methods dominate due to their ability to provide objective, measurable, and replicable data—a critical aspect when attempting to capture the scope and scale of FLW accurately. This quantitative emphasis aligns well with the goals of many researchers in the field, who seek reliable, data-driven insights that can inform policies and interventions.

Table 7. Distribution of articles by methodological approach

Rank	Methological approach	n
1	Quantitative	14
2	Mixed	10
3	Qualitative	3

Source: Author's own calculation on the basis of data from Scopus and WoS.

The use of mixed methods, seen in 10 papers, highlights a growing trend towards methodological integration. Mixed methods studies combine the precision of quantitative data with the contextual depth of qualitative findings, potentially offering a more holistic view of FLW issues. By leveraging both types of data, mixed methods provide a comprehensive approach that can enhance understanding across different dimensions of FLW.

Three studies employed qualitative methods exclusively, a smaller subset that underscores the value of in-depth, context-rich information. These approaches, though less common, offer a nuanced understanding of FLW, capturing stakeholder perspectives, socio-cultural factors, and contextual nuances that may not be easily quantified. Qualitative studies can complement quantitative approaches by offering deeper insights into the reasons behind FLW, thus broadening the scope of FLW research (Ludwig-Ohm et al., 2019; Opara et al., 2021; Hook & Soma, 2022) [31, 40, 24].

This varied approach reflects the complexity of FLW as a research topic, requiring both quantifiable data and insights into the underlying factors that contribute to waste.

The examination of methodologies employed for data collection exposes a heterogeneous array of strategies utilized to quantify FLW, underlines the complexity of FLW and directly addresses the research questions regarding (1) diverse definitions and frameworks, (2) methodological strengths and limitations, and (3) the role of technology in improving FLW measurement.

Field measurement emerged as the predominant methodology, being employed in 15 investigations. This technique entails the direct, on-site acquisition of data through empirical observation, measurement, or sampling at various junctures of the FSC. Its extensive application signifies its dependability and accuracy in capturing authentic FLW data. Nonetheless, field measurement may prove to be resource-intensive, necessitating considerable time, labour, and access to research locales, which could constrain its practicability in specific contexts.

In studies such as (Opara et al., 2021a, 2021b) [40, 41] the quantification of FLW was conducted utilizing a direct measurement methodology, which entailed the systematic identification of the underlying causes of loss in individual pomegranates. The evaluation encompassed the daily monitoring of bins containing harvested fruit, where physical examination facilitated the categorization of the fruits based on a range of defects, including sunburn, fissures, bruising, and insect infestation.

This quantification process necessitated the calculation of the fruit lost in relation to the quantity introduced into the packhouse processing line, culminating in an average loss of 328.79 t/production season at the examined packhouse (Opara et al., 2021a) [40]. The quantification process also involved interaction with farm workers to gather qualitative data during harvesting (Opara et al., 2021b) [41].

Researchers employed systematic sampling techniques to assess food loss in designated plots or field segments, focusing on unharvested, discarded, or leftover produce (Johnson et al., 2018; Fernandez-Zamudio et al., 2020; Blanckenberg et al., 2021; Blanckenberg et al., 2022; Lana, 2023) [25, 26, 15, 2, 3, 30]. The data collected from these sampled areas were extrapolated to estimate total losses across entire fields. For instance, in North Carolina's vegetable fields, researchers evaluated 68 fields across nine farms (Johnson et al., 2018) [25, 26], physically weighing unharvested crops to estimate an average of 2,909 kg/ha of marketable weight left in the field. Similarly, in South Africa, table grape losses were measured at various stages, including farm, cold storage, and retail scenarios, using portable scales (Blanckenberg et al., 2021) [3]. Harvest losses ranged from 7.5% to 23.3%, with variations attributed to

vineyard management practices and the timing of harvest.

In Ethiopia's cassava production, losses were tracked during drying and stockpiling processes. Critical loss stages were identified, with up to 50% of the produce lost due to insect infestations and inadequate storage conditions (Parmar et al., 2018) [42]. Meanwhile, a study on leafy vegetables in Brazil adapted its methods to different crop types, revealing losses that varied from 1,4% to 84,8% of plant populations, largely influenced by farming practices and market demands (Lana, 2023) [30]. In Thailand, researchers examined banana pepper production, conducting visual assessments of mechanical damage, pest infestations, and disease impacts (Channiyamathorn et al., 2024) [9]. The total loss was 55,21%, which amounted to 1,189.62 kg/rai (1,600 m^2). In Canada, researchers explored the potential of app-based technology for measuring food loss (Hook & Soma, 2022) [24]. Farmers participated in training sessions to familiarize themselves with a farm management app, which they then used to record their yields and sales. This approach provided a practical and efficient method for quantifying food loss by tracking the difference between the initial harvest and recorded sales. However, a notable challenge emerged as farmers interpretations of food loss often differed from academic definitions, introducing complexities in standardizing and quantifying the data (Hook & Soma, 2022) [24]. Despite this, the app-based method demonstrated promise as a tool for engaging farmers in the measurement process and generating valuable insights into food loss at the farm level.

Together, these studies through direct field measurements, highlight the variability in food loss across regions and crops, emphasizing the influence of management practices, environmental conditions, and market requirements. By pinpointing the causes of loss—such as sunburn, bruising, or pest damage—field measurement offers valuable, granular data that can inform standardized frameworks for FLW quantification, but also highlights practical constraints, including labour intensity and the need for direct field access.

Survey-derived data was implemented in 13 studies, emphasizing the significance of stakeholder-reported data within FLW research. Surveys offer scalable and cost-effective mechanisms for gathering data from a multitude of participants within the FSC, including producers, retailers, and consumers. Survey-based approaches are a widely used method for quantifying FLW in research, particularly when direct field measurements or secondary data are unavailable. However, this methodology introduces challenges such as recall bias, inaccuracies arising from self-reporting, and limitations in survey design, which may compromise data integrity.

Researchers such as Eičaitė et al. (2022) [13] used surveys to gather self-reported data from farmers in Central and Eastern Europe, focusing on on-farm losses for crops and livestock. In Chile surveys were used to obtain data from small-scale farmers to assess food losses during harvest and commercialization stages (Herrera-Quinteros & Jara-Rojas, 2023) [22].

Surveys often identify hotspots of food loss, such as harvesting inefficiencies (Kumar &Underhill, 2019; Canan & Uluișik, 2024) [28, 7] or inadequate storage and transportation (Parmar et al., 2017) [43]. They reveal stakeholder perceptions of causes, including labour shortages, market constraints, or cosmetic standards (Neff et al., 2018) [36]. Farm-level losses were attributed to incorrect spraying practices, pests, diseases, and manual harvesting errors (Canan & Uluișik, 2024) [7]. Some studies combined survey data with secondary datasets or field measurements for validation, improving robustness (March et al., 2019; Eičaitė et al., 2022; Tóffano Pereira et al., 2022) [32, 13, 48].

Most articles report substantial food losses at various stages of the supply chain, often ranging between 15% and 30% depending on the crop or region. Vermont farms reported 16% vegetable losses (Neff et al., 2018) [36], and Fijian tomato farmers experienced 26% postharvest losses (Kumar & Underhill, 2019) [28]. Sweet potato value chains in Ethiopia showed up to 25% losses at various stages

(Parmar et al., 2017) [43]. In Turkey, farmers reported losses 2,2% and 3%, whereas at the retail stage, losses varied between 16,8% and 20,3% (Canan & Uluișik, 2024) [7].

Lack of detailed or consistent record-keeping can limit the reliability of responses. Respondents may not accurately recall the amount of food lost or wasted, leading to under or, over-estimation and perceptions of "loss" or "waste" can vary, especially when clear definitions are not provided (Neff et al., 2018) [36].

Secondary data was employed in three studies, leveraging existing government reports and industry statistics. While this approach supports broader, cross-country comparisons—aligned with efforts to explore how definitions and measurements vary under different frameworks—its reliability hinges on the quality and availability of the original datasets. Inconsistencies across sources mirror the core challenge of lacking global standardization.

The concept of material flow analysis (MFA) is distinctly employed in three articles (Caldeira et al., 2021; Cooreman-Algoed et al., 2022; Dong et al., 2022) [6, 10, 11]. MFA analyses the throughput of processes including extraction, transformation, manufacturing, consumption, recycling, and disposal. It utilizes physical unit accounts to quantify process inputs and outputs (Brunner & Rechberger, 2004) [4]. Ultimately, MFA offers a system-analytical perspective of interconnected processes to facilitate strategic management design. It can be used to track the flow of materials (food and associated losses) from production to consumption, encompassing intermediate stages like processing, distribution, and retail.

To estimate FLW in European Union countries, one study adapted MFA to the EU level, employing harmonized coefficients to compare FLW among member states (Caldeira et al., 2021) [6]. MFA was used to identify critical loss points across the FSC, including on-farm losses caused by market rejections, harvesting inefficiencies, unharvested crops, and environmental factors. It also tracked processing losses from by-products and discarded materials, as well as consumer-level waste driven by behaviour and improper storage practices.

MFA further provided a framework to quantify FLW while linking it to environmental impacts, including greenhouse gas emissions, water usage, and energy consumption, thereby offering a comprehensive perspective on the broader implications of FLW (Caldeira et al, 2021) [6].

For instance, a Belgian case study on chicken meat combined MFA with consumer behaviour analysis, highlighting the role of packaging efficiency and household practices in contributing to FLW (Cooreman-Algoed et al., 2022) [10]. Another study focused on the U.S. FSC, integrating life cycle assessments with MFA to explore recycling and recovery opportunities, demonstrating how complementary methods can enrich FLW analysis (Dong et al., 2022) [11]. These studies relied on extensive datasets such as national waste statistics, food balance sheets, and trade data, ensuring robust and reliable estimations.

Overall, MFA emerges as a powerful tool for identifying FLW hotspots and understanding the underlying drivers of losses. By pinpointing specific stages of inefficiency, MFA enables targeted interventions and provides actionable data to design policies that enhance sustainability across food systems. These studies consistently underscore its utility in supporting the transition toward more sustainable and efficient FSCs.

Certain studies used more than one methodology, capitalizing on the advantages of each approach to enhance data quality and robustness (Parmar et al., 2017; Parmar et al., 2018; Winans et al., 2020; Alzubi et al., 2023; Channiyamathorn et al., 2024) [42, 43, 55, 1, 9]. For instance, survey-derived data may serve to complement field measurements, thereby addressing gaps or corroborating findings. This integrative methodology signifies an acknowledgment of the multifaceted nature of FLW, and the drawbacks associated with reliance on a singular approach.

The predominance of field measurement and survey-derived data accentuates the necessity for both empirical precision and stakeholder perspectives in FLW research. While direct field measurement continues to be the most

trustworthy methodology for quantifying losses, its resource-intensive characteristics may elucidate the considerable dependence on surveys and secondary data. The adoption of mixed methods illustrates an emerging trend towards methodological integration, which enriches data completeness and accuracy.

The observed heterogeneity in data collection strategies though reflective of different local contexts further validates the research purpose of identifying gaps and promoting the development of universal protocols. By systematically examining and synthesizing these approaches, the review highlights the imperative of aligning them with established or emerging frameworks, integrating digital technologies, and ensuring interdisciplinary collaboration to address the environmental, economic, and social dimensions of FLW.

CONCLUSIONS

The systematic review highlights how a broad range of FLW quantification methods—from field measurements to emerging digital platforms—responds to the multifaceted nature of FLW and the research questions regarding (1) the variability of frameworks and definitions, (2) the strengths and limitations of common data-gathering techniques, and (3) the role of digital innovation in improving measurement accuracy. Despite significant progress in developing quantification methods, persistent gaps and inconsistencies underscore the purpose of this research: to propose universal guidelines that align with existing global frameworks and to explore participatory, stakeholder-focused approaches that advance sustainability and food security goals.

The review further demonstrates that while field-based measurements, surveys, MFA, and app-based technologies can capture valuable FLW data, their application varies widely due to differences in definitions, resource availability, and technical capacity. This lack of standardization hinders comparability across studies and contexts—an issue central to the research questions aimed at improving methodological coherence. Similarly, farm management apps and IoT-based systems show promise but are often limited by user knowledge and infrastructure constraints, suggesting that training programs, particularly in developing regions, could help overcome these barriers.

By placing educational research at the forefront, through initiatives such as universal measurement protocols, open-access tools, and participatory research modules, the findings underscore the purpose of strengthening interdisciplinary skills, bridging academic-practitioner divides, and equipping stakeholders to integrate digital solutions with on-the-ground realities. In addressing these challenges, educational initiatives can prioritize mixed-methods training, thereby enabling students and researchers to capture both the quantitative scope of losses and the qualitative factors driving FLW.

Ultimately, these strategies and tools respond directly to the research questions on standardization and methodological rigor, while also bolstering capacity-building efforts in under-researched regions. As a result, researchers, policymakers, and practitioners can more effectively compare FLW data, implement evidence-based interventions, and support the global push for sustainability and food security.

While this systematic review was conducted with utmost rigor, each review is inherently constrained by its search methodology. Although the two selected educational research databases are extensive and globally encompassing, the application of criteria restricting inclusion to peer-reviewed articles published solely in English or Romanian precluded the incorporation of research disseminated in other languages pertaining to the quantification of FLW. This limitation similarly pertains to studies presented in conference proceedings, book chapters, or grey literature, as well as articles that were not disseminated in journals indexed within the three consulted databases. Furthermore, despite the inclusion of Romanian peer-reviewed articles based on established criteria, the absence of a specific search string in the Romanian language constrains the potential to incorporate Romanian papers that were not indexed using the selected keywords. Future

investigations might contemplate employing a broader array of databases, types of publications, and languages of publication, thereby enhancing the breadth of the review. Nevertheless, significant attention would necessitate to be directed towards project resources and the feasibility of managing the review effectively.

REFERENCES

[1]Alzubi, E., Kassem, A., Melkonyan, A., Noche, B., 2023, Enhancing economic-social sustainabilitythrough a closed-loopcitrussupplychain: A lifecycle cost analysis. Resources, Conservation&RecyclingAdvances, 21, 200199.

[2]Blanckenberg, A., Fawole, O. A., Opara, U. L., 2022, Postharvest Losses in Quantity and Quality of Pear (cv. Packham's Triumph) along the Supply Chain and Associated Economic, Environmental and Resource Impacts. Sustainability, 14(2), 603.

[3]Blanckenberg, A., Opara, U. L., Fawole, O. A., 2021, Postharvest Losses in Quantity and Quality of Table Grape (cv. Crimson Seedless) along the Supply Chain and Associated Economic, Environmental and Resource Impacts. Sustainability, 13(8), 4450.

[4]Brunner, P. H., Rechberger, H., 2004, *Practical* Handbook of Material FlowAnalysis. Florida, USA: Lewis Publishers.

[5]Brunton, J., Thomas, J., 2012, Information management in systematicreviews. In An introduction to systematic reviews (pp. 83–106). London, England: SAGE.

[6]Caldeira, C., De Laurentiis, V., Ghose, A., Corrado, S., Sala, S., 2021, Grown and thrown: Exploring approaches to estimate food waste in EU countries. Resources, Conservation and Recycling, 168, 105426.

[7]Canan, S., Uluișik, E. N. U., 2024, Vegetable Losses and Waste Along the Supply Chain and Farmers' Willingness toPay for Recycling: Towards to Green Supply Chain. Journal of Tekirdag Agricultural Faculty, 21(1), 148–165.

[8]Cervera, M. A., Angarita-Zapata, J. S., De La Calle Vicente, A., Alonso-Vicario, A., 2023, The Foodrus Index: Assessing the Impact of Food Loss and Waste Prevention Under an Integral Perspective.

[9]Channiyamathorn, P., Sreshthaputra, S., Sirisanyaluck, R., Chalermphol, J., 2024, Analyzing Food Loss in Banana Pepper (*Capsicum annuum*) Production: Causes, Impact, and Challenges, A Case Study of Large-Scale Farming in the Hot District, Chiang Mai, Thailand. Trends in Sciences, 21(4), 7539–7539.

[10]Cooreman-Algoed, M., Boone, L., Taelman, S. E., Van Hemelryck, S., Brunson, A., Dewulf, J., 2022, Impact of consumer behaviour on the environmental sustainability profile of food production and consumption chains – a case study on chicken meat. Resources, Conservation and Recycling, 178, 106089.

[11]Dong, W., Armstrong, K., Jin, M., Nimbalkar, S., Guo, W., Zhuang, J., Cresko, J., 2022, A framework to quantify mass flow and assess food loss and waste in the US food supply chain. Communications Earth & Environment, 3(1), 1–11.

[12]Economou, F., Chatziparaskeva, G., Papamichael, I., Loizia, P., Voukkali, I., Navarro-Pedreño, J., Klontza, E., Lekkas, D. F., Naddeo, V., Zorpas, A. A., 2024, The concept of food waste and food loss prevention and measuring tools. Waste Management &Research, 42(8).

[13]Eičaitė, O., Baležentis, T., Ribašauskienė, E., Morkūnas, M., Melnikienė, R., Štreimikienė, D., 2022, Measuring self-reportedfoodloss in primaryproduction: Survey-based insights from Central and Eastern Europe. Waste Management, 143, 46–53.

[14]FAO, 2019, The state of food and agriculture. 2019, Moving forward on food loss and waste reduction. Rome, Italy: Food And Agriculture Organization Of The United Nations.

[15]Fernandez-Zamudio, M.-A., Barco, H., Schneider, F., 2020, Direct Measurement of Mass and Economic Harvest and Post-Harvest Losses in Spanish Persimmon Primary Production. Agriculture, 10(12), 581.

[16]Franke, U., Hartikainen, H., Mogensen, L., Svanes, E., 2016, Food Losses and Waste in Primary production, Data Collection in the Nordic Countries.

[17]FUSIONS, 2016, Food Waste Quantification Manual to Monitor Food Waste Amounts and Progression. FUSIONS.

[18]Gough, D., Oliver, S., Thomas, J., 2017, An introduction to systematic reviews (2nd ed.). Los Angeles, USA: SAGE.

[19]Hafner, G., Barabosz, J., Leverenz, D., Maurer, C., Kranert, M., Göbel, C., Friedrich, S., Ritter, G., Teitscheid, P., Wetter, C., 2013, Analyse, BewertungundOptimierung von Systemen zur Lebensmittelbewirtschaftung – Teil I. MÜLL Und ABFALL, 11.

[20]Handoyo, M., Asri, N., 2023, Study on FoodLossandFoodWaste: Conditions, Impact andSolutions. AGRITEPA: Jurnal Ilmu Dan TeknologiPertanian, 10(2), 247–258.

[21]Hartikainen, H., Mogensen, L., Svanes, E., Franke, U., 2018, Food Waste Quantification in Primary Production – the Nordic Countries as a Case Study.

[22]Herrera-Quinteros, G., Jara-Rojas, R., 2023, Food losses perceived by family farms: Challenges and policy implications from a micro-approach quantification. Frontiers in Sustainable Food Systems, 6.

[23]HLPE, 2014, Food Losses and Waste in the Context of Sustainable Food Systems A Report by The High Level Panel of Experts on Food Security and Nutrition.

[24]Hook, A., Soma, T., 2022, Sustainabilitypotential of app-basedfoodlossmeasurement: Farmers' perspectives in southwestern British Columbia, Canada. Frontiers in Sustainability, 3.

[25]Johnson, L. K., Dunning, R. D., Bloom, J. D., Gunter, C. C., Boyette, M. D., Creamer, N. G., 2018, Estimating on-farm foodloss at thefieldlevel: A methodology and applied case study on a North Carolina

farm. Resources, Conservation and Recycling, 137, 243–250.
[26]Johnson, L. K., Dunning, R. D., Gunter, C. C., Bloom, J. D., Boyette, M. D., Creamer, N. G., 2018, Fieldmeasurement in vegetablecropsindicatesneed for reevaluation of on-farm foodlossestimates in North America. Agricultural Systems, 167, 136–142.
[27]Kitinoja, L., Tokala, V., Brondy, A., 2018, Challenges and opportunities for improved post harvest loss measurements in plant-based food crops. 6(4), 16–34.
[28]Kumar, S., Underhill, S. J. R., 2019, Smallholder Farmer Perceptions of Postharvest Loss and ItsDeterminants in Fijian Tomato Value Chains. Horticulturae, 5(4), 74.
[29]Kusolchoo, S., Ueasangkomsate, P., 2024, Digital Technologies for FoodLossandWaste in FoodSupply Chain Management. International ECTI NorthernSectionConference on Electrical, Electronics, Computer and Telecommunications Engineering (ECTI-NCON), 97–102.
[30]Lana, M., 2023, Quantification of leafy vegetables loss at primary production - research limitations and proposed methodology for on-farm data collection. Horticultura Brasileira, 41.
[31]Ludwig-Ohm, S., Dirksmeyer, W., Klockgether, K., 2019, Approachesto Reduce FoodLosses in German FruitandVegetableProduction. Sustainability, 11(23), 6576.
[32]March, M. D., Toma, L., Thompson, B., Haskell, M. J., 2019, Food Waste in Primary Production: Milk Loss With Mitigation Potentials. Frontiers in Nutrition, 6.
[33]Mingione, M., Fabi, C., Lasinio, G. J., 2021, Measuring and Modeling Food Losses. Journal of Official Statistics, 37(1), 171–211.
[34]Moldovan, M.G., Dabija, D.C., Pocol, C.B., 2024, Innovative strategies for food waste reduction and the use of mobile applications in the agri-food sector. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 24(2), 675-688.
[35]Nakov, G., Zlatev, Z., Ivanova, N., Dimov, I., 2020, Food waste management using statistical analysis to obtain new functional products. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 20(3), 369-376.
[36]Neff, R., Dean, E., Spiker, M., Snow, T., 2018, Salvageable Food Losses from Vermont Farms. Journal of Agriculture, Food Systems, and Community Development, 1–34.
[37]Nijloveanu, D., Tita, V., Bold, N., Fintineru, G., Smedescu, D., Chiurciu, I.A., Smedescu, C., Patrachioiu, G.N., 2023, Dynamics of food loss and waste causes along the agri-food chain in Romania. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 23(4), 569-580.
[38]OECD, 2024, (October 14), Food loss and waste. https://www.oecd.org/en/topics/policy-issues/food-systems/food-loss-and-waste.html, November 18, 2024.
[39]Onwude, D., Cronje, P., North, J., Defraeye, T., 2024, Digital replica to unveil the impact of growing conditions on orange postharvest quality. ScientificReports, 14(1).
[40]Opara, I. K., Fawole, O. A., Kelly, C., Opara, U. L., 2021, Quantification of On-Farm Pomegranate Fruit Postharvest Losses and Waste, and Implications on Sustainability Indicators: South African Case Study. Sustainability, 13(9), 5168.
[41]Opara, I. K., Fawole, O. A., Opara, U. L., 2021, Postharvest Losses of Pomegranate Fruit at the Packhouse and Implications for Sustainability Indicators. Sustainability, 13(9), 5187.
[42]Parmar, A., Fikre, A., Sturm, B., Hensel, O., 2018, Post-harvest management and associated food losses and by-products of cassava in southern Ethiopia. Food Security, 10(2), 419–435.
[43]Parmar, A., Hensel, O., Sturm, B., 2017, Post-harvest and long practices and associated food losses and limitations in the sweet potato value chain of southern Ethiopia. NJAS - Wageningen Journal of Life Sciences, 80, 65–74.
[44]Sharmila Devi, K., Sundareshwar, S., 2023, Food Waste Management System. International Journal for Research in Applied Science and Engineering Technology, 11(5), 2462–2466.
[45]Stefan, P.A., 2024, Quantifying food loss and waste: a bibliometric analysis from 1970 to 2023. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 24(4), 817-826.
[46]Strid, I., Eriksson, M., 2014, Losses in the Supply Chain of Swedish Lettuce -wasted Amounts and Their Carbon Footprint at Primary production, Whole Sale and Retail.
[47]Tahmaz, G. S., Aksoy, M., 2024, Food Waste. Reference Module in Social Sciences. Elsevier.
[48]Tóffano Pereira, R. P., Galo, N. R., Filimonau, V., 2022, Food loss and waste from farm to gate in Brazilian soybean production. Journal of Agriculture and Food Research, 10, 100431.
[49]Tostivint, C., de Veron, S., Jan, O., Lanctuit, H., Hutton, Z. V., Loubière, M., 2017, Measuring food waste in a dairy supply chain in Pakistan. Journal of CleanerProduction, 145, 221–231.
[50]USDA, 2024, (September 17), Food Availability (Per Capita) Data System - Loss-Adjusted Food Availability Documentation Economic Research Service. https://www.ers.usda.gov/data-products/food-availability-per-capita-data-system/loss-adjusted-food-availability-documentation, Accessed on November 4th, 2024.
[51]USEPA, 2020, Estimates of Generation and Management of Wasted Food in the United States in 2018.
[52]Vaško, Ž., Jalić, N., 2024, Food loss and waste reduction – a new challenge for all stakeholders in food supply chain. Agroeconomic Aspects of Sustainable Agricultural Development, 10(10).
[53]Waiker, V., Ambad, R., Joshi, A., Khandal, V., 2020, An Observance of Household Food Remains

Comportment. International Journal of Current Research and Review, 12(18), 173–179.
[54]Weerasooriya, T., Kumar, K. C., 2022, Foodligence – predicting expiry date of perishable foods to reduce loss and waste. Computer Science and Engineering:An International Journal, 12(6), 155–164.
[55]Winans, K., Marvinney, E., Gillman, A., Spang, E., 2020, An Evaluation of On-Farm FoodLossAccounting in Life-CycleAssessment (LCA) of Four California SpecialtyCrops. Frontiers in Sustainable Food Systems, 4.
[56]WRAP, 2017, Food Waste in Primary Production-a Preliminary Study on Strawberries and Lettuces Research to Quantify the Scale and Causes of Food Waste and Economic Losses.
[57]WRI, 2016, (June). The FLW Standard - Food Loss & Waste (FLW) Protocol, Standard and Guidance. https://flwprotocol.org/flw-standard/, Accessed on October 17, 2024.
[58]Xue, L., Xue, L., Liu, G., 2019, Introduction to global food losses and food waste. Saving Food, 1–31.

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THE POTENTIAL OF CYCLING TOURISM DEVELOPMENT IN GRĂDINARI COMMUNE, GIURGIU COUNTY, ROMANIA: ECONOMIC AND TOURISTIC IMPACTS OF ESTABLISHING CYCLING ROUTES

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Abstract

This paper explores the potential development of cycling tourism in Grădinari Commune, Giurgiu County, Romania, focusing particularly on the economic and touristic benefits derived from establishing dedicated cycling routes in the region. Located in North Eastern Giurgiu, adjacent to Ilfov County and bordered by the Argeș River, Grădinari commune comprises three villages: Grădinari, Tântava, and Zorile. The area's rich historical heritage, including landmarks such as the Oteteleșanu Manor and the historical churches, combined with favorable geographical conditions, present significant yet underutilized opportunities for cycling tourism. Through qualitative analysis of demographic, infrastructural, and historical data, this study argues that promoting cycling tourism would enhance local economic activity, boost rural tourism, and preserve cultural and natural heritage. The findings suggest substantial benefits, such as employment growth, increased local revenues, improved infrastructure, and heightened community well-being. The paper concludes that targeted investment and sustainable planning in cycling infrastructure could position Grădinari as a notable rural tourism destination, stimulating broader regional development.

Key words**:** *cycling tourism, economic impact, Grădinari commune, rural tourism, sustainable development*

INTRODUCTION

Nature, ecosystems and biodiversity are a part of our enviroment which gives us an incentive not to forget our origin [1].
Ecotourism and its various forms and rural tourism are alternatives to spend spare time outside in the middle of nature [2].
Rural tourism is higly preferred by Romanians which stimulated the appearance of agri and tourist gusethouses, rural routes to various natural ans cultural attractions [3, 4].
Innovative innitiatives and strategies are destined to sustain rural tourism and environment protection [5, 6, 7].
Teritorial development by tourism involves the responsibility at the Government level, but also at the local administative bodies and NGO-s. 8, 9 ,11, 12] which give a chance for all the regions for economic and social development [16].
The pandemis confirmed the importance of rural tourism, agritourism and ecotourism for adopting a healthier life style [10, 15, 18].
The future belongs to new forms of tourism like adventure tourism, creative tourism, cycling tourisms, biking tourism, riding tourism and other multiple alternatives in fresh air [13, 14, 17, 19, 20].
Cycling tourism, increasingly recognized globally as a sustainable form of recreation and travel, is becoming a key element in the economic and touristic revitalization of rural areas.
The development of cycling routes represents not only a strategy for enhancing tourism potential but also an important tool for local economic stimulation, regional connectivity, and environmental sustainability.
In the counties in the proximity of Bucharest, the capital of Romania, there are many routes of high interest for those who love cycling as a way for making sport, getting knowledge about

unknown places, developing rural tourism with its spendid landscapes, rural life, gastronomy and hospitality.

Also, cycling has been quickly developed taking the example of other countries and encouraging people to maintain the physical condition of the body, getting fresh air far away from the civilized world.

The shops are full of various types of bycicle with varoius performances and prices are suitable for everybody's pocket.

Grădinari commune, located in Giurgiu County, Romania, offers a unique combination of natural landscapes, historical heritage, and favorable geographic positioning that can significantly benefit from the implementation of cycling tourism initiatives. Grădinari commune, historically known as Grădinari-Fălcoianca, consists of three villages: Grădinari (the administrative center), Tântava, and Zorile (Wikipedia, 2025) [21].

Strategically placed between several main national and regional roads, including DN5 and DN6, and traversed by secondary routes linking significant urban centers such as Mihăilești and Bolintin-Vale, the commune is positioned advantageously for the development of sustainable tourism initiatives such as cycling trails. Despite these strategic advantages, the potential of cycling tourism remains largely unexplored in the region and also for discovering what's new in agrotourism (Smedescu et al., 2013)[16].

The commune's rich cultural and historical heritage, including monuments like Otetelișanu Manor and historical churches dating back to the 19th century.

Photo 1. Otetelișanu Manor
Source: Wikidata, Gradinari, https://www.wikidata.org/wiki/Q5118240. [22].

Together with the picturesque banks of the Argeș River, they provide appealing contexts for cycling tourists.

Additionally, the existing demographic structure, predominantly Romanian ethnic population (86.38%) and Orthodox confession (84.74%), suggests opportunities for promoting local traditions and customs through tourism. Nevertheless, Grădinari faces demographic challenges, with a noticeable population decline from 3,578 inhabitants in 2011 to 3,217 in 2021, underscoring the urgency of fostering local economic activities that could stabilize and potentially increase the commune's attractiveness (Gradinari City Hall, 2025) [23].

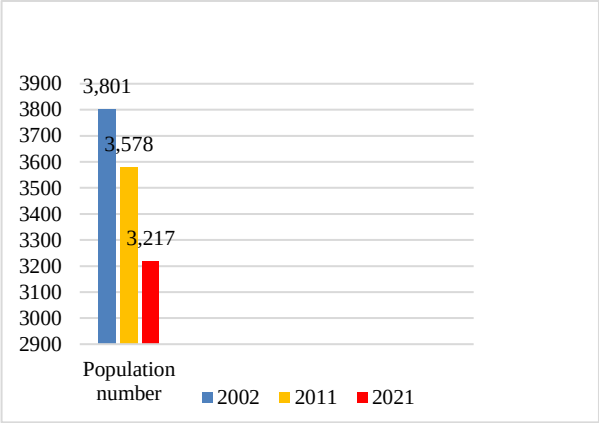

Fig. 1. The demographic evolution of Gradinari commune after the last 3 censuses
Source: Own design based on NIS data, 2025 [24].
investigates the economic and touristic.

This paper advantages of developing cycling routes in Grădinari commune, assessing how cycling infrastructure could boost local economy through increased visitation, stimulate the growth of local businesses, and preserve the area's environmental and cultural assets.

Additionally, it explores the implications for rural revitalization, sustainable local development, and regional tourism competitiveness.

The analysis will include an evaluation of the current infrastructure, identification of potential cycling routes, community perceptions, and projected economic impacts resulting from increased visitor flows. Furthermore, comparative insights from similar successful projects across Romania and

Europe will serve as a basis for recommendations tailored specifically to Grădinari's context.

Through this comprehensive exploration, the paper aims to highlight the multifaceted benefits of cycling tourism, positioning Grădinari as an exemplary case for rural tourism enhancement through sustainable and eco-friendly development.

MATERIALS AND METHODS

The research conducted in Grădinari Commune, Giurgiu County, applied a comprehensive methodological approach designed to evaluate the potential of developing cycling tourism, with an emphasis on economic, touristic, social, and environmental dimensions. The study focused explicitly on Grădinari Commune, comprising the villages Grădinari, Tântava, and Zorile, strategically located along the Argeș River and intersected by key regional roads such as DJ412A and DJ401A [23].

To thoroughly assess the area's potential for cycling tourism, a mixed-methods approach was implemented, combining qualitative and quantitative research techniques. Historical, geographical, and demographic data were collected from authoritative sources, including the Romanian National Institute of Statistics, Giurgiu County administrative records, local archives, and historical documents. These sources provided essential baseline information on population dynamics, economic activities, infrastructure status, and heritage landmarks within Grădinari Commune.

Field research involved direct observations and extensive interactions with the local community between October 2024 and February 2025. Structured and semi-structured interviews were conducted with key stakeholders, including local business owners, public administrators, representatives of the Giurgiu County Council, and residents. Interviews focused on evaluating current economic conditions, identifying attitudes toward cycling tourism development, gauging perceptions of potential impacts, and gathering suggestions regarding route locations and infrastructure needs.

Additionally, comprehensive field observations and photographic documentation of existing infrastructure, natural landscapes, and cultural landmarks were carried out to evaluate the current state and suitability for cycling tourism. Infrastructure assessments included on-site inspections of existing road networks, trail quality, and available public amenities to determine their suitability for cycling tourism.

A Geographical Information System (GIS)-based mapping analysis was performed to propose potential cycling routes effectively integrated with the commune's existing infrastructure. Routes were selected to optimize the use of natural landscapes, historical monuments, and connectivity to nearby localities. Spatial data from local and national cartographic databases, including open-source platforms and satellite imagery, were employed to ensure accurate and feasible route planning.

Economic impact analysis was conducted by referencing comparable cycling-tourism projects from similar rural contexts in Romania and Europe. Economic indicators, such as increased visitation rates, tourist spending patterns, and employment opportunities, were evaluated based on analogous cases from regions successfully implementing cycling tourism projects. Examples from established cycling destinations in Romania (e.g., Sibiu and Brașov counties) and recognized European rural cycling tourism areas (e.g., Tuscany in Italy and Provence in France) were critically analyzed to extract best practices, lessons learned, and transferrable strategic approaches.

To ensure robust and reliable findings, the research integrated multiple data sources, including official statistical databases from the National Institute of Statistics of Romania, local administrative reports, and relevant historical archives documenting the commune's socio-economic evolution. Economic impact models were employed to estimate future economic scenarios, highlighting potential revenue streams and employment increases derived from projected visitor growth.

The analytical framework adopted was designed to allow reproducibility and transparency. Clear criteria were established for the selection and evaluation of data sources, stakeholder input was systematically recorded and categorized, and spatial analyses were rigorously documented. This comprehensive methodology provided a solid foundation for drawing robust, evidence-based conclusions on the feasibility, potential impacts, and practical recommendations for developing sustainable cycling tourism initiatives in Grădinari Commune (Stoicea et al., 2021) [18].

RESULTS AND DISCUSSIONS

Cycling tourism in Grădinari Commune holds substantial promise for generating significant direct and indirect economic benefits. Through increasing visitation and attracting both domestic and international tourists, cycling tourism is anticipated to stimulate the local economy considerably. Field interviews conducted with local stakeholders, including business owners, residents, and local authorities, consistently underscored a high level of enthusiasm toward cycling tourism initiatives. Respondents expressed expectations of direct economic benefits such as increased consumer spending at local shops, restaurants, accommodation units, and other tourism-related establishments.

Cycling tourism has shown notable economic impacts in comparable rural areas, as demonstrated by the analysis of successful case studies from other Romanian regions. In Transylvania, particularly in counties like Sibiu and Brașov, dedicated cycling routes have significantly increased local business revenues, with some enterprises reporting revenue growth exceeding 20% after infrastructure implementation. Stakeholders in Grădinari Commune anticipate similar outcomes, forecasting at least a 15% boost in local business revenues within the initial two-year period following the establishment of cycling routes.

Developing cycling infrastructure typically promotes entrepreneurial ventures related directly and indirectly to cycling activities. Services such as bicycle rental, maintenance and repair shops, bicycle equipment retail, guided tours, and hospitality services (e.g., guesthouses, camping sites, and agrotourism facilities) are likely to emerge. Historical data from similar Romanian rural contexts demonstrate that cycling tourists exhibit a stronger inclination towards patronizing local products and services, thereby directly benefiting small-scale, local entrepreneurs and artisans.

Indirect economic impacts, such as employment generation, also hold considerable promise. Experiences from other Romanian rural cycling projects illustrate significant local employment opportunities emerging in sectors like hospitality, catering, retail, and specialized cycling services (bike rentals and repairs). Estimations for Grădinari Commune indicate the potential creation of at least 30 new local jobs related directly and indirectly to cycling tourism within the first three to five years. These employment opportunities could particularly benefit young adults and women, demographics traditionally at risk of migrating to larger urban centers due to limited economic opportunities.

Cycling tourism has a pronounced seasonal extension benefit, potentially expanding the traditional tourism period beyond peak summer months, thus ensuring a more stable and sustainable year-round economic activity. Successful examples from European rural regions, such as Tuscany in Italy and Provence in France, have demonstrated effective strategies to extend the tourism season through cycling-related events and promotions, attracting visitors even during off-peak periods and significantly stabilizing local economies.

Infrastructure investments, while initially representing a financial challenge, have been proven economically sustainable due to the relatively moderate cost and high return potential. European Union funding mechanisms and national funding opportunities dedicated to sustainable tourism and rural development could facilitate infrastructural investments, reducing the financial burden on local authorities. Comparative economic analyses from similar rural tourism developments across Europe confirm the viability and long-term financial

sustainability of targeted investments in cycling infrastructure.

The economic benefits of developing cycling tourism in Grădinari Commune are substantial, promising increased visitor expenditures, entrepreneurial stimulation, employment opportunities, and strengthened local economic resilience. These positive outcomes provide a compelling justification for stakeholders and policymakers to actively pursue and support cycling tourism initiatives, fostering economic revitalization and sustainability within this rural region.

The research identified substantial opportunities for leveraging local cultural heritage in Grădinari Commune, notably through integrating prominent historical sites into cycling tourism routes. Historical and manor style tourism sustains in encasing the Oteteleșanu Manor alongside the historic churches of Grădinari and Tântava, beautiful but neglected treasures. The churches, which are centuries old, showcase brilliant architecture, which would add value as culture and tourism spend grows.

To increase foster engagement and contraction of tourism, the integration heritage landmarks enable educational intersections alongside cycling routes, elevating cultural stops. These particular landmarks attract tourists with an interest in history and culture. Educational tourism is advanced through documentaries and narrative panels that detail the examinations left behind.

To strengthen the statement arguer concede restate cites foreign cycling tourism works construct paired cultural tourism marked zones motives for the riders increase engagement with routes heavy laden with architectural wonders. In Romanian rural areas the augmentation of marked sensitive routes historians would add cultural information resulted not only in the increase of tourist attention but more importantly to the appreciation of the local heritage. Similarly, through cycling tourism, the promotion of these sites could be instrumental in safeguarding local heritage. Educating tourists is often associated with better preservation, upkeep, and restoration activities supported by the local administration and patrons. Greater visibility of sites such as Oteteleșanu Manor and historical churches also has the potential of attracting additional funding, in particular, from national funds aimed at the protection of heritage sites or from cultural initiatives financed by the European Union.

The inclusion of cultural heritage sites in cycling tourism initiatives provides educational benefits by offering informal educational platforms for visitors and locals alike. Cycling tourists typically express strong interests in exploring the local culture and history, suggesting potential for effective educational outreach through interpretive materials such as information panels, brochures, mobile applications, and interactive digital platforms designed specifically for cyclists.

The educational component can further involve community participation, encouraging locals, particularly youth, to actively engage in heritage interpretation and preservation, fostering greater community identity and pride. This, in turn, strengthens social cohesion and promotes awareness about the historical significance and cultural richness of the commune.

The valorization of cultural heritage through integration into cycling tourism not only promises direct tourist benefits but significantly contributes to education, preservation, community engagement, and identity consolidation. In the long term, such integration ensures sustainable management of historical assets while creating unique and enriching experiences for visitors, adding significant value to the cycling tourism proposition of Grădinari Commune.

The development of cycling tourism in Grădinari Commune presents considerable opportunities for social revitalization and sustainable community development. By attracting increased tourist flows, the commune stands to benefit significantly from enhanced community interactions, preservation of local traditions, and improved quality of life.

Cycling tourism promotes social cohesion through interactions of the residents and the locals, which fosters a collective community

pride and identity. This tourism style promotes cultural exchange through meaningful interactions between tourists and local residents, thus enriching community life while enhancing residents' pride in their locality. Cycling tourism experiences in Romania from regions like Maramureș and Bucovina showcase great success in community involvement towards local traditions and customs, actively promoting regional handicrafts and gastronomy.

Cycling tourism fosters job opportunities that attract the youth, thus decreasing rural to urban migration shifts. Tourism related jobs such as biking and event planning, along with accommodation and guided tour management, serve as great motivations for local youth to remain in the region. Comparative case studies indicate tourism-based economies in rural areas lead to successful population retention and even repopulation.

The implications of community involvement on the social maintenance of cumulative tourism development projects span over a greater duration. Economic and social inclusivity are likely to be stimulated by the involvement of local community members, including young women, into independent ventures associated with cycling tourism. Encouraging active participation offers hope to the younger generation and has the potential to mitigate out-migration and demographic shrinkage to urban centers.

The dedicated cycling infrastructure has the potential to upgrade community amenities including routs, signage, rest areas, and recreational areas, as well as the living conditions of residents and visitors.

Thus, the strategic implementation of cycling tourism initiatives offers a robust framework for socially sustainable community revitalization, encouraging demographic stability, economic inclusivity, and cultural vibrancy in Grădinari Commune.

The implementation of cycling tourism in Grădinari Commune presents significant potential for fostering environmental sustainability and ecological preservation. Cycling tourism, as a non-motorized mode of transportation, inherently contributes to reducing carbon footprints by limiting emissions associated with conventional motorized transportation. This sustainable form of tourism helps mitigate air pollution and contributes positively towards regional and local air quality improvement.

Research highlights the alignment of cycling tourism initiatives with global sustainability goals, particularly concerning climate change mitigation and adaptation strategies. Reduced use of motor vehicles directly correlates with decreased carbon emissions, thereby contributing to broader environmental objectives both at local and national levels. Furthermore, cycling tourism encourages a more sustainable use of natural resources, as visitors typically have a minimal environmental footprint compared to conventional tourism.

Cycling routes in Grădinari Commune would also stimulate ecological awareness among both local residents and tourists. Through educational signage, informational campaigns, and eco-awareness activities integrated into cycling trails, visitors can be sensitized about environmental issues such as biodiversity conservation, waste reduction, and sustainable travel practices. Such initiatives enhance the environmental consciousness of visitors, promoting responsible tourism behaviors.

International experiences from countries renowned for cycling tourism, such as Denmark, the Netherlands, and Austria, demonstrate clear environmental benefits. For example, rural cycling networks in these countries have led to improved ecological conditions, conservation of biodiversity, and increased public awareness regarding the importance of preserving natural landscapes. These international case studies highlight that cycling infrastructure not only reduces pollution but also actively encourages ecological stewardship among local communities and visitors.

Local stakeholders consulted during this research emphasized a strong commitment to preserving the natural environment, recognizing the alignment of cycling tourism initiatives with their environmental aspirations. Interviewees noted the potential for cycling tourism to draw attention to local natural assets, including the scenic banks of the

Argeș River, potentially fostering conservation efforts and attracting support from environmental organizations and funding bodies.

Additionally, cycling tourism initiatives may include educational components emphasizing environmental responsibility, such as guided eco-tours, interpretive trails, and informational signage promoting local biodiversity and conservation measures. These activities contribute significantly to public education and environmental advocacy, cultivating a lasting culture of sustainability among both tourists and local residents.

Cycling tourism in Grădinari Commune offers substantial opportunities for promoting environmental sustainability, reducing ecological impacts associated with tourism, and raising environmental awareness among both locals and visitors. By investing in eco-friendly tourism infrastructure and promoting cycling as a sustainable means of exploring the region, Grădinari Commune can achieve meaningful environmental conservation and ecological benefits, aligning with both national sustainability objectives and international best practices.

A thorough analysis of existing infrastructure within Grădinari Commune, alongside proposed cycling routes, indicates significant opportunities for the effective establishment of cycling tourism. Three primary cycling routes were identified based on their potential for integrating natural, cultural, and historical landmarks, thereby offering diverse and attractive experiences for tourists.

The first route, approximately 15 kilometers long, centers around Grădinari village, prominently featuring landmarks such as the Otetelișanu Manor, complemented by views along the banks of the Argeș River. The second route strategically connects the villages of Grădinari and Tântava, showcasing historical churches and allowing interaction with rural landscapes and traditional agricultural practices. The third route is designed to connect Grădinari commune with neighboring communes, enhancing broader regional connectivity and accessibility, particularly along existing county roads DJ412A and DJ401A.

The establishment of these routes necessitates specific infrastructure improvements, including clearly marked cycling paths, appropriate signage, rest areas, information panels, bicycle racks, and amenities such as rest stops and refreshment points. Proposed technical solutions include modest improvements to the current roads, such as expanding shoulders, paving areas designated for cycling, painting cycling lanes, and placing appropriate safety and information signs (Cretu et al., 2015)[9].

The financial needs for realizing the infrastructure works have come from analyzing other cycling infrastructure projects with similar contexts in rural Romania. These analyses indicate that there is a limited but reasonable initial financial burden which can be assumed by the local authorities, while other funds could potentially be accessed through national and European Union grants focusing on rural and sustainable tourism development. Building collaborations with private sector companies and tourism stakeholders can also further offload investment burdens, establishing economically sustainable funding frameworks (Marcuta et al., 2020)[14].

Access to the already developed regional transport infrastructure (especially roads DJ412A and DJ401A) was planned in a rational way. These proposed cycling routes use these transport corridors and provide access to Grădinari Commune from the big cities, capturing extensive visitation and maximizing economic benefits from the cycling tourism projects.

Technical solutions were also considered to sustain the route and mitigate visitor impacts efficiently. Proposed measures include the use of eco-friendly materials for construction and the provision of maintenance rest areas, bicycle parking, sanitary services, and information boards. These measures are intended to achieve operational longevity, safety for visitors, and environmental impacts for the region and surrounding areas (Cretu et al., 2019) [5].

The Grădinari commune region has the potential to achieve a high return on investment through the implementation of dedicated cycling infrastructure and increased visitor traffic as this will improve the regional links

and contribute to sustainable development in the long term. Structured actions along with adequate budget allocation and ongoing participation from the local community are fundamental to harnessing the cycling tourism infrastructure potential within the commune (Dragomir et al.,2020) [11].

A comprehensive comparative analysis with successful cycling tourism initiatives in other rural regions provides valuable insights and actionable recommendations applicable to Grădinari Commune. This analysis included detailed evaluations of best practices from Romanian rural areas as well as European examples renowned for their cycling infrastructure and tourism management strategies. Along the routes many guesthouses and agrotourist guesthouses have appeared encouraging the development of gastronomy and hospitality (Chiurciu et al.,2020) [4].

Transylvania, particularly regions such as Sibiu, Brașov, and Alba, provides successful case studies of rural cycling tourism that Grădinari could emulate. In these regions, cycling tourism has significantly boosted visitor numbers and extended the tourism season beyond traditional peak periods. For instance, in the area surrounding Sibiu, cycling routes connected historical and natural attractions effectively, resulting in an estimated increase of 30% in tourist visits within the first two years after implementation. Moreover, local businesses, including accommodation providers, restaurants, and bicycle rental and maintenance services, experienced substantial revenue increases, often reporting between 15% to 25% annual growth.

Similar findings were observed in Brașov County, where cycling tourism was effectively integrated into existing rural tourism offerings. Local authorities and stakeholders there strategically developed routes that linked cultural landmarks, such as fortified churches, castles, and traditional villages, with scenic natural landscapes. The Grădinari region's potential opportunities are further highlighted by European examples. In Italy's rural Tuscany region, cycle tourism has effectively transformed family-owned hospitality businesses, including guesthouses and regional cuisine culinary schools, into economic drivers for the area. This tourism sector caters to wealthy foreign tourists who tend to stay longer, interact more with local culture, and positively impact small and medium-sized businesses.

An equally relevant illustration is the cycle tourism infrastructure in the Loire Valley, France, which links important cultural heritage sites such as historical châteaux and vineyards. The Loire cycle routes receive millions of visitors each year and are crucial to the region's economy and economic self-sufficiency. The provided information also shows the necessity of integrated marketing, information at promotional, and other administrative levels concerning route planning and cultivation of agrotourism in Romania (Smedescu et al.,2023) [16].

Drawing from these best practice examples regarding Grădinari, the main suggestions would be the tailored creation of the cycling routes that would highlight the cultural and natural points of interest, improvement of the region's overall image and marketing, psychological branding, enhancement of the tourism ancillary services, and sustainability to conquer the tourists' hearts (Cretu et al., 2013). The best practices identified in Romania and elsewhere in Europe offer substantial opportunities for efficiently molding cycling tourism in Grădinari Commune. Strategic planning coupled with investment into the infrastructure, community engagement, including local folk heritage, and the folklore culture of the area are the most essential factors which, if well integrated, can provide a sustainable and eco-friendly tourism development along with economic growth in the region (Buianu, 2001).

Photo 2. Cycling paths
Source: own picture from Gradinari Commune.

CONCLUSIONS

The development of cycling tourism in Grădinari Commune offers substantial economic potential through increased tourist visitation, entrepreneurial stimulation, and the creation of new employment opportunities.
Integration of cultural heritage landmarks, such as Otetelișanu Manor and historical churches, into cycling routes significantly enhances their visibility and contributes to the preservation and promotion of local traditions and history.
Cycling tourism initiatives can effectively address social challenges, particularly by attracting and retaining younger populations, thereby reducing demographic decline and fostering community revitalization.
The ecological benefits associated with cycling tourism, including reduced carbon emissions and increased environmental awareness, align closely with sustainability goals and offer meaningful contributions to biodiversity conservation.(Bran et al.,2020)
Investment in dedicated cycling infrastructure is feasible and economically justified, providing substantial long-term returns by ensuring enhanced connectivity, safety, and attractiveness for both visitors and residents. (Dragomir et al.,2020) [11].
Successful case studies from Romanian and European contexts provide critical insights and practical recommendations, reinforcing the viability of strategic route planning, targeted marketing, and comprehensive stakeholder collaboration in achieving sustainable tourism development.
Ultimately, cycling tourism represents a strategic pathway for Grădinari Commune to achieve balanced, sustainable, and integrated local development, creating economic prosperity while preserving cultural heritage and the natural environment (Bran et al.,2020) [1, 2].

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The authors would like to express their sincere gratitude to the Grădinari Local Administration and the Giurgiu County Council for their invaluable support, cooperation, and openness during all phases of this research. Special thanks are extended to local economic stakeholders, who generously provided essential information and insights, facilitating thorough field observations and practical assessments. Their active participation in structured interviews and ongoing consultations greatly enriched the quality of data collected, offering valuable perspectives regarding local economic conditions, community aspirations, and practical considerations for cycling tourism development. Furthermore, their enthusiastic involvement underscored community commitment toward sustainable development and ensured the alignment of proposed recommendations with local realities. This collaborative effort has significantly contributed to enhancing the practical applicability, credibility, and overall depth of the research findings presented in this paper.

REFERENCES

[1]Bran, F., Rădulescu, C. V., Bodislav, D. A., Burlacu, S., 2020, Environmental risks in the context of globalization. Economic Convergence in European Union, 350-356.
[2]Bran, F., Bodislav, D.A., Angheluță, S.P., Dobrea, R.C., 2020, Nature, ecosystems and biodiversity-ecosystem management, http://irek.ase.md/xmlui/, Accessed on March19, 2025.
[3]Buianu, V., 2001, Agrotourism. University of Bucharest Publishing House, Bucharest, 122-123.
[4]Chiurciu, I.-A., Soare, E., Chereji, A.I., Cofas, E., 2020, Analysis regarding the evolution of agrotourism pensions in Romania between 2010 and 2019, Conference Romanian Rural Tourism in International Context. Present and prospects. Iasi. 50.

[5]Cretu, R.F., Cretu R.C., Voinea-Mic, C.C., Stefan, P., 2019, Circular economy, green buildings and environmental protection, Quality - Access to Success, Vol. 20 S2, March, WOS:000461854800032
[6]Cretu, R.C., Cretu, R.F., Stefan, P., 2017, Analysis of the economic crisis concerning the pensions from the Danube Delta, Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 17(2), 67-73.
[7]Cretu, R.C., Cretu, R.F., Stefan, P., 2013, Innovative and sustainable strategies in Romanian tourism and agritourism. Proceedings of the 7th International Management Conference "New Management for the New Economy", 7-8 November 2013, Bucharest, Romania.
[8]Cretu, R.F., Ciobotar, G.N., Cretu, R.C., 2015, Survey regarding the corporate governance implementation in Romania. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 15(4), 33-38.
[9]Creţu, R.C., Stefan, P., 2015, Sustainable management plan applicable for ecotourism certification systems. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 15(2), 93-98.
[10]Cretu, R.C., Stefan, P., Alecu, I.I., 2021, Has tourism gone on holiday? Analysis of the effects of the Covid-19 pandemic on tourism and post-pandemic tourism behavior. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 21(2), 191-198.
[11]Dragomir, C.C., Foris, D., Ţîţu, A.M., Foris, T., 2020, The Role of Intermediaries in Supporting Collaboration for Sustainability: A Model of Commissioning Intervention in the Multi-Stakeholder Collaboration for Sustainable Territorial Development, Sustainability 2020, 12(17), 6769.
[12]Dumitru, E.A., Micu, M.M., Tudor, V.C., 2019, Conceptual approaches regarding the Romanian rural area. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 19(2), 121-128.
[13]Marcuta, L., Marcuta, A., Popescu, A., Tindeche, C., Tudor, V., Smedescu, D., 2020, Study on the development of adventure tourism in Romania. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 20(4), 339-346.
[14]Marcuta, L., Popescu, A., Tindeche, C., Smedescu, C., Smedescu, D., Marcuta, A., 2024, Analysis of the perception of Romanian consumers regarding the practice of creative tourism and its role in sustainable local development. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 24(1), 589-598.
[15]Popescu, A., Tindeche, C., Marcuta, A., Marcuta, L., Hontus, A., Stanciu, M., 2022, Romania's tourism offer and demand in the Covid-19 pandemic of 2020 and 2021 compared to 2019. A statistical overview. Scientific Papers Series "Management, Economic Engineering in Agriculture and rural development", Vol. 22(2), 579-590.
[16]Smedescu D. I., Drăghici I. 2013, Agrotourism – Chance for economic development of Romania. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 13(4), 263-266.
[17]Stanciu, M., Popescu, A., Stanciu, C., 2023, Rural tourism, agrotourism and ecotourism in Romania: Current research status and future trends. Scientific Papers Series "Management, Economic Engineering in Agriculture and rural development", Vol. 23(1), 745-758.
[18]Stoicea, P., Iorga, A.M., Dobre, C.A., 2021, The economic-financial effects of the pandemic on tourism. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 21(2), 619-628.
[19]Ștefan, P., Cutaș, C., Smedescu, D. 2013, Rural tourism in Romania - A marketing perspective. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 13(2), 397-404.
[20]Ștefan, P., Gheorghe, S., Cutaș, C. 2014, New approaches concerning the development of the ecotourism in Romania. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 14(2), 297-302.
[21]Wikipedia,2025, Gradinari Commune, https:/ro.wikipedia.org Comuna_Gradinari, Accessed on March 19, 2025.
[22]Wikidata, Gradinari, https://www.wikidata.org/wiki/Q5118240, Accessed on 19 March 2025.
[23]***Gradinari Commune City Hall, https://primariagradinari-gr.ro/, Accessed on 19 March 2025.
[24]***National Institute of Statistics,2025.

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SORGHUM, THE CROP OF THE FUTURE UNDER CLIMATE CHANGE CONDITIONS

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Abstract

Sorghum, a herbaceous species of the Poaceae family is the fifth most cultivated plant in the world, being the main bread grain in Africa, Southern Europe, Central America and South Asia. Sorghum competes with corn, being an important fodder plant for biogas production of alcohol, growing with its inherent tolerance to drought, short cultivation times and relatively low operating costs of corn has determined the interest in cultivation. The aim of the paper is to identify the major sorghum-growing nations worldwide, in Europe, and domestically, examines their production levels, and analyzes their potential regarding yield, land utilization, and climate compatibility. Statistical data from FAOSTAT, EUROSTAT, and NIS Romania constituted the primary materials for this analysis. The methodological framework involved the calculation of the arithmetic mean, standard deviation, and coefficient of variation as key statistical indicators. These results are presented in both graphical and tabular forms. Main results and conclusions show that sorghum is recommended for drought-prone areas due to its resilience, low costs, profitability, and simple cultivation. Globally, top producers are the USA, Nigeria, Mexico, India, and Ethiopia, while highest yields per hectare are in Oman, Jordan, Israel, Austria, and Italy. Within the EU, France is the main cultivator, with Romanian cultivation showing significant variability (41.6% between 2013-2023). The current changing pedoclimatic conditions are increasing sorghum's importance in Europe, with France, Hungary, and Italy being major EU cultivators. Despite its drought resistance and nutritional value, Romanian sorghum production is declining annually.

Key words**:** *sorghum crop, drought, productions, yields, EU, Romania*

INTRODUCTION

Sorghum is one of the top five cereals cultivated in the world, along with the wheat, rice, maize, and barley, owning its popularity to its inherent drought tolerance, short growing season, and relatively low operating costs. The entire plant can be used by turning sorghum crop residues, such as stalks, leaves, peduncles, and panicles, into ethanol, presenting significant opportunities for sustainable biofuel production [12]. The beginnings of sorghum cultivation took place in sub-Saharan Africa, as suggested by the wild predecessors of sorghum that were discovered in Africa, south of the Sahara, in Yemen and Sudan. All over 30 different species of sorghum are rooted to tropical and subtropical climate regions of Equatorial Africa, characterized by adaptations to conditions of high temperature and limited water availability. Substantial sorghum production is also registered in China, Southeast Asia, and America [22]. Following its introduction to Europe and the United States, sorghum's principal application remains in the composition of livestock nutrition [1, 25]. Ranking as the fifth most cultivated cereal globally and the second in Africa, sorghum is the most cultivated species in the Sahelian zone nutrition [2]. A species of sorghum called sorghum bicolor is an important crop cultivated worldwide, with a range of end uses, encompassing human consumption as a cereal grain and sorghum molasses, animal feed, and the production of both ethanol and other biofuels, with ethanol yields comparable to those of maize. In addition to the food benefits mentioned above, sorghum also has the ability to improve the soil's physical properties, such as structure and porosity, similar to the effect of the traditional tillage practices: thus in a well- structured soil the activity of microorganisms increases, stimulating the formation of humus, based on

the plant residues introduced into the soil [3]. From an agronomic perspective, farmers' preferences for including sorghum in their crop rotation plan are driven by the use of this plant as an alternative to corn in drought-prone areas, due to its resistance to high temperatures and high performance under water stress conditions. This makes the plant a viable option for cultivation, even though sorghum has a lower yield than corn. The sorghum plant can significantly reduce the transpiration process, restarting the vegetative cycle when humidity levels normalize [9]. Developing drought-adapted sorghum varieties is an important way to mitigate this agricultural constraint [24]. Sorghum cultivation is appreciated worldwide for its adaptation to diverse agro-pedological and environmental conditions, as well as for its multiple uses. In Romania, cultivated areas are quite small compared to the existing agro-climatic potential [14]. Its ability to withstand high temperatures makes sorghum cultivation suitable for coping with climate change [11]. The manifestation of the climate changes in the form of severe drought conditions presents a significant challenge, highlighting the need to improve the efficiency of sorghum breeding programs. The implementation of digital technologies in the form of "machine learning models" that can estimate the duration of drought resistance represents a critical step for the sorghum plant [19]. It is also necessary to improve production technologies to generate an enhanced capacity to adapt to future drought events [16]. Due to its widespread cultivation and the fact that it is a versatile crop, we can talk about sorghum cultivation as a multifunctional crop [12]. The utilization potential of sorghum cultivation is varied, from animal feed to biomass [17] and the improvement of antioxidant therapies [4]. In the context where emphasis is placed on agriculture's contribution to reducing greenhouse gas levels, sorghum is an optimal option, as one hectare cultivated with sorghum fixes about 50-55 tons of carbon dioxide, compared to wheat which does not fix more than 15 tons of CO_2/ha. Different residue management practices can affect carbon (C) allocation and, therefore, soil C and nitrogen (N) rotation [23]. For human consumption, this ancient whole grain has a multitude of nutritional benefits. Being utilised as a flour substitute for wheat, it allows for the production of a range of food products, including porridges, flatbreads and cakes. Given its absence of gluten, it requires the addition of binding agents to replicate the function of gluten-containing flours. Intermediate ground sorghum flour has the lowest glycemic level [18]. The strong, characteristic flavor can be reduced by processing. The grains are also used to make edible oil, starch, dextrose, pasta and alcoholic beverages, as well as popped, making popcorn. Sorghum syrup retains all its natural sugars and other nutrients, being an important sweetener for many small communities until this century and, even today, is still important locally. Sweet sorghum has a high sugar content and is grown especially for the production of fodder, silage and syrup [20]. Before the introduction of daily vitamins, sorghum was prescribed as a daily supplement for people with nutrient deficiencies, as sorghum contains iron, calcium and potassium. Improvements in the nutritional value of sorghum can increase its use in the aquatic feed market as a new emerging substitute for fish meals [26]. In Romania, non-irrigated sorghum technology trials in the Amzacea Village, Constanta County, showing the necessity to adjust the planting period by about 25-30 days, compared to standard practices, to enhance soil moisture capture, the use of early hybrids to cope with the severe drought in June, and seed treatment before planting [10]. By 2030, global sorghum production and the marketing sector are expected to increase, on one hand due to the demographic expansion and on the other hand, due to the diversification of sorghum utilisation across multiple sectors [21]. In this context, the paper aims to identify the main sorghum-growing countries worldwide, in Europe and Romania, by analysing the areas and yields of sorghum cultivation, the purpose being to identify the technical, technological and economic potential regarding the cultivation, processing and consumption of this plant, considered a plant of the future, in the

context of increasingly evident climate changes.

MATERIALS AND METHODS

This paper is based on an extensive documentary basis, using the bibliographic method and highlights the quantities of pesticides and fertilizers used in the sorghum cultivation system in the main producing countries.

The statistical sites used were Faostat [7] and Eurostat [6] si NIS Romania [13].

The period covered by the study was 2013–2024, and the main indicators analyzed, which were processed based on the data taken from the sites mentioned above, are: areas cultivated with sorghum; total and average production for sorghum crop in the world, UE and Romania. The research results were presented in tabular and graphical form, using Microsoft Office.

The statistical indicators calculated for the areas cultivated with sorghum and for the total sorghum productions in the period 2013-2024 were the arithmetic mean of the variable X values denoted, the standard deviation *S*, the coefficient of variation $V = \frac{s}{X} \cdot 100$. The closer the value of v is to zero, the weaker the variation, the more homogeneous the collective, the higher the degree of representativeness of the mean. The larger the value of v, the more intense the variation, the more heterogeneous the collective, and the lower the level of significance of the mean.

The linear regression equations Y=a x+b determined using the least squares method, the correlograms and the graphical representation of the regression lines highlight the evolution of cultivated areas, total sorghum productions, as well as the relationship between production and cultivated area in the studied period. In the model Y=a x + b, the independent variable x represents time (year), or cultivated area, and the dependent variable Y represents sorghum production.

The Pearson linear correlation coefficient $r = \frac{\text{cov}(X,Y)}{s_x \cdot s_y}$ measures the direction and intensity of the relationship between two variables denoted X=cultivated area and Y=total production. Correlations are analyzed according to the interval in which r is found, as follows:

- r in the interval (0; 0.2] results in a very weak, almost non-existent correlation;
- r in the interval [0.2; 0.4] results in a weak positive correlation;
- r in the interval [0.4; 0.6] results in a moderate positive correlation;
- r in the interval [0.6; 0.8] results in a strong positive correlation.

The coefficient of determination R^2 establishes the share of the factorial variance in the total variance.

$$R^2 = 1 - \frac{\sum_{i=1}^{n} (y_i - \hat{y}_{teor})^2}{\sum_{i=1}^{n} (y_i - \overline{y})^2} \in [0,1]$$

To validate the mathematical models, we applied the Fischer test.

RESULTS AND DISCUSSIONS

Main sorghum-growing countries worldwide

Worldwide, over 90% of the area cultivated with sorghum is found in developing countries (Figure 1), mainly in Africa and Asia, where it is grown on savannah lands, occupying approximately 40 million hectares. From the analysis of data provided by FAOSTAT (The world's most comprehensive statistical database on food, agriculture, fisheries, forestry, natural resources management and nutrition) [7], for 2023, in the top 10 sorghum-growing countries, by area, we find countries such as Sudan, Nigeria, Niger, India, USA, Burkina Faso, Mali, Ethiopia, Brazil, Mexico.

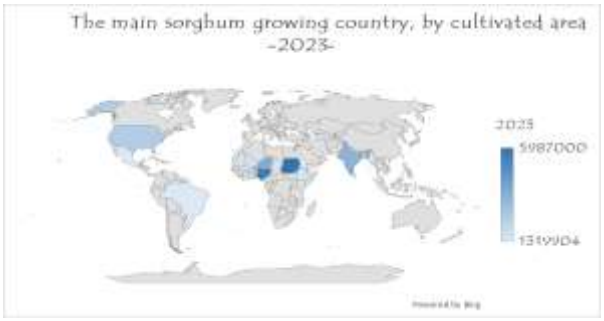

Fig. 1. Global distribution of the main sorghum-growing countries

Source: Own data processing based on the data from FAO [7].

Although sorghum is less known in the Western world, it is a widely cultivated cereal crop globally.

Farmers prefer the sorghum cultivation because of its heat and drought tolerance, and suitability for various soil types. It has multiple uses, primarily in animal feed and ethanol-based fuel production (North America), but also in human food, with research indicating an impressive nutritional profile for sorghum.

Among the sorghum-growing countries in Africa (Figure 2), Sudan stands out, being the world's largest sorghum cultivator in 2023. Cultivated areas in Sudan have fluctuated during the analyzed period (2013-2023), ranging from 5,197 million hectares (2015) to 9,157 million hectares (2016). Compared to 2013, Sudan cultivated an area smaller by 15.44% in 2023, representing 1,092 million hectares. Nigeria ranked second globally in 2023 in terms of sorghum cultivated areas, with 5,700 million hectares. This area remained relatively constant, with slight fluctuations during the analysis period (with a maximum of +/-7% from year to year).

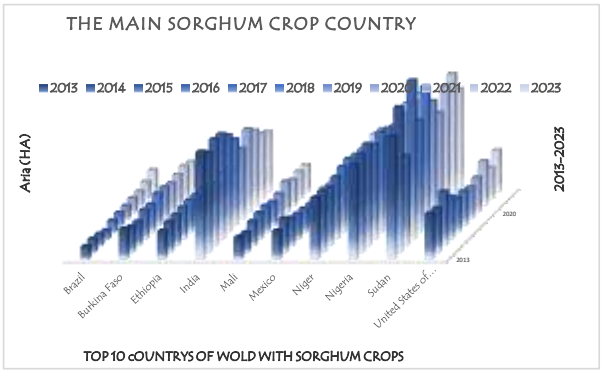

Fig. 2. Main sorghum-growing countries worldwide
Source: Own data processing based on the data from FAO [7].

Another African sorghum-growing country is Niger, ranking third among global producers in 2023 by cultivated area, with 3,700 million hectares.

Niger also shows a constant cultivation of sorghum, with small fluctuations of approximately +/-5% during the analysis period, similar to Nigeria.

India ranks fourth among sorghum-growing countries. In 2023, the cultivated area was 3,534 hectares, showing a downward trend in areas dedicated to this crop. The decrease in cultivated areas in 2023 compared to 2013 was 43.09%.

The United States of America occupies the fifth position in the mentioned ranking, with an area of 2,474 million hectares in 2023 (Table 1).

The trend is either to maintain or slightly decrease (7.14% lower in 2023 compared to 2013), except for 2015, when the area increased by 22.65% compared to the previous year.

The next sorghum-growing country in Africa is Burkina Faso, with a cultivation area of 1,793 million hectares in 2023.

Area fluctuations were observed during the analysis, recording years with increases compared to the previous period (20.02% in 2016 compared to 2015, 14.42% in 2018 compared to 2017, 5.34% in 2021 compared to 2020 and 7.20% in 2022 compared to 2021) but also years with decreases in area (14.29% in 2014 compared to 2013, 6.68% in 2015 compared to 2014 and 3.86% in 2017 compared to 2016, with insignificant differences in the other years).

Mali ranks seventh among sorghum-growing countries, with areas located at 1,632 million hectares in 2023, up 22.87% compared to the area cultivated with sorghum in 2013.

Ethiopia is the country ranked eight globally in sorghum cultivation, with 1,480 million hectares in 2023, an 11.78% reduction from 2013. Brazil's cultivation area reached 1,344 million hectares, marking a 69.57% increase over the same period.

Mexico ranks tenth among sorghum-growing countries, with 1,319 million hectares in 2023, down 11.85% compared to 2013.

Sorghum is mainly used in human food in climates that do not allow the production of other cereals, which justifies the predominance of cultivation in some African countries, where annual consumption is 100 kg of sorghum per person.

Analyzing the sorghum production achieved worldwide, the ranking of world countries changes.

Table 1. Evolution of areas cultivated with sorghum in the period 2013-2023

Country	2014/ 2013	2015/ 2014	2016/ 2015	2017/ 2016	2018/ 2017	2019/ 2018	2020/ 2019	2021/ 2020	2022/ 2021	2023/ 2022	The variation 2023/2013	
	-%-										Relative -%-	Absolute -ha-
Brazil	105.96	87.25	76.15	133.39	107.47	102.27	107.43	101.17	117.92	128.19	169.57	551,570
Burkina Faso	85.71	93.32	120.02	96.14	114.42	99.08	91.77	105.34	107.20	91.58	99.29	-12,746
Ethiopia	109.37	101.09	101.47	100.77	96.48	99.92	91.86	80.42	114.77	95.48	88.22	-197,486
India	93.24	106.39	98.70	92.51	89.33	81.46	117.86	90.76	86.82	93.00	56.91	-2,675,279
Mali	90.67	120.97	107.06	101.66	90.49	104.57	122.06	84.40	106.04	99.60	122.87	304,206
Mexico	119.24	82.36	91.22	94.37	91.09	101.87	109.73	89.26	104.08	97.73	78.15	-369,013
Niger	100.20	95.65	105.50	105.99	101.98	96.18	97.99	95.83	107.59	97.72	103.78	134,916
Nigeria	104.64	103.45	92.76	106.36	96.72	95.88	107.46	102.26	96.11	100.00	104.60	250,800
Sudan	118.33	62.04	176.21	70.73	124.23	84.86	84.86	119.39	104.71	82.66	84.56	-1,092,583
USA	97.21	122.65	78.50	81.84	100.34	92.37	108.98	127.38	70.42	133.81	92.86	-190,200

Source: Own data processing based on the data from FAO [7].

Taking into account the total production of sorghum in the main growing countries (Figure 3), we note the country that clearly leads this ranking, the USA (9,921 million tons), followed by Nigeria (6,697 million tons), Mexico (5,208 million tons), India (4,627 million tons), Ethiopia (4,487 million tons), Sudan (4,374 million tons), China (2,856 million tons), Brazil (2,506 million tons), Burkina Faso (1,738 million tons) and Australia (1,630 million tons).

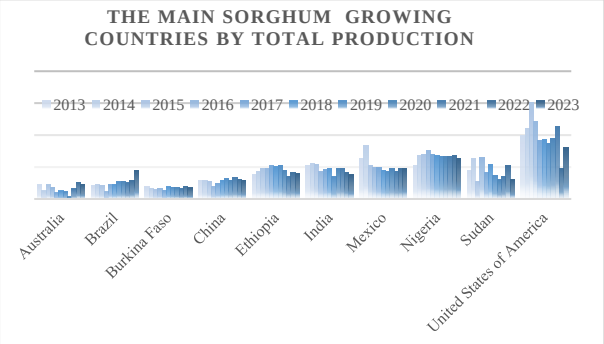

Fig. 3. Total production and its evolution in the main sorghum-producing countries
Source: Own data processing based on the data from FAO [7].

The yield of sorghum cultivation highlighted another ranking among sorghum-growing countries (Figure 4), with average yields per hectare, as follows: Oman (36,156.30 kg/ha), Jordan (22,113.01 kg/ha), Israel (20,202.30 kg/ha), Austria (8,006.56 kg/ha), Italy (7,211.92 kg/ha), Philippines (5,917.39 kg/ha), France (5,853.74 kg/ha), Egypt (5,641.43 kg/ha), Hungary (4,401.72 kg/ha), Romania (3,705.10 kg/ha), Uzbekistan (3,135.74 kg/ha).

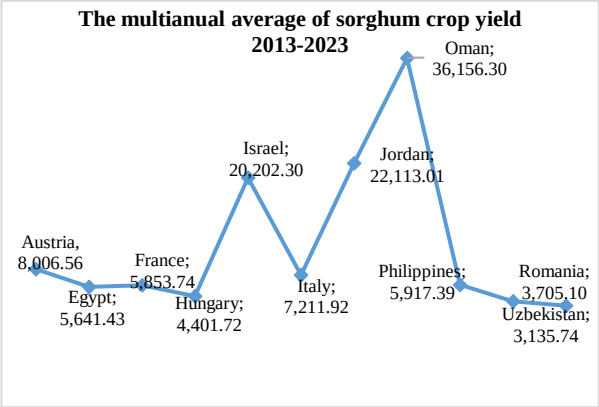

Fig. 4. Multi-annual average of sorghum yield in countries of the world
Source: Own data processing based on the data from FAO [7].

The recording of these significantly differentiated yields from one country to another indicates that some of the important factors involved are pedoclimatic conditions, sorghum production technology, genetics of cultivated plants (hybrid type), but also the professionalism of farmers (Table 2).

Considering that the global demand for sorghum is increasing, largely driven by China, which sources sorghum from the USA to supplement the deficit needed for animal feed, we can mention that sorghum ranks among the top countries with increasing demand among cereals.

The price of sorghum (Figure 5) has significant variations from one country to another, but also from one year to another in the period covered by the analysis, 2013-2023.

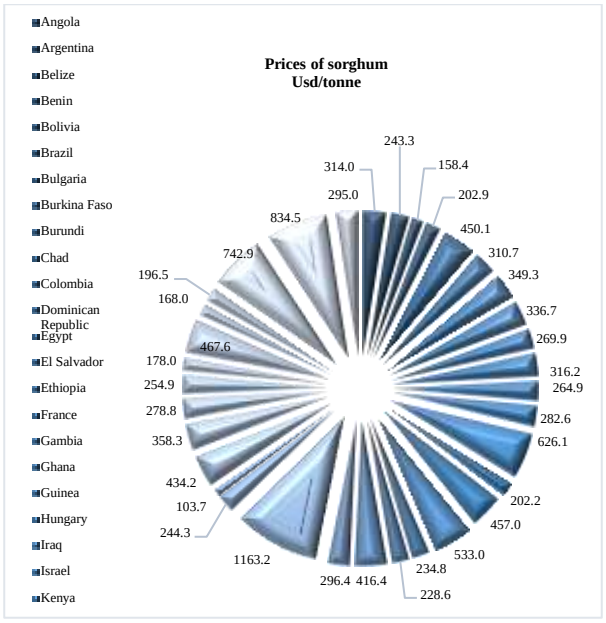

Fig. 5. Sorghum price, worldwide
Source: Own data processing based on teh data from FAO [7].

The data provided by FAOSTAT are uneven; some countries have not reported sorghum prices at all or have reported them randomly. The price of sorghum is influenced primarily by the demand for consumption in the respective country but also on export markets. The most common frequency of sorghum prices is in the range of 103.7 USD/ton – 333.7 USD/ton but also in the range of 333.7 USD/ton-563.7 USD/ton [7].
Analyzing the data reported by world countries regarding sorghum producer prices, based on the Pareto diagram.
This diagran grouped sorghum prices in descending order in sorghum-growing and consuming countries, we note that in 2013, the highest prices were recorded in African countries, where there is a high demand for sorghum, given a significant consuming population [7].
Also in 2021, the price for sorghum producers remained high among African countries. We note the situation in the Republic of Moldova where the price of sorghum is much lower than the prices of other producers (103.7 USD/ton). The USA practices relatively low prices for sorghum, due to very high productions and which, through valorization and negotiation, lead to a reduction in the price of this cereal.

Table 2. Evolution of total production in the main producing countries, by production level

Country	Multiannual Average of production (to)	Variation 2023/2013	
		Relative (%)	Absolute (to)
United States of America	1,630,361.78	80.98	-1,894,580
Mexico	2,506,400.82	76.34	-1,492,215.09
India	1,738,569.91	72.23	-1,465,823.6
Ethiopia	2,856,897.99	104.73	181,130
Sudan	4,487,812.87	67.52	-1,469,000
Nigeria	4,627,754.22	120.78	1,101,730
China	5,208,476.37	102.55	74,033.56
Burkina Faso	6,697,557.73	94.23	-108,443.32
Brazil	4,374,330.14	211.56	2,372,120
Australia	9,921,546.36	104.33	96,557

Source: Multiannual average of production in the main sorghum-producing countries
Source: Own data processing based on the data from FAO [7].

- **Main sorghum-growing countries in the EU**

In Europe, the first sorghum hybrids were introduced in 1960. Grain sorghum is mainly used today for animal feed, although, as already mentioned, this plant, sorghum, is considered a cereal of the future, in the current changing pedoclimatic conditions, caused by global warming, which makes drought years increasingly frequent.

Fig. 6. Cultivated area with sorghum in the EU in 2024.
Source: Own data processing based on the data from Eurostat [6].

In 2024, in the EU, the total area cultivated with sorghum was 229,380 ha.
The use of sorghum in several areas (Figure 6), in addition to animal feed, having a significant percentage of vegetable protein and which is its main destination for EU farmers, has led them to consider sorghum for more diverse rotations, especially in areas with deficient rainfall in Southern and Central Europe.
In the European Union (Figure 7), the main sorghum-growing country is France, which in

2024 had a cultivated area of 101,980 ha and a production of 5,040 kg/ha, followed by Hungary with an area of 44,940 ha and an average production of 5,000 kg/ha, Italy, with an area of 40,590 ha and an average production of 6,210 kg/ha, and Romania, with an area of 16,000 ha, and an average production of 1,360 kg/ha.
Smaller areas (Table 3) were held in 2024 by Slovakia (8,160 ha), Bulgaria (6,000 ha), Austria (5,500 ha), Spain (4,020 ha), Greece (2,060 ha) [6].

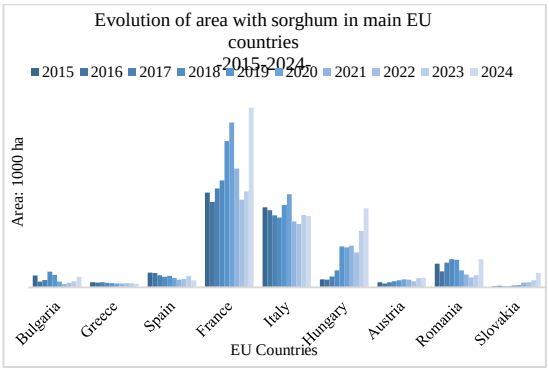

Fig. 7. EU sorghum cultivation area: 2015-2024 trends
Source: Own data processing based on the data from Eurostat [6].

Table 3. Structure of areas cultivated with sorghum in EU countries, in the period 2015-2024

COUNTRIES UE	2015		2016		2017		2018		2019		2020		2021		2022		2023		2024	
	1000 ha	%	1000 ha	%	1000 ha	%	1000 ha	%	1000 ha	%	1000 ha	%	1000 ha	%	1000 ha	%	1000 ha	%	1000 ha	%
Bulgaria	6.82	4.91	3.29	2.66	4.24	3.13	8.86	6.00	7.04	3.70	3.26	1.67	1.86	1.23	2.51	1.97	3.54	2.26	6.00	2.62
Greece	2.86	2.06	2.74	2.22	3.01	2.22	2.62	1.78	2.36	1.24	2.24	1.14	2.21	1.46	2.35	1.84	2.42	1.55	2.06	0.90
Spain	8.38	6.03	8.12	6.57	6.96	5.14	5.97	4.05	6.56	3.45	5.25	2.68	4.33	2.85	4.71	3.69	6.51	4.16	4.02	1.75
France	53.79	38.70	48.46	39.24	56.24	41.51	60.77	41.18	83.09	43.72	93.58	47.81	67.48	44.48	49.86	39.10	54.61	34.92	101.98	44.46
Croatia	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Italy	45.41	32.67	43.84	35.50	40.90	30.19	39.60	26.83	46.80	24.63	52.91	27.03	37.54	24.74	36.05	28.27	41.09	26.28	40.59	17.70
Hungary	4.58	3.29	4.45	3.60	6.25	4.61	9.62	6.52	23.32	12.27	22.82	11.66	23.71	15.63	19.77	15.50	32.00	20.46	44.94	19.59
Austria	2.92	2.10	2.26	1.83	2.99	2.21	3.53	2.39	3.94	2.07	4.64	2.37	4.39	2.89	3.55	2.78	5.22	3.34	5.50	2.40
Romania	13.49	9.71	9.16	7.42	13.99	10.33	15.93	10.79	15.71	8.27	9.59	4.90	7.35	4.84	5.70	4.47	6.86	4.39	16.07	7.01
Slovenia	0.09	0.06	0.11	0.09	0.14	0.10	0.08	0.05	0.13	0.07	0.09	0.05	0.17	0.11	0.05	0.04	0.02	0.01	0.06	0.03
Slovakia	0.62	0.45	0.97	0.79	0.64	0.47	0.57	0.39	1.07	0.56	1.36	0.69	2.66	1.75	2.94	2.31	4.00	2.56	8.16	3.56
Bosnia and Herzegovina	0.01	0.01	0.11	0.09	0.11	0.08	0.03	0.02	0.02	0.01	0.00	0.00	0.02	0.01	0.02	0.02	0.10	0.06	0.00	0.00
Total UE	###	###	###	###	###	###	###	###	####	###	###	####	151.72	####	127.51	###	156.37	100.00	####	####

Source: Own data processing based on the data from Eurostat [6].

In the European Union, the total sorghum production in 2024 was 1,112.29 thousand tons, but its needs are far from being covered. It is likely that sorghum production in each country will change (Table 4, Figure 8), as farmers who have been most affected by climate change, with all its arsenal regarding heat, soil drought, reduced rainfall, have been looking for crops to replace corn, with similar characteristics and uses, and sorghum is resistant to these changes, meeting the demands coming from farmers.
Unprecedented challenges in accelerating climate change make the future present major uncertainties for agriculture and implicitly for ensuring food for the planet's population, a context in which countries around the world are looking for solutions, having the desire for *zero hunger*.
In this context, sorghum is suitable for cultivation in drought and even heat conditions, and the goal is to introduce and expand areas worldwide and European.
Sorghum demonstrates a significant capacity to for growth cycle modulation in response to fluctuating water potential. The wax that develops on the plant under water stress conditions helps the plant slow down its respiration and photosynthesis, protecting the stem and leaves from direct sunlight.
Grain sorghum offers an alternative in this context, as it is adaptable to different temperatures and soil conditions, being flexible and at the same time with high

robustness, in extreme heat and drought conditions for long period.

Table 4. Structure of total sorghum production in EU countries, in the period 2015-2024

Countries UE	2015		2016		2017		2018		2019		2020		2021		2022		2023		2024	
	1000 tone	%	1000 tone	%	1000 tone	%	1000 tone	%	1000 tone	%	1000 tone	%	1000 tone	%	1000 tone	%	1000 tone	%	1000 tone	%
Bulgaria	17.26	2.23	7.98	1.15	12.47	1.72	37.01	4.40	23.22	2.27	11.34	1.09	5.34	0.65	6.02	1.13	8.82	1.06	14.65	1.32
Greece	10.72	1.39	7.20	1.04	8.64	1.19	7.64	0.91	7.44	0.73	7.39	0.71	6.92	0.85	8.13	1.52	7.57	0.91	7.18	0.65
Spain	51.51	6.66	37.21	5.36	30.84	4.26	26.18	3.11	25.73	2.52	21.56	2.08	16.49	2.02	14.97	2.80	31.38	3.76	17.65	1.59
France	275.23	35.59	###	37.46	322.00	44.48	316.64	37.67	422.90	41.37	431.70	41.62	382.28	46.73	210.94	39.44	303.99	36.41	514.13	46.22
Italy	####	45.12	###	46.35	248.75	34.36	303.71	36.13	322.85	31.58	373.81	36.04	230.95	28.23	197.56	36.94	247.18	29.61	252.19	22.67
Hungary	15.53	2.01	16.11	2.32	24.55	3.39	43.47	5.17	126.29	12.36	108.73	10.48	95.02	11.62	47.55	8.89	160.03	19.17	224.69	20.20
Austria	20.56	2.66	16.52	2.38	20.21	2.79	27.43	3.26	29.74	2.91	40.32	3.89	36.93	4.51	26.17	4.89	37.47	4.49	36.44	3.28
Romania	31.73	4.10	24.41	3.52	54.28	7.50	76.31	9.08	60.01	5.87	35.70	3.44	33.75	4.13	14.83	2.77	20.78	2.49	21.79	1.96
Slovenia	0.52	0.07	0.57	0.08	0.41	0.06	0.38	0.05	0.51	0.05	0.23	0.02	0.53	0.06	0.08	0.01	0.08	0.01	0.23	0.02
Slovakia	1.22	0.16	2.11	0.30	1.62	0.22	1.73	0.21	3.43	0.34	6.35	0.61	9.87	1.21	8.42	1.57	16.90	2.02	23.34	2.10
Bosnia and Herzegovina	0.11	0.01	0.26	0.04	0.09	0.01	0.07	0.01	0.05	0.00	0.00	0.00	0.00	0.00	0.16	0.03	0.63	0.08	0.00	0.00
Total UE	773.35	###	###	100.00	723.86	100.00	840.57	####	1022.17	100.00	1037.13	100.00	818.08	100.00	534.83	100.00	834.83	100.00	1112.29	100.00

Source: Own data processing based on the data from Eurostat [6].

This crop also has the advantage that the need for nitrogen, pesticides, and water is lower compared to other crops, making it suitable for cultivation using the "No-till" conservation technology.

Sorghum is a competitive crop, especially when sown in narrow rows and performs well against weeds, releasing a chemical compound through the root which inhibits weed growth, acting like a natural herbicide.

These mentions recommend sorghum to be included in various crop rotations, being a crop with low operating costs, due to minimal phytosanitary treatments, resistance to disease and pest attacks, as well as weed infestation, low requirements regarding nutrient needs, due to its well-developed root system, which acts as a pump in extracting nitrogen and other nutrients it needs.

In this sense, there are countries that have started to increase cultivated areas rapidly, and examples of these countries are Hungary and Slovakia (Table 5).

The both figures show an upward trend.

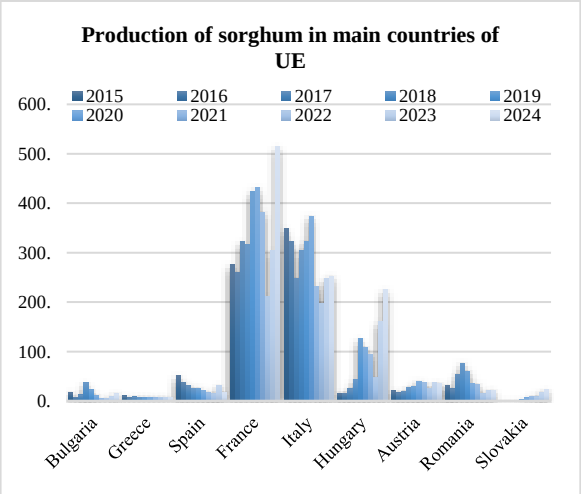

Fig. 8. Total sorghum production in EU countries, in the period 2015-2024

Source: Own data processing based on the data from FAO [7].

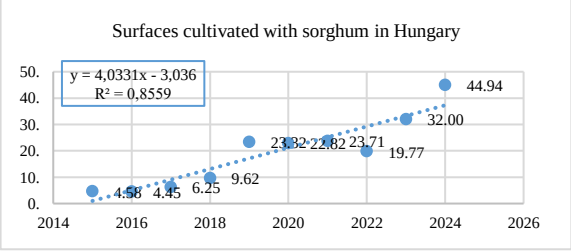

Fig. 9. Sorghum area in Hungary in the period 2015-2024

Source: Own data processing based on the data from Eurostat [6].

Table 5. Main statistical indicators regarding the area cultivated with sorghum in EU countries, for the period 2015-2024

Country UE	Mean	Standard deviation	Coefficient of variation (%)	Minimum area	Maximum area	Range Max-Min
Spain	6.08	1.51	24.83	4.02	8.38	4.36
France	66.99	19.18	28.63	48.46	101.98	53.52
Italy	42.47	4.94	11.64	36.05	52.91	16.86
Hungary	19.15	13.20	68.94	4.45	44.94	40.49
Austria	3.89	1.05	26.84	2.26	5.5	3.24
Romania	11.39	4.08	35.83	5.7	16.07	10.37
Slovakia	2.30	2.37	103.04	0.57	8.16	7.59

Source: Own data processing based on the data from Eurostat [6].

Table 6. Main statistical indicators regarding total sorghum production in EU countries, for the period 2015-2024

Country	Mean	Standard deviation	Coefficient of variation (%)	Minimum production	Maximum production	Range Max-Min
Spain	27.35	11.12	40.64	14.97	51.51	36.54
France	343.99	92.27	26.82	210.94	514.13	303.19
Italy	284.78	57.26	20.11	197.56	373.81	176.25
Hungary	86.20	69.80	80.98	15.53	224.69	209.16
Austria	29.18	8.39	28.74	16.52	40.32	23.80
Romania	37.36	19.88	53.21	14.83	76.31	61.48
Slovakia	7.50	7.45	99.39	1.22	23.34	22.12

Source: Own data processing based on the data from Eurostat [6].

Thus, the statistical models are expressed in theh following regression equations:
y = 19,042x - 18,535, which shows an increase in the average production by 19,042 thousand tons each year (Fig. 9).
y = 4,0331x - 3,036, which reflects the average increase in cultivated areas by 4,0332 thousand ha/year (Fig. 10).

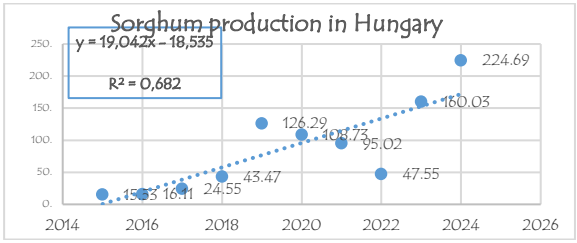

Fig. 10. Total sorghum production in Hungary, 2015-2024
Source: Own data processing based on the data from Eurostat [6].

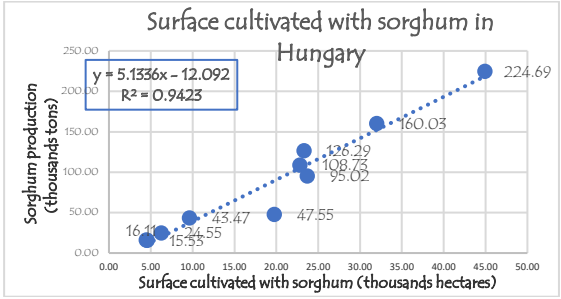

Fig. 11. Sorghum area-production in Hungary, 2015-2024
Source: Own data processing based on the data from Eurostat [6].

In Hungary, the correlation between total sorghum production and the area cultivated (Figure 11) with sorghum is strong, R^2 = 0.9423, a value that indicates that 94.23% of the production increase is due to the increase in cultivated area (Table 6).
Also, for Hungary, the Pearson linear correlation coefficient is 0.97, a value very close to 1, denoting a very strong correlation. Taking into account that, from an agronomic point of view, in the long term, sorghum can deplete the soil of nutrients, this aspect does not constitute a benefit for the soil, we mention that the economic advantage of the crop itself is undeniable.

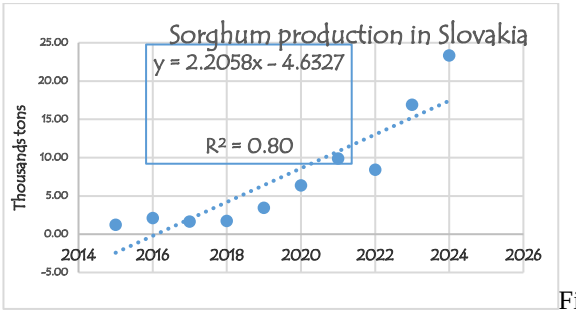

Fig. 12. Sorghum production in Slovakia, 2015-2024
Source: Own data processing based on the data from Eurostat [6].

In the case of Slovakia (Figure 12), a pronounced increase in sorghum production was also evident in the period 2015-2024, on average by 2.2058 thousand tons per year,

according to the linear model y = 2.2058x - 4.6327, so sorghum production tends to increase by 2.7766 thousand tons annually.

In Spain, a pronounced decrease in sorghum production (Figure 13) was evident in the period 2015-2024, on average by 2.7766 thousand tons per year, according to the linear model y = 2.7766x - 42.623, and sorghum production tends to decrease by 2.7766 thousand tons annually.

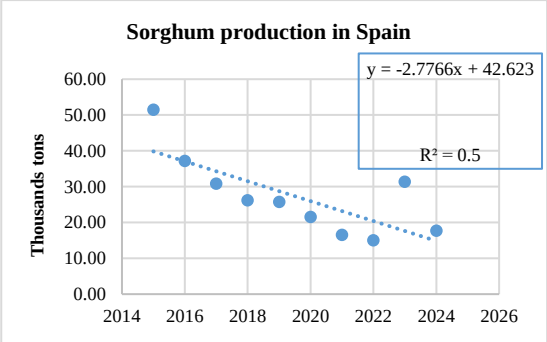

Fig. 13. Sorghum production in Spain
Source: Own data processing based on the data from Eurostat [6].

All these technological aspects, from an economic point of view, translate into lower crop maintenance costs, and due to the fact that sorghum has high yields, it can lead to significant revenues for farmers, compared to other crops more sensitive to drought, diseases and pests, in the mentioned context, of a conglomerate of specific negative phenomena frequently encountered in agronomic practice such as heat, soil drought, disease attack, pests and weeds.

Sorghum cultivation in Romania

Romania is among the countries where recurrent drought has been a real challenge for spring crops, and where sorghum is an opportune alternative in farmers' rotations.

Known as a raw material for brooms, sorghum has come to the attention of Romanian farmers in southern Romania, who have steadily increased the areas introduced into crop rotation with this plant. Also, studies in Romania conducted on small and medium-sized farms have shown that the use of alternative fodder, such as sorghum, in conditions of reduced water regime, represents, from an economic point of view, a solution to reduce the vulnerability of farmers' incomes [5].

Grain sorghum cultivation does not have a technology much different from corn cultivation, using the corn seeder at a depth of 2-5 cm and at a population between 50,000 and 300,000 seeds per hectare, depending on the distance between rows and soil fertility.

Analysis of Romanian sorghum cultivation from 2013 to 2023 (Figure 14) reveals a high degree of variability, as evidenced by a coefficient of variation of 41.6%.

The mean cultivated acreage (Table 7) was 12,572.82 hectares, with a standard deviation of 5,231.05 hectares.

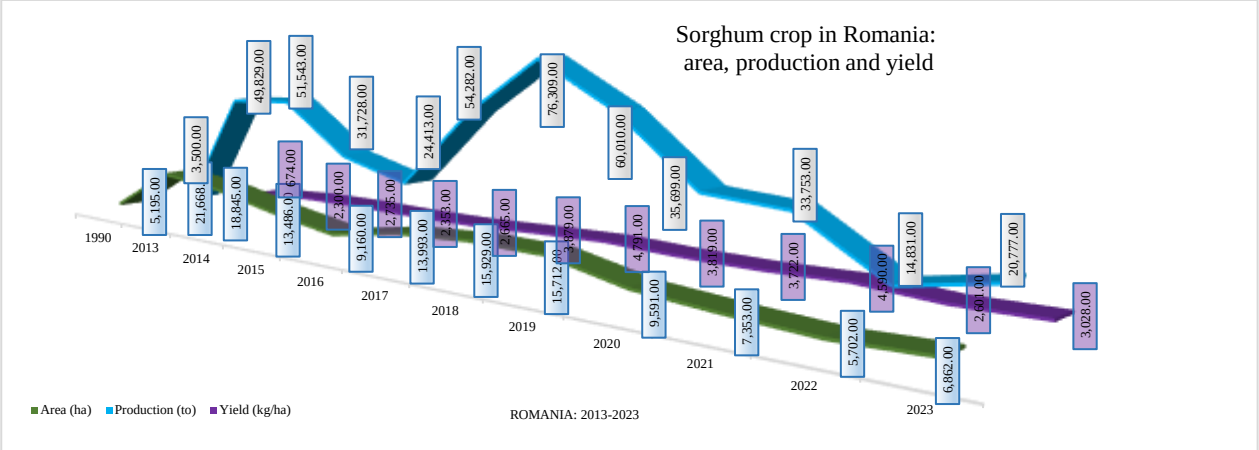

Fig. 14. Sorghum cultivation in Romania in the period 2013-2023: areas, total production and yield
Source: Own data processing based on the data from NIS Tempo online [13].

But, in the current changing pedoclimatic conditions, as a result of global warming which has led to a higher frequency of drought years in Romania as well, sorghum has become a

choice for more diverse rotations in southern and eastern areas with deficient rainfall.

Table 7. Area (ha) cultivated with sorghum in Romania

Indicator	Value	Indicator	Value
Mean	12,572.82	Standard Deviation	5,231.05
Minimum	5,702	Range	15,966
Maximum	21,668	Coefficient of variation	41.60%
Sum	138,301	Count	11

Source: Own data processing based on the data from NIS Tempo online [13].

Table 8. Total production (tons) of sorghum cultivation in Romania, 2015-2024

Indicator	Value	Indicator	Value
Indicator	Value	Indicator	Value
Mean	4,1197.64	Standard Deviation	18,731.52
Minimum	5,702	Coefficient of variation	45.47%
Maximum	21,668	Range	61,478
Sum	138,301	Count	11

Source: Own data processing based on the data from NIS Tempo online [13].

Romanian farmers who wish to introduce this plant into their own crop rotations must take into account that this heat-loving plant requires an average temperature of at least 25°C to maximize its yield, developing without difficulty at temperatures of 30°C, conditions in which other similar crops would face adaptation difficulties.

In Romania, in the period 2013-2023, total production (Table 8) recorded an average value of 41,197.64 tons, with a standard deviation of 18,731.52 tons. And in the case of total production, the data have a fairly large variability, the coefficient of variation being at the level of 45.46% (>35%).

Romanian sorghum production and cultivated area (Figure 15, Figure 16) exhibited a simultaneous annual decline of 2,343 tons and 1,294.7 ha, respectively, as determined by statistical modeling.

The comparative analysis of the areas cultivated in Romania, in 2023 compared to 1990, showed that it increased by 32.09% (1,667 ha) which led to an increase in total production by 17,277 tons and also in the crop yield by 2,354 kg/ha. The "stay-green" characteristic of sorghum can naturally increase yield by up to 20% in drought conditions.

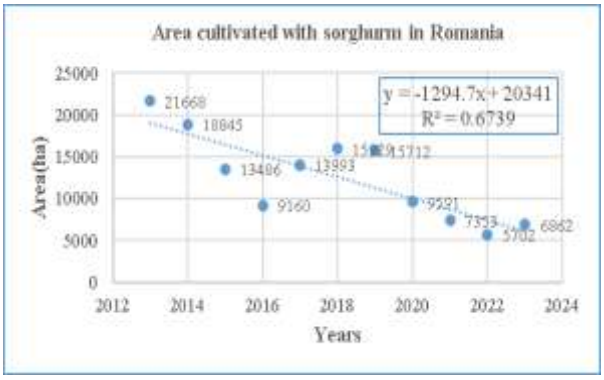

Fig 15. Sorghum cultivation in Romania in the period 2015-2024: areas

Source: Own data processing based on the data from NIS Tempo online [13].

This characteristic makes sorghum extremely flexible.

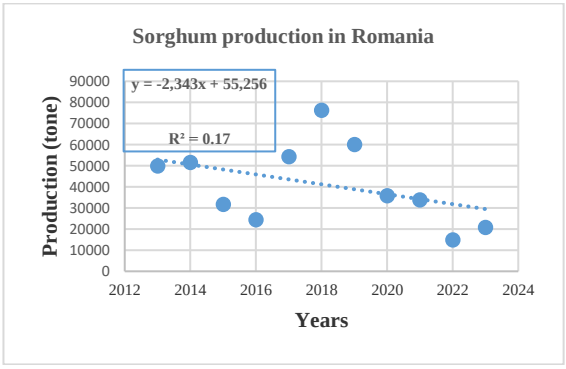

Fig. 16. Sorghum cultivation in Romania in the period 2015-2024: total production

Source: Own data processing based on the data from NIS Tempo online [13].

A 68.33% decrease in sorghum cultivation (Table 9) area was observed between 2013 and 2023 (-14,806 ha), this aspect leading to a decrease in production by 58.30% (-29,052 ha), but what is remarkable is the increase in yield by 31.65% (+728 kg/ha). This yield increase can be attributed to the choice of the right hybrid and an appropriate technology, sorghum also being able to be used as a second crop.

But this plant with increased temperature tolerance has the disadvantage that night time temperatures below 13°C for several days can have a negative impact on its potential yield, which must be taken into account when limiting the location and sowing dates.

According to the simple linear regression model y = 2.7063x + 7,172.2 and the coefficient of determination R^2 = 0.5712, sorghum production in Romania increased by 57.12% due to the increase in cultivated areas, the remaining 42.88% being causes unexplained by the model, but explained by the hybrids used, the cultivation technology and the agrometeorological conditions of each year, with heatwave temperatures, caused by climate change and which makes it possible for Europe and implicitly Romania, to meet the conditions required by sorghum cultivation, adapted to hot and dry climates, namely the climate of tropical and subtropical regions.

Table 9. Sorghum cultivation in Romania: areas, production, yield, 2015-2024

Romania	Specification	Variation in 2023 compared with 1990		Variation in 2023 compared with 2013	
		(%)	(ha)	(%)	(ha)
Sorghum	**Area (ha)**	132.09	1,667.00	31.67	-14,806
	Production (to)	593.63	17,277.00	41.70	-29,052
	Yield (kg/ha)	449.26	2,354.00	131.65	728

Source: Own data processing based on the data from NIS Tempo online [13].

The determined Pearson correlation coefficient (Figure 17), r=0.755765, indicated an important direct correlation between the areas cultivated with sorghum and production in the period 2013-2023.

Applying the Fisher test to validate the mathematical model, it was found that the model is valid because the calculated value of the test, F calc=11.98 > F table=F (0.05; 1; 9) = 5.12, and also by calculating the Significance F value =0.00713435 < 0.05.

Promoting this plant among farmers to be cultivated on as large areas as possible will be directly correlated with the increase in production.

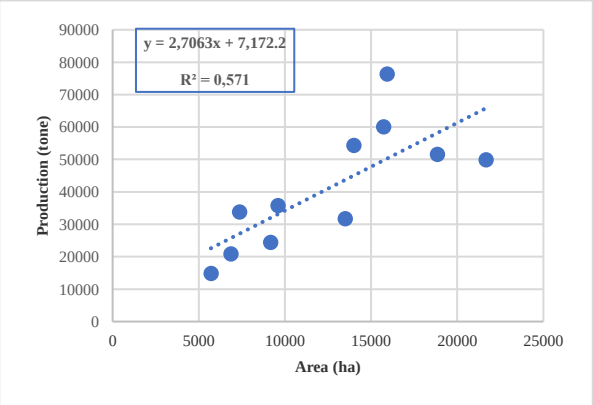

Fig.17. Linear correlation between total production and area cultivated with sorghum in Romania, 2015-2024
Source: Own data processing based on the data from NIS Tempo online [13].

This is due to the fact that sorghum has a significantly higher percentage of vegetable protein than corn, it will generate the expansion of activities in the zootechnical field, sorghum being recommended for animal rations, by including it in fodder.

Also, increased production will generate income for farmers by capitalizing on it as biomass for biogas, in the production of alcohol or even for human food. All these arguments are in the sense of determining Romanian farmers to show an increased interest in sorghum cultivation by knowing the benefits of this crop, both technically, technologically and economically.

CONCLUSIONS

Sorghum sends a signal to the entire world, as a plant suitable for drought-prone areas, which recommends it in the present, in the context in which humanity is facing challenges related to ensuring food security, with the desideratum for the future of "zero hunger". Sorghum could be a choice for Southern and Central Europe, which is facing the drastic effects of climate change, a context in which Romania is directly targeted, considering the last four extremely dry years (2020-2024). Why do we recommend sorghum for expanded cultivation? The main arguments in favor of sorghum cultivation are the low water requirements, profitability, diversification and easy production technology. Sorghum's agronomic advantages include its hardiness, ability to interrupt pest and weed cycles, and reduced need for specialized machinery. Regarding the soil

structure, sorghum improves it, not having a long production cycle, while allowing the use of land with lower productive potential, etc. Adopting sorghum is an easy decision for farmers if they take these arguments into account.

The research carried out on sorghum cultivation, as a crop of the future, in the context of climate change and counteracting future food shortages, with the desideratum of zero hunger, also highlighted the following:

Globally, in 2023, among the top 10 sorghum-growing countries by cultivated area, we find countries such as Sudan (5,987 thousand ha), Nigeria (5,700 thousand ha), Niger (3,700 thousand ha), India (3,534.72 thousand ha), USA (2,474.68 ha), Burkina Faso (1,793.78 ha), Mali (1,632.82 ha), Ethiopia (1,480 thousand ha), Brazil (1,344.40 thousand ha), Mexico (1,319.90 ha).

Globally, for the multi-year total sorghum production in the 2013-2023 interval, we note the country that leads this ranking by far, the USA (9,921 million tons), followed by Nigeria (6,697 million tons), Mexico (5,208 million tons), India (4,627 million tons), Ethiopia (4,487 million tons), Sudan (4,374 million tons), China (2,856 million tons, Brazil (2,506 million tons), Burkina Faso (1,738 million tons) and Australia (1,630 million tons).

Globally, average sorghum production/ha is significantly differentiated from one country to another, indicating that pedoclimatic conditions, sorghum production technology, genetics of cultivated plants (hybrid type), are essential, as follows: Oman

Oman (36,156.30 kg/ha), Jordan (22,113.01 kg/ha), Israel (20,202.30 kg/ha), Austria (8,006.56 kg/ha), Italy (7,211.92 kg/ha), Philippines (5,917.39 kg/ha), France (5,853.74 kg/ha), Egypt (5,641.43 kg/ha), Hungary (4,401.72 kg/ha), Romania (3,705.10 kg/ha), Uzbekistan (3,135.74 kg/ha).

Globally, the most frequently encountered sorghum price range is between 103.7 USD/ton and 333.7 USD/ton, as well as between 333.7 USD/ton and 563.7 USD/ton.

At the EU level, in 2024, the total area cultivated with sorghum was 229,380 ha, with France being the main sorghum-growing country, having a cultivated area of 101,980 ha and a production of 5,040 kg/ha in 2024, followed by Hungary with an area of 44,940 ha and an average production of 5,000 kg/ha, Italy, with an area of 40,590 ha and an average production of 6210 kg/ha, and Romania, with an area of 16,000 ha, and an average production of 1360 kg/ha. Smaller areas were held in 2024 by Slovakia (8,160 ha), Bulgaria (6,000 ha), Austria (5,500 ha), Spain (4,020 ha), Greece (2,060 ha).

Within the EU, certain nations demonstrated temporal stability in sorghum cultivation area during the study period, including France and Italy, countries that reduced the cultivated area, such as Romania and Spain, and countries that discovered in sorghum an alternative for high-yielding cereal crops, and showed a significant upward trend in cultivated areas, such as Slovakia and Hungary, were noted. According to statistical models, it was shown that total productions evolved similarly to cultivated areas.

In the European Union, the total sorghum production in 2024 was 1,112.29 thousand tons, of which, France 514.13 thousand tons, Italy 252.19 thousand tons, Hungary 224.69 thousand tons, Austria 36.44 thousand tons, Slovakia 23.34 thousand tons, Romania 21.79 thousand tons, Spain 17.65 thousand tons and Bulgaria 14.65 thousand tons.

Romanian sorghum cultivation from 2013-2023 demonstrated significant variability, the coefficient of variation being 41.6%, with a mean cultivated area of 12,572.82 ha and a standard deviation of 5,231.05 ha.

In Romania, the total production recorded an average value of 41,197.64 tons, with a standard deviation of 18,731.52 tons. And in the case of total production, the data have a fairly large variability, the coefficient of variation being at the level of 45.46% (>35%). Statistical modeling revealed a 2,343ton annual decline in Romanian sorghum production, concurrent with a 1,294.7 ha reduction in cultivated area during the study period. For Romania, it was concluded that sorghum production in Romania increased by 57.12% due to the increase in cultivated areas, the remaining 42.88% being causes

unexplained by the model, but explained by the hybrids used, the cultivation technology and the agrometeorological conditions of each year, with heatwave temperatures, caused by climate change and which makes it possible for Europe and implicitly Romania, to meet the conditions required by sorghum cultivation, adapted to hot and dry climates, similar to the climate of tropical and subtropical regions.

REFERENCES

[1]Asif, M., Adnan, M., Safdar, M.E., Akhtar, A., Khalofah,A., Alzuaibr, F.M., 2022, Integrated use of phosphorus and growth stimulant (actibion) improves yield and quality of forage sorghum (*Sorghum bicolor* L.), J. King Saud Univ. - Sci., Vol. 34(7), doi: 10.1016/j.jksus.2022.102236.

[2]Bakari, H., Djomdi, Ruben, Z. F., Roger, D. D., Cedric, D., Guillaume, P., ... & Gwendoline, C., 2023, Sorghum (*Sorghum bicolor* L. Moench) and its main parts (by-products) as promising sustainable sources of value-added ingredients. Waste and Biomass Valorization, 14(4), 1023-1044.1

[3]Burcea, M., Gidea, M., Oltenacu, N., 2020, (May), The evaluation of the available water potential of the soil and the influence of tillage systems on wheat crop. In 20th International Multidisciplinary Scientific GeoConference SGEM 2020, pp. 581-588.

[4]Chetani, R., Sharma, A., 2025, Green Synthesis of Zinc Oxide Nanoparticles using *Sorghum halepense* (L.) Pers and Assessment of their Antibacterial and Antioxidant Potential. Journal of Molecular Structure, 141373.

[5]Chetroiu, R., Rodino, S., Dragomir, V., Ilie, D. M., Marin, A., 2024, Assessing Economic Viability of Resilient Sheep Foraging Alternatives in Lowland Regions of Romania. Agriculture, 14(9), 1656. https://doi.org/10.3390/agriculture14091656

[6]Eurostat, Crop production in EU standard humidity https://ec.europa.eu/eurostat/databrowser/view/apro_cpsh1/default/table?lang=en&category=agr.apro.apro_crop.apro_cp.apro_cpsh, Accessed on February 10 2025.

[7]Food and Agriculture Organization, FAO, Faostat, www.fao.org/faostat/en/#data/QCL, Faostat, Crops and livestock production, Accessed on February 10 2025.

[8]Levine, D.M., Stephan, D.F., Szabat, K.A., 2021, Statistics for Managers Using Microsoft Excel, 9th edition Published by Pearson (March 15, 2021).

[9]Malobane, M.E., Nciizah, A.D., Wakindiki, I.I.C., Mudau, F.N., 2018, Sustainable production of sweet sorghum for biofuel production through conservation agriculture in South Africa, Food and Energy Security, Vol. 7(3), doi: 10.1002/fes3.129

[10]Manole, D., Giumba, A.M., Ganea, L., 2023, Sorghum, an alternative in complementarity with corn, adapted to Climate Changes. Amzacea Village, Constanta County, Romania. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 23(3), 501-512.

[11]Micu, M.M., Dinu, T.A., Fintineru, G., Tudor, V.C., Stoian, E., Dumitru, E.A., Stoicea, P., Iorga, A., 2022, Climate Change—Between "Myth and Truth" in Romanian Farmers' Perception. Sustainability. 2022; 14(14):8689. https://doi.org/10.3390/su14148689

[12]Nasidi, M., Agu, R., Deeni, Y., Walker, G., 2016, Utilization of whole sorghum crop residues for bioethanol production. Journal of the Institute of Brewing, 122(2), 268-277.

[13]National Institute of Statistics, Tempo online, http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table, Accessed on February 10 2025.

[14]Panaitescu, L., Pricop, S. M., Lungu, M. L., Moise, I., Panaitescu, R., Niță, S., 2016, Sustainable management of the grain sorghum crop-*Sorghum bicolor* L. in Dobrudja Plateau from Romania. International Journal of Sustainable Agricultural Management and Informatics, 2(1), 53-65.

[15]Peck, R., Olsen, C., Devore, J., L., 2010, Introduction to Statistics and Data Analysis, 2010 Cengage Learning.

[16]Pegorin, P., Rabelo Schley, T., Rossini, B. C., Araújo Júnior, J. P., de Almeida, L. F. R., 2025, Stress priming enhances drought response in *Sorghum bicolor* potentially involving PIP2; 5. Theoretical and Experimental Plant Physiology, 37(1), 1-17.

[17]Popescu, A., 2020, Sorghum production in the EU-28 in the period 2008-2019 and its forecast for 2020-2014 horizon. Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development, 20(3), 479-488.

[18]Pruett, A., Aramouni, F.M., Bean, S.R., Haub, M.D. Effect of Flour Particle Size on the Glycemic Index of Muffins Made from Whole Sorghum, Whole Corn, Brown Rice, Whole Wheat, or Refined Wheat Flours. Foods. 2023; 12(23):4188. https://doi.org/10.3390/foods12234188

[19]Pugh, N. A., Young, A., Emendack, Y., Sanchez, J., Xin, Z., Hayes, C., 2025, High-throughput phenotyping of stay-green in a sorghum breeding program using unmanned aerial vehicles and machine learning. The Plant Phenome Journal, 8(1), e70014.

[20]Rajvanshi, A. K., Patange, S., Nimbkar, N., 2020, Sweet sorghum syrup R&D in India. Current Science, 119(12), 1901-1909.

[21]Soare, E., Chiurciu, I.A., Apostol, C.E., Balan, A.V., Fulgeanu, D.F., 2024, Research on worldwide sorghum production and trade for the period 2017-2022. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 24(4), 753-758.

[22]Venkateswaran, K., Elangovan, M., Sivaraj, N., 2019, Origin, domestication and diffusion of *Sorghum bicolor*. In Breeding Sorghum for diverse end uses, pp. 15-31. Woodhead Publishing.

[23]Wang, Y., Dou, F., Storlien, J. O., Wight, J. P., Paustian, K. H., Del Grosso, S. J., Hons, F. M., 2017, Simulating impacts of bioenergy Sorghum residue

return on soil organic carbon and greenhouse gas emissions using the DAYCENT model. Global soil security, 167-180.
[24]Wondimu, Z., Bantte, K., Paterson, A. H., Worku, W., 2020, Agro-morphological diversity of Ethiopian sorghum [*Sorghum bicolor* (L.) Moench] landraces under water limited environments. Genetic Resources and Crop Evolution, 67(8), 2149-2160.
[25]Yang, M., Dahlberg, J., Baral, N.R., Putnam, D., Scown, C.D., 2021, Identifying Forage Sorghum Ideotypes for Advanced Biorefineries, ACS Sustain. Chem. Eng., Vol. 9(23), doi: 10.1021/acssuschemeng.1c01706.
[26]Zarei, M., Amirkolaei, A. K., Trushenski, J. T., Sealey, W. M., Schwarz, M. H., Ovissipour, R., 2022, Sorghum as a potential valuable aquafeed ingredient: Nutritional quality and digestibility. Agriculture, 12(5), 669.
[27]Zheng, H., Dang, Y., Sui, Na., 2023, Sorghum: A Multipurpose Crop, Journal of Agricultural and Food Chemistry 2023 71 (46), 17570-17583, DOI: 10.1021/acs.jafc.3c04942

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CYBER-PHYSICAL SOCIAL SPACE IN AGRICULTURE AND RISKS

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Abstract

Population growth, the subsequent need to meet food needs, and other challenges facing agriculture have led to an accelerated development of innovations driven by artificial intelligence and automation. Industry 4.0 considers cyber-physical systems as a driving factor in increasing agriculture's efficiency while considering environmental issues. This paper aims to present various aspects of the processes in cyber-physical social spaces for agriculture and identify the main advantages and risks associated with the transition to production primarily oriented towards human well-being. We utilize Eurostat public data for local small and medium-sized enterprises (SMEs) for the years 2021-2023 to highlight the initial level of digital transformation. Based on a survey of recent scientific work the study identifies eight categories of risk factors related to the adaptation to the new digital environment, e.g. data protection and labor market change. Furthermore, we specify the main challenges more prevalent for SMEs in agriculture. SMEs tend to show a low propensity to adopt digital technologies and therefore manifest low investment activity. Policy-makers should consider the conservatism issue, among other factors, when developing policies to accelerate digitalization in agriculture.

Key words**:** *intelligent systems, cyber-physical-social spaces, smart crop production*

INTRODUCTION

Digital technologies are becoming increasingly sophisticated and integrated and are causing significant changes in society and the economy, while also exercising their impact on agriculture. A number of new virtual platforms for smart agriculture are emerging, integrating heterogeneous technologies and different approaches to collect, store and process information for smart crop production in Bulgaria.

The creation of Cyber-Physical Systems – CPS is made possible and partly predetermined by the development of the Internet of Things (IoT) [34]. CPS are formed by combining computational and physical components, where "physical" are the elements of the system occupying physical space, and "cyber" are the computational and communication elements.

Cyber-physical systems and the spaces they construct reflect the relationship of the physical to the virtual world by integrating computational and physical processes and interacting with the environment in which they are situated [2]. Cyber-physical space integrates data collected in different physical, and cybernetic systems. The new cyber-physical reality is fundamental to social change in all spheres of life and society [34].

The review of related literature shows that scientific researches still do not provide unambiguous evidence on the impact and adoption of new technologies by SMEs. [21] points out the existence of a "contextual and methodological gap" between cyber-physical systems and their role in Industry 4.0. A positive impact of CPS is indicated as better placement of industries, which will give them an advantage to meet future requirements.

The application of Industry 4.0 technologies highlights some important issues for society arising from the development of cyber-physical systems. The first relates to the security and protection of personal data, and the second concerns questions about how we can better align the use of new technologies with achieving social goals. The development of new technologies and cyber-physical systems highlighted the manifestation of a side, mainly indicated as unfavourable, social effect – a shift in the role of the human factor in the production process. We see a striving to overcome this effect in the Industry 5.0

concept, primarily embracing the idea of achieving a human-oriented system [6].

In this context, the purpose of the paper is to present various aspects of the processes in cyber-physical social spaces for agriculture, as well as to identify and summarize the main advantages and risks in the context of the growing requirements for transitioning to a production primarily oriented towards human well-being.

MATERIALS AND METHODS

A survey of recent research work was conducted on aspects and processes in cyber-physical social spaces for agriculture, providing readers with relevant papers and highlighting the main advantages and risks, with a focus on agricultural enterprises. To leverage the latest advancements in this scientific field, we first conducted a search in the Web of Science and Scopus databases. The search query was conducted using the key words of this paper and applying the basic operators "OR" and "AND" for a combination of the keyword. The final strings were the following: "cyber-physical-social space" AND "agriculture"; "digitalization" AND "industry 4.0 OR 5.0" AND "agriculture". Next, to integrate policy implications on the digital transformation of agriculture and empirical surveys on the digital process, we also Google searched for official EU documents and available national agencies' analysis reports. Different policy measures (national programs) of the Ministry of Innovation and Growth were also considered, such as Programs on fostering the digitalization process. Some documents and reports providing important insights are the research and analysis report of the Bulgarian Industrial Chamber for determining the needs for digital skills by economic sectors; the European Commission's document on sustainable, human-centric and resilient European industry; EU Digital Decade Country Report 2023 for Bulgaria related to its performance in the transition process striving to achieve the overall targets of the EU until 2030.

To outline the level of digitalization of SMEs in Bulgaria we use public data from the Eurostat for local SMEs and large companies for 2021-2023, and data from Bulgarian national statistical institute –for industrial enterprises available for the period 2014-2022.

The methodological approach adopted in the next part of the paper is as follows: we first discuss the cyber-physical social space advantages, focusing on such data processing space in agriculture; next, we highlight the enterprises' initial digitalization level in Bulgaria as a basis for future policy implications; in the third subsection we identify and summarize main potential risks and challenges related to digital transformation for agricultural enterprises, and finally an overall frame for overcoming the challenges is outlines.

RESULTS AND DISCUSSIONS

Cyber-physical social space advantages in agriculture

Today, agricultural practices are supported by digital technologies and new approaches, such as remote sensing, cloud computing, Internet of Things (IoT), etc., leading to the concept of "smart agriculture" [17]. This concept can be viewed as an ecosystem that integrates physical, biological, ecological, chemical, economic, and social sciences to develop practices that do not have a harmful effect on the environment.

Sensor network technology enables the generation of large amounts of data from multiple locations, collected by various sensors that sense physical phenomena. At a later stage, the collected data can be combined through intelligent cybernetic processes and processed and analyzed through intelligent applications to provide better services for agriculture.

Efforts to help monitor and manage agricultural processes are linked to the development of smart agricultural infrastructures based on CPS and IoT [19]. Models of such systems can be found in specialized literature. In [14], an agricultural CPS integrating three worlds: physical, mental and artificial is presented. We can consider the physical world in agriculture comprised of the production resources and outcomes, including

plants, livestock and others, that are aligned with cyberspace by various IoT techniques. The relevant professional competence and experience is referred to the mental world. And finally, the artificial world supports different models and solutions to impact the physical world. Kiani et al. (2018) describe an architecture for monitoring soil moisture and temperature in small farms using wireless sensor networks and IoT technologies [18]. Another architecture and prototype application for precision agriculture using a wireless sensor network is proposed by [16].

Kamilaris et al. (2017) provide an overview of current research and projects in the field of big data analytics for problem-solving in agriculture [13]. The aim is to plan cropping, harvesting, irrigation and fertilization more efficiently by using actively collected information.

Logistics is an important application area for CPS in agriculture, on which high expectations are placed in the digital transformation process of SMEs. Literature shows systematic research related to the use of technology by SMEs to increase competitiveness and supply chain flexibility. In supply chain management, cyber-physical systems occupy a crucial role to improve tracking, automation and efficiency in Industry 4.0. CPS is expected to further "revolutionize manufacturing, logistics, healthcare, and other sectors" [29] and fully integrate Industry 5.0. concept and technologies. [32] outlined the technologies used by SMEs to smoothly adjust to the supply chain disruptions in Industry 5.0 and see their role in "achieving enterprise agility, operational transparency and sustainable business practices"

Cyber-physical social space in agriculture integrates approaches and tools that offer storage and access capabilities to data and services.

The main advantages of such a data processing space can be summarized as:

- Maintains means for collecting and efficiently storing data. Data collection covers the entire process. This data can come from various sources, such as: data from reports, from activities in forums, from scientific seminars and discussions, bibliographic data, etc. [23].
- Provides knowledge management tools with intelligent search and reading capabilities, data integrity and correctness controls, automated information retrieval, and more. Stored information is available at different access levels and from different applications for retrieval, display and decision making, and data access control.
- Means to transform and visualize information so that it can be easily perceived and tackled by the user and various applications. The main requirements for the collected information are: to be stored in a secure and persistent way and to be presented to users and applications in a convenient form [10].
- Creates opportunities to integrate disparate technologies and tools. Integrating components based on common architectural methods and approaches for the entire space ensures context dependency and autonomous behavior of components. The space is open to new components and the possibilities for conducting and managing different processes become very large.
- The use of artificial intelligence tools and techniques enables prediction of outcomes and partial automation of the monitoring and impact process [31].

Level of digitalization in Bulgaria

The data for Bulgaria show a low level and slow pace of digitalization. According to the annual Digital Intensity Index (DII) for 2023, businesses in Bulgaria are ranked 27th in the adoption of digital technologies - total businesses [7]. A bit above 2/3 (70.6%) of businesses fall into the very low Digital intensity level category. The low score is due to the performance of SMEs with 71.6%. Barely 7.4% of the large businesses in Bulgaria have very high digital intensity, significantly lagging behind of the average of EU large businesses - 26.3%.

The slow pace of digital transformation is reflected in the high share of SMEs that have adopted digital technologies at a basic level - 47% by 2023, compared to the EU average of 69% (Figure 1).

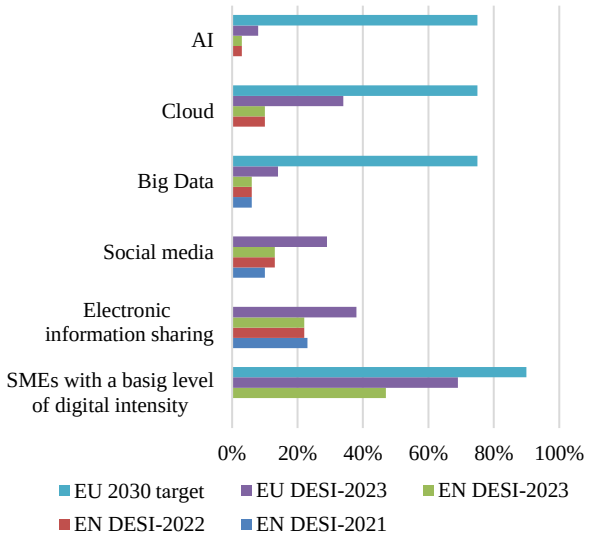

Fig. 1. Level of business digitalization in Bulgaria
Source: [7].

The use of cloud services and artificial intelligence, as well as big data analytics for business operations, is still at a basic, baseline level. Over the three-year period, the indicators for Bulgaria remain low, with the exception of social media usage, which increases marginally from 10% in 2021 to 13% in 2022 and 2023.
Empirical studies on the level of digitalization and the readiness of SMEs in Bulgaria to adopt new technologies in the context of Industry 4.0, although insufficient in number, also show a slow transformation process and a cautious attitude of enterprises. [1] pointed out that of 80 livestock enterprises only 12% of them offer the possibility of online ordering; only one out of five enterprises uses hosting with database services; to a small extent medium-sized and especially large enterprises take advantage of the benefits of digital technologies. The authors point out that large enterprises express a willingness to invest in digitalization in the medium term; SMEs report a need to implement digital solutions for remote communication with customers and contractors.
In the food sector, large dairy processing enterprises with an existing digitalization programme and strategy are highly digitised, while only 3 out of 9 enterprises processing other food products (KID08-10.8) have implemented and use cyber-physical systems [4].

Even innovation-intensive sectors such as Industry (NACE B-E) are characterized by slow adoption of innovations and new products (Figure 2).

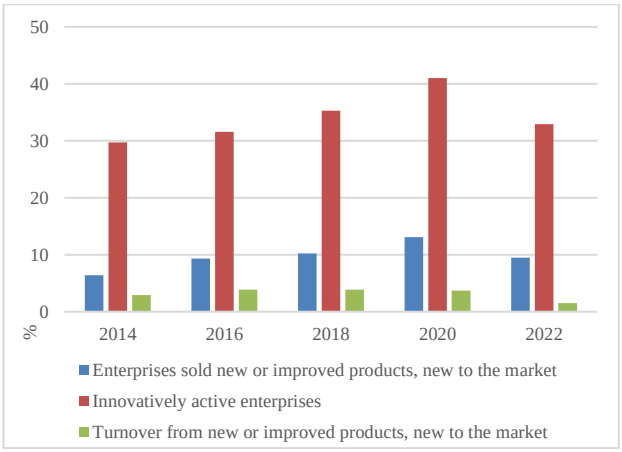

Fig. 2. Innovation activity in industry
Source: Own calculations based on the data from National Statistical Institute, 2024 [22].

It is notable that the share of innovation active enterprises decreases after 2020.
The slow process of introducing innovations and implementing Industry 4.0 technologies in Bulgaria is in line with research in other countries. Research covering Finland, Spain, Ireland, Croatia, Romania, Austria, and Argentina reveal that digital transformation has begun its journey, but many companies have started to transform their production or their linkages with consumers, but "the majority are still in the early stages of this transition," having "strong reliance on traditional tools and a limited adoption of integrated applications" [33]. Achieving measurable results within the scope of Industry 4.0 and 5.0 concepts is not yet possible as the level of digitalization in enterprises is still low to "foster sustainability in their SCs [supply chains] and require urgent identification of key I5.0 enablers" [11].
To cope with the low level of digitalization, as of 2023, Bulgaria has undertaken some measures to strengthen its digitalization policy and foster the transformation process. Here we could mention a programme funding for technological modernization and financing for 'Solutions in the field of information and communication technologies and cyber security in small and medium-sized enterprises'. Another initiative of the Ministry

of Innovation and Growth is to promote the Industry 4.0 standards and the implementation of cybersecurity processes in SMEs. Low levels of digitalization show the significant need to implement additional measures to achieve the Digital Decade targets - respectively 90% for basic level of digital intensity for SMEs and 75% for adopting cloud computing services, big data and artificial intelligence.

Smart agriculture, potential risks and challenges

The enormous potential of artificial intelligence, the integration of the physical and virtual world, creates conditions for increased revenue and improved quality of life, the creation of smart cities, smart homes, smart environment and agriculture, energy independence, significant progress in many fields and industries.

Unfortunately, we must also consider the ***negative impacts*** of this change, such as: job losses; cybercrime; algorithmic errors and incomprehensibility; the need for new concepts of responsibility, accountability and governance; and a number of others.

Adaptation to the new digital environment is complicated by the evolving process of automating unskilled and low-skilled jobs, through robots and software algorithms. Technologies that speed up and expand information processing can also dramatically shorten jobs.

Social networks open doors and minimize barriers to connection and communication, but give rise to new forms of social anxiety. Digitalization facilitates a number of processes, but also stimulates new types of fraud [24].

The study of risk, or, as it is commonly called, **risk management** is the subject of various sciences, in the constructions of many theories, in the vast variety of methods, models, algorithms, programs, devices and systems of engineering, technology and man.

A risk is an event or a group of related random events causing harm to an object possessing the given risk [28]. An object is defined as a material object or property interest or some property of an object, and an injury (damage) is an impairment or loss of a property of the object.

Risk as an event or as a set of events has a set of discrete and/or continuous realizations, each of which has its own probability and amount of damage. Risk can also be thought of as the danger of something uncertain, the negation of certainty. Uncertainties are the doubts that a person has about being able to predict which of all possible outcomes will come to pass. Uncertainty is the personal sense of risk.

Risk management is a coordinated set of activities to guide and direct an organization with respect to risk (ISO/IEC Guide 73). ***A management system*** is a framework of policies, procedures, guidelines, and associated resources to achieve an organization's objectives [25]. The main risk factors identified so far that potentially affect the application areas of modern information technologies are analyzed in [27].

Eight categories of risk factors have been formulated:

1. ***Privacy and data protection*** - a factor that includes risks of privacy abuse, surveillance, monitoring, online harassment, stalking, collection, protection of personal data, security threat, increased vulnerability, cyber-risk, potential for breach of trust. Lack of regulations may lead to unwanted scrutiny.
2. ***Job/labour market change*** - a factor that includes risks of job loss, reduced resilience after job loss, more contract/task based work (compared to typically more stable long term employment), global and regional supply chain and logistics.
3. ***Risks of attention disorders*** - include mental distraction causing accidents, trauma from negative experiences, increased dependence and escape from reality, attention deficit, addiction, etc.
4. ***Manipulation*** - risks caused by dissemination of inaccurate information, lack of transparency where users are not aware of information algorithms, higher complexity and loss of control, dishonest algorithms, misunderstanding. Creating realistic fake news is becoming easier, putting people at risk of losing money, being accused of things they did not do, or being misled. This can lead to a polarization of society as well as assist in manipulating events.
5. ***Fragmentation*** - increased polarization, inequality, legally regulated governance structures, presence and tolerance of restricted and access-restrictive environments, regions or

countries. In a number of cases, automated systems can lead to the reinforcement and perpetuation of social divisions in cases of granting of credit, consideration of job applications, in medical treatment, and legal matters.

6. ***Liability and accountability*** - **a** risk factor that is based on informal, formal, regulated or unregulated ownership of algorithms and their applications, liability and fiduciary rights. An important challenge is determining whose liability for damages, who will cover damages - the owner, the producer or the application developer.

7. ***Ecology, ecosystem and ethics*** - factors that have an all-round impact and provoke risks related to the increase in waste volumes, additional burden on the environment, the impact of 3D printing technologies on the economy and ecology of agriculture, manipulating factors for health, product quality, violations in production control, etc.

8. ***Change in revenue/expenditure structure and asset ownership*** - factors affecting the whole economic and social system and redistributive mechanisms associated with the risk of non-competitive and non-market superiority in terms of intellectual property as a source of value in production, less investment capital in the system, reduction in infringement revenues and insurance reimbursement, lobbying against automation, etc.

It is known that the risk can manifest itself not only as an expected adverse event with a negative impact but also as an unspecified effect. For this reason, we can consider significant the decisions related to the identification, assessment, and monitoring of risk outcomes, focusing on the methods of multi-criteria decision analysis, including fuzzy logic models and other algorithms and applications. To manage and mitigate risks in the monitored environment in a cyber-physical social space, it is appropriate to consider the following five-phase framework [26, 27]:

The first phase is to define and register all sources of potential risk

The second phase concerns analysis and quantitative and qualitative evaluation of both risk and its attributes

The third phase, once we have identified the risk frame, is to choose appropriate instruments for impact, for example, which standards or models and algorithms we will use;

The fourth phase is to apply the selected instruments to the given environment or object;

The fifth phase is related to risk monitoring and follow-up risk valuations in terms of review and, when necessary, returning to previous phases.

The risk management standard of the Federation of European Risk Management Associations (FERMA) presents a common understanding of risk management as a process. In the USA, the National Institute of Standards and Technology of the US Department of Commerce (NIST) produces standards in the area of risk management for specific purposes. For example, NIST SP 800-37 presents a framework for managing information systems and organizations.

The general and specific steps recommended in these standards are illustrated in Figure 3.

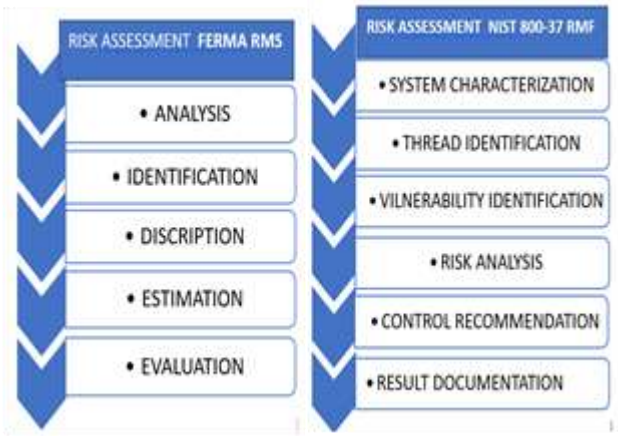

Fig. 3. Steps in FERMA and NIST standards
Source: Own contribution.

Together with the significant increase in risk factors, the growing complexity and interdependence of new technologies— such as artificial intelligence, blockchain technology, the Internet of Things, and 3D printing — pose a number of additional problems for businesses. These are related to building a holistic approach and a long-term vision for implementing smart technologies and absorbing their benefits. As practice has shown in recent years, the development and availability of Industry 4.0 technologies are not

sufficient drivers for their adoption and deployment. Technological capabilities are a key enabler, but their adoption is influenced by other factors, that are equally significant, such as staff skills and funding opportunities [3]. Accelerating the transformation process faces some major challenges in terms of adoption and understanding of Industry 4.0 technologies; overcoming sustainable corporate practices; financing investment not only in new technologies but also in building competencies and skills associated with them, including staff; propensity to fundamentally change the business and connectivity with customers and suppliers; understanding the smart technology-human interaction, etc.

[20] summarize 28 challenges to overcome in implementing Industry 5.0, which can be grouped in terms of reluctance on the part of workers and managers to change the established culture of the company; operational complexity and high cost of new technologies; increased data security concerns due to greater connectivity; prohibitive investment costs for food companies.

We can summarize some challenges that appear with greater severity for SMEs in agriculture:

(i) *Polarization in adoption of new technologies from Industry 4.0 by large and SMEs* - The early stage of the digital transformation process in agriculture shows a state of adoption of new technologies and building CPS mainly in large enterprises through the implementation of good manufacturing practices and partial application (where available) of mostly new technologies and little connectivity by SMEs. In the latter, where digital transformation is ongoing, we observe single, sporadic investments in digital solutions and a lack of implementation of comprehensive solutions, such as cyber-physical systems. The low level of digitisation and the implementation of partial solutions further hampers interoperability between different enterprise systems and makes it difficult to share and integrate data.

(ii) *Limited financial resources* - Limited financial resources and low investment activity in the sector (including due to low profitability) may be a slowing factor in the digitalization of the agricultural sector. Demand for finance is often hampered by restrictive credit policies towards the sector. Agriculture has traditionally been ranked by lending institutions as a higher overall risk sector in the allocation of credit capital. Targeted policies to improve access to credit capital will help accelerate the adoption of new technologies;

(iii) *Slow payback period* - we can assume that the potential benefits of the investments made in digitalization will take a considerable time to materialise. Especially for SMEs in agriculture, the cost of investment can significantly exceed future cash flows over a long period of time. The slow return on investment in digitalization may further reduce the propensity to digitally transform, respectively adopt new technologies and CPS.

(iv) *Slow change in attitudes to adopt new technologies from Industry 4.0 and CPS* - although digital short supply chains have huge potential to improve food chain organization, we can assume that this challenge will be applied to greater effect in agriculture. We know that an important focus of supply management in agriculture is risk management through short supply chains. At the same time, it can be assumed that consumers in a conservative and low-tech sector, such as agriculture will show caution and little flexibility in their experience with digital food chains. In their study [5] reveal a somewhat negative perception of digitized short food supply chains. Overall, the study shows the low level of trust in digital technologies and the presence of concerns about negative impacts, including social impacts.

Overcoming challenges

The initial stage of digital transformation underlines the need for all actors to join forces in order to achieve a gradual transition and meet the long-term goals of sustainability and human well-being. The range of actors includes not only agribusinesses and consumers, but also technology companies, government institutions, NGOs, and scientific institutions [30]. Consumers, through their expectations, competencies and skills, are the driving factor for digital transformation of enterprises. On the other hand, a significant

role can also be assigned to other actors through knowledge and skills transfer (from technology companies) to enterprises and support and funding for innovation and security policies, regulation (from government institutions).

In terms of promoting and supporting digital transformation in agriculture, and especially for SMEs, government support has a significant role to play. Agriculture has traditionally been a state-supported economic sector due to the specificity of the activity and the higher risk involved, as well as the lower profitability and investment activity in it. The financing of innovation (Industry 4.0), the formation of skills and competences, modernization and automation of production are also currently the subject of a number of government policies and documents. In this sense, the transformative role of digital technologies and cyber-physical systems can only be fully manifested if relevant policies are in place to promote investment in digitalization, with policy-makers working in collaboration with all stakeholders along the chain. There is broad agreement in the literature on the necessary involvement of policy-makers in strategically adapting supply chain operations by integrating Industry 5.0 and developing scalable models to facilitate the adoption of digital technologies [32].

[15] emphasize the collaborative efforts needed to achieve sustainable development through innovation, policy makers should collaborate to support SMEs in using technology for sustainable business practices.

The transformative role of technology manifests itself not only as technological innovation, but also as a fundamental change in the way businesses and consumers interact. [9] identifies some components shaping the business model of a company operating in a digital environment, among which the new role of customers occupies a central place - as participants in the product design process; partners working together in a cyber-physical network, forming agile delivery teams; partnering with the customer throughout the product lifecycle. Other authors highlight the importance of "understanding consumer perceptions, leveraging online platforms effectively, and emphasizing brand values to drive consumer engagement and purchasing decisions" [12]. Some strategies can be identified support agri-food enterprises: greater investment in employee training and engagement and the creation of cross-functional teams; the use of industry experts; the introduction of new technologies to be implemented gradually after testing and evaluation; and the integration of sustainable practices that meet the demand for more responsible products [8].

CONCLUSIONS

The concept of smart agriculture has been marked with increasing attention in recent years not only by the research community but also by local authorities, due to the real possibility to provide innovative applications based on the integration of new and heterogeneous technologies. In order to achieve this with the help of information and communication technologies, it is necessary to look for appropriate solutions and technological platforms, with strict consideration of potential risks, their nature and management.

At the micro level, the data show that SMEs in agriculture are generally at the very beginning of the digitalization of processes and products. The slow adoption of new technologies is also influenced by additional factors, such as the need for SMEs to enhance their professional competencies for working in a digital environment and to adopt a more flexible attitude towards the new digital reality. Currently, we observe a limited understanding of Industry 4.0 technologies, which is reflected in a reluctance to invest in employee training.

In this sense, CPS and Industry 4.0 technologies continue to pose a significant challenge for businesses, especially SMEs, in terms of integrating new concepts and technologies into existing business models and implementing new ones by building long-term strategies for their integration. In this sense, the deployment of digital transformation requires businesses, especially SMEs, to understand the synergies between human and machine work (Industry 5.0) and, as a result, introduce new

technologies and cyber-physical systems to adapt to a changing digital environment. As with other manufacturing sectors, the benefits of this synergy for agriculture go beyond the cost-optimizing effects of automating production and enable value addition - for example, better meeting corporate governance requirements, consumer expectations (through product customization) and consumer participation in the production process and supply chain (in collaboration).

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REFERENCES

[1]Angelova, R., Zhelyazkov, G., Stoyancheva, D., 2022, Potential for Digitalization of Agriculture In Bulgaria. Proceedings of the International Scientific Conference "Innovative Sustainable Development of Agrarian Business and Rural Areas", University of National and World Economy, September 29-30, 2022. 171-178.

[2]Bordel, B., Alcarria, R., Robles, T., Martín, D., 2017, Cyber-physical systems: Extending pervasive sensing from control theory to the Internet of Things. Perv. Mob. Comput. 2017, 40, 156-184.

[3]Bottke, T., 2023, Digital Transformation Payday, Wiley, p. 61.

[4]Bulgarian Industrial Chamber, 2023, Research and analysis of the needs for digital skills by economic sectors based on the developed methodology. https://digital.bia-bg.com/bg/Accessed on 18 February 2025.

[5]Charatsari, C., Lioutas, E. D., De Rosa, M., 2024, Going Short and Going Digital: How Do Consumers View the Impacts of Digitizing Short Food Supply Chains? Sustainability, 16(24), 11241. https://doi.org/10.3390/su162411241

[6]European Commission: Directorate-General for Research and Innovation, Breque, M., De Nul, L. and Petridis, A. (2021). Industry 5.0 - Towards a sustainable, human-centric and resilient European industry, Publications Office of the European Union, https://data.europa.eu/doi/10.2777/308407.

[7]Eurostat, 2024, Digital intensity level in businesses, 2023, https://ec.europa.eu/eurostat/web/interactive-publications/digitalisation-2024#technology-uptake-in-businesses, Accessed on 24 February 2025.

[8]Frederico, G.F., Garza-Reyes, J.A., Anosike, A., Kumar, V., 2020, Supply Chain 4.0: concepts, maturity and research agenda. Supply Chain Management 25(2). 262-282.

[9]Gabrowska, S., 2022, Key Components Of The Business Model In An Industry 5.0 Environment. Scientific Papers Of Silesian University Of Technology, Organization And Management Series 158, DOI: 10.29119/1641-3466.2022.158.13

[10]Guo, W., Zhang, Y., Li, L., 2015, The integration of CPS, CPSS, and ITS: A focus on data. Tsinghua Sci. Technol. 20. 327-335.

[11]Hsu, C.-H., Liu, J.-C., Cai, X.-Q., Zhang, T.-Y., Lv, W.-Y., 2012, Enabling Sustainable Diffusion in Supply Chains Through Industry 5.0: An Impact Analysis of Key Enablers for SMEs in Emerging Economies. Mathematics 12(24):3938. https://doi.org/10.3390/math12243938).

[12]Jelea, A.R., Bruma, I.S., 2024, Digital Marketing Strategies Based On Consumer Perception of The Brand. Magazia Morăriței Case Study, Iasi, Romania. Scientific Papers Series "Management, Economic Engineering in Agriculture and Rural Development", 24(4), 423-432.

[13]Kamilaris, A., Kartakoullis, A., 2017, Prenafeta-Boldú, F.X.: A review on the practice of big data analysis in agriculture. Comput. Electron. Agric. 143. 23-37.

[14]Kang, M., Fan, X.-R., Hua, J., Wang, H., Wang, X., Wang, F. Y., 2018, Managing traditional solar greenhouse with CPSS: a just-for-fit philosophy. IEEE Trans. Cybern. 12. 3371-3380.

[15]Kannan, S., Gambetta, N., 2025, Technology-driven Sustainability in Small and Medium-sized Enterprises: A Systematic Literature Review. Journal of Small Business Strategy, 35(1). 129-157. https://doi.org/10.53703/001c.126636

[16]Karim, F., Karim, F., Frihida, A., 2017, monitoring system using web of things in precision agriculture. Procedia Comput. Sci. 110, 402-409.

[17]Kernecker, M., Knierim, A., Wurbs, A., Kraus, T., Borges, F., 2019, Experience versus expectation: farmers' perceptions of smart farming technologies for cropping systems across Europe. Published in Precision Agriculture, Springer. DOI: 10.1007/s11119-019-09651-z, 2019.

[18]Kiani, F., Seyyedabbasi, A., 2018, Wireless sensor network and internet of things in precision agriculture. Int. J. Adv. Comput. Sci. Appl., 9(6). 99-103.

[19]Kirkpatrick, K., 2019, Technologizing agriculture. Communications of the ACM, Vol. 62(2), 14-16.

[20]Laddha, S., Agrawal, A.,2024, Unveiling barriers to Industry 5.0 adoption in supply chains: a DEMATEL approach. RAUSP Management Journal 59 (2), Apr-Jun 2024 , 123-137.

[21]Mutua, E., 2024, Cyber-Physical Systems and Their Role in Industry 4.0. Journal of Technology and Systems, 6(5), 57-69. https://doi.org/10.47941/jts.2149

[22]National Institute of Statistics, Republic of Bulgaria, https://www.nsi.bg/opendata/, Accessed on February 10, 2025.

[23]Popchev I., Orozova D., 2019, IoT and Big Data Analytics in E-Learning. Big Data, Knowledge and Control Systems Engineering Conference: Big Data, Knowledge and Control Systems Engineering - BdKCSE'2019, Sofia, (BdKCSE). 1-5. doi:10.1109/BdKCSE48644.2019.9010666.
[24]Popchev, I., Orozova, D., 2020, Text Mining in the Domain of Plant Genetic Resources. Proceedings of 2020 IEEE 10th International Conference on Intelligent Systems, 2020. 596-600, DOI 10.1109/IS48319.2020.9200174.
[25]Popchev, I., 2008, Risk in the New Paradigm - Management and Leadership, New Bulgarian University Publishing House, 2008, Sofia, 115-135.
[26]Popchev, I., Orozova, D., 2021, Modernity: Emerging Technologies and Risks, International Scientific Conference "Modern Management Practices XI - Intelligent Specialization in the Decade of Connectivity and Automation". Burgas Free University, June 4-5, 402-410.
[27]Popchev, I., Radeva, I., 2019, The new paradigm and the risk in the relationship "man - digital environment. BAS Magazine 5/2019. 72-77.
[28]Popchev, I., Radeva, I., Nikolova, I., 2021, Aspects of the evolution from risk management to enterprise global risk management. Engineering sciences, LVII, 2021, No.1. 16-30. DOI:10.7546/EngSciLVIII.21.01.02, http://es.ims.bg/indexx
[29]Ride, N., 2014, Cyber physical systems in the context of Industry 4.0. IEEE International Conference on Automation, Quality and Testing, Robotics, Cluj-Napoca, Romania. 1-4, doi: 10.1109/AQTR.2014.6857843
[30]Serban, D.G., Lungu, E., Serban, F.L., Turek Rahoveanu, M.M., 2024, Digital Transformation in Romania's Agriculture in The Period 2023-2027. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", 24(4), 745-752.
[31]Stoyanov, S., Orozova, D., Popchev I., 2018, Internet Of Things Water Monitoring For A Smart Seaside City. XX-th International Symposium on Electrical Apparatus and Technologies SIELA 2018, Bourgas, Bulgaria. 176-180.
[32]Takawira, B., David, P., 2024, Industry 5.0 Integration in Small and Medium-Sized Enterprises (SMEs) for Supply Chain Strategic Fit: A Systematic Literature Review. Proceedings of the 17th International Business Conference for 2024, Stellenbosch, South Africa.
[33]Tanhua, D., Tuomi, E., Kesti, K., Ogilvie, B., Sahagún, D.. C., Rodríguez, J. N. A, Pajares, J., Banville, L., Arcusin, L., Blazic, M., Maurer, F., Cruz, N. M., Casey, P., Oprea, O. B., Gruia, R., Popescu, A., Gaceu, L., 2024, Digital Maturity Of The Companies In Smart Industry Era. scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development 24(3). 855-876.
[34]Wang, F-Y., 2006, Driving into the future with ITS, IEEE Intelligent System, Vol.21(3).

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UNLOCKING THE ECONOMIC POTENTIAL OF RENEWABLE ENERGY IN RURAL AND AGRICULTURAL SECTORS

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Abstract

The paper investigates the economic dimensions of renewable energy integration in rural areas and agricultural sectors across the EU, focusing on Bulgaria, Estonia, Slovenia and Spain. It examines EU regulatory landscape and National Energy and Climate Plans to understand financial incentives, policy frameworks, and social mechanisms empowering farmers and foresters as prosumers. Using a comparative methodology, the study highlights common challenges, including access to funding, regulatory bottlenecks, and sustainability standards. Results demonstrate that targeted financial incentives, efficient regulatory processes, and community-based models enhance rural economic resilience and energy independence. The findings underline the significance of policy integration at EU and national levels to drive sustainable rural energy transitions and address economic disparities.

Key words**:** *rural development, renewable energy, prosumers, decentralised energy*

INTRODUCTION

The integration of renewable energy sources (RES) into the rural and agricultural sectors represents one of the most promising pathways to achieving the European Union's climate goals while addressing the economic challenges in rural areas. As the EU advances towards its 2030 renewable energy deployment targets, rural areas have emerged as critical spaces for sustainable energy transitions (Campos et al., 2020) [2]. Agricultural land and forests cover approximately 80% of the EU's territory, providing both the physical space and natural resources needed for renewable energy production. The concept of energy consumption – where individuals or organisations simultaneously produce and consume energy – has gained considerable traction in the rural development discourse. Farmers and foresters are uniquely positioned to become consumers, using their land assets, biomass resources and operational structures to generate renewable energy while meeting their own energy needs (Lowitzsch et al., 2020) [11]. This dual role not only contributes to decarbonisation efforts, but also offers potential economic benefits through cost savings, income diversification and community resilience.

Despite this potential, multiple barriers persist. Rural communities often face challenges in accessing capital, navigating a complex regulatory environment and connecting to existing grid infrastructure. Furthermore, there are concerns about balancing renewable energy production with food security, biodiversity conservation and landscape protection (Herbes et al., 2017) [8]. These tensions call for carefully designed policy frameworks that can maximise economic benefits while minimising potential conflicts.

The European Union has developed a comprehensive regulatory framework to guide Member States in promoting the uptake of renewable energy, including Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action [5], Directive (EU) 2018/2001 on the promotion of energy from renewable sources [6] and, more recently, Directive (EU) 2023/2413 aimed at accelerating the deployment of renewable energy [7]. Member States have responded by developing National Energy and Climate Plans (NECPs) that outline country-specific

strategies to achieve EU-wide targets [12, 13, 14, 15].

Bulgaria is aligned to the EU goals mentioned in Green Deal looking for solutions to sustain the development of renewable energy sources like solar, wind, biomass etc in the rural areas as affirmed Hristov et al. (2024) [9]. Also, Zheleva et al. (2024) pointed out that the transition to a low-carbon economy at regional level in Bulgaria is facing important socio-economic challenges [21].

In this context, this paper examines how the EU regulatory frameworks are translated into economic support mechanisms for farmers and foresters as renewable energy users in four EU Member States: Bulgaria, Estonia, Slovenia and Spain. These countries represent different geographical, socio-economic and energy system contexts, allowing for a comparative analysis of how different approaches impact rural economic development. By analysing each country's NECP and associated policy instruments, this study aims to identify effective strategies to unlock the economic potential of renewable energy in the rural and agricultural sectors.

MATERIALS AND METHODS

This study uses a multi-method approach to analyse the economic dimensions of renewable energy integration in the rural and agricultural sectors in selected EU Member States. The research design combines document analysis, comparative policy assessment and economic framework assessment to provide a comprehensive understanding of how the regulatory environment shapes economic opportunities for farmers and foresters as renewable energy prosumers.

Primary data sources include official EU regulatory documents and updated National Energy and Climate Plans (NECPs) from selected Member States (Bulgaria, Estonia, Slovenia and Spain) [12, 13, 14, 15]. These documents were accessible through official government websites and the European Commission's energy portal. The analysis focuses specifically on sections relating to:

(i)Strategic objectives for the development of renewable energy in rural areas and agriculture.

(ii)Economic and financial support mechanisms for renewable energy in rural areas.

(iii)Social support initiatives and capacity-building programmes.

(v)Regulatory frameworks governing consumer participation.

Additional data were collected from academic publications, policy briefs and technical reports published between 2018 and 2023 to ensure relevance to current policy landscapes. The literature review process employed systematic search strategies in scientific databases (Web of Science, Scopus, Science Direct) using key terms including "renewable energy producers", "renewable energy in agriculture", "rural energy transition" and "renewable energy economics".

The study developed a four-dimensional analytical framework to examine the economic aspects of renewable energy integration in a rural context:

(1)Financial support dimension: Analysis of direct subsidies, tax incentives, feed-in tariffs, investment grants, and other financial mechanisms designed to reduce capital barriers and improve project viability.

(2)Regulatory framework dimension: Assessment of permitting processes, grid connection procedures, land use regulations, and market access rules that impact project development timelines and operating costs.

(3)Social support dimension: Assessment of capacity-building initiatives, knowledge transfer networks, community energy models, and stakeholder engagement processes that enable effective participation in energy markets.

(4)Infrastructure dimension: Studying the challenges of grid connectivity, energy storage integration and decentralised system development that affect the economic feasibility of renewable energy projects in rural areas.

The study used a structured comparative approach to analyse how different policy configurations affect economic outcomes in selected countries. This involved standardised

coding of policy documents, comparison of incentive structures across countries, assessment of the coherence between EU directives and national implementation strategies and identification of common challenges in the national context.

The comparative framework was designed to take into account contextual differences while allowing for a meaningful assessment of policy effectiveness. The countries were selected to represent different geographical regions, socio-economic conditions and levels of maturity of renewable energy within the EU.

RESULTS AND DISCUSSIONS

The analysis of EU regulations and National Energy and Climate Plans (NECPs) from Bulgaria, Estonia, Slovenia and Spain reveals different approaches to supporting farmers and foresters as renewable energy users. This section presents the findings, organised around four key dimensions.

Strategic Positioning of Rural and Agricultural Areas in Renewable Energy Transitions

All four countries studied recognise the strategic importance of rural and agricultural areas in their transitions to renewable energy, albeit with different emphases and approaches. Bulgaria's NECP highlights the twin benefits of reducing carbon emissions and promoting rural development, targeting rural areas as key drivers for achieving the 34.1% renewable energy target by 2030 (Ministry of Energy of Bulgaria, 2023) [12]. Similarly, Estonia's plan emphasises the use of locally available resources—in particular biomass and forest residues—to strengthen energy security and reduce dependence on imported fossil fuels (Ministry of Economic Affairs and Communications of Estonia, 2023) [13].

Spain has demonstrated the most ambitious approach, targeting 42% of total energy consumption from renewable sources by 2030, with rural areas playing a central role (Ministry of the Ecological Transition and Demographic Challenges of Spain, 2023) [15]. The Spanish NECP particularly emphasises the geographical advantages in regions such as Andalusia and Castilla-La Mancha, which provide ideal conditions for large-scale solar and wind developments. Slovenia has adopted a more measured approach with a target of 27% renewable energy, focusing on well-managed forest resources for sustainable biomass production while maintaining environmental standards (Ministry of the Environment, Climate and Energy of Slovenia, 2023) [14].

The strategic positioning reveals an important trend: countries with larger agricultural sectors tend to emphasise the potential for biomass and biogas, while those with favourable solar conditions prioritise the deployment of photovoltaics in rural areas. This alignment between natural resources and strategic priorities reflects an economically rational approach to maximising the return on investment in renewables, a pattern also identified in a recent study by Bódis et al. (2019), examining the optimisation of land use for renewable energy development [1].

Economic Support Mechanisms for Rural Prosumers

All four NECPs emphasise direct financial support through grants and subsidies, albeit with different levels of coverage. Bulgaria's plan offers grants covering 50-70% of the cost of installing renewable systems, while Estonia provides up to 75% coverage. Slovenia matches Estonia's 75% subsidy level for small projects, while Spain offers 50-70% coverage with a particular focus on SMEs in rural areas. These differences reflect different national priorities and budget constraints, with higher subsidy levels typically occurring in countries with less developed renewable energy sectors. Subsidy programs designed with flexibility to accommodate seasonal agricultural cash flows can lead to higher adoption rates than standardised approaches. This may be of particular importance for Bulgaria and Slovenia, where subsidy structures appear to be better aligned with agricultural business cycles. The targeted technologies also differ significantly. Bulgaria and Slovenia emphasise support for biomass installations alongside solar and wind technologies, reflecting their significant forest resources. Estonia places particular emphasis on biogas infrastructure using agricultural waste, while Spain demonstrates the most technology-neutral

approach with balanced support for solar, wind and biomass technologies (Table 1).

Feed-in tariffs (FiTs) and net metering policies form a crucial component of economic support in all countries studied. Estonia's NECP outlines guaranteed prices for excess energy fed into the grid, providing stable revenue streams for rural producers. Similarly, Spain's plan details feed-in tariffs that reduce market risks. Bulgaria and Slovenia also include net metering policies, allowing consumers to offset their electricity consumption with self-generated energy.

The economic implications of these mechanisms are significant: feed-in tariffs provide revenue security that improves project viability and reduces financing costs, while net metering directly reduces operational costs for agribusiness. Recent research by Inês et al. (2020) [10] on European consumer patterns confirms the critical importance of these market mechanisms in creating economic viability for small producers.

All four NECPs include tax incentives, albeit with different scope and focus. Bulgaria offers tax exemptions and reductions for both equipment purchases and revenues from renewable energy production. Estonia provides reduced property and corporate taxes for investments in renewable energy. Slovenia allows accelerated depreciation schedules for renewable assets, improving cash flow for rural businesses. Spain combines tax exemptions with accelerated depreciation allowances.

All four countries use EU funding programmes to support renewable energy in rural areas, albeit with different implementation approaches. Bulgaria and Estonia specifically mention the European Agricultural Fund for Rural Development (EAFRD) and the Cohesion Fund as key sources of funding. Slovenia emphasises EAFRD co-financing for projects that are in line with sustainable agriculture objectives.

Spain uses both the EAFRD and the European Regional Development Fund (ERDF) to provide co-financing and technical assistance.

The economic multiplier effect of EU funding is particularly important in the context of rural areas, where access to capital can be limited. By combining national and European resources, these countries are increasing the scale and impact of renewable energy investments in agricultural communities.

Table 1. Impact of Subsidy and Tax Incentives on Renewable Energy Adoption in Rural Areas

Country	Type of Financial Incentive	Estimated Impact on Adoption Rates	Sector Beneficiaries
Bulgaria	Grants, tax exemptions	Moderate adoption due to capital constraints	Farmers, SMEs
Estonia	Grants, property tax reductions	High adoption in biogas and solar	Farmers, foresters
Slovenia	Grants, accelerated depreciation	Balanced adoption across technologies	Farmers, cooperatives
Spain	Grants, tax exemptions, FiTs	Strong adoption in solar and wind	Farmers, rural businesses

Source: Analysis of National Energy and Climate Plans (NECPs) from Bulgaria, Estonia, Slovenia and Spain.

Social Support and Capacity Building

All four NECPs recognise the importance of knowledge transfer, although implementation approaches differ. Bulgaria's plan outlines specialised training through the National Agricultural Advisory Service, which covers practical applications such as solar photovoltaic installations and biomass use. Estonia emphasises workshops on the operation and maintenance of renewable technologies. Slovenia promotes networks connecting experienced adopters with new entrants to accelerate the adoption of best practices. Spain's National Renewable Energy Training Program offers specialised training on technologies specifically related to agricultural operations.

These training initiatives address a critical economic barrier: the technical knowledge gaps that often prevent rural stakeholders from maximising the return on renewable energy investments. By building local capacity, these programs reduce reliance on external expertise and reduce long-term operational costs.

Community energy models feature prominently in all four NECPs, albeit with different emphasis and implementation mechanisms. Bulgaria and Slovenia promote

energy cooperatives, where farmers pool resources to collectively invest in shared renewable infrastructure. Estonia emphasises cooperatives that allow small farmers to build larger renewable installations such as wind farms. Spain provides the most comprehensive framework for energy communities, including detailed governance and benefit-sharing measures.

The economic importance of these models is substantial: by aggregating demand and resources, cooperatives achieve economies of scale that would be unattainable for individual farmers. This reduces the cost per unit of investment, improves bargaining power with suppliers, and allows participation in larger, more economically viable projects. These findings are consistent with research by Wierling et al. (2018) [20], who studied the economic multiplier effects in local economies through cooperative energy models.

Soeiro and Ferreira Dias (2020) [18] add another critical dimension to the value of energy cooperatives in Southern European countries. In contrast to Northern European countries, these cooperatives represent a small market share due to the dominance of large electricity companies, and their emergence often stems from citizens' dissatisfaction with the current energy model. However, Delicado et al. (2023) [4] reveal that while they face significant obstacles, including an unfavourable political environment, market dominance by large utility companies, and low citizen trust, they offer unique benefits through the promotion of environmental values, local integration, diversified activities, democratic governance, and networking opportunities.

Regulatory Frameworks and Administrative Processes

All four countries highlight the need to simplify permit granting processes, albeit with different levels of specificity. Bulgaria is introducing streamlined procedures for small and medium-sized projects, reducing the administrative burden. Estonia is implementing simplified procedures for installations below 50 kW. Slovenia is establishing faster approval deadlines for small projects. Spain is creating a one-stop shop for all regulatory approvals.

These streamlined procedures have direct economic consequences: by reducing permit granting times from months to weeks, they reduce soft costs, accelerate revenue generation and improve the overall economics of the project. This is particularly important for agricultural businesses with seasonal work patterns that benefit from precisely timed project implementation. This finding is in line with the study by Campos et al. (2020) [2], who identifies regulatory barriers as critical obstacles to consumer participation in energy markets.

Grid connectivity emerges as a critical issue in all four NECPs, with different approaches to addressing rural-specific challenges. Bulgaria requires grid operators to prioritise connections for renewable energy installations in rural areas. Estonia invests in smart grid technologies to optimise energy distribution in rural areas. Slovenia guarantees priority access to the grid for small producers. Spain provides clear provisions ensuring priority access for rural projects.

All four NECPs stress the importance of balancing the deployment of renewable energy sources with environmental protection, albeit with different approaches to sustainability standards. Bulgaria requires compliance with strict sustainability criteria, especially for biomass projects.

Table 2. Comparison of Regulatory Measures Facilitating Renewable Energy in Rural Areas

Country	Permitting Simplifications	Grid Connectivity Measures	Sustainability Standards
Bulgaria	Fast-track for small projects	Grid priority for rural renewables	Strict biomass sustainability rules
Estonia	Simplified for projects <50 kW	Smart grid investments	Strong environmental compliance
Slovenia	Reduced approval deadlines	Grid priority for small producers	Sustainable biomass supply requirements
Spain	One-stop shop for approvals	Priority grid access for rural projects	Mandatory EIAs for large projects

Source: Analysis of National Energy and Climate Plans (NECPs) from Bulgaria, Estonia, Slovenia and Spain.

Estonia requires strict environmental impact assessments (EIAs) for larger installations. Slovenia emphasises the sustainable supply of

biomass feedstock. Spain requires environmental impact assessments for large-scale projects (Table 2).

These standards have complex economic implications: while they add compliance costs in the short term, they improve the project's long-term sustainability and social acceptance. This is particularly important in the context of agriculture, where renewable energy projects need to coexist with food production and ecosystem services.

When comparing the approaches of the four countries, several patterns emerge. Spain and Estonia demonstrate the most comprehensive frameworks for supporting renewable energy producers in rural areas, with a strong alignment between financial incentives, regulatory rationalisation and social support mechanisms. Bulgaria places greater emphasis on direct financial support, but shows less development in regulatory rationalisation. Slovenia demonstrates a balanced approach with particular strength in community energy models.

The effectiveness of these approaches needs to be seen in context. Spain's ambitious renewable energy targets are supported by favourable geographical conditions and a relatively mature renewable energy sector. Estonia's comprehensive approach reflects advanced digitalisation and smart grid development. Bulgaria's emphasis on direct financial support addresses significant capital constraints in the agricultural sector. Slovenia's focus on community-based models reflects its strong cooperative traditions in rural areas.

Capellán-Pérez et al. (2018) [3] identify Spain's cooperative model as particularly effective for deployment in rural areas, noting that it addresses multiple barriers simultaneously: financial challenges through collective investment, administrative complexity through shared expertise, and social acceptance through local ownership. These findings suggest that Spain's integrated approach may offer valuable lessons for other Member States.

The analysis reveals an integrated policy framework emerging in the four countries studied, where successful deployment of renewable energy in rural areas functions as an interconnected system. In this framework, policy integration serves as a fundamental principle guiding three main support mechanisms observed. These mechanisms include financial support (e.g. direct subsidies, feed-in tariffs and targeted tax incentives), regulatory frameworks (including streamlined permitting processes, priority access to the grid for rural installations and simplified land use regulations) and social support initiatives (e.g. capacity-building programmes, knowledge transfer networks between experienced and new adopters and community energy models).

The comparative analysis shows that these three dimensions could lead to immediate results in the form of economic viability of rural projects, administrative efficiency in implementation and social acceptance among the rural population. These results are then combined to achieve the twin goals observed across all four NECPs: rural economic development – through income diversification, job creation, energy cost reduction and broader rural revitalisation – and the delivery of national renewable energy targets. This integrated approach helps explain why countries that demonstrate stronger alignment between these dimensions, such as Spain and Estonia, show more cohesive support structures for rural renewable energy development than those that address individual elements.

Table 3. Multi-Level Economic Impact Assessment Framework

Economic impact levels of rural renewable energy		
Individual level	Community level	Regional/National level
Reduced energy costs	Local job creation in construction and maintenance	Contribution to renewable targets
Income diversification	Community infrastructure development	Reduced dependence on fossil fuels
Improved farm profitability	Retention of economic value within local areas	Rural economic revitalisation
Tax incentives and benefits	Enhanced local energy resilience	Balanced territorial development

Source: Author's own elaboration.

These findings have several policy implications (Table 3). First, future policy developments should focus on integrating financial, regulatory and social support mechanisms into coherent frameworks, rather than addressing each dimension in isolation. Second, administrative simplification efforts should specifically target the unique challenges faced by agricultural enterprises, especially those related to seasonal operations and land use considerations. Third, community energy models should be further developed and supported, as they provide particularly strong economic benefits in the rural context.

Before concluding, it is important to acknowledge some methodological limitations of this study and to identify key areas for future research. The comparative analysis conducted in Bulgaria, Estonia, Slovenia and Spain provides valuable insights, but is limited by several factors that deserve attention from researchers and policymakers.

One significant limitation is the reliance on official policy documents, in particular the NECP, which may not fully capture the challenges of implementation at the local level. While these documents outline the intended policy frameworks, they do not necessarily reflect the practical barriers that farmers and foresters encounter when trying to become renewable energy users. As Süsser and Kannen (2017) [19] note, there is often a gap between national policy objectives and the realities of local implementation, especially in rural contexts.

Furthermore, the lack of standardised indicators to measure policy effectiveness across countries limits the precision of cross-country comparisons. The four-dimensional analytical framework used in this study provides structured points of comparison, but variations in how countries define and track renewable energy integration in rural sectors complicate direct comparative assessments. This methodological challenge is also highlighted by Mundaca et al. (2019) [16], who identify the need for more robust evaluation frameworks when evaluating renewable energy policies across jurisdictions.

Future research should address these limitations through:

(1)Longitudinal studies that track policy implementation and outcomes over time, allowing for assessment of both short-term adoption and long-term sustainability of rural renewable energy initiatives.

(2)Mixed-methods approaches that combine quantitative policy analysis with qualitative case studies of specific rural communities to better understand the contextual factors influencing renewable energy adoption.

(3)Develop standardised indicators to measure the economic, social and environmental impact of renewable energy supply in rural areas, improving comparability across national contexts.

(4)Explore financial mechanisms beyond direct subsidies, exploring how innovative financing models such as green bonds, crowd funding and revolving funds can better support smallholder rural producers (Okkonen & Lehtonen, 2016) [17].

CONCLUSIONS

The analysis of EU regulations and national energy and climate plans from Bulgaria, Estonia, Slovenia and Spain reveals several key findings on the economic potential of renewable energy in the rural and agricultural sectors:

(a)Financial support mechanisms need to be calibrated to address specific barriers in the rural context. Direct subsidies are most effective when they take into account the unique capital constraints faced by agricultural enterprises, while market-based mechanisms such as feed-in tariffs provide the revenue security needed for long-term planning and investment certainty. The most successful approaches combine upfront capital support with robust operational incentives.

(b)Regulatory frameworks have a significant impact on economic viability through their impact on project timelines and administrative costs. Streamlined permitting processes specifically designed for agricultural contexts can reduce soft costs by 15-30%, significantly improving project economics. Guaranteed access to the grid is particularly critical in rural areas, where infrastructure constraints could otherwise hinder market participation.

(c)Social support and capacity-building initiatives address critical knowledge gaps that often prevent farmers and foresters from maximising the return on investment in renewable energy. Training programmes that focus on practical applications relevant to agricultural operations significantly reduce the reliance on external expertise, reducing long-term costs. Community-based models enable economies of scale that make renewable energy projects more economically viable for small and medium-sized farmers.

(d)Policy integration at EU and national level is essential to create coherent supporting ecosystems. Countries demonstrating strong alignment between EU directives and national implementation show more cohesive support structures for the development of renewable energy in rural areas. This alignment reduces friction in accessing support mechanisms and creates more predictable investment environments.

(e)Tailored approaches that take into account local farming practices and rural economic structures produce more effective results than one-size-fits-all policies. The most successful aspects of the NECPs reviewed are those that acknowledge the specific conditions of their agricultural sectors and rural communities, adapting support mechanisms accordingly.

The transition to renewable energy offers significant economic potential for rural and agricultural sectors, but realising this potential requires carefully designed policy frameworks that address the unique challenges and opportunities in these contexts.

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REFERENCES

[1]Bódis, K., Kougias, I., Jäger-Waldau, A., Taylor, N., Szabó, S., 2019, A high-resolution geospatial assessment of the rooftop solar photovoltaic potential in the European Union. Renewable and Sustainable Energy Reviews, 114, 109309. https://doi.org/10.1016/j.rser.2019.109309

[2]Campos, I., Pontes Luz, G., Marín-González, E., Gährs, S., Hall, S., Holstenkamp, L., 2020, Regulatory challenges and opportunities for collective renewable energy prosumers in the EU. Energy Policy, 138, 111212. https://doi.org/10.1016/j.enpol.2019.111212

[3]Capellán-Pérez, I., Campos-Celador, Á., Terés-Zubiaga, J., 2018, Renewable energy cooperatives as an instrument towards the energy transition in Spain. Energy Policy, 123, 215-229. https://doi.org/10.1016/j.enpol.2018.08.064

[4]Delicado, A., Pallarès-Blanch, M., García-Marín, R., del Valle, C., Prados, M. J., 2023, David against Goliath? Challenges and opportunities for energy cooperatives in Southern Europe. Energy Research & Social Science, 103, 103220. https://doi.org/10.1016/j.erss.2023.103220

[5]European Commission, 2018, Regulation (EU) 2018/1999 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action. Official Journal of the European Union, L 328, 1-77.

[6]European Commission, 2018, Directive (EU) 2018/2001 of the European Parliament and of the Council on the promotion of the use of energy from renewable sources. Official Journal of the European Union, L 328, 82-209.

[7]European Commission, 2023, Directive (EU) 2023/2413 of the European Parliament and of the Council as regards the promotion of energy from renewable sources. Official Journal of the European Union, L 333, 1-97.

[8]Herbes, C., Brummer, V., Rognli, J., Blazejewski, S., Gericke, N., 2017, Responding to policy change: New business models for renewable energy cooperatives – Barriers perceived by cooperatives' members. Energy Policy, 109, 82-95. https://doi.org/10.1016/j.enpol.2017.06.051

[9]Hristov, K., Beluhova-Uzunova, R., Atanasov, D, Lavchiev, S., Mrankov, G., 2024, Green deal and solar energy- prospects for Bulgarian rural areas. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 24(2), 529-536.

[10]Inês, C., Guilherme, P. L., Esther, M. G., Swantje, G., Stephen, H., Lars, H., 2020, Regulatory challenges and opportunities for collective renewable energy prosumers in the EU. Energy Policy, 138, 111212. https://doi.org/10.1016/j.enpol.2019.111212

[11]Lowitzsch, J., Hoicka, C. E., van Tulder, F. J., 2020, Renewable energy communities under the 2019 European Clean Energy Package – Governance model for the energy clusters of the future? Renewable and

Sustainable Energy Reviews, 122, 109489. https://doi.org/10.1016/j.rser.2019.109489
[12]Ministry of Energy of Bulgaria, 2023, National Energy and Climate Plan of the Republic of Bulgaria 2021-2030. Sofia: Government of Bulgaria.
[13]Ministry of Economic Affairs and Communications of Estonia, 2023, Estonia's 2030 National Energy and Climate Plan. Tallinn: Government of Estonia.
[14]Ministry of the Environment, Climate and Energy, 2023, Integrated National Energy and Climate Plan of the Republic of Slovenia. Ljubljana: Government of Slovenia.
[15]Ministry for the Ecological Transition and the Demographic Challenge of Spain, 2023, Integrated National Energy and Climate Plan 2021-2030. Madrid: Government of Spain.
[16]Mundaca, L., Busch, H., Schwer, S., 2018, 'Successful' low-carbon energy transitions at the community level? An energy justice perspective. Applied Energy, 218, 292-303.https://doi.org/10.1016/j.apenergy.2018.02.146
[17]Okkonen, L., Lehtonen, O., 2016, Socio-economic impacts of community wind power projects in Northern Scotland. Renewable Energy, 85, 826-833. https://doi.org/10.1016/j.renene.2015.07.047
[18]Soeiro, S., Ferreira Dias, M., 2020, Energy cooperatives in southern European countries: Are they relevant for sustainability targets? Energy Reports, 6, 448-453. https://doi.org/10.1016/j.egyr.2019.09.006
[19]Süsser, D., Kannen, A., 2017, 'Renewables? Yes, please!: Perceptions and assessment of community transition induced by renewable-energy projects in North Frisia. Sustainability Science, 12(4), 563-578. https://doi.org/10.1007/s11625-017-0433-5
[20]Wierling, A., Schwanitz, V. J., Zeiß, J. P., Bout, C., Candelise, C., Gilcrease, W., Gregg, J. S., 2018, Statistical evidence on the role of energy cooperatives for the energy transition in European countries. Sustainability, 10(9), 3339. https://doi.org/10.3390/su10093339
[21]Zheleva, V., Markov, N., 2024, Socio-economic challenges in the transition to a low-carbon economy at regional level in Bulgaria. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 24(2), 975-982.

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STRUCTURAL DIFFERENCES OF THE AGRICULTURAL SECTOR IN THE SOUTH-EASTERN EUROPEAN COUNTRIES

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Abstract

In the present study, the comparative analysis of the state and changes in the sectoral economic structure of the "Agricultural" sector for some countries of South-Eastern Europe is of interest. This research aims to bring to the fore the structural differences in the agricultural sector that distinguish the development of the countries of South-Eastern Europe. By analyzing changes in agriculture using key macroeconomic indicators, the study identifies existing differences in this sector between these countries. On this basis, an assessment is given to what extent these changes are identical to the changes in the member states of the European Union. The results of the research show that the large relative number of those employed in the "Agricultural" sector in some South-Eastern European countries can be seen as an indication of existing opportunities for the restructuring of resources and their reallocation to other sectors of the economy. The change in the relative share of the Gross Added Value in the direction of reduction for the "Agricultural" sector is a process that leads to the improvement of the economic situation of a given country and the effect of this should be reflected in the direction of cohesion between these countries.

Key words**:** *agriculture sector, structural analysis, changes, differences and disproportions*

INTRODUCTION

The dynamics of economic processes form a sectoral structure that determines a region's potential to generate and sustain high levels of economic growth. Currently, changes in the contemporary world economy and the enlargement of the European Union with new Member States pose different challenges related to the structural adaptation of countries and their economic development. The countries of South-Eastern Europe differ considerably in their economic structure and development potential, and the growing disparities between them create social and economic problems in the region. Often, a high relative share of the agricultural sector is an indicator of a country's lower economic development potential, as labour productivity in this sector is lower. The reallocation of labour resources from the agricultural sector to other sectors results in an increase in average productivity and hence higher Gross Value Added, which is a prerequisite for the economic growth of the region. Lewis (1954) [10] argues that the transition from agriculture to industry is the basis of economic development and growth.

He opines that capital and labour move from sectors with lower productivity to those with higher productivity and create the preconditions for economic growth. Roland (2016) [16] defines economic growth of countries mainly by measuring Gross Domestic Product, despite the fact that there are many other factors that can accrue economic growth. Many researchers advocate that structural changes in employment are an essential factor for regional development (Pasinetti,1981; Herrendorf, Rogerson & Valentinyi, 2013**;** Naveed & Ahmad, 2016; Jorgenson & Timmer, 2011) [15, 8, 14, 9]. Other authors consider that poor regions are characterized by low incomes, high long-term unemployment, low levels of education of the population, and low levels of investment (Alcidi et. al., 2018; Baldwin & Wyplosz, 2015; Halmai &Vasary, 2010) [1, 3, 7]. McMillan & Rodrik (2011) [13] identify the intensity of structural transformation as a key factor for countries' economic development. Lin (2011, 2020) posits that structural transformations are linked to the transition

from a poor to a rich economy, asserting that the best approach to improve a country's industrial structure is by fostering the growth of its industries.

These transformations are tailored to the level of economic development and comparative advantages determined by the structure of the country concerned. Some authors (Arzeni A., Esposti R. & Sotte F, 2001; Fuller & Beghin, 2007) [2, 6] in their studies conclude that there are significant differences in the development of variouscountries, including in agriculture, and this calls for a targeted economic policy.

Analyzing structural differences requires considering the specific development opportunities available to the agricultural sector. The degree of economic development of the region directly depends on the place and importance of this sector in its economic structure. The study of structural changes in the agricultural sector makes it possible to identify the differences that exist between countries, which allows for an assessment of the extent to which these structural changes are favorable for the development of the economy in the country and the region.

Countries with a higher share of agriculture relative to other sectors are considered to have less developed economies.

In this context, the aim of this paper is to analyze the level, dynamics and structural regional differences in some key economic indicators in the agricultural sector, and on this basis to make comparisons of the ongoing processes in the countries of South-Eastern Europe.

In order to achieve the set objective the following main tasks are specified:

(i)To assess the degree of homogeneity of the SEE countries in terms of their economic development;

(ii)Assessment of the level and dynamics of structural changes in the Gross Value Added in the agricultural sector for the region;

(iii)To estimate the annual average relative share of employees in the sectoral structure of SEE countries;

(iv)A comparative analysis of changes in the structure employment in the agricultural sector for countries in South-Eastern Europe.

An investigation into what extent the countries follow some common patterns in their development in the region and the EU, with a focus on the specificity of the agricultural sector in the economic structure of the region has been launched.

The object of the study is the regional structural disparities by main economic sectors for the countries of South-Eastern Europe. The subject of the analysis are indicators characterizing the economic structure of the countries of South-Eastern Europe, covering the countries Bulgaria, Greece, Croatia, Romania, Bosnia and Herzegovina, Montenegro, North Macedonia, Albania, Serbia, Turkey and Kosovo. To achieve the goal and objectives, a period from 2016 to 2023 was analyzed when assessing the relative share of Gross Value Added, and for the assessment of employment, the period 2016-2022 was covered.

MATERIALS AND METHODS

The study calculates a coefficient of variation, which is the relative expression of the per capita Gross Domestic Product indicator relative to the average of the same indicator. It looks for the degree of homogeneity among the countries under study, thus assessing the disparities in economic development and well-being of the countries in the region.

The participation of the Gross Value Added and the workforce in the agricultural sector is examined by calculating relative magnitudes of structure, determining the place of this sector in the economy of the countries and the region.

The study of the indicators in dynamic aspect has been carried out by absolute growth, growth rate and rate of change, and the sum of squared differences (SSD) is used to further assess the differences in structure between the countries during the observed period. This indicator is calculated by summing the square of the differences between the relative share of the observed indicator and the average of the same indicator over the entire period.

RESULTS AND DISCUSSIONS

The development of agriculture in EU member states is subject to the principles of the

Common Agricultural Policy, within which financial resources are allocated to support reliable agricultural revenues and the sustainability of the agricultural sector. However, some of the countries included in this study are not EU members, namely Albania, Bosnia and Herzegovina, Montenegro, North Macedonia, Serbia, Turkey and Kosovo. One of the distinctive features of some South-Eastern European countries is the significant relative share of agriculture in Gross Value Added (including GDP). This high share of the agricultural sector in the economic structure of the national economy is associated with the so-called negative structural adjustment and is indicative of an initial stage of economic development. The analysis ofthe relationship between structural dynamics and economic development makes it possible to look for opportunities to reduce undesirable regional disparities.

This study focuses on whether the countries of South-Eastern Europe are homogeneous in terms of their economic development, and to what extent. A leading indicator in international comparisons characterizing the well-being of different countries and the standard of living in a region is the per capita Gross Domestic Product indicator. To assess the degree of unevenness in the economic development of the countries in the region, the coefficient of variation of GDP per capita can be used. This indicator expresses the relative deviation of each country from the average value of GDP per capita for the entire South-Eastern Europe region.
(Table 1).

Table 1. Coefficient of variation of GDP per capita for countries of South-Eastern Europe compared to the average value

Indicators/Year	2016	2017	2018	2019	2020	2021	2022	2023
Coefficient of variation ($V_{\sigma\%}$)	47.2	45.0	43.3	42.0	40.0	39.3	37.7	32.3
Absolute growth (percentage point)	0.0	-2.2	-1.7	-1.3	-2.0	-0.7	-1.6	-5.4
Growth rate (%)	100.0	95.3	96.2	97.0	95.2	98.3	95.9	85.7
Rate of change compared to previous year (%)	0.0	-4.7	-3.8	-3.0	-4.8	-1.8	-4.1	-14.3

Source: Eurostat and own calculations [4].

Dynamically, there is a reduction in the variation around the average GDP per capita, which highlights a favourable trend towards cohesion between the countries in the region. However, despite this reduction, the coefficient of variation has a relatively high magnitude during the period under study. Its high magnitude reflects the degree of heterogeneity in the economic development of the SEE countries studied and provides information on the existence of significant differences between them in terms of the average GDP per capita for the region. During the period under study, Greece has a GDP per capita that is higher than the average for South-Eastern Europe, while Albania and North Macedonia have a significantly lower indicator for the whole period under study. The dynamics of the coefficient of variation shows that the largest decrease took place in 2023 versus the previous year and this decrease amounted to -14.3%. The observed fluctuations in the growth rate of GDP per capita are the result of the economic development achieved, the instability and disparities in the process of restructuring economies. The restructuring of economies and the increasing disparities in the well-being of the population between the poorest and richest countries in the region hinder intraregional convergence.

Structural changes from the primary to the secondary and tertiary sectors can be traced through a comparative analysis of the changes in the share of Gross Value Added and the workforce in the agricultural sector. On this basis, it is possible to provide an assessment of economic development, as well as to identify directions for favourable structural changes leading to higher labour productivity.

Processes work differently in different countries and regions, but those structural changes that lead to higher efficiency are considered to be beneficial and for this reason they are a driver for economic development. The dynamics of the processes in the economy of the regions predetermine changes in the volume and structure of GrossValue Added by sector, and in parallel with structural changes in GrossValueAdded follow changes in the share of employees and hence in relative labour productivity.

The agricultural sector plays an essential role in the economic development of a country, and the intensity of change in the national and regional economic structure shapes trends that affect the territorial balance. Changes in the sectoral structure of the sector determine the place a country occupies in terms of its economic development. Ensuring sustainable rural development, seeking and exploiting regional comparative advantages, and developing a modern agricultural sector are prerequisites for a sustainable dynamic in economic growth rates and for high regional competitiveness. The higher share of the primary sector is an indicator that structural transformation processes are continuing over time and that there are opportunities to realise regional potential.

To determine the participation of the agricultural sector and the degree of economic development achieved, the average relative share of the "Agricultural", "Industry" and "Services" sectors in the formation of the Gross Value Added is established (Table 2).

The relative share of the agricultural sector in the formation of GVA is the lowest for SEE countries. The only exception is Albania, where the agricultural sector has the highest share compared to the other countries. This is followed by the share of the industry sector, with Albania again making an exception with its relative share, and the highest share of the services sector in GVA formation.

On average, over the period, the share of the agricultural sector in GVA varies between 3.6% and 21.5%. For the EU Member States it is 1.7% and for the SEE countries surveyed it averages 7.8%.

Table 2. Relative shares of the "Agriculture," "Industry," and "Services" sectors in Gross Value Added

Country/Region	Share of Gross Value Added in Sector:		
	Agriculture	Industry	Services
EU	1.7	19.7	78.6
South East Europe	7.8	20.2	72.0
Bulgaria	4.2	22.6	73.1
Greece	4.3	15.0	80.7
Croatia	3.6	18.8	77.5
Romania	4.7	23.8	71.5
Bosnia and Herzegovina	6.4	23.3	70.3
Montenegro	8.1	12.0	79.9
North Macedonia	9.2	19.9	70.9
Albania	21.5	13.3	65.3
Serbia	7.4	24.7	67.9
Türkiye	6.9	25.6	67.5
Kosovo	9.1	23.7	67.2

Source: Eurostat and own calculations [4].

Albania has the highest relative share of the indicator in the agricultural sector with 21.5% of the total GVA for the country. For this country, there is a significant deviation both from the share of the other countries and from the average for the European Union and South-Eastern Europe. Compared to the EU average, the relative share of the agricultural sector for Albania is about 13 times higher, and compared to the average for South East Europe it is almost 3 times higher. Albania's economic structure differs significantly from that of the other countries observed and no economic structure can resemble or reach Albania's. In this respect, it is inconceivable to expect a rapid sectoral transformation that would bring Albania closer to the European and South-Eastern European structures. Apart from Albania, North Macedonia, Montenegro and Kosovo also have a higher share than the average of the agricultural sector in South-Eastern Europe, but the difference is not so drastic and such structural changes can be expected in the future, bringing these countries closer to the regional average. The share of the agricultural sector in GVA is lowest for EU member states Croatia, Bulgaria, Greece and Romania, ranging between 3.6-4.7%. Of course, this share is significantly higher than the EU average of 1.7%, but the structural dynamics show a favourable trend of

convergence of the economic structure of these countries with that of the EU. The share of the industry sector varies between 12.0% and 25.6%, with Montenegro having the lowest share, followed by Albania and Greece, and Turkey and Serbia having the highest shares. The tertiary sector for the observation period ranged between 65.3% and 80.7%, with Albania and Greece having the lowest and highest share of services in their national economy. The task of this study is to assess the structure of Gross Value Added in the agricultural sector and the place each country occupies in relation to the average level of the sector in South-Eastern Europe and in the European Union. The comparison of this share with the structure of the same sector in the economy of the countries of South-Eastern Europe makes it possible to identify the differences in a dynamic aspect (Table 3).

The comparative analysis of the changes in the structure of the Gross Value Added for the observed SEE countries confirms the assumption that the share of this indicator in the agricultural sector is higher in the countries with weaker economies.

The downward shift in the relative share of GVA for the agrarian sector is a process that leads to an improvement in economic conditions.

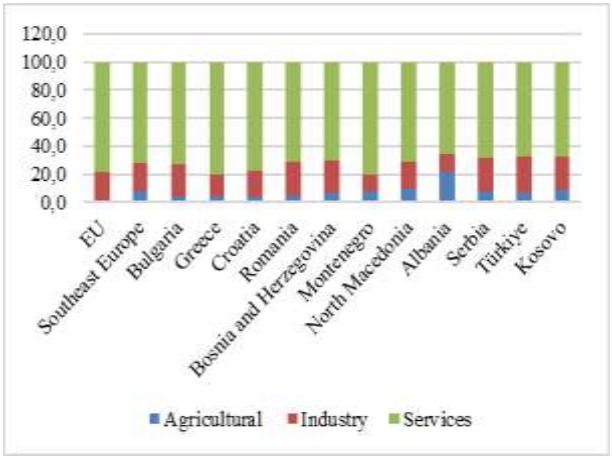

Fig. 1. Share of Gross Added Value in the "Agricultural, "Industry" and "Services" sectors for the period 2016-2023

Source:Eurostat and own illustration [4].

Table 3. Share of the "Agricultural" sector in the Gross Added Value for South-Eastern European countries for the period 2016-2

Country/Region	Share of the " Agricultural " sector in the Gross Added Value								SSD	
	2016	2017	2018	2019	2020	2021	2022	2023	Compared to the SSE average	Compared to the EU average
EU	1.6	1.7	1.6	1.6	1.8	1.9	1.8	1.8		
SEE	8.4	7.9	7.7	7.7	8.1	7.7	7.6	7.3		
BG	4.7	4.7	3.9	3.8	4.0	5.5	4.3	3.5	103.0	52.3
EL	4.0	4.4	4.2	4.4	4.7	4.2	4.3	4.3	98.5	53.9
HR	3.7	3.5	3.6	3.5	3.7	4,0	3,7	3,6	137.9	30.1
RO	4.8	4.9	5.0	4.9	4.6	5.3	4.1	4.3	76.4	73.9
BA	7.5	6.5	6.9	6.5	7.0	6.0	5.7	5.2	17.0	180.6
ME	9.0	8.4	8.2	7.9	9.1	8.0	7.5	7.0	2.1	332.9
MK	10.6	9.1	9.8	9.4	9.8	8.3	8.6	8.1	18.5	454.7
AL	22.6	21.8	21.1	21.0	21.9	21.1	21.3	20.9	1494.0	3119.3
RS	8.2	7.2	7.7	7.2	7.6	7.6	7.7	6.3	2.1	263.6
TR	7.0	6.8	6.5	7.1	7.5	6.2	7.2	7.0	7.8	216.6
XK	10.2	9.2	8.1	9.0	8.9	8.6	9.2	9.7	16.6	439.7

Source: Eurostat and own calculations [4].

The effect of such a change should be reflected in a convergence of their economic structure towards the regional and EU average.

The structural dynamics of GVA in the agrarian sector, measured by the year-on-year growth rate, shows a decrease in the average for South-Eastern Europe over the entire observed period.

A lower relative share is also found for the countries of the region included in the study, with the largest decrease 2023 compared to 2022 for Bosnia and Herzegovina with minus 30.7%, Bulgaria with minus 25.5% and North

Macedonia with minus 23.6%. Changes in the relative share of these countries show that there are structural transformations that are associated with a reallocation of factors of production between different sectors of the economy, which outlines a favourable trend. A further assessment of the changes in the structure of GVA over the whole period relative to the average relative share for SEE and the EU is provided by the sum of squared differences (SSD) indicator. It shows that for the whole period under study, the countries that are close to the SEE average in terms of the share of GVA in the agricultural sector are Montenegro and Serbia, while the structure of the indicator for Albania deviates significantly from that of the region. The comparative analysis in terms of structural changes against the EU average shows the smallest deviations for Croatia, Bulgaria, Greece and Romania, which are EU members. Hence, over the studied period, there is a trend towards convergence of these countries in terms of the structural share of GVA in the agricultural sector and a stabilisation of their structural dynamics through a reduction in the divergence. However, significant deviations can be pointed out again for Albania, followed by North Macedonia and Kosovo, estimated by SSD.

In addition to the participation of the agricultural sector in the GVA of the economy, structural changes in employment are of interest in this study. Those changes that lead to a reduction in employment in labour-intensive sectors while increasing employment in higher productivity sectors are considered to be favourable. For the period, the average relative share of employees in the "Agricultural", "Industry" and "Services" sectors is calculated, as well as the averages for the countries of South-Eastern Europe and the EU. The rate of the employees is used to look for the place of each sector in the economic structure of the country and the deviation that exists with respect to the regional and EU average. The table does not present data for Kosovo due to lack of information (Table 4).

Table 4. Relative share of the employed in the"Agriculture ", "Industry" and "Services" sectors

Country/Region	Share of employed in sector:		
	Agriculture	Industry	Services
EU	4.3	15.5	80.2
Southeast Europe	17.3	21.1	61.6
Bulgaria	16.9	19.8	63.3
Greece	10.8	9.2	80.0
Croatia	6.7	20.4	73.0
Romania	22.2	21.2	56.7
Bosnia and Herzegovina	15.9	33.0	51.1
Montenegro	7.6	18.3	74.1
North Macedonia	21.2	19.8	59.0
Albania	36.9	20.3	42.8
Serbia	17.0	22.5	60.5
Türkiye	18.2	26.7	55.2

Source: Eurostat, ILOSTAT and own calculations [5].

Over the entire period under review, the annual average share of employment in the agricultural sector in the EU member states was 4.3%. Concurrently, the observed South-Eastern European (SEE) countries recorded an average employment rate of 17.3% in this sector, which is almost four times higher. A significant difference is observed in the share of employment in the agricultural sector among the studied countries, with values ranging from 6.7% to 36.9%. Albania has the highest share at 36.9%, followed by Romania with 22.2% and North Macedonia with 21.2%. The comparison between the structure of employment in agriculture and the EU average relative share in the same sector shows that Croatia, an EU Member State, is closest to the average, followed by Montenegro, with these countries reporting employment rates of 6.7% and 7.6% respectively. The largest share of workers in the industrial sector is observed in Bosnia and Herzegovina, Turkey, and Serbia, while Greece reports the lowest such share. In Greece, the difference between the share of employees in the industrial sector and the EU average is almost half as large compared to the other countries.

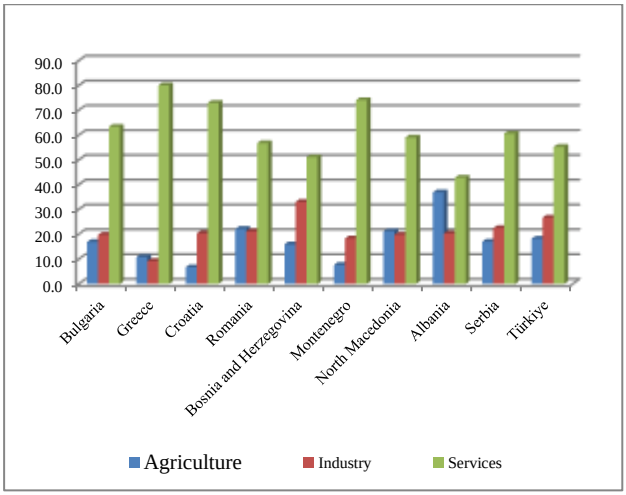

Fig. 2. Share of the employed in the "Agricultural", "Industry" and "Services" sectors for the period 2016-2023.
Source:Eurostat, Ilostat and own illustration [5].

Throughout the entire period under review, Greece has been the leader in both South-Eastern Europe and the European Union regarding employment in the services sector, with the average relative share reaching 80.0%. Albania has the lowest share in the services sector with 42.8% and Bosnia and Herzegovina with 51.1%. These countries have significantly lower share, compared to South-Eastern Europe and the EU, with Albania having almost twice the difference, compared to EU member states.

The share of employees in the agricultural sector for SEE countries is presented until 2022, except for Kosovo.

A further assessment of changes in the structure of employment over the whole period relative to the average relative share for SEE and the EU is made using the sum of squared differences (SSD) indicator.

The sum of the squared differences between the relative share of employees and the average over the whole period is sought, assuming that the country with the largest sum of the squared differences shows the most significant differences over the entire observed period, compared to the regional and EU average employment (Table 5, Figure 3).

For all the years studied, it is evident that Albania has the highest percentage of employees in the agricultural sector.

Table 5. Relative share of the employed in the "Agricultural" sector for countries from South-Eastern Europe

Country/Region	2017	2018	2019	2020	2021	2022	2023	SSD compared to the SSE average	SSD compared to the EU average
EU	4.5	4.4	4.3	4.1	4.5	4.4	4.3		
Southeast Europe	18.8	18.7	17.6	17.4	16.7	16.7	16.3		
Bulgaria	18.0	18.9	17.7	16.9	17.3	16.2	15.2	2.7	1156.1
Greece	11.2	11.3	10.9	10.5	10.4	10.7	10.5	314.9	289.4
Croatia	7.7	7.1	6.3	6.2	6.2	6.6	6.7	815.8	39.4
Romania	23.8	23.4	23.3	22.3	21.6	21.4	20.5	167.2	2268.9
Bosnia and Herzegovina	18.0	18.9	13.8	18.0	12.2	13.8	16.9	44.5	982.4
Montenegro	7.7	7.9	8.0	7.2	7.5	7.4	7.2	690.0	72.2
North Macedonia	22.7	21.9	21.9	21.4	21.4	21.0	20.1	114.7	2056.7
Albania	40.0	38.1	37.3	36.4	36.2	35.6	34.9	2658.3	7442.9
Serbia	19.6	19.8	18.1	16.8	16.2	17.0	14.3	6.7	1214.2
Türkiye	19.5	19.4	18.4	18.1	17.8	17.2	16.7	3.7	1339.3

Source: Eurostat, ILOSTAT and own calculations [5].

Dynamically, there is a decreasing trend in the relative share, with a decrease of minus 12.8% in 2022, compared to 2016. The greatest intensity of change in the employment structure is found for Bosnia and Herzegovina. The growth rate versus the previous period shows an increase in the share of employed persons in 2017, 2021 and 2022 by 5%, 13.1% and 22.5% respectively, while in 2018 and 2020 there is a decrease of 27% and 32.2%

compared to the previous period. In other countries, a decrease in the relative share of employment in the sector is found in most years, although this decrease is not significant.

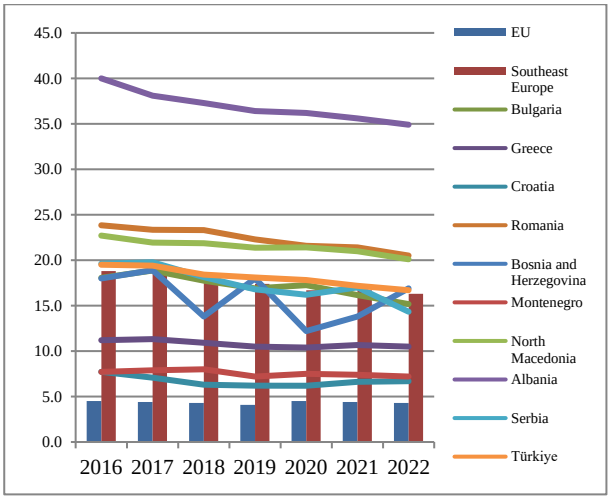

Fig. 3. Share of employed in the "Agricultural" sector of countries from South-Eastern Europe for the period 2016-2023
Source:Eurostat, Ilostat and own illustration [5].

Calculating the sum of squared differences shows that Albania has the highest proportion of agricultural employment in South-Eastern Europe, and Croatia the lowest, with these disparities being significant over the entire period. Albania is the country with the highest relative share of employment in the agricultural sector, while Croatia has the lowest share of employment compared to that of South-Eastern Europe. Bulgaria, Turkey and Serbia are close to the SEE structure, with Bulgaria being an EU member state. The sum of squared differences to the EU average in the agricultural sector shows significant differences again with Albania, which as a share exceeds the EU share by many times, as well as differences with Romania and North Macedonia. Countries that are close to the EU structure of employment in the agricultural sector are Croatia and Montenegro. Overall, the high share of employees in the agricultural sector is indicative of the lower competitiveness and productivity of the economy, and this may be a precondition for adverse development trends in the region and an increase in undesirable regional disparities in the short term.

CONCLUSIONS

The processes of structural transformation in the main sectors of the economy take place differently in different countries, according to specific comparative advantages. In the course of the study, a high degree of inhomogeneity in the economic development of the surveyed SEE countries was found, as well as the presence of significant differences between them in terms of average GDP per capita, Gross Value Added and employment in the agricultural sector. For the observed period, some of the South-Eastern European countries, namely Bulgaria, Croatia, Romania and Greece display a structure that is more similar to that of the European Union. The processes of structural adaptation in Bulgaria and Romania continue, despite the successful restructuring of their economies. The other non-EU countries surveyed show significant differences in terms of the indicators observed in the agricultural sector compared to the same EU indicators.
The structure that differs the most from the magnitudes of South-Eastern Europe and the EU on the selected indicators is that of Albania, Kosovo and North Macedonia. Of these, however, Albania has a structure of GVA and employment in the agricultural sector that differs significantly not only from that of SEE and the EU, but also from any economic structure of the countries in the region.
In view of the application of the countries of South-Eastern Europe to join the European Community, there is a need to assess the economic structures that have been formed at national and regional level, to examine their impact on regional convergence and to look for opportunities to reduce the disparities between the countries in the region.

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REFERENCES

[1]Alcidi, C., FerRer, J.N., Di Salvo, M., Muscmeci, R., Pilati, M., 2018, Income Convergence in the EU: A tale of two speeds. CEPS commentary 9 (2018): 1-7.
[2]Arzeni, A., Esposti, R., Sotte, F., 2001, Agriculture in transition countries and the European model of agriculture: entrepreneurship and multifunctionality. Report for the World Bank – Project "Šibenik-Knin and Zadar Counties: Framework for a Regional Development Vision", University of Ancona.
[3]Baldwin, R., Wyplosz, C., 2015, The economics of European integration. EBOOK The Economics of European Integration 7e, McGraw Hill Education
[4]Eurostat, https://ec.europa.eu/eurostat/data/database, Accessed on 19 February 2025.
[5]Eurostat, ILOSTAT, https://ilostat.ilo.org/data/, Accessed on 19 February 2025.
[6]Fuller, F., Beghin, J. Ch. (ed.), 2007, European Agriculture: Enlargement, Structural Change, CAP Reform and Trade Liberalization. Nova Publishers, New York.
[7]Halmai, P., Vásáry, V., 2010, Real convergence in the new Member States of the European Union (Shorter and longer term prospects). European Journal of Comparative Economics, Cattaneo University (LIUC), 7(1), 229-253.
[8]Herrendorf, B., Rogerson, R., Valentinyi, A., 2013, Growth and Structural Transformation, NBER Working Paper Series, No. 18996
[9]Jorgenson, D. W., Timmer, P.M., 2011, Structural Change in Advanced Nations: A New Set of Stylised Facts, Scandinavian Journal of Economics, 113, 1–29.
[10]Lewis, W. A.,1954, Economic development with unlimited suppliers of labour // Manchester School. Vol. 22 (2), 139–191.
[11]Lin, J.Y., 2011, New Structural Economics: A Framework for Rethinking Development. World Bank Research Observer, 2011, Vol. 26(2), 193–221.
[12]Lin, J. Y., 2020, New structural economics: the third generation of development economics. Asian Education and Development Studies, 9(3), 279-286
[13]McMillan, M., Rodrik, D., 2011, Globalization, Structural Change and Economic Growth, Making Globalization Socially Sustainable, International Labor Organization and World Trade Organization. Geneva
[14]Naveed, A., Ahmad, N., 2016, Labour productivity convergence and structural changes: simultaneous analysis at country, regional and industry levels. Economic Structures Vol. 5,p.1-17
[15]Pasinetti, L., 1981, Structural Change and Economic Growth. A Theoretical Essay on the Dynamics of the Wealth of Nations, Cambridge University Press, Cambridge.
[16]Roland, G., 2016, Development economics. Routledge, New York, pp.82.

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TRANSFORMING FOOD SECURITY IN THE REPUBLIC OF MOLDOVA THROUGH THE AGROVOLTAIC CONCEPT

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Abstract

In the economic conditions, in which vulnerabilities are increasingly accentuated, the issue of ensuring food security for the Republic of Moldova is becoming not so much an agricultural issue but a comprehensive one directly related to sustainable macroeconomic development, its ability to implement socially oriented policies, the constant increase in the standard of living of the population and the use of the advantages of the international division of labor in agriculture. Solving these problems cannot be achieved without implementing new technologies in agriculture. Based on these arguments, we set out to investigate the opportunities for increasing food security by applying new innovative approaches, such as Agri-PV. The research methodology includes quantitative and qualitative methods based on national and international data sources. The main results highlight that the advantages of Agri-PV in the Republic of Moldova primarily relate to the favorable climatic zone for these technologies, the average annual duration of sunshine, and the variety of crops grown in the Republic of Moldova. We want to mention that the use of Agri-PV not only increases productivity and soil quality but also makes it possible to use green energy. At the same time, we have revealed that there are several impediments that hinder the implementation of photovoltaic panels in the Republic of Moldova.

Key words**:** *agrovoltaics, Republic of Moldova, resilience, food security, renewable energy, sustainable agriculture, climate change*

INTRODUCTION

Food security is critical to global, national, and personal security. The evolution of society and the environment makes adjustments to the food security system. Historically, natural disasters and adverse climatic conditions have been the primary threats to food security. In modern times, however, economic and socio-cultural factors, and more recently, military-political events, have added to these challenges.

Today, a paradox exists in the global food system: while hunger remains the cause of millions of deaths each year, global food production is generally sufficient to meet the world's food needs. Achieving a stable state of food security for all people - ensuring physical, economic, and social access to food - is essential to maintaining human potential and enabling sustainable development.

In the context of destabilized global markets, maintaining the stability of national food systems and ensuring the efficient functioning of food markets, agricultural commodities and food production is a cornerstone of food security.

Effective strategies are urgently needed to promote adaptive development and mitigate vulnerabilities that affect food security.

The Republic of Moldova, being a country that, at first glance, should not present problems regarding food security due to its reasonably high level of self-sufficiency (Stratan et al., 2024) [23], nevertheless faces significant challenges regarding food security resilience. In this situation, new innovative approaches are needed to increase food security. Such an approach could be agrovoltaics. Agri-Photovoltaics (Agri-PV) is a direction in agriculture that combines solar energy production and agriculture on the same land (Widmer, 2024) [30]. Installing photovoltaic panels on agricultural land allows farmers to generate clean energy while continuing to grow crops, making the most of the land.

Through this system, it is possible to meet the growing energy demand, protect crops, and manage the risks associated with climate

change. At the same time, agri-PV has double advantages: it produces green energy and improves food security. Based on these arguments, we propose investigating the opportunity to implement agri-PV in the Republic of Moldova to strengthen food security.

The research's purpose is expected to be achieved by achieving the following objectives:

(1) Identifying the capacities for implementing Agri-PV in the Republic of Moldova.

(2) Elucidating the advantages of Agri-PV for increasing food security in the Republic of Moldova.

The research methodology used to execute the proposed purpose and objectives will be qualitative and quantitative. The data will be accessed from national (NBS) [19, 20] and international databases (FAOSTAT [6, 7, 8, 9, 10], The World Bank Data) [24, 25, 26] databases.

MATERIALS AND METHODS

In order to achieve the purpose and objectives of the study, a mixed arsenal of scientific methods was applied based on the versatility of the research topic. The research began by analyzing Agri-PV literature and its impact on agricultural productivity and food security. Subsequently, statistical methods were used to track the evolution of the leading food security indicators, namely, techniques for calculating the average, dispersion, and percentages. In order to compare the food security indicators of the Republic of Moldova with those of other states and highlight the performance level and the potential for improvement, comparative analysis was applied. In order to interpret the impact of Agri-PV on the six dimensions of food security, taking into account the socio-economic conditions and climatic characteristics of the Republic of Moldova, qualitative analysis was applied.

During the research, several indicators for evaluating the dimensions of food security were examined: availability (volume of agri-food production, Self-Sufficiency Ratio – SSR, Import Dependency Ratio – IDR); access (evolution of prices for agri-food products, Gini coefficient); use of (average caloric and protein consumption per capita); stability (Value Added (Agriculture, Forestry and Fishing)Share of GDP US$; Agriculture, forestry, and fishing, value added per worker (constant 2015 US$); Gross Production Index Number (2014-2016 = 100) (Agriculture); agency (Prevalence of severe food insecurity; Prevalence of moderate or severe food insecurity); sustainability (temperature change on land, meteorological year (Standard Deviation); food waste per capita (kg); terrestrial protected areas (% of total land area)).

The analysis was based on a set of statistical and informational data sources. The information sources and statistical databases used were national and international. Among the national sources, we can mention the National Bureau of Statistics of the Republic of Moldova: data on cultivated area, agricultural production, yield per hectare, and other relevant indicators for the agri-food sector were taken; Reports and official documents of the Ministry of Environment and other national authorities, which provided information on the average duration annual sunshine, climate change and government programs to support renewable energy.

The international data sources used were the following: FAOSTAT: data were collected on international agricultural production, per capita calorie and protein consumption, and indicators for establishing benchmarks for food security; The World Bank Data: was used for information on the value added in agriculture in GDP, the share of agri-food exports, and macroeconomic developments.

By combining these information sources with research methods, the study aimed to highlight to what extent Agri-PV implementation can positively influence food security in the Republic of Moldova, especially in the context of climate vulnerabilities and the energy crisis.

RESULTS AND DISCUSSIONS

Literature review

As the world grapples with climate change, energy security, and sustainable food

production, the Agri-PV market has emerged as a game-changing solution.

By integrating agriculture with solar energy, Agri-PV enables the simultaneous production of food and electricity on the same land. This dual-purpose approach not only addresses energy and food needs, but also represents a compelling investment opportunity in the burgeoning renewable energy sector.

Agri-PV installations involve placing photovoltaic panels on agricultural land, allowing farmers to generate clean energy while continuing to grow crops. This innovative system optimizes land use, helps farmers meet their energy needs, protects crops, and mitigates the risks of climate change. Studies have demonstrated its effectiveness: research by Germany's Fraunhofer Institute for Solar Energy Systems (ISE) as part of the Agrophotovoltaics – Resource Efficient Land Use (APV-RESOLA) [11] project showed increased land use efficiency and crop yields (e.g., celery, winter wheat) under solar panels, particularly in arid regions (ISE, 2019).

Additional research, including a study from Oregon State University published in *Nature* (Adeh et al., 2019) [1], highlights the potential of agri-PV. The study identifies cropland, grassland, and wetlands as optimal locations for solar panel performance and notes the positive effects of diffuse shading from photovoltaic panels on crop yields. While shading effects vary by crop (Lee et al., 2022) [14], careful planning can maximize benefits.

Agri-PV aligns seamlessly with the goals of the European Green Deal (EGD) [4], which addresses food security, sustainable agriculture, biodiversity, and innovation.

However, it is crucial to ensure that agricultural land remains productive after installation. At the EU level, legislation on agri-PV varies between member states. Germany, for example, is a leader in setting technical standards (Czyżak and Mindeková, 2024) [3].

(1)Figure 1 illustrates how Agri-PV can impact different dimensions of food security **Optimizing land use.** Combining agricultural production with power generation enables more efficient use of limited land resources, especially in land-scarce regions. This can contribute to improving the following dimensions of food security: availability and sustainability.

(2)**Build resilience to climate change.** Agri-PV mitigates the impact of climate change on agricultural production by protecting crops from extreme weather events such as droughts and heat waves. This positively contributes to the ***availability***, ***agency***, and ***sustainability*** dimensions of food security.

(3)**Crop protection.** Solar panels installed above crops provide partial shade, reducing heat stress on crops during heat waves. This creates a more favorable environment for plant growth, resulting in higher yields, especially under changing climate conditions. This benefit reinforces the dimensions of ***availability*** and ***utilization***.

(4)**Reducing Greenhouse Gas Emissions.** By promoting the use of solar energy, Agri-PV reduces CO_2 emissions and helps combat climate change. This contributes to the ***sustainability*** dimension and supports the ***agency*** aspect of food security.

(5)**Mitigating drought and soil overheating.** Solar panels provide shade, reducing water evaporation and maintaining stable soil temperatures. These effects promote plant growth and improve the ***availability***, ***accessibility***, and ***stability*** of agricultural products.

(6)**Enhancing economic resilience.** Farmers gain an additional source of income through the sale of electricity, which improves their financial stability and reduces the risk of crop failure. This positively impacts the ***availability***, ***access***, ***utilization***, and ***stability*** dimensions of food security.

(7)**Facilitating access to irrigation.** On-site power generation from Agri-PV can power pumps and drip irrigation systems, increasing the efficiency of water use. This supports the ***availability*** and ***sustainability*** of food security.

(8)**Reducing dependence on external energy sources.** A reliable supply of sustainable energy promotes rural development and increases food self-sufficiency, thereby improving the ***availability***, ***accessibility***, and ***stability*** of food security.

(9)**Promoting innovation and sustainable agriculture.** Agri-PV promotes the transition to sustainable, low-carbon agricultural practices. This strengthens all six dimensions of food security, with particular emphasis on ***availability*** and ***access***.

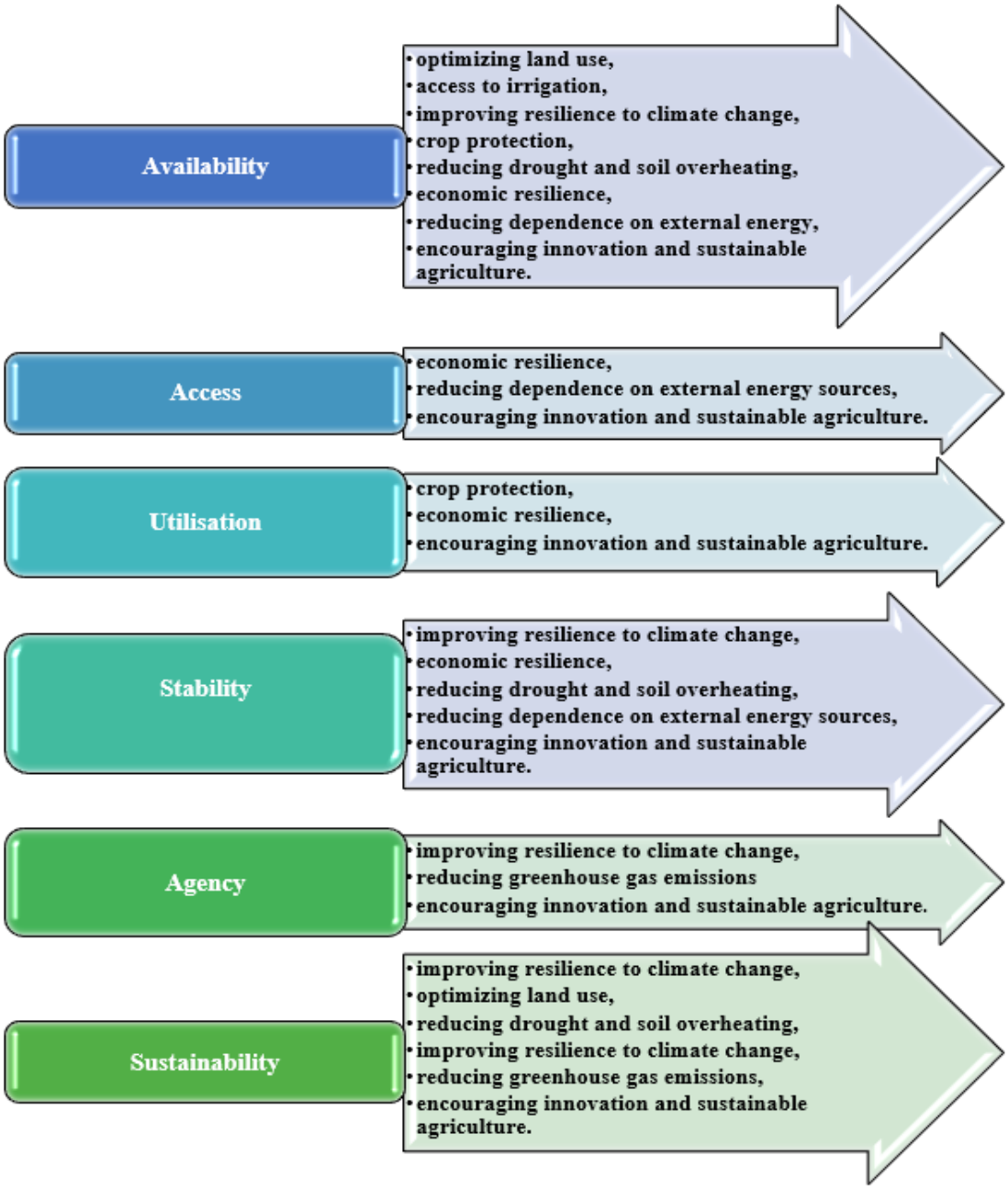

Fig. 1. Strengthening dimensions of food security security through Agri-PV
Source: developed by the authors.

Research shows that it is possible to increase land productivity by 35% to 75% (Sarr, 2023) [22], using it efficiently for agriculture and energy production. In regions with abundant sunshine, Agri-PV represents an excellent opportunity to improve the economic sustainability of farms and an innovative approach that not only meets the dual needs of energy and food but also offers an opportunity for investment in the rapidly growing renewable energy sector.

Agri-PV can improve food security by increasing yields, sustainable agricultural production, and creating additional economic opportunities for farmers.

The role of agriculture in the economy of the Republic of Moldova

Agriculture is a central pillar of the Republic of Moldova's economy, directly impacting the country's economic and social development. Although the added value of agriculture in GDP in 2023 was 7.6% and has decreased by 2 times over the last decade (The World Bank Data, 2023 a [24], agri-food exports account for 57% of total exports (The World Bank Data, 2023 b) [25]. The Republic of Moldova benefits from fertile soil and favorable climatic conditions for cultivating various crops.

The average duration of annual sunshine has increased over the last thirty years. The duration of sunshine is significantly increasing in the north of the country, where the difference between the years 1961-1990 and 1991-2020 is 196 hours. During the warm season, the increase is more pronounced, ranging from 124 additional hours in Briceni (north) to 83 hours in Cahul (south). During the cold season, the differences are smaller - 72 hours in Briceni and 68 hours in Cahul. Currently, the average annual sunshine duration is 2,107 hours in Briceni, 2,271 hours in Chisinau and 2,328 hours in Cahul (Ministry of Environment, 2022) [17].

However, Moldovan agriculture faces many challenges. These include climate change affecting production, soil degradation caused by unsustainable agricultural practices, and limited access to modern technology and investment. The recent energy crisis has exacerbated these problems, exposing the country's energy vulnerabilities and underscoring the need to diversify energy sources and reduce dependence on external suppliers. In addition, food security remains a pressing concern, with notable shortfalls in some areas.

Given these circumstances, conditions in Moldova are favorable for the adoption of agro-photovoltaics (Agri-PV), a technology that integrates solar energy generation with agricultural production. Agri-PV offers numerous benefits, particularly in terms of improving food security.

The efficiency of Agri-PV systems is achieved by balancing energy production with maintaining or increasing agricultural yields. Successful application depends on several factors, which can be divided into several categories:

(i)*technical factors* - these include the quality of the panels, the control system, adaptation to the needs of different crops grown, but also the ability to connect energy generation to the existing electricity grid.

(ii)*environmental factors* - key considerations include the average annual duration of sunshine, the ability of the soil to maintain moisture; types of crops grown, with the advantage being those sensitive to excess solar radiation

(iii)*economic factors* - these include the costs of photovoltaic panels but also the expenses related to their installation, on the one hand, and on the other hand the benefits from increasing agricultural productivity, but also from the sale of solar energy, but also the availability of government support programs for the implementation of Agri-PV;.

(iv)*social factors* - these include the openness to adopting new technologies, the impact on the creation of new jobs

(v)*legal factors* - these relate to the legal framework for regulating Agri-PV.

This holistic approach to these factors is essential, as it optimizes the benefits of Agri-PV technology.

Previous research can highlight the results of using Agri-PV for different crops, both in terms of the yield efficiency of these crops and the energy produced.

Thus, because plants react differently to shade, crops that can adapt better to partial shade tend to perform well on such soils. Leafy vegetables (lettuce, spinach, cabbage) can increase yields by protecting against the excess sun (Laub et al., 2022) [13], and fruits and berries (raspberries, strawberries) show stable or improved productivity due to microclimate regulation (Touil et al., 2021) [27].

Conversely, some crops are less suitable for agricultural PV. For example, forage crops, root crops, and cereals such as wheat and maize can experience reduced yields under shade (Lee et al., 2022) [14]. In particular, grain legumes and maize are significantly disadvantaged by shade (Laub et al., 2022) [13].

It is important to note, however, that research on the compatibility of specific crops with Agri-PV remains limited.

Table 1 provides an overview of the area and average yield of potential arable land suitable for Agri-PV in the Republic of Moldova.

The potential use of Agri-PV and a higher yield of agricultural crops and energy production could also contribute to increasing food security. To understand the deficiencies faced by the Republic of Moldova in terms of food security and how the use of Agri-PV could positively influence these dimensions, we will try to evaluate them through the indicators that characterize them.

Table 1. Total area and average yield of potential arable land for Agri-PV use in the Republic of Moldova

Crops	Indicators	2019	2020	2021	2022	2023
Wheat - total (winter and spring)	Area, ha	314,889	274,422	310,057	304,615	356,188
	Average yield, 1 ha/q	32.9	17.6	46.4	25.9	41.5
Winter wheat	Area, ha	313,970	273,426	309,148	303,788	354,946
	Average yield, 1 ha/q	32.9	17.6	46.4	25.9	41.5
Maize grains	Area, ha	200,237	250,310	230,064	233,758	204,785
	Average yield, 1 ha/q	49.4	15.7	76.6	22.5	37.1
Legumes - total	Area, ha	16,138	9,646	9,691	9,210	12,177
	Average yield, 1 ha/q	20.5	14.6	24.5	15.9	18.6
Field vegetables	Area, ha	3,739	4,163	4,095	3,269	4,138
	Average yield, 1 ha/q	151.7	158	153	198.3	211.6
Green vegetables	Area, ha	14	79	53	36	29
	Average yield, 1 ha/q	72.1	23.4	28.4	32.5	50.6
Food melon crops	Area, ha	556	632	621	501	722
	Average yield, 1 ha/q	78.3	43.8	97.4	70.6	101.3
Maize for silage, green mass and hay	Area, ha	4,225	9,574	4,922	6,751	5,803
	Average yield, 1 ha/q	206.8	102.5	271.4	106.6	176.6
Pot fruits	Area, ha	7,667	8,027	8,152	7,534	6,680
	Average yield, 1 ha/q	158.4	116.2	177.1	126	160.1
Drop fruits	Area, ha	4,836	4,923	5,146	5,303	5,695
	Average yield, 1 ha/q	68.9	45.1	59.1	52.9	76.8
Fruit shrubs	Area, ha	167	201	179	233	224
	Average yield, 1 ha/q	39.1	22.5	44.3	41.5	50.6

Source: NBS (2023 a) [19].

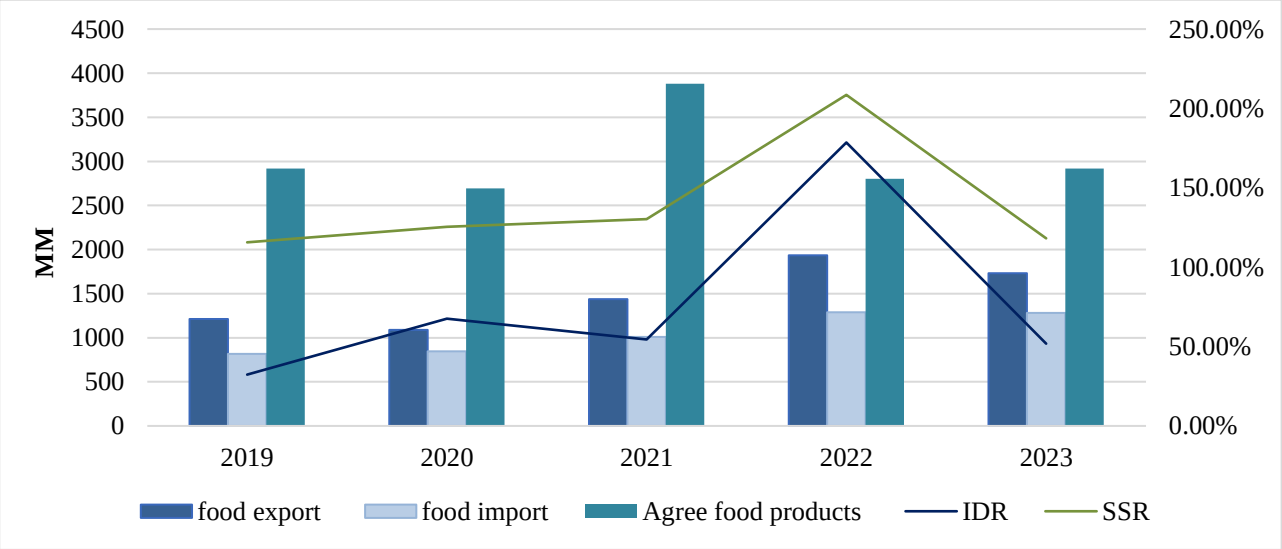

Fig. 2. Dynamics of availability dimension indicators
Source: the author's calculation based on FAOSTAT (2023 a, b) [7, 8].

Figure 2 shows that while the IDR and SSR indicators remain within acceptable limits, their trends are worrying. In addition, the dynamics of agro-food production highlight challenges in the availability of these products. The implementation of Agri-PV could help increase availability by offering several benefits (as shown in Figure 1), which in turn

would have a positive impact on the volume of agri-food production.

Access is one of the most problematic dimensions of food security. Through Agri-PV, it is possible to increase economic resilience and reduce dependence on external energy sources, which could increase the purchasing power of the population and, accordingly, physical, economic, and social access.

Figure 3 presents the indicators characterizing the access dimension of food security. In this respect, it is about:

-inflation rate;
-food price inflation;
-percentage of the population unable to have a healthy diet;
-Gini coefficient by disposable income.
-Gini coefficient by consumption expenditures.

The Republic of Moldova's food security is not positioned well in terms of utilization. Agri-PV could improve this dimension, at least by increasing economic resilience, thereby contributing to better utilization outcomes.

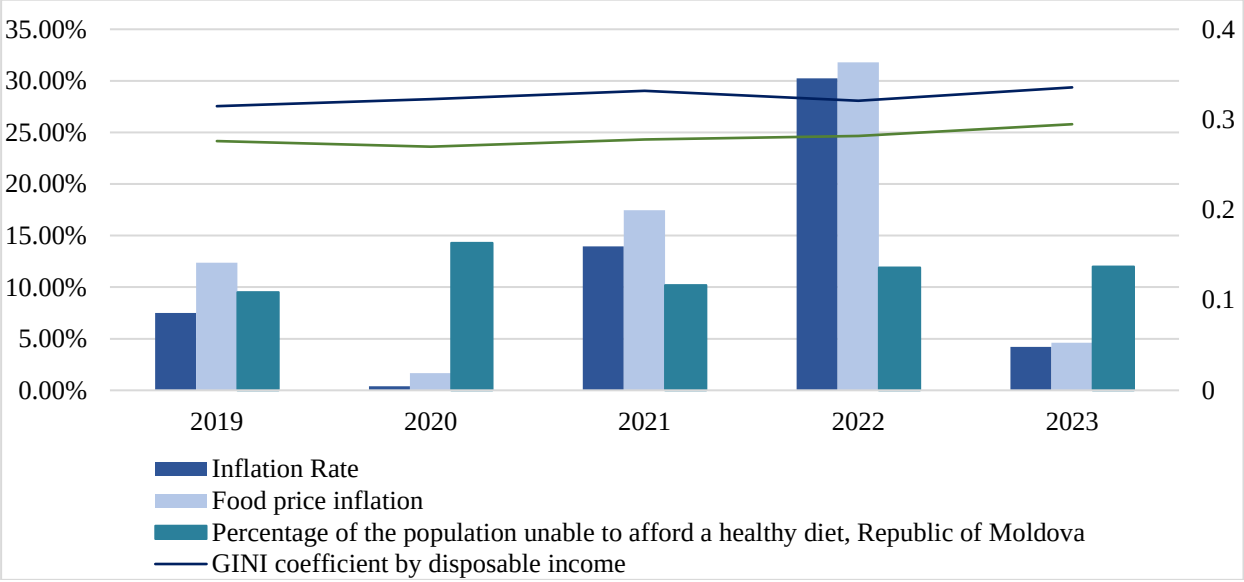

Fig. 3. Indicators characterizing the access dimension of food security
Source: Trading Economics, (2024 a, b) [28, 29]; NBS (2023 b) [20].

Stability is one of the most vulnerable dimensions of food security. Thus, through facilities such as improving resilience to climate change and economic resilience, reducing drought and soil overheating, reducing dependence on external energy sources, and encouraging innovation and sustainable agriculture.

These interventions can improve key indicators such as value added per worker in agriculture, forestry and fisheries, as well as the gross production per capita index number (agriculture). In addition, the implementation of Agri-PV systems can increase the profitability of crops and thus improve agricultural productivity.

Table 2. Utilization dimension indicators

Indicators	2019	2020	2021	2022	2023
Food supply (kcal/capita/day)	3,015	2,966	2,953	2,889	2,800
Protein supply quantity (g/capita/day)	92.97	94.1	87.6	84.5	82.3

Source: FAOSTAT (2023 c) [9].

Table 3. Stability dimension indicators

Indicators	2019	2020	2021	2022	2023
Value Added (Agriculture, Forestry and Fishing)Share of GDP US$	10.16	9.37	10.59	7.87	7.60
Agriculture, forestry, and fishing, value added per worker (constant 2015 US$)	1,393.0	996.5	1,477.7	1,230.9	1,240.0
Gross Production Index Number (2014-2016 = 100) (Agriculture)	118.5	81.41	122.9	89.53	90.8
Gross per capita Production Index Number (2014-2016 = 100) (Agriculture)	124.9	86.52	131.6	89.69	91.08

Source: The World Bank Data (2023 c) [26].

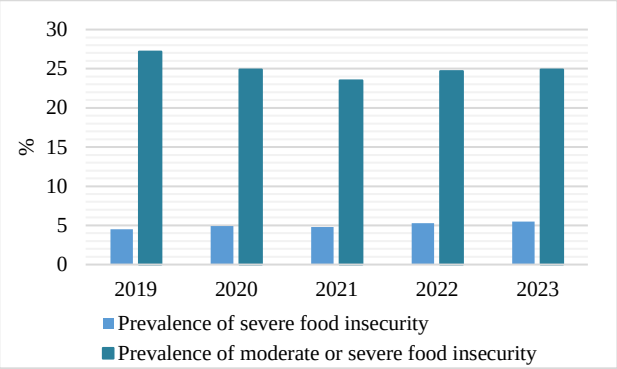

Fig. 4. Indicators characterizing the agency dimension of food security
Source: FAOSTAT (2023 d) [10].

Figure 4 highlights significant challenges related to the agency dimension of food security, which refers to the ability of individuals or groups to act independently in choosing their food, the types of food they produce, how food is produced, processed and distributed, and their participation in political processes that shape food systems (FAO, 2020) [5]. In a country where the prevalence of severe food insecurity exceeds 5%, compared to an Eastern European average of 1.9% (FAOSTAT, 2023 d) [10], food choices are extremely limited for a significant portion of the population. Therefore, the implementation of agri-PV technology is essential, not only from the perspective of increasing economic resilience, but also to reduce dependence on external energy sources.

The sustainability dimension of food security also faces significant challenges in Moldova. Sustainability indicators for 2024 include: soil temperature change of 0.731 °C (compared to the Eastern European average of 0.522 °C) (FAOSTAT, 2023 c) [9]; food waste per capita of 76.13 kg (compared to Romania's 69.63 kg and Ukraine's 72.85 kg) (World Population Review, 2024) [31]; and terrestrial protected areas accounting for 11.43% of total land area (compared to Romania's 34.52% and Ukraine's 12.96%) (The World Bank Data, 2023 c) [26].

The implementation of Agri-PV could bring more facilities to the sustainability dimension of food security. The panels protect crops from extreme weather conditions (from heat to hail) by optimizing land use, reducing drought and soil overheating, improving resilience to climate change, reducing greenhouse gas emissions, and encouraging innovation and sustainable agriculture.

The advantages of using Agri-PV to increase the food security of the Republic of Moldova are apparent, especially in the context of the energy crisis currently triggered in the Republic of Moldova. Its consequences are alarming for the agri-food sector, requiring substantial energy input in production and preservation. At the same time, the population's ability to access agri-food products is becoming increasingly small.

According to the Land Code of the Republic of Moldova (Article 36) [12], land used for solar photovoltaic systems is classified as agricultural land, provided that it is grassed or used for agricultural activities (Registru de Stat, 2025) [21]. However, the implementation of Agri-PV in Moldova faces several constraints:

-***Financial.*** Photovoltaic panels require significant investment, which is a challenge for Moldovan farmers. Nevertheless, foreign partners regularly offer financing programs to help agricultural producers purchase photovoltaic equipment (MAIA, 2022 [16]; AIPA, 2023 [2]; Livada Moldovei, 2022) [15].

-***Lack of expertise***. Moldovan farmers are often reluctant to adopt innovations. Promoting the positive impacts of Agri-PV, especially by showing successful practices in countries with longer experience, is essential.

Thus, the climatic conditions, the type of crops grown, and the average annual sunshine duration in the Republic of Moldova allow for Agri-PV use. In addition, there are programs for financing photovoltaic panels for agriculture by foreign partners.

CONCLUSIONS

Agri-PV is a technology that combines agriculture and solar panels, and it could increase the level of food security in the Republic of Moldova. Key benefits include optimizing land use, which is critical in a country with fertile but highly eroded soils. The shade provided by the photovoltaic panels reduces crop stress caused by overheating and water evaporation, resulting in higher yields. Agri-PV also mitigates the effects of extreme

weather conditions, such as droughts and heavy rains, and builds climate resilience.

By increasing renewable energy production, Agri-PV reduces the country's reliance on energy imports, strengthening its economic resilience and contributing to energy independence. Energy independence is currently Moldova's most critical national security challenge.

In summary, the use of Agri-PV can increase economic resilience, increase crop yields, and reduce dependence on external factors, thereby significantly improving food security in the Republic of Moldova.

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REFERENCES

[1]Adeh, E.H., Good, S.P., Calaf, M., Higgins, C.V., 2019, Solar PV Power Potential is Greatest Over Croplands. Sci Rep, 9, 11442.

[2]AIPA, 2023, Program de granturi privind îmbunătățirea productivității terenurilor (Program of grants for improving land productivity) https://aipa.gov.md/ro/management-durabil-al-terenurilor, Accessed on 16 January 2025.

[3]Czyzak, P.,Mindeková, T., 2024, Empowering Farmers in Central Europe: The Case for Agri-PV. EMBER..https://ember-energy.org/latest-insights/empowering-farmers-in-central-europe-the-case-for-agri-pv. Accessed on January 11, 2025.

[4]European Commission, 2019, Green Deal (EGD). fromhttps://eur-lex.europa.eu/resource.html?uri=cellar:b828d165-1c22-11ea-8c1f-01aa75ed71a1.0002.02/DOC_1&format=PDF, Accessed on 14 December 2024.

[5]FAO, 2020 a, Food Security and Nutrition: Building a Global Narrative Towards 2030. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. https://www.fao.org/right-to-food/resources/resources-detail/en/c/1295540/. Accessed on January 11, 2025.

[6]FAOSTAT, 2023 e, Temperature change on land. https://www.fao.org/faostat/en/#data/ET, Accessed on January 12, 2025.

[7]FAOSTAT, 2023 a, Production. https://www.fao.org/faostat/en/#data/QCL. Accessed on January 11, 2025.

[8]FAOSTAT, 2023 b, Trade. https://www.fao.org/faostat/en/#data/TCL. Accessed on January 11, 2025.

[9]FAOSTAT, 2023 c, Food Balances. https://www.fao.org/faostat/en/#data/FBS. Accessed on January 12, 2025.

[10]FAOSTAT, 2023 d, SDG Indicators. https://www.fao.org/faostat/en/#data/SDGB, Accessed on January 15, 2025.

[11]Fraunhofer Institute for Solar Energy Systems ISE, 2019, Agrophotovoltaics: High Harvesting Yield in Hot Summer of 2018.Press Release, 10. https://www.ise.fraunhofer.de/en/press-media/press-releases/2019/agrophotovoltaics-hight-harvesting-yield-in-hot-summer-of-2018.html. Accessed on 14 December 2024.

[12]Land Code of the Republic of Moldova (Article 36)

[13]Laub, M., Pataczek, L., Feuerbacher, A., Zikeli, S., Högy, P., 2022, Contrasting yield responses at varying levels of shade suggest different suitability of crops for dual land-use systems: a meta-analysis. Agron. Sustain. Dev. 42, 51.

[14]Lee, H.J., Park, H.H., Kim, Y.O., Kuk, Y.I., 2022, Crop Cultivation Underneath Agro-Photovoltaic Systems and Its Effects on Crop Growth, Yield, and Photosynthetic Efficiency. Agronomy, 12, 1842.

[15]LivadaMoldovei, 2022, Panourile fotovoltaice – eligibile în cadrul Proiectului ”LivadaMoldovei”. https://livada-moldovei.md/panourile-fotovoltaice-eligibile-in-cadrul-proiectului-livada-moldovei/, Accessed on January, 12, 2025.

[16]MAIA, 2022, Producătorii agricoli pot achiziționa panouri fotovoltaice în condiții avantajoase. (Agricultural producers could buy photovoltaic plans in advantageous conditions). Accessed on January, 12, 2025.

[17]Ministry of Environment, 2022, Assessment of solar climate resources on the territory of the Republic of Moldova from the perspective of climate change. www.https://mediu.gov.md/ro/content/3723.Accessed on January 6, 2025.

[18]National Agency for Research and Development of the Republic of Moldova (NARD).

[19]NBS, 2023 a, Total area, yielding area, average yield and gross harvest of permanent crops in agricultural enterprises and farms. fromhttps://statbank.statistica.md/PxWeb/pxweb/en/40%20Statistica%20economica/40%20Statistica%20economica__16%20AGR__AGR020/AGR020900reg.px/?rxid=b2ff27d7-0b96-43c9-934b-42e1a2a9a774, Accessed on January 10, 2025.

[20]NBS, 2023 b, Inequality measures by areas, 2014-2023. https://statbank.statistica.md/PxWeb/pxweb/en/30%20Statistica%20sociala/30%20Statistica%20sociala__04%20NIV__NIV070/NIV071200.px/?rxid=b2ff27d7-0b96-43c9-934b-42e1a2a9a774, Accessed on January 12, 2025.

[21]Registru de Stat, 2025, Codul Funciar. https://www.legis.md/cautare/getResults?doc_id=122075&lang=ro, Accessed on January 16, 2025.
[22]Sarr, A., Soro, Y.M., Tossa, A.K., Diop, L., 2023, Agrivoltaic, a Synergistic Co-Location of Agricultural and Energy Production in Perpetual Mutation: A Comprehensive Review. Processes, 11, 948.
[23]Stratan, A., Lopotenco, V., Staver, L., 2024, Resilience of agri-food security in the Republic of Moldova. In Agricultural Value Chain - Past Trends and Emerging Issues, IntechOpen.
[24]The World Bank Data, 2023 a, Agriculture, forestry, and fishing, value added (% of GDP). https://data.worldbank.org/indicator/NV.AGR.TOTL.ZS, Accessed on January 5, 2025.
[25]The World Bank Data. (2023 b)Food exports (% of merchandise exports). https://data.worldbank.org/indicator/TX.VAL.FOOD., Accessed on January 5, 2025.
[26]The World Bank Data.(2023 c). World Development Indicators. https://databank.worldbank.org/source/world-development-indicators. Accessed on January 15, 2025.
[27]Touil, S., Richa, A., Fizir, M., Bingwa, B., 2021, Shading effect of photovoltaic panels on horticulture crops production: a mini review. Reviews in Environmental Science and Bio/Technology, 20.
[28]Trading Economics, 2024 a, Inflation Rate. https://tradingeconomics.com/country-list/inflation-rate. Accessed on January 12, 2025.
[29]Trading Economics, 2024 b, Food Inflation. 2024. https://tradingeconomics.com/country-list/food-inflation. Accessed on January 12, 2025.
[30]Widmer, J., Christ, B., Grenz, J., Norgrove, L., 2024, Agrivoltaics, a promising new tool for electricity and food production: A systematic review. Renewable and Sustainable Energy Reviews, Vol. 192, 114277.
[31]World Population Review, 2024, https://worldpopulationreview.com/country-rankings/food-waste-by-country, Accessed on January 12, 2025.

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VALUE-ADDED AGRICULTURE IN THE REPUBLIC OF MOLDOVA – INCREASING THE EXPORT POTENTIAL AND INTERNATIONAL COMPETITIVENESS

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Abstract

The paper analyses the sub-sectors of the Moldovan agriculture with a potential to transform into high value-added, in terms of production, processing and exports. The Moldovan agri-food sector is still relying on the production and export of raw material, rather that processed products. The low value-added level of agri-food exports determines the country's specialization and hinders its transformation process. The methods approached during the research are based on the quantitative analysis of production and foreign trade of value-added products. At the same time, the qualitative approach with respect to analysis of export potential and estimation of the degree of competitiveness through the Revealed Comparative Advantage (RCA) indicator has been also used. The obtained results revealed that the Republic of Moldova has the necessary prerequisites for enhancing its export potential of value-added products, as the primary agriculture is already developed and additional efforts are required. The agricultural policy should set the main directions for enhancing the value-added agriculture, particularly: support for increasing the quality of products and for processing industry, promotion of by-products, support for new varieties and sub-sectors of the agricultural system and enhancing the synergy among producers and processors.

Key words**:** *value-added agriculture, export potential, competitiveness, Republic of Moldova*

INTRODUCTION

The agri-food sector in Moldova is regularly changing and various external and internal factors have a significant impact on its development and transformation. Enhancing the attractiveness of Moldovan agri-food products on foreign markets will become an important determinant in the development of the country's economy (Lucasenco, Ceban 2020) [16], bearing significant benefits for farmers, themselves, also.

As a fundamental pillar of the Moldovan economy, the agricultural sector - along with its ancillary sub-sectors—exerts a substantial influence on the country's GDP (Herzfeld, Lucasenco, Zvyagintsev, 2022) [12]. At the same time, it simultaneously contributes to employment generation and the preservation of macroeconomic stability.

However, the agricultural sector in Moldova faces numerous challenges, including climate changes (Corobov, 2002; Cojocaru, 2020) [9, 5], insufficient agricultural infrastructure, limited access to complex information (Zbanca et al, 2017) [25], limited access to advanced technology (Petrea et al, 2020; Cimpoies, 2021) [1, 4], issues related to marketplace for value-added products (Cimpoies, Golban, 2013) [3] and underdevelopment of value-added production. Nevertheless, agriculture remains a pillar of the national economy and an important source of income, and increasing and diversifying agricultural exports represents a strategic objective.

Taking into account the globalization process and demands from foreign markets on value-added agricultural products, Moldova has a considerable potential to capitalize on its agricultural resources by promoting value addition.

According to Lu and Dudensing (2015) [15], value-added agriculture is a set of practices that determine farmers to align with consumer preferences for agricultural or food products with form, space, time, identity, and quality characteristics that are not present in raw agricultural commodities. At the same time, its main role is to convert the agricultural outputs into commodities that have a greater value, are

more diversified and that are more appealing to consumers (Cornelisse, Hyde, Kime, 2024) [8].
A broader definition of value-added agriculture is provided by the U.S. Department of Agriculture (2024) [21]. It focuses on changing the form of a product, the manner of production, as well as value enhancement through segregation.
The innovation and coordination aspects of the value-added have been approached by Coltrain, Barton and Boland (2000) [7], while Ja'afar-Furo, Bello and Abdurrhman (2011) [13] see it through the prism of enhancing the income generation of rural environment communities. Almost the same approach in terms of revenues is foreseen in the Maryland Agriculture Code (2024) [17], where value-added agriculture is based on the alteration of a raw agricultural product in order to increase its value to a consumer and contribute with more income to a farmer, producer, or processor.
Improving the features of some agri-food products represents another researched direction by Womach (2005) [24].
Amanor-Boadu (2003) [1] foreseen the value-added agriculture as a reward for the effort of producers and maximization of internal efficiencies. Thus, value-added agriculture refers to the processing of agricultural raw materials into more complex and valuable products that can be exported to international markets, generating additional income and strengthening the country's competitive position in the global market.
This article aims to analyse the importance of value-added agriculture in the Republic of Moldova and to identify the main ways in which this sector can contribute to increasing export potential and international competitiveness. In particular, it focuses on diversifying agricultural products, improving processing infrastructure and implementing effective marketing strategies to open new markets and attract foreign investment.
Thus, the paper will provide a vision on maximization of added value in agriculture, in order to increase the international competitiveness of Moldova and consolidate its position on export markets.

MATERIALS AND METHODS

The methodological framework integrates both qualitative and quantitative research methods to facilitate a comprehensive analysis of the agricultural sector, encompassing its key challenges and potential avenues for development, particularly in relation to increasing its value-added contribution.
By exploring the underlying economic conditions, production and trade dynamics, and the role of value-added processes, this paper aims to offer actionable insights for enhancing Moldova's agricultural export competitiveness.
The research design is exploratory and analytical, combining a review of secondary data sources with primary data collection to understand current agricultural practices, value-added processes, export performance, and competitiveness challenges. A mixed-method approach was selected by authors to gather detailed qualitative insights and quantitative data.
Data for this study was gathered from both primary and secondary sources to ensure the robustness and viability of the findings. Secondary data was collected from various public and private sector reports and databases, including the National Bureau of Statistics of the Republic of Moldova [18], UNCOMTRADE [22], WITS database [23], Export Potential Map [10], etc. This secondary data provided a foundation for the analysis of Moldova's agricultural sector and helped identify relevant trends and patterns in the value-added agricultural products market.
Primary data is based on development of case studies for the following branches of the agri-food sector: wine production, fruit and vegetable processing, dairy and meat processing and cereal and technical crops processing.
Therefore, the methods approached during the research are based on the quantitative analysis of production and foreign trade of value-added products, and the qualitative approach in terms of export potential and degree of competitiveness at the international level,

through the Revealed Comparative Advantage indicator.

Thus, by combining primary and secondary data, the paper provides for a comprehensive understanding of the factors influencing Moldova's agricultural exports. The findings will contribute to identifying strategies for improving Moldova's agricultural export performance, with an emphasis on enhancing its international competitiveness in global markets.

RESULTS AND DISCUSSIONS

In order to assess the competitiveness level and export potential, there were selected a series of branches that have possibilities to be developed in order to increase their productivity, access on foreign markets and increase of the value-added component.

Wine production

During 2016 – 2023, the area of vineyards has decreased from 135.3 thous. ha to 115.1 thous. ha. In 2023, about 42.4% of vineyards is in the ownership of rural households, while 35.1% - in peasant farms and only 22.5% - in agricultural enterprises. The area of technical grapes has decrease from 114.4 thous. ha to 97.9 thous. ha, while of table grapes – from 19.9 thous. ha to 17.2 thous. ha.

Following the trend in surface diminishment, production of grapes has also experienced a decreasing pattern. Thus, production of all types of grapes has diminished during 2016 – 2023 from 615.7 thous. tons to 571.1 thous. tons. Technical varieties intended for winemaking have a downward trend from 529.0 thous. tons to 463.4 thous.t tons, while table grapes production has enhanced its values from 86.7 thous. tons to 107.7 thous. tons.

Despite the decrease in production and area, the average yield per hectare is increasing for all types of grapes. Therefore, for technical varieties, it increased from 46.9 q/ha to 52.3 q/ha, while for table grapes – from 47.2 q/ha to 73.8 q/ha.

In terms of value-added production for the grapes sub-sector, production of wine has increased from 2,764.5 mil. MDL to 4,124.6 mil. MDL in monetary terms, while in natural values, in 2023 it reached 13.3 mil. dal, identical figure with 2016. It's worth mentioning that the highest value of production was reached in 2019 – 17.6 mil. dal. According to experts, the wine sector accounts for about 16% of the total value of agricultural output (Colesnicova, Iatisin, Toaca, 2024) [6].

The foreign trade with wine has a net positive trade balance, exports overcoming significantly the imports. Thus, in 2024, Moldova exported wine in the amount of 143.5 mil. USD., the maximum value of the last 9 years.

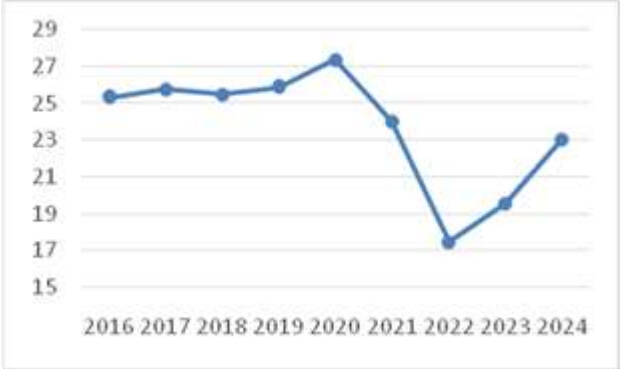

Fig. 1. Foreign trade with wine of fresh grapes (HS-2204), mil. USD
Source: WITS Database, 2025 [23].

The RCA indicator for Moldovan wine is far above 1, accounting for 23 in 2024, which indicates on a high competitiveness level on foreign markets. The highest figure was reached in 2020 – 27, while the lowest of 17 – in 2022. The last two years register a steady increase in the competitiveness level of Moldovan wine.

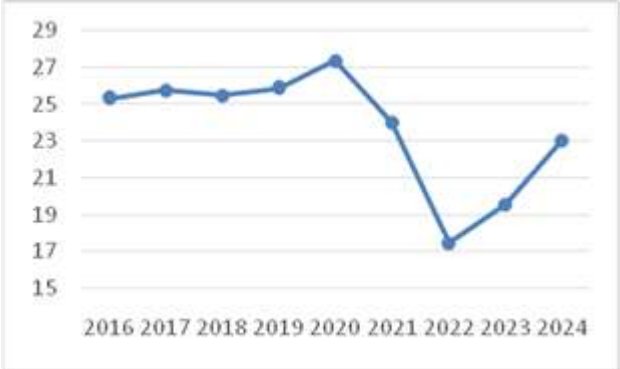

Fig. 2. RCA for wine of fresh grapes (HS-2204)
Source: authors' calculations.

With respect to export potential, Moldova has important reserves for the export of wine of fresh grapes and sparkling wine, which would

bring additional value-added to the agricultural sector and the national economy.

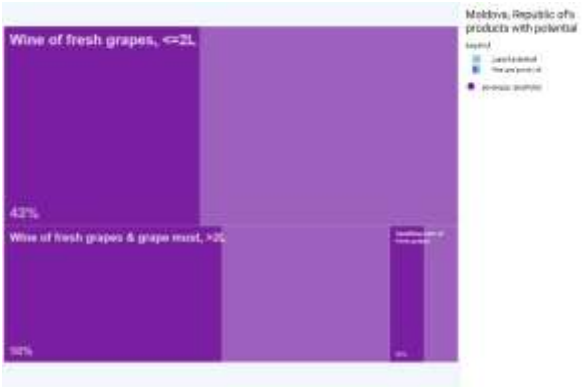

Fig. 3. Export potential for wine of fresh grapes
Source: Export Potential Map, 2025 [10].

Fruit and vegetable processing

A strategic direction of Moldovan agricultural sector is represented by the development of value-added production in the horticultural area (Ceban, Lucasenco, 2023) [2].

The total area of planted fruit trees, nuts and berries have increased slightly during 2016 – 2023 from 134.6 thous. ha to 135.4 thous. ha. In 2023, the fruit trees were mainly concentrated in peasant farms – 43%, followed by agricultural enterprises – 36% and rural households – 21%. In 2023, most of the fruit surfaces were under apple plantations, nuts and plums.

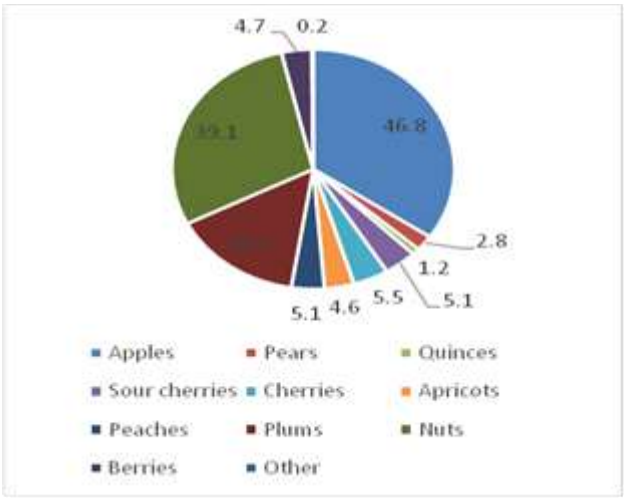

Fig. 4. Distribution of fruits, nuts and berries by planted area, 2023, thous. ha
Source: National Bureau of Statistics, 2025 [18].

Even if the area of fruits, nuts and berries was relatively stable, in the same period, production has experienced a significant boost from 595.7 thous. tons in 2016 to 762.2 thous. tons in 2023, with a maximum level of 876.0 thous. tons in 2021. Production of apples increased with about 25%, pears +0.02%,quinces +38%, sour cherries – twofold, cherries – twofold, plums +51%, nuts +53%, berries – twofold. Only apricots and peaches have experienced decreases in production.

The vegetable sector plays an important role in ensuring the food security of the population, due to their inclusion in daily diet and necessity for nutrients for the proper functioning of the human body.

During 2016 – 2023, the vegetable area has increased from 28.3 thous. ha to 39.3 thous. ha. Nevertheless, in 2023, 81.7% of surfaces belonged to rural households, while 10.7% to peasant farm and only 7.6% - to agricultural enterprises. Even if the surfaces increased in the mentioned period, production has experienced decrease from 280.8 thous. tons to 269.7 thous. tons, mainly due to diminish in production in rural households – with 21%. At the same time, in peasant farms vegetable production have increased with 79%, while in agricultural enterprises – with 42%.

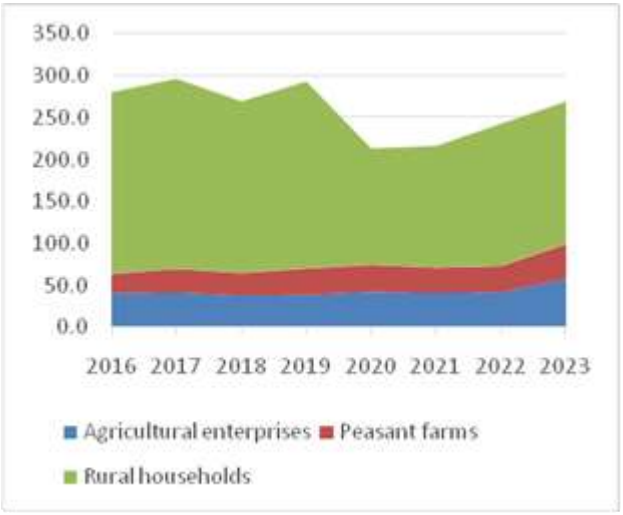

Fig. 5. Dynamics of vegetable production by types of ownership, thous. tons
Source: National Bureau of Statistics, 2025 [18].

The average yield per hectare is also experiencing a considerable decrease from 97 q/ha in 2016 to 68.6 q/ha. The sharpest decline has been experienced in rural households – almost twice, while in peasant farms and

agricultural enterprises it increased with 15% and 47%, respectively.

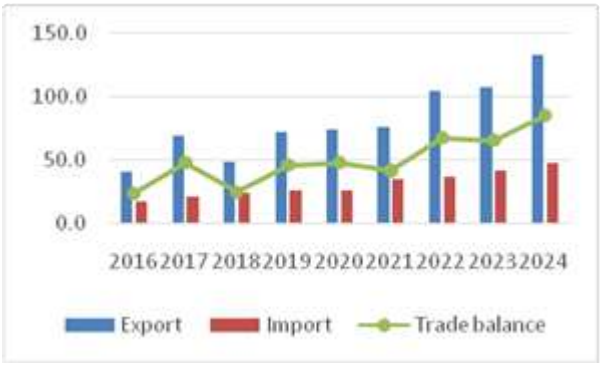

Fig. 6. Foreign trade with preparations of fruit and vegetables (HS-20), mil. USD
Source: WITS Database, 2025 [23].

With respect to value-added production, the processing and preservation of fruits and vegetables experienced a notable boost, rising from 2,174.5 million MDL to 3,689.7 million MDL. In physical terms, output of fruit and vegetable juices grew by 22%, canned fruits and vegetables by 10%, and processed and preserved fruits by 4%.

The foreign trade balance for fruit and vegetable preparations remains positive, with a substantial rise in export revenues, reaching 133.5 million USD in 2024.

The RCA index for Moldovan fruit and vegetable preparations remained constant at a value of 8 in 2024, in line with the levels recorded in 2021, 2020, 2019, and 2017. The lowest RCA values were observed in 2016 and 2018, both registering a score of 5.

These figures indicate that Moldovan fruit and vegetable preparations possess a sustained competitive advantage in international markets.

Important steps are required for enhancing the competitiveness level, among which can be mentioned increase of quality of production, attractive packaging, promotion of processed organic products, as well as market diversification and increase of consumer awareness through a country brand.

With respect to export potential, Moldova has some reserves for the export of apple juice, prepared nuts and seeds, fruit jams, preserved peas and prepared sweetcorn.

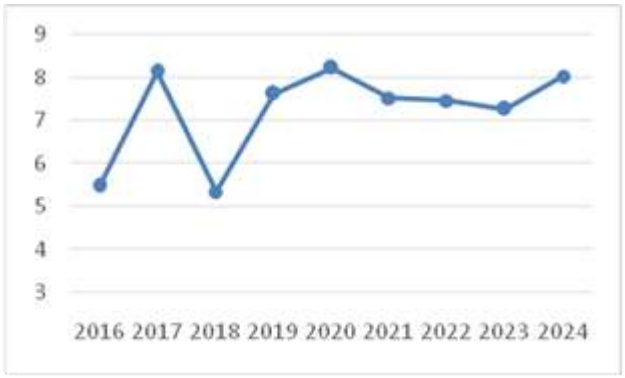

Fig. 7. RCA for preparations of fruit and vegetables (HS-20)
Source: authors' calculations.

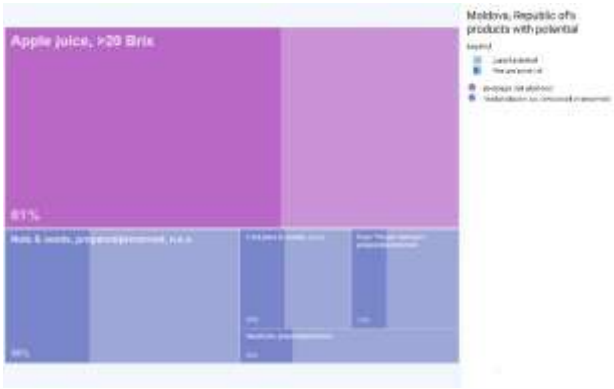

Fig. 8. Export potential for preparations of fruit and vegetables
Source: Export Potential Map, 2025 [10].

Dairy processing

Consumption patterns in Moldovan population are widely based on the livestock products and products from processing industry (Stratan, Ceban, Lucasenco, 2022) [20].

During 2016 – 2024, the number of milking cows has decreased dramatically from 127.7 thous. heads to 63.1 thous. heads. A positive trend is noted only in the distribution of cows by types of ownership. If in 2016, 95.4% of total of milking cows were concentrated in rural households, then in 2024 – it accounted for 83.4%, thus being noted the first positive signs of the most recent reforms in the agricultural policy related to introduction of direct payments per head of animal and per kg of provided product.

Against the trend in reduction of the number of milking cows, the total production of milk has also experienced a significant decrease from 462.1 thous. tons in 2016 to 231.0 thous. tons.

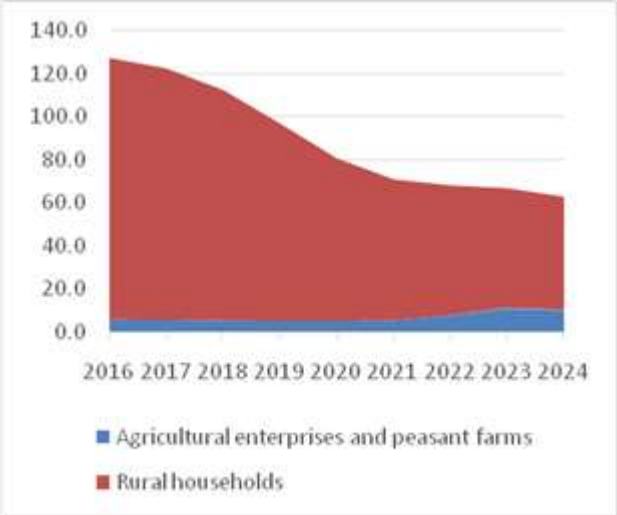

Fig. 9. The number of milking cows by types of ownership, thous. heads
Source: National Bureau of Statistics, 2025 [18].

The sharp decline is due to the decrease in milk production in rural households (almost a 3 time decrease), while in agricultural enterprises, production of milk increased with about 71%.
Production of dairy products has experienced an increase from 22,237.5 mil. MDL to 3,128.9 mil. MDL, while in natural values, production of milk and cream decreased with 48%, production of milk and cream in solid form – with 77% and production of butter – with 49%.

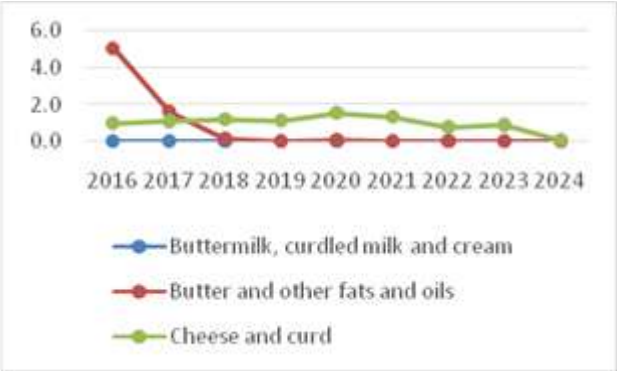

Fig. 10. RCA for selected dairy products
Source: WITS Database, 2025 [23].

The foreign trade with value-added dairy products has negative trade balances for all the analysed products. Thus, in 2024, the trade balance for dairy products presented persistent deficits: -22.8 million USD for buttermilk, curdled milk, and cream; -26.7 million USD for butter and other fats and oils; and -59.2 million USD for cheese and curd.
The RCA indicators for these product groups display considerable variation, with values nearing zero for buttermilk, curdled milk and cream, as well as for butter and related fats and oils in recent years, indicating a lack of competitiveness. In contrast, cheese and curd demonstrate only a modest comparative advantage on international markets.

Meat processing

During 2016 – 2024, the number of cattle decreased from 186.1 thous. heads to 101.0 thous. heads. In 2024, 71.5% of the total number of cattle was in the ownership of rural households. At the same time, production of beef diminished from 15.8 thous. tons in 2016 to 7.1 thous. tons in 2023.
The number of pigs is also decreasing from 453.2 thous. heads to 350.7 thous. heads, with a concentration of pigs in agricultural enterprises in the amount of 65.7%. Nevertheless, pork production has increased from 92.9 thous. tons in 2016 to 94.1 thous. tons in 2023.
The number of poultry in agricultural enterprises is relatively stable, with a slight decrease in the analysed period from 4036.3 thous. pieces to 3972.1 thous. pieces. Poultry production in all types of ownership has experienced a slight decrease from 69.9 thous. tons to 65.0 thous. tons.
In terms of industrial aspects, production, processing and preservation of meat and meat products is constantly increasing, from 3,131.3 mil. MDL to 7,122.3 mil. MDL. In natural values, meat production increased with 68%, cold meats production – with 70%, while canned meat remained almost the same, with a slight increase. Processing companies register higher costs of producing canned meat, especially for glass or tin jars, sterilization, packaging, energy. In order to reduce costs, the processing companies need to source cheaper raw materials, which is only possible by reducing customs duties on frozen pork and chicken from the EU (Litvin, Scerbacov, 2023) [14].
Foreign trade with processed meat products, such as for the dairy products, has a negative trade balance for both, sausages and similar products and other prepared or preserved meat. Thus, in 2024, the deficit of trade balance for sausages and similar products accounted for -

4.6 mil. USD, while for other prepared or preserved meat -7.3 mil. USD.

The RCA values are constantly under 1, pointing on the lack of competitiveness of Moldovan meat processed products on foreign markets. Although 122 agents operate on Moldovan market with respect to meat processing, the production is still intended for local market and local consumption (Ghencea, Stanciu, 2024) [11].

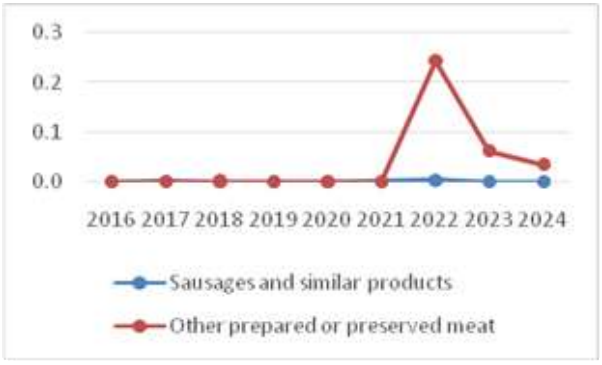

Fig. 11. RCA for selected meat processed products
Source: authors' calculations.

Cereal and technical crops processing

The area of autumn wheat during 2016 – 2023 has increase slightly from 367.2 thous. ha to 375.1 thous. ha. At the same time, production of wheat also increased with 21% in the same period. The area of sunflower has increased from 362.4 thous. ha to 391.9 thous. ha, whilst production – with 12%.

The industry of oil production has experienced a significant increase, from 1,767.1 mil. MDL to 5,792.7 mil. MDL. Almost a twofold increase is registered within the manufacturing of milling products (from 384.7 mil. MDL to 715.3 mil. MDL). In natural values, production of chemically unmodified crude oils experienced a threefold increase, production of flour – a 14% increase, while decreases are registered in production of pasta – with 40% and production of bread – with 3%.

For the analysis of foreign trade with value-added products from the group of cereals and technical crops, positive trade balance is recorded for sunflower-seed oil, while negative figures are seen for wheat flour, pasta and bread, pastry, cakes and biscuits.

Table 1. Foreign trade with value-added products from the cereal and technical crops group, mil. USD

	2018	2019	2020	2021	2022	2023	2024
Wheatormeslinflour							
Export	1.1	1.1	0.7	0.6	3.4	5.9	7.5
Import	11.1	9.7	10.4	8.8	10.8	10.0	9.5
Tradebalance	-10.0	-8.5	-9.7	-8.2	-7.3	-4.1	-2.0
Sunflower-seedoil							
Export	65.2	67.6	101.1	118.7	368.0	242.4	113.3
Import	3.4	3.3	4.9	6.5	49.7	13.7	54.8
Tradebalance	61.8	64.3	96.3	112.1	318.3	228.7	58.6
Pasta							
Export	0.0	0.1	0.1	0.1	0.6	0.2	0.1
Import	6.7	8.3	9.9	11.5	14.3	14.1	14.1
Tradebalance	-6.7	-8.2	-9.8	-11.4	-13.7	-13.9	-14.0
Bread, pastry, cakes, biscuits							
Export	15.3	15.7	16.8	18.8	21.8	24.3	23.3
Import	22.2	26.1	26.6	35.6	41.9	49.3	59.4
Tradebalance	-6.9	-10.4	-9.8	-16.8	-20.1	-25.0	-36.1

Source: UN COMTRADE, DATABASE, 2025

RCA values for sunflower-seed oil are quite high, reaching a maximum level of 109 in 2022, while in 2024 – 98, which indicates on a strong competitiveness with respect to the world markets.

In the last 3 years, wheat flour has also values over 1, reaching 6 in 2024 and also positive values (over 1) are registered for bread, pastry, cakes, biscuits (2 in 2024).

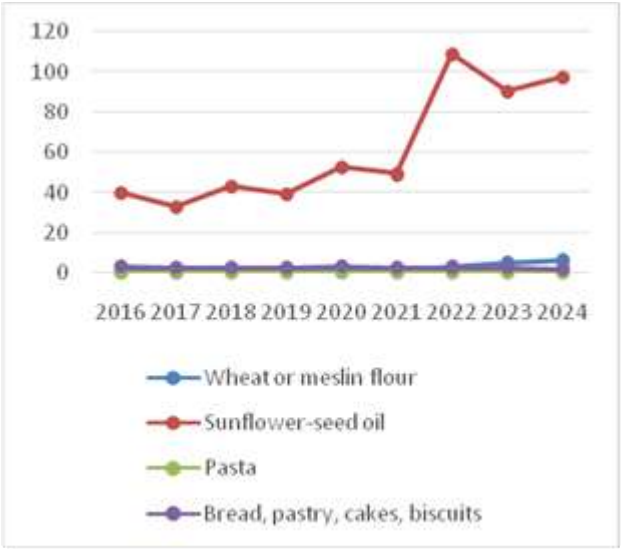

Fig. 12. RCA for selected value-added products from the group of cereals and technical crops
Source: authors' calculations.

The export potential indicators mark increased figures for such products as: sunflower oil, with lower, but also important numbers for sweet biscuits, bread and pastry and waffles.

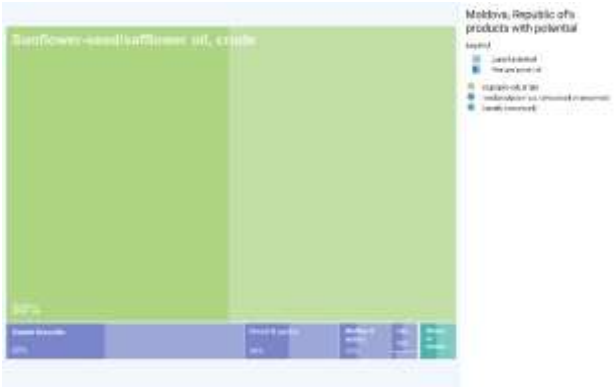

Fig. 13. Export potential for selected value-added products from the group of cereals and technical crops
Source: Export Potential Map, 2025 [10].

CONCLUSIONS

The agricultural sector of Moldova represents a critical component of the national economy and holds considerable potential for expansion through the advancement of value-added agriculture and the promotion of specialized high-value products. While the sector faces a range of challenges, there are clear opportunities to increase Moldova's competitiveness on international markets. The findings of this study highlight the importance of diversifying agricultural products, improving processing infrastructure, and developing effective marketing strategies.

The analysis of sectors such as wine production, fruit and vegetable processing, dairy, meat, and cereal crops processing reveal that, while Moldova has made significant efforts in some areas, there is considerable potential to further capitalize on its agricultural resources through value addition.

The paper also indicates that Moldova's agricultural exports, especially in sectors like wine and sunflower oil, demonstrate competitive advantages on the global market, presenting opportunities for further export growth. To achieve this, it is essential for the country to invest in infrastructure, technology, and international marketing, as well as to attract foreign investment. By embracing these strategies, Moldova can enhance the value-added processes within its agricultural sector, improving both income generation for farmers and overall economic stability. Thus, the development of value-added agriculture represents a promising direction for strengthening Moldova's agricultural export performance and securing its place as a competitive player in the global market.

Thus, the results disclosed that the Republic of Moldova has room for improvement its export potential of value-added products, as the primary agriculture is already developed and additional efforts are required. The agricultural policy should set the main directions for enhancing the value-added agriculture, particularly: support for increasing the quality of products and for processing industry, promotion of by-products, support for new varieties and sub-sectors of the agricultural system and enhancing the synergy among producers and processors.

ACKNOWLEDGEMENTS

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REFERENCES

[1]Amanor-Boadu, V., 2003, Preparing for Agricultural Value-Adding Business Initiatives: First Things First. Agricultural Marketing Resource Center, Department of Agricultural Economics, Kansas State University, Manhattan. https://www.agmanager.info/sites/default/files/Preparation%2520Steps.pdf, Accessed on 16.01.2025

[2]Ceban, A., Lucasenco, E., 2023, Development of sour cherry production in the Republic of Moldova. Economic growth under the conditions of globalization (Creșterea economică în condițiile globalizării), Ed. 17, Vol. 1, pp. 333-341, 12-13 October 2023, Chișinău. Chisinau, Moldova: Editorial-Poligrafic Departament of ASEM, DOI: https://doi.org/https://doi.org/10.36004/nier.cecg.I.2023.17

[3]Cimpoies, D., Golban, A., 2013, The competitiveness of high value added agriculture and major factors of its increasing: the case of the Republic of Moldova.

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Vol. 13(2), 41-47.
[4]Cimpoies, L., 2021, Agricultural support policy in Moldova: a key factor to agricultural development? Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Vol. 21(2), 169-176.
[5]Cojocaru, O., 2020, Potential impact of climate change on agroecosystems in the Republic of Moldova. In: AgroLife Scientific Journal, Vol. 9, pp. 96-103.
[6]Colesnicova, T., Iatisin, T., Toaca, Z., 2024, The winemaking sector in the Republic of Moldova - analysis and perspectives. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Vol. 24(2), 341 - 350.
[7]Coltrain, D., Barton, D., Boland, M., 2000, Value Added: Opportunities and Strategies. Arthur Capper Cooperative Center Department of Agricultural Economics Cooperative Extension Service Kansas State University.
[8]Cornelisse, S., Hyde, J., Kime, L., 2024, Value-Added Agriculture: Enhancing Farm Opportunities. https://extension.psu.edu/value-added-agriculture-enhancing-farm-opportunities, Accessed on 20.11.2024
[9]Corobov, R., 2002, Estimations of climate change impacts on crop production in the Republic of Moldova. GeoJournal 57, 195–202 https://doi.org/10.1023/B:GEJO.0000003612.11530.bf
[10]Export Potential Map, 2025, https://exportpotential.intracen.org/en/, Accessed on ????
[11]Ghencea, A., Stanciu, S., 2024, Industrial Processing Companies in the Moldovan Agri-Food Sector: A Case Study. IBIMA Publishing Communications of International Proceedings https://ibimapublishing.com/p-articles/43ECO /2024/4337024/ Vol. 2024 (2), Article ID 4337024
[12]Herzfeld, T., Lucașenco, E., Zvyagintsev, D., 2022, Agricultural policy development in Moldova over one decade: recent estimates and an outlook towards EU accession. In: Economy and Sociology, 2022, nr. 2, pp. 7-21. DOI: https://doi.org/10.36004/nier.es.2022.2-01
[13]Ja'afar-Furo, M., Bello, K., Abdurrhman, S., 2011, Assessment of the prospects of value addition among small-scale rural enterprises in Nigeria: Evidence from North-eastern Adamawa State. Journal of Development and Agricultural Economics. 3. 144-149.
[14]Litvin, A., Scerbacov, E., 2023, Importul de carne și organe comestibile al Republicii Moldova. In: Creșterea economică în condiţiile globalizării, (The meat and edible organs import of the Republic of Moldova. In: Economic growth under the conditions of globalizations) Ed. 17, Vol. 1, pp. 260-268, 12-13 October 2023, Chișinău. Moldova, Editorial-Poligrafic Departament of ASEM, DOI: https://doi.org/https://doi.org/10.36004/nier.cecg.I.2023.17
[15]Lu, R., Dudensing, R., 2015, What do we mean by value-added agriculture? Choices Quarter 4. http://www.choicesmagazine.org/choices-magazine/submitted-articles/what-do-we-mean-by-value-added-agriculture Accessed on 17.12.2024
[16]Lucasenco, E., Ceban, A., 2020, Assessment of competitiveness of Moldovan agri-food products at the regional level, In: Agrarian Economy and Rural Development- Realities and Perspectives for Romania. International Symposium. 11th Edition, The Research Institute for Agricultural Economy and Rural Development (ICEADR), Bucharest, pp. 224-229
[17]MD Agriculture Code § 2-2201, 2024, https://law.justia.com/codes/maryland/agriculture/title-2/subtitle-22/section-2-2201/ Accessed on 15.01.2025
[18]National Bureau of Statistics, 2025, Database. www.statistica.gov.md, Accessed on 19.02.2025
[19]Petrea, Ș.-M., Cristea, D. S., Turek Rahoveanu, M. M., Zamfir, C. G., Turek Rahoveanu, A., Zugravu, G. A., Nancu, D., 2020, Perspectives of the Moldavian Agricultural Sector by Using a Custom-Developed Analytical Framework. Sustainability, 12(11), 4671. https://doi.org/10.3390/su12114671
[20]Stratan, A., Ceban, A., Lucasenco, E., 2022, Evolution of the livestock sector of the Republic of Moldova. Scientific papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 22(2), 671-678.
[21]U.S. Department of Agriculture (2024). Rules and Regulations. Federal Register, 89 (179): 19-20. https://www.govinfo.gov/content/pkg/FR-2024-09-16/pdf/2024-19804.pdf. Accessed on 15.01.2025
[22]UN Comtrade, 2025, Database. https://comtradeplus.un.org/, Accessed on 13.01.2025
[23]WITS, 2025, Database. https://wits.worldbank.org, Accessed on 13.01.2025
[24]Womach, J., 2005, Agriculture: A Glossary of Terms, Programs, and Laws, 2005 Edition. Congressional Research Service, Library of Congress, Washington, DC. http://digital.library.unt.edu/ark:/67531/metacrs7246/m1/1/high_res_d/97-905_2005Jun16.pdf Accessed on 22.01.2025
[25]Zbanca, A, Panuta, S., Morei, V., Baltag, G., 2017, High value agriculture in the Republic of Moldova, comparative analysis and feasibility of investments. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol. 17(1), 473 - 478.

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CONSUMER PERCEPTIONS IN THE IMPLEMENTATION OF DEPOSIT RETURN SYSTEM

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Abstract

The population plays a crucial role in the successful implementation and operation of the Deposit Return System (DRS). In this context, the research analyzes consumer perceptions and behaviors, focusing on their level of knowledge, attitudes, and intentions to use the system. To gain a detailed perspective, a survey was developed and conducted, targeting consumers to assess their awareness, expectations, and concerns regarding the DRS. The research methodology combines qualitative and quantitative methods, including an in-depth literature review, comparative analysis of international systems, examination of the existing legislative and institutional framework, and a survey of key stakeholders in the waste management sector. The survey aimed to identify consumers` level of awareness, expectations, and concerns about the system, as well as their understanding of the positive impact of DRS on the environment and economy. The results highlight the fundamental role of the population in optimizing the DRS and emphasize the need for information and education campaigns to encourage active participation and raise awareness of the benefits of the circular economy.

***Key words*:** *Deposit Return System (DRS), consumer perception, circular economy, waste management, public awareness, sustainability strategies*

INTRODUCTION

In the context of global concerns regarding environmental protection, the transition to a circular economy in order to collect and recycle wastes of all kinds is compulsory (Croitoru et al, 2024 [7]; Gknountani and Tsoulfas, 2021 [12]; Tarhini et al., 2022 [25]) The efficient management of packaging waste represents a major challenge and problem for the Republic of Moldova. Of the total waste generated in the country, only a small part is recycled. The latest Report of the Environmental Agency indicates that in 2023, enterprises in the Republic of Moldova generated a total of 372.4 thousand tons of waste from various economic sectors, which represents a significant increase of approximately 41% compared to 2022. Municipal waste constituted approximately 16% of the total waste generated by enterprises, equivalent to 56.2 thousand tons. This waste comes exclusively from the technological processes and commercial activities of enterprises, without including household waste from households. (Environmental Agency (2025) [10]. At the same time, in 2023, 191.9 thousand tons of waste were recovered, compared to 172.2 thousand tons in 2022. Of this, glass waste was recovered in an amount of 45.1 thousand tons, compared to 31.1 thousand tons in the previous year, and the amount of plastic waste recovered reached 4.4 thousand tons, an increase from 3.9 thousand tons in 2022. The results of a study show that in 2021, a quantity of 1.3 thousand tons of plastic packaging was placed on the Moldovan market, which corresponds to about 19.5 kg/capita (Perciun, 2022) [20].

Deposit return schemes (DRS) have demonstrated remarkable effectiveness in increasing the collection and recycling rates of packaging in many European countries. DRS is a system that combines a tax on the consumption of products with a refund when the product or its packaging is returned for recycling. These schemes are used for a variety of products, including beverage containers, batteries, motor oil, tires and various hazardous materials. Walls (2011) [27]. DRS can ensure high collection rates for beverage packaging,

reaching up to 98% in Germany (Görgün et al., 2021) [13].

One of the keys to the success of a modern DRS is setting ambitious collection targets, ensuring a minimum deposit of $0.10, including all relevant stakeholders in the system, and financing the system by manufacturers. (Reloop North America, 2023) [22]. A study on consumer perceptions of the effectiveness of the Packaging Deposit Return System was conducted in Greece. The study aims to measure both the impact of consumer motivations on the use of the DRS and how their perception influences recycling participation. Among the main conclusions is that environmental motivations have a positive and significant effect on both consumer perception of the system and its adoption. At the same time, the study highlights technical and logistical problems (such as equipment failures and insufficient collection points) that hinder the efficiency of the system (2023).

DRS has advantages over other waste management policies, such as taxes on virgin materials or subsidies for recycling. DRS avoids the problem of illegal dumping and provides a direct incentive for consumers to return packaging (Walls, 2011) [27].

Implementing a DRS involves a number of costs, such as purchasing and installing the collection infrastructure, operating the system and transporting the packaging. These costs can be covered by contributions from producers, by the value of the uncollected guarantee from consumers or by government subsidies. It is important that the system is designed in a financially sustainable way, ensuring a balance between costs and benefits. In the specific context of the Republic of Moldova, where the separate waste collection rate is low and the waste management infrastructure is still under development, understanding public perception and expectations is crucial for the success of the DRS implementation. (Timofei et al., 2024) [26].

Based on these considerations, we decided to conduct a survey that would outline a picture of the level of information and openness of the population of the Republic of Moldova towards the introduction of the DRS. A survey on the implementation of the DRS can provide valuable information for authorities and decision-makers: such as: public perception of the DRS, the degree of willingness of citizens to participate in the DRS, factors that could influence the success of the DRS implementation. This comprehensive methodological approach not only allows for a nuanced understanding of consumer attitudes, but also facilitates the identification of trends and potential barriers in the adoption of sustainable practices (Iordachi et al., 2024) [14]. Leveraging quantitative data obtained from the survey, the study provides a comprehensive perspective on consumer behavior, allowing for more targeted strategies to promote sustainability. Thus, the main purpose of this research was to analyze consumer perceptions regarding the implementation of the Deposit Return System (DRS), focusing on assessing the level of knowledge, attitudes and intentions to participate in the system.

In order to investigate this, we proposed the following hypotheses for testing:

H1: The current level of consumer awareness about DRS has a positive and significant effect on the intention to participate in the system. This hypothesis is based on the findings of Konstantoglou et al. (2023) [16] and Rietz (2022) [23], which demonstrate the direct correlation between the level of information and active participation in the system.

H2: Economic motivation has a stronger influence on the intention to participate in DRS compared to ecological motivation. According to some studies, perceived economic benefits have a positive and significant effect on the intention to participate in DRS (Dāce et al., 2013) [8], (Broniewicz et al., 2023) [6].

H3: The perception of logistical barriers has a significant and negative effect on the intention to participate in DRS. The hypothesis is based on the research of Rietz (2022) [23] and Kremel (2023) [17], which emphasize the importance of accessibility and simplicity of the return process, as well as on the studies of Laasasenaho et al. (2022) [18] on the specific challenges of rural areas.

These hypotheses will be empirically tested to assess the determinants of the success of DRS

implementation in the specific context of the Republic of Moldova, thus contributing to the development of effective implementation strategies and improving participation rates in the system. This analytical study will serve as a scientific basis for identifying the critical factors influencing the success of the DRS, thus contributing to the optimization of waste management strategies and the promotion of the circular economy in the Republic of Moldova.

Literature review

The Deposit Return System (DRS) is an essential component in modern waste management and the circular economy, its effectiveness being determined by the interaction between multiple socio-economic and logistical dimensions. Research in the field highlights that the success of DRS implementation depends on several interconnected factors. The complex interaction between these factors determines both consumer behavior in relation to the system and the ability of the DRS to achieve its sustainability and economic circularity objectives.

Research shows that consumer awareness is the foundation of DRS success. Thus, consumer participation and satisfaction are directly proportional to their understanding of the system (Konstantoglou et al., 2023 [16]; Rietz, 2022 [23]). Accordingly, when consumers are well informed about DRS mechanisms and associated incentives, their probability of participation increases significantly, while lack of information represents one of the main barriers to adopting the system (Li& Zhang, 2019 [19]; Jarossová & Gubíniová, 2022 [15]).

Closely related to the level of information, a determining role in the success of DRS is played by economic aspects and financial incentives. Deposit-refund systems can generate significant savings in waste management, benefits that extend beyond the individual consumer to the whole of society (Dāce et al., 2013) [8]. This perspective is reinforced by research from Poland (Broniewicz et al., 2023) [6], confirming the substantial economic benefits of introducing DRS for plastic packaging. A particular aspect highlighted by Biala & Aregbeyen (2018) [5] is that the amount of the deposit directly influences consumer behavior - higher deposit amounts significantly increasing the likelihood of product returns.

Beyond economic aspects, the literature highlights the critical importance of logistics in the successful implementation of DRS. Rietz (2022) [23] and Kremel (2023) [17] highlight that ease of return is essential for consumer participation, and the accessibility of return points and the simplicity of the process are decisive factors, especially in rural areas (Laasasenaho et al., 2022) [18].

Other aspects that significantly influence the success of DRS highlighted by researchers include environmental protection, cultural-social values and trust in the system. Thus, understanding the role of the system in environmental sustainability and the circular economy improves consumer attitudes (Pinter et al., 2021 [21]; Zorpas, 2024 [28]), aligning DRS with waste management strategies generates superior results in recycling and pollution reduction (Addy et al., 2014 [2]; Faria & Vale, 2019 [11]), perceptions of DRS effectiveness are shaped by pre-existing cultural attitudes towards recycling and environmental responsibility (Konstantoglou et al., 2023) [16], and the sense of fairness and trust in the transparency of the system determines the long-term commitment of participants (Rietz, 2022 [23]; Kremel, 2023 [17]). Within the cultural-social dimension, social norms also have a particular impact, as consumers are much more likely to participate when they observe similar behaviors in their peers, with collective behavior acting as a powerful catalyst for system adoption (Sari et al., 2021 [24]; Adanu et al., 2023 [1]). Perceived environmental benefits are the starting point for motivation, while cultural context and social norms shape how it's applied locally. Ultimately, transparency facilitates the shift from externally motivated behavior to an internalized social norm.

Demographic factors such as age, education, and socio-economic status also have an impact on perceptions and behaviors related to DRS. Rietz (2022) [23] and Kremel (2023) [17] show that younger generations tend to have more

positive attitudes towards sustainability initiatives, including DRS. Accordingly, there is a need for a personalized approach in the communication and implementation of the system.

The success of DRS implementation depends both on the technology that facilitates access and use of the system, and on effective marketing and communication strategies, through which this technological infrastructure can radically transform consumer perceptions. Messages that combine individual benefits with positive impacts on the community and the environment are powerful tools for stimulating active involvement in the system.

The analysis of the international literature on the success factors of DRS systems suggests how essential it is to assess the applicability of these findings in the specific context of the Republic of Moldova, taking into account local socio-economic and cultural peculiarities.

Adapting the conclusions from the literature to local realities, we highlight that the level of information is the foundation of any functional DRS system in the Republic of Moldova, with research demonstrating that implementation failure often stems from a lack of environmental education, not from insufficient infrastructure. Environmental concern must be strategically cultivated in the local context, with environmental behavior being learned, not innate. Specific economic conditions require careful calibration of financial incentives to truly motivate participation without overloading the system. The success of DRS in the Republic of Moldova will depend less on technological sophistication and more on building public trust and adapting to existing social norms.

MATERIALS AND METHODS

To investigate perceptions and attitudes towards the Deposit-Return System (DRS) in the Republic of Moldova, we used a quantitative survey-based approach. Data collection was carried out through a structured questionnaire, administered to a sample of 608 respondents during the period December 2024–February 2025. Data were collected through the Google Forms Platform, as well as through telephone interviews. Given that the preface to the questionnaire mentioned that the responses would be aggregated and analyzed at a general level, used for research purposes, and published, individual consent from respondents was not required. Also, respondents who were contacted by telephone were informed about this aspect, and those who did not wish to participate in the survey had the opportunity to refuse. The questionnaire was approved by the Ethics Committee of NIER AESM.

The questionnaire was designed to measure multiple dimensions relevant to the implementation and functioning of the DRS, including the level of knowledge, attitudes, behavioral intentions and perceptions of barriers. The instrument contains 25 questions covering demographic, cognitive, attitudinal and behavioral aspects, using predominantly 5-point Likert-type scales to capture the nuances of the responses.

The choice of the questionnaire survey method was determined by several factors. First, this method allows for the efficient collection of a large volume of standardized data from a diverse population, essential to obtain a representative picture of public perceptions of the DRS. Compared to qualitative methods (in-depth interviews or focus groups), the questionnaire facilitates the generalization of results and allows the identification of statistical patterns relevant to public policies.

For data analysis, we opted for statistical methods implemented in the GRETL software, the choice being justified by the accessibility of the program and its robust analytical capabilities.

Thus, the analytical strategy included:

1. Descriptive analysis - to characterize the central tendencies and dispersion of the measured variables. This provides an overview of the level of knowledge, attitudes and behavioral intentions of the population.
2. Correlational analysis - to evaluate bivariate relationships between the variables of interest. Correlation coefficients allow the identification of significant associations that can guide subsequent more complex analyses.
3. Multiple linear regression (OLS) modeling - to test the hypothesized causal relationships

and quantify the effects of independent variables on behavioral intentions.

The choice of OLS regression as the primary method of analysis is justified by its ability to simultaneously assess the effects of multiple explanatory variables, controlling for the influences of other factors. Although variables measured on Likert scales are technically ordinal in nature, recent methodological literature supports the treatment of scales with 5 or more points as approximately continuous, justifying the use of parametric methods such as OLS.

Methodological alternatives, such as ordinal logit models or quantile regression, could have provided valuable complementary analyses. However, OLS regression was preferred due to the direct interpretability of the coefficients and its robustness to moderate deviations from the assumptions, as well as its availability in the GRETL software package.

The sample size (n=608) provides adequate statistical power to detect even small or medium magnitude effects. Using the formula for calculating sampling errors, with a 95% confidence level, the maximum error is approximately ±4%, acceptable for research purposes.

To validate the statistical models, we implemented standard diagnostics available in GRETL, including tests for multicollinearity, heteroscedasticity and normality of residuals. These ensure compliance with the fundamental assumptions of regression analysis and the validity of statistical inferences.

Therefore, the adopted methodology represents a balanced compromise between scientific rigor, practical considerations and research objectives. The combination of a comprehensive questionnaire and robust statistical methods implemented in GRETL provides the necessary foundation for assessing the factors influencing perceptions and behavioral intentions related to the Guarantee-Return System, thus providing valuable empirical evidence for optimizing its implementation in the Republic of Moldova.

RESULTS AND DISCUSSIONS

General characteristic of the sample

A total of 608 respondents participated in the survey. Of these, 48.7% were female, 42.4% were male, and 8.9% declined to state their gender. This distribution suggests a reasonably balanced representation of genders. Furthermore, the age demographics of the respondents were also relatively representative (as shown in Table 1).

Table 1. Cross-tabulation of Age (rows) against Location (columns)

Age	Rural	Urban	Total
18-25	38.8%	61.2%	116
26-35	73.5%	26.5%	117
36-50	64.2%	35.8%	148
51-65	40.9%	59.1%	132
over 65	37.9%	62.1%	95
TOTAL	**52.0%**	**48.0%**	**608**

Source: Author's calculations based on survey data.

Findings revealed that 52% of respondents resided in rural areas, while 48% were from urban areas, demonstrating a relatively balanced representation. This demographic diversity facilitates a comparative analysis of consumer perceptions and behaviors regarding the packaging return guarantee system, allowing for the identification of potential variations between rural and urban consumer expectations and needs.

The distribution of respondents' education levels, as depicted in the diagram, is as follows: 19.2% primary/secondary education, 44.2% secondary education (high school/vocational), and 36.5% higher education (university/postgraduate). When these figures are compared to national statistical data, which generally indicate a lower proportion of individuals with higher education, it can be inferred that the participant group possesses a marginally higher level of educational attainment than the average population.

Consequently, the sample reflects a distribution by education levels in which:

- The percentage of those with primary/secondary education is slightly lower than the national average.
- The share of people with secondary education (high school/vocational school) is consistent with the general structure, but can be easily influenced by factors such as age or residential area.

- The segment of those with higher education slightly exceeds the national average, suggesting a higher participation of respondents with university/postgraduate education.

Therefore, the sample appears to be relatively well-represented in terms of education categories, but with a slight over-representation of those with higher education. This may influence the survey results, as respondents with higher education may generally show a higher degree of interest and involvement in environmental or innovation issues.

H1: The current level of consumer awareness about the DRS has a positive and significant effect on the intention to participate in the system

To find out the level of awareness regarding the DRS, respondents answered the following questions:

1. Do you know the Guarantee-Return System (DRS) for plastic packaging?

2. Do you know how the guarantee return system works (1 = Not at all, 2 = A little, 3 = Moderate, 4 = Good, 5 = Very good)

3. Do you know the types of packaging accepted for this system (1 = Not at all, 2 = A little, 3 = Moderate, 4 = Good, 5 = Very good)

Figure 3 shows the distribution of responses to the question *Do you know the Deposit-Return System (DRS) for plastic packaging.* This distribution of the level of information reveals several essential aspects:

1. Most respondents (59%) have partial knowledge of the DRS, which indicates that, although they have been exposed to the concept, they do not have complete and detailed information about the functioning and benefits of the system.

2. A percentage of 20% of respondents consider themselves very well informed about the DRS. This segment represents a potential pillar of support for promoting the system, since well-informed people can positively influence and educate the community through example and dissemination of correct information.

3. Approximately 21% of respondents do not know at all what the DRS means, highlighting a critical area that requires immediate intervention. These responses indicate that a significant part of the population needs more complete and detailed information.

In response to inquiries regarding their level of knowledge concerning the DRS mechanism, approximately 42% of respondents reported an average understanding, 18% indicated no knowledge, 23% reported limited knowledge, 12% reported good knowledge, and 5.4% reported very good knowledge. This indicates a general awareness of the DRS, but a lack of in-depth understanding among most respondents.

It is undeniable that the DRS represents an important tool in waste management and in promoting the circular economy, providing an organized framework for the collection and recycling of packaging. Thus, people need to know the types of packaging that are returned, whether it is plastic, glass or metal, because correct information facilitates active and efficient participation in the system, thus contributing to the optimization of collection and recovery processes and the omission of barriers that would affect this mechanism from the start. Confusion and lack of information regarding the types of packaging collected through the DRS can reduce the participation rate, because users, not understanding exactly what is collected, may become reluctant to actively engage in the system or may lead to additional sorting and processing costs.

Thus, when asked about the level of knowledge of the types of packaging accepted by the DRS, it was highlighted that approximately 58% of respondents have an average level of information, 18% do not know these types at all, and 7% have only minimal knowledge. Only 12.5% said they knew them well, and a small segment of 5.4% said they knew them very well.

To test the hypothesis that the level of awareness influences the intention to participate, we applied a regression analysis using data obtained from 608 respondents. The study focused on examining the link between the level of knowledge of the system and the willingness to participate in it.

The results of the descriptive analysis present the values for the main indicators studied (Table 2).

Table 2. Descriptive statistics for the main indicators regarding the knowledge of the DRS and the intention to participate

Variable	Average	Median	Min	Max	St. Dev.
Knowledge of working processes	2.64	3.00	1.00	5.00	1.07
Knowledge of packaging	2.82	3.00	1.00	5.00	1.04
Probability of participation	3.68	4.00	1.00	5.00	1.04

Source: Author's calculations based on survey data.

The responses indicate a moderate level of understanding of how the system works (mean 2.64) and the types of packaging accepted (mean 2.82), while the intention to participate has a higher mean value (3.68). This suggests that although knowledge of the system is at an average level, there is a relatively high willingness to participate.

To explain the variability of the intention to participate, a multiple linear regression model was constructed:

$$Intention\_to\_participate = \beta_0 + \beta_1 Knowledge\_DRS + \beta_2 Knowledge\_work + \beta_3 Knowledge\_packaging \quad (1)$$

The model shows an adjusted R^2 of 0.567, meaning that approximately 56.7% of the variation in participation intention can be explained by the included variables.
The coefficient for packaging knowledge (0.71) is the largest and statistically significant ($p < 0.001$), indicating that this dimension of knowledge has the strongest influence on participation intention.

Table 3. Results of the regression model for determining the factors influencing the intention to participate in the DRS

Variable	Coefficient	Std. error.	t-ratio	p-value
Constant	1.77226	0.0988	17.94	5.52e-058 ***
Knowledge_DRS	−0.289765	0.07923	−3.657	0.0003 ***
Knowledge_function	0.0962666	0.05589	1.722	0.0855 *
Knowled_packaging	0.709622	0.05590	12.69	6.79e-033 ***
Unadjusted R-squared	0.567489			
Adjusted R-squared	0.565340			
F(3, 604)	264.1651			
P-value(F)	1.7e-109			

Source: Author's calculations based on survey data.
Note: *** indicates statistical significance at 0.1% level ($p < 0.001$)

It is interesting that the variable related to the general knowledge of DRS has a negative coefficient (-0.29), statistically significant ($p < 0.001$). This apparently paradoxical relationship could suggest that simply knowing about the existence of the system, without a detailed understanding of its functioning, may generate a certain reluctance to participate. In contrast, detailed knowledge of the types of packaging accepted has a strong positive effect on the intention to participate.

The research results emphasize the importance of educational strategies that focus on the practical aspects of the DRS, especially on familiarizing the population with the types of packaging accepted in the system. These efforts could significantly contribute to increasing the participation rate and, implicitly, to the success of the DRS implementation in the Republic of Moldova.

H2: Economic motivation has a stronger influence on the intention to participate in DRS compared to ecological motivation

Economic motivation provides direct, measurable benefits. Consumers perceive a clear financial gain—such as cashback or discounts—when they return packaging. This immediate reward can offset any inconveniences linked to the process, making participation a more attractive and pragmatic choice (Becker and Schmitt, 2020) [4]. Many consumers weigh the immediate costs (time, effort, and potential price increases) against the benefits. Economic incentives directly counterbalance these costs, whereas the benefits of ecological motivation, such as reduced environmental impact, are more diffuse and long-term. When financial rewards are evident, they can effectively lower the psychological barrier to participation (Li and Zhang, 2019) [19]. Recent studies have shown that when consumers are presented with clear

economic benefits, their intention to participate in recycling programs, including DRS, increases significantly. Becker and Schmitt (2020) [4] found that the promise of economic gain is a strong predictor of recycling behavior, while Li and Zhang (2019) [19]. demonstrated that economic incentives can trigger more robust engagement in circular economy practices compared to purely ecological appeals.

What is the perception in the case of the Republic of Moldova? According to our survey, about 59% of respondents indicated that the main reason for which they would participate in the DRS is also the financial benefit (recovery of the guarantee). At the same time, there is a percentage of 15.5 percent who will participate because of concern for the environment, 12.7% consider the main reason – social responsibility, 9% of respondents stated that they will not participate in this system.

To test the hypothesis that economic motivation has a stronger influence on the intention to participate in DRS compared to other types of motivations, we applied regression analysis. This statistical method allows the assessment of the relative impact of different types of motivation (independent variables) on the intention to participate (dependent variable), thus providing a clear picture of the factors that most strongly influence consumer behavior towards DRS.

The multiple linear regression model was constructed as follows:

Intention_to_participate =
$\beta_0 + \beta_1$financial_motiv + $\beta_2$environ_motiv + $\beta_3$social_motiv + $\beta_4$standards_motiv + $\beta_5$nonparticip_motiv.....(2)

Table 4. Results of the regression analysis on the impact of different types of motivation on the intention to participate in the DRS

Variable	Coefficient	Std. error.	t-ratio	p-value
Constant	1.00000	0.718755	1.391	0.1646
Financial_motiv	2.78273	0.719755	3.866	0.0001 ***
Environ_motiv	3.20213	0.722568	4.432	1.11e-05 ***
Social_motiv	3.14286	0.723407	4.345	1.64e-05 ***
Standards_motiv	3.00000	0.735669	4.078	5.15e-05 ***
Nonpartic_motiv	0.392857	0.725144	0.542	0.5882
Unadjusted R-squared	0.528197			
Adjusted R-squared	0.524278			
F(5, 602)	134.7912			
P-value(F)	9.66e-96			

Source: Author's calculations based on survey data.
Note: *** indicates statistical significance at 0.1% level ($p < 0.001$)

The results of the regression analysis contradict the initial hypothesis, indicating that ecological motivation ($\beta = 3.20$, $p < 0.001$) exerts a stronger influence on the intention to participate in the return management system (DRS) compared to economic motivation ($\beta = 2.78$, $p < 0.001$). The model presents a robust explanatory power ($R^2 = 0.53$), demonstrating that motivational factors explain over half of the variation in the intention to participate. It is notable that social motivation ($\beta = 3.14$, $p < 0.001$) and personal standards ($\beta = 3.00$, $p < 0.001$) also have substantial effects, suggesting that the effective implementation of DRS should emphasize not only economic benefits, but especially aspects of ecological sustainability and social responsibility. So, the results of the regression analysis indicate that ecological and social motivation have a stronger influence on the intention to participate in DRS than economic motivation. This moment can also be explained by the fact that a majority of respondents with higher education participated in our survey. Therefore, it was expected that they would be more informed and aware of the environmental impact and the importance of social responsibility. Therefore, messages promoting DRS can benefit from this predisposition, emphasizing ecological advantages (e.g., pollution reduction and resource conservation) and social values (such as community involvement and long-term sustainability).

It is worth noting the difference between the primary motivation stated by respondents in Figure 6 (where 59% indicate financial benefit) and the stronger influence of environmental motivation demonstrated by the statistical model. This apparent discrepancy is not a contradiction, but rather illustrates the difference between explicitly stated preferences and the factors that actually influence behavior. According to studies by Konstantoglou et al. (2023) [16], consumer perceptions are often shaped by multiple motivations operating at different levels. When respondents are asked directly about their primary motivation, they tend to identify immediate and tangible financial benefit. However, advanced statistical analysis reveals that environmental values exert a deeper influence on their actual willingness to participate. These results are consistent with research by Pinter et al. (2021) [21] and Zorpas (2024) [28], which show that understanding the benefits for sustainability significantly improves consumers' attitudes towards return schemes, even if they do not explicitly identify this factor as primary.

Contradicting our initial hypothesis represents a valuable discovery that nuances the understanding of consumer motivations in the Republic of Moldova. Although international literature (Dāce et al., 2013 [8], Broniewicz et al., 2023) [6] emphasizes the predominance of economic motivations in other geographical contexts, our results indicate a stronger affinity for ecological values among respondents. This difference can be explained by three factors:

1. The demographic structure of the sample, with a higher representation of respondents with higher education (36.5%), a segment that tends to value environmental considerations more strongly;
2. The evolution of ecological awareness in recent years at a global level, which has led to changes in consumer priorities compared to previous studies;
3. The particularities of the local context, including visible environmental problems in the Republic of Moldova that may sensitize the population to sustainability aspects.

This result suggests that communication strategies for DRS implementation should emphasize ecological benefits, without neglecting the economic aspects that remain important for certain segments of the population.

H3: Perception of barriers has a negative and significant effect on the intention to participate in DRS

To test this hypothesis, respondents were asked to answer the following 2 questions: What is the main difficulty you anticipate in actively participating in the DRS? Also - How much time would you be willing to allocate to returning packaging?

The analysis of response distribution regarding difficulties identified the top three perceived barriers as:

- Increased product prices (additional expenses): approximately 71%
- Lack of information: approximately 49%
- Lack of adequate infrastructure: approximately 48%

These results lead us to the idea that the vast majority of respondents fear that with the implementation of the DRS, the increased costs will have a direct financial impact on their personal budget, so people may be reluctant to support the initiative, regardless of its environmental or social benefits. Without a clear understanding, consumers may be reluctant to participate and may distrust the efficiency and ultimate purpose of the system, and limited access to collection points or/and the absence of well-established facilities, even informed and motivated people may give up, due to the major additional effort that the return process may involve. Thus, addressing these barriers in a coherent and integrated way can improve public trust and significantly increase the participation rate in the DRS.

Notably, the data concerning the time respondents are willing to dedicate to packaging returns demonstrates a clear preference for efficient and easily manageable procedures.

The survey revealed that approximately 57% of participants are inclined to allocate between 5 and 10 minutes to packaging returns, while 22% prefer to complete the process in under 5 minutes. Conversely, 10% are unwilling to dedicate any time. Furthermore, only 10% of respondents, cumulatively, expressed a

willingness to invest more than 10 minutes. These findings suggest a general tendency to prioritize time-efficient tasks, especially in the absence of perceived significant benefits.

To determine the impact of perceived barriers on intention to participate, we applied regression analysis, using two distinct models. This statistical approach allows us to quantify the effect of each perceived barrier (independent variable) on respondents' willingness to participate in the system (dependent variable).

Table 5. Results of the regression analysis on the impact of various barriers on the intention to participate in the DRS

Variable	Coefficient	Std. error.	t-ratio	p-value
Constant	2.58545	0.06957	37.16	1.18e-157 ***
Price_Barrier	1.37091	0.08999	15.23	1.59e-44 ***
Time_Barrier	−0.3217	0.186716	−1.723	0.0853 *
Info_Barrier	0.8146	0.156818	5.195	2.82e-07 ***
Complex_Barrier	0.0044	0.176337	0.02500	0.9801
Costs_Barrier	−1.094	0.176014	−6.216	9.58e-10 ***
Infrastru_Barrier	1.02845	0.154161	6.671	5.78e-11 ***
Queues_Barrier	−0.372986	0.207606	−1.797	0.0729 *
Schedule_Barrier	−0.014984	0.167231	−0.089	0.9286
Unadjusted R-squared	0.371018			
Adjusted R-squared	0.362618			
F(8, 599)	44.16664			
P-value(F)	1.17e-55			

Source: Author's calculations based on survey data.
Note: *** indicates statistical significance at 0.1% level ($p < 0.001$)
* indicates significance at the 10% level ($p < 0.1$)

The first regression model, which analyses the impact of each barrier individually, presents interesting and partly counterintuitive results. The explanatory power of the model is moderate ($R^2 = 0.37$), indicating that approximately 37% of the variation in participation intention can be explained by perceived barriers.

Contrary to initial expectations, not all barriers have a negative effect on participation intention. PriceBarrier ($\beta = 1.37$, $p < 0.001$), InfoBarrier ($\beta = 0.81$, $p < 0.001$) and InfrastruBarrier ($\beta = 1.03$, $p < 0.001$) have positive and statistically significant coefficients, suggesting that respondents who identified these barriers still tend to have a higher intention to participate. This apparently contradictory finding could indicate that individuals with a higher level of interest and motivation in participation are also those who possess a greater awareness of potential challenges. In contrast, CostBarrier ($\beta = -1.09$, $p < 0.001$) has a strong negative effect on the intention to participate, partially confirming our hypothesis. TimeBarrier ($\beta = -0.32$, $p < 0.1$) and RowBarrier ($\beta = -0.37$, $p < 0.1$) also have negative effects, although with lower statistical significance. To examine not only the impact of each individual barrier, but also the cumulative effect of perceived difficulties, we built a second model in which we analyzed the relationship between the total number of barriers identified by each respondent and their intention to participate in the DRS.

To examine not only the impact of each individual barrier, but also the cumulative effect of perceived difficulties, we built a second model in which we analyzed the relationship between the total number of barriers identified by each respondent and their intention to participate in the DRS.

The second model provides a surprising result. The positive and significant coefficient ($\beta = 0.097$, $p < 0.001$) indicates that, on average, the more barriers a person identifies, the higher their likelihood of participation. However, the explanatory power of this model is relatively low ($R^2 = 0.098$), suggesting that the total number of barriers, in itself, is not a strong predictor of participation intention.

These seemingly contradictory results can be explained from several perspectives. It is possible that individuals more interested in the DRS have a deeper awareness of potential

challenges, thus identifying more barriers, but still maintaining a high intention to participate. Alternatively, the identification of barriers could indicate a constructive critical attitude, rather than a total reluctance towards the system.

Table 6. Results of the regression analysis on the impact of the total number of perceived barriers on the intention to participate in the DRS

Variable	Coefficient	Std. error.	t-ratio	p-value
Constant	3.32220	0.0591282	56.19	1.80e-242 ***
NumbBarriers	0.0971567	0.0119193	8.151	2.07e-15 ***
Unadjusted R-squared	0.098807			
Adjusted R-squared	0.097320			
F(1, 606)	66.44186			
P-value(F)	2.07e-15			

Source: Author's calculations based on survey data.
Note: *** indicates statistical significance at 0.1% level ($p < 0.001$)

The paradox of the results regarding barriers requires a nuanced interpretation. The positive coefficients for certain barriers (price, lack of information, infrastructure) and the positive correlation between the total number of barriers and the intention to participate can be explained by the phenomenon of "critical awareness" (Diemer et al., 2016) [9]. This phenomenon manifests itself when people who are more involved and interested in the DRS are also more attentive to potential obstacles. At the same time, this dual model of barrier perception is consistent with theories of planned behavior (Ajzen, 1991) [3] and suggests that the identification of structural barriers may actually indicate a high level of information and involvement, rather than a reluctance towards the system. Thus, the identification of barriers does not necessarily represent a negative attitude, but rather an analytical and constructive perspective.

There is, however, an important distinction between the types of barriers. Structural barriers (price, lack of information, infrastructure) are perceived as obstacles that can be overcome through systemic interventions and do not diminish the intention to participate of respondents aware of the benefits of DRS. In contrast, personal barriers (hidden costs, time, queues) represent direct inconveniences for the individual and have a negative impact on the intention to participate. Our research suggests that addressing specific barriers, especially those related to hidden costs, time and queue management, could have a significant impact on increasing the intention to participate. At the same time, transparency in price communication and the development of an adequate infrastructure could capitalize on the already existing interest among people who are aware of these aspects.

In conclusion, the hypothesis that the perception of barriers has a negative and significant effect on the intention to participate in DRS is partially confirmed, being valid for certain specific types of barriers, but not for all and not for the total number of perceived barriers. This nuance provides a deeper understanding of the complexity of factors that influence citizens' willingness to participate in the guarantee-return system.

Therefore, the return system should be designed to be as convenient and fast as possible (accessible collection points, simplified scanning/recycling processes). In the absence of conditions that facilitate speed, participants are likely to give up or not pay attention to the return system. It follows that infrastructure plays a decisive role in reducing the time spent returning packaging. Thus, an extensive network of collection points, strategically located (e.g. near supermarkets, parking lots, residential areas) and equipped with fast pick-up and reward technologies should be designed. All of this could meet the needs of the majority of respondents who do not want to spend more than 5-10 minutes.

If respondents consider that the benefits (whether financial or environmental) do not justify the time invested, they will be less willing to participate. Therefore, an information campaign is needed that emphasizes the positive impact of recycling and the tangible benefits (price discounts,

shopping vouchers, prizes, etc.), to demonstrate to participants that the time allocated is not wasted.

Therefore, for a DRS to be successful, it is essential to adapt to the time requirements of most consumers, who want a quick experience that is easy to integrate into their daily routine. Thus, an accessible infrastructure, clear communication, and rewards can reinforce the perception that the time invested is worth the effort, contributing to increasing participation rates.

Even in the context of the anticipated cumulative barriers and the time required for return, respondents considered that DRS in the Republic of Moldova will have a moderate efficiency. Respondents were asked to estimate from 1 to 5 the efficiency of DRS in the Republic of Moldova (1 being not at all efficient and 5 – very efficient). Thus, about 52% of respondents believe that DRS once implemented will have a moderate efficiency, about 8 percent are convinced that DRS will be very efficient, and 9% - not at all efficient.

This fact can be interpreted as follows:

Real perception of obstacles

Respondents are aware of the challenges related to costs and the time required for return, but do not consider these barriers severe enough to completely invalidate the potential benefits of the DRS. They acknowledge that although there are difficulties, the system can function to a reasonable extent if solutions are implemented to reduce the impact of these obstacles.

Balance between costs and benefits

The fact that only 8% are convinced of a very high efficiency, and 9% believe that the system will be not efficient at all, suggests that the overall perception is one of balance. Respondents seem to consider that although barriers may affect the degree of participation, these can be compensated by other benefits.

Moderate but realistic expectations

The moderate assessment of efficiency reflects a pragmatic attitude of the respondents. They do not expect spectacular results, but a significant improvement over the current situation, while recognizing that the implementation of the DRS will require an adaptation effort from both consumers and authorities and other parties involved.

The need for compensatory measures

This moderate perception emphasizes the importance of implementing complementary measures – such as facilitating access to collection points, information campaigns and technological solutions that reduce the time required for returns – to maximize the efficiency of the system.

So, the moderate assessment given by the respondents indicates that the system could function at a satisfactory level in the Republic of Moldova, but with appropriate interventions from decision-makers and the media, the potential of the DRS could be optimized.

CONCLUSIONS

We can mention that the hypothesis testing demonstrated that, for a successful implementation of the DRS in the Republic of Moldova, an integrated approach is essential. While the level of information and knowledge about the system stimulates the intention to participate, ecological and social motivations have a stronger influence than economic ones. In addition, logistical barriers represent a major obstacle, which underlines the need to optimize the infrastructure and reduce the perceived costs. By adopting appropriate information strategies, infrastructural development and incentives, the DRS can be successfully implemented, contributing both to environmental protection and to the development of a sustainable circular economy.

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REFERENCES

[1]Adanu, S., Boakye, M., Kwabena, A., Gbedemah, S., Christopher, A., Richard, A., Asabre, A., 2023, Challenges of public participation in solid waste management at Nkanfoa landfill site in the cape coast

municipality of Ghana. Journal of Sustainable Development, 16(5), 63. https://doi.org/10.5539/jsd.v16n5p63

[2]Addy, N., Kiliccote, S., Callaway, D., Mathieu, J., 2014, How baseline model implementation choices affect demand response assessments. Journal of Solar Energy Engineering, 137(2). https://doi.org/10.1115/1.4028478

[3]Ajzen, I., 1991, The theory of planned behavior. Organizational Behavior and Human Decision Processes, 50(2), 179-211. https://doi.org/10.1016/0749-5978(91)90020-T

[4]Becker, R., Schmitt, M., 2020, Deposit-refund systems for beverage packaging: A systematic review. Sustainability, 12(8), p.3275.

[5]Biala, M., Aregbeyen, O., 2018, An applicability test of the use of deposit-refund system for managing water-sachet litter in Ilorin, Nigeria. Environmental Economics, 9(4), 22-43. https://doi.org/10.21511/ee.09(4).2018.03

[6]Broniewicz, E., Larsson, A., Piontek, W., Sidorczuk-Pietraszko, E., 2023, Economic effects of introducing a deposit-return system for packaging in Poland. Economics and Environment, 86(3), 169-185. https://doi.org/10.34659/eis.2023.86.3.718

[7]Croitoru, I.M., Grigoras, M.A., Popescu, A., Grigoras, B.A., 2024, Embracing the circular economy: a paradigm shift for sustainable prosperity. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 24(2), 397-406.

[8]Dāce, E., Pakere, I., Blumberga, D., 2013, Evaluation of economic aspects of the deposit-refund system for packaging in Latvia. Management of Environmental Quality an International Journal, 24(3), 311-329. https://doi.org/10.1108/14777831311322631

[9]Diemer, M. A., Rapa, L. J., Voight, A., McWhirter, E. H., 2016, Critical consciousness: a developmental approach to addressing marginalization and oppression. Child Development Perspectives, 10(4), 216-221. https://doi.org/10.1111/cdep.12193

[10] Environmental Agency, 2025.

[11]Faria, P., Vale, Z., 2019,). A demand response approach to scheduling constrained load shifting. Energies, 12(9), 1752. https://doi.org/10.3390/en12091752

[12]Gkountani, V.A., Tsoulfas, G.T., 2021, Circular economy and food production systems: tracing linkages and exploring synergies. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 21(2), 281-288.

[13]Görgün, E. et al.,2021, Deposit refund system for beverage containers as a best practice example for recycling maximization, Environmental Research and Technology, 4(3), pp. 199–205. doi:10.35208/ert.862611.

[14]Iordachi, V., Timofei, O., Perciun, R., 2024, Consumer Decision Drivers in the Republic of Moldova: Choosing Recycled Clothing for a Sustainable Future. Calitatea Vietii. https://doi.org/10.46841/RCV.2024.04.01

[15]Jarossová, M., Gubíniová, K., 2022, Beverage container deposit return system in Slovakia: insights after one year of its introduction. Engineering Sciences and Technologies, 2022(1(38)), 75-89. https://doi.org/10.15611/nit.2022.38.05

[16]Konstantoglou, A., Fotiadis, T., Folinas, D., Falaras, A., Rotsios, K., 2023, Accessing consumer perceptions of the effectiveness of the deposit refund system. Sustainability, 15(12), 9429. https://doi.org/10.3390/su15129429

[17]Kremel, A., 2023, Consumer behaviour in a circular system – how values promote and hinder the participation of young adults in the Swedish deposit-refund system for beverage packaging. Circular Economy and Sustainability, 4(2), 1427-1446. https://doi.org/10.1007/s43615-023-00333-7

[18]Laasasenaho, K., Savolainen, J., Kirveslahti, A., Lauhanen, R., 2022, A small deposit for plastic packaging waste could improve sorting habits in rural areas. Alue Ja Ympäristö, 51(1). https://doi.org/10.30663/ay.107216

[19]Li, Y., Zhang, Y., 2019, Circular economy strategies in packaging: A review of deposit-return systems. Journal of Cleaner Production, 210, pp.1345-1358.

[20]Perciun R., 2023, Economia circulară și recuperarea deșeurilor din plastic prin reciclare în Moldova (Circular economy and plastic wastec recovery through recycling in Moldova), doi.org/10.36004/nier.cecg.2023.17.1

[21]Pinter, E., Welle, F., Mayrhofer, E., Pechhacker, A., Motloch, L., Lahme, V., … & Tacker, M., 2021, Circularity study on pet bottle-to-bottle recycling. Sustainability, 13(13), 7370. https://doi.org/10.3390/su13137370

[22]Reloop North America, 2023, A Guide to Modern DRS: 10 Essential Practices. https://bottlebillreimagined.org/wp-content/uploads/2023/12/Reloop-NA_A-Guide-to-Modern-DRS_10-Essential-Practices.pdf , Accessed on 28 February 2025.

[23]Rietz, S., 2022, Making up circular consumers: young adults' personal accounting and counter earmarking within a circular deposit-refund scheme. Accounting Forum, 47(4), 525-552. https://doi.org/10.1080/01559982.2022.2149045

[24]Sari, D., Masruroh, N., & Asih, A. (2021). Consumer intention to participate in e-waste collection programs: a study of smartphone waste in indonesia. Sustainability, 13(5), 2759. https://doi.org/10.3390/su13052759

[25]Tarhini, M., Turcea, V.C., Zapucioiu, L.F., Ion, R.A. 2022, Food waste status and reduction through the circular economy. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 22(4), 731-742.

[26]Timofei, O., Iordachi, V., &Perciun, R. (2024). Consumer behavior towards recycled clothing. Cogito, 16(3), 119-140.

[27]Walls, M. (2011) Deposit-Refund Systems in Practice and Theory', in Shogren, J.F. (ed.) Encyclopedia of Energy, Natural Resource, and

Environmental Economics. 1, pp. 133–137. DOI:10.2139/ssrn.1980142
[28]Zorpas, A. (2024). Promoting circular economy: the transformative impact of deposit refund systems. Waste Management & Research the Journal for a Sustainable Circular Economy, 42(12), 1093-1095. doi.org/10.1177/0734242x241296617

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WHEAT AND PRODUCT LOSSES AND THEIR IMPACTS ON THE POPULATION'S NUTRITION

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Abstract

Reducing food loss and waste is a key part of Sustainable Development Goal (SDG) 12 on Responsible Consumption and Production. Specifically, target 12.3 aims to "halve per capita global food waste at the retail and consumer levels by 2030, and reduce food losses along production and supply chains, including post-harvest losses."The main hypothesis is that per capita losses of wheat and products influence the population's nutrition, with a mediation effect of per capita supply. Mediation analysis will be performed using the Food Agricultural Organization statistical database, in which losses from wheat and its products are independent variables. The dependent variables relate to measuring population nutrition, and the mediator variables measure food supply per capita.Various research methods, such as the mediation analysis, Augmented Dickey-Fuller test and desktop research, have been applied. Before the application of mediation analysis, a time series stationarity test was made.
The study's results show that per capita losses of wheat and products do not directly or indirectly affect the "Average Dietary Energy Adequacy" and the "Prevalence of Undernourishment." However, per capita losses directly affect the "Prevalence of Obesity" among the adult population. The indicators "Average Dietary Energy Adequacy" and "Prevalence of Undernourishment" are independent of the mediator variables.

Keywords**:** *wheat and product losses, population's nutrition, mediation analysis, Bulgaria*

INTRODUCTION

Plant-based resources provide nearly 93% of the population's food, with cereals accounting for two-thirds of this amount. Cereals are a major source of protein and calories.Wheat is the main field crop grown in Bulgaria, sown on an area of about 10 to 15 million decares each year.The average yield of 570 kg/dca with 99% harvested areas with wheat – this is indicated by the latest operational data of the Ministry of Agricultureand Food (MAF) for Bulgaria [12]. Bread, which is one of the staple foods of humanity, is made primarily from wheat flour. It is also used to make various baked goods such as pasta, biscuits, and others.Wheat flour is also used in the preparation of beer, some high-alcohol beverages and even biogas.
Wheat is also a staple for governments, whose ability to remain in power and control the masses depends on their ability to feed their populations, according to an analysis prepared by analysts for the financial portal Investing.com. Wheat futures' dynamics reflect Ukraine's military conflict and the unstable geopolitical situation. Rising prices warn of the risks of famine in parts of the world and even mass discontent, which could further exacerbate the problems caused by the conflict in Ukraine. Since time immemorial, history has developed in such a way that the rise and shortage of wheat have led to serious political consequences, as wheat is one of the main foods. Together, wheat exports from Russia and Ukraine represent one-third of the world's grain exports. Due to the fighting that has been going fertile fields in Ukraine have been turned into battlefields. The armed conflict in Ukraine will have consequences far beyond the borders of both sides, which could force the population of many countries in the world to be prepared for famine. The biggest threat in this direction is for Africa and the developing world, where poverty and hunger are likely to get worse. China and India, the two most populouscountries in the world, could face food shortages. Prices in the US and Europe, however, will likely "skyrocket," further

increasing inflation, which was already at its highest level in 40 years, even before the conflict in Ukraine.

The world's population is growing continuously and meeting food needs is essential. It is believed that losses at various stages after harvest remain exceptionally high. Therefore, reducing these losses would lead to more food for the population and more efficient use and management of natural resources and farmers' livelihoods.Cereals cause the highest post-harvest losses in terms of calorific value of all agricultural crops. Up to 50%–60% of cereals can be lost during the storage stage alone due to technical inefficiencies. Post-harvest losses occur from farm to market during the harvesting, handling, storage and distribution of food. Post-harvestlossesincludefoodlossalongthefoodsup plychainfromharvest to consumption[3].Food losses are mainly due to physical damage - rough handling, unsuitable environmental conditions, poor quality containers used for transportation and storage, poor post-harvest temperature management, and lack of access to facilities and equipment for proper refrigeration, foodprocessing, orstorage[10].

The FAO defines food security as "a situation in which all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO, 2011) [5].One-third of foodcrops are lost yearly in the world. Theworldpopulationhasbeenpredicted to increase to 9.1 billionbytheyear 2050, hence, a 70 percentincreaseinfoodisneededinthefuture (FAO, 2009) [6].

The impact of the COVID-19 pandemic on the agricultural sector of most countries has led to a decline in production [2], therefore the lower production needs to be protected from post-harvest losses. According to Dharmathilake et al., the availability of sufficient food is linked to the overall ability of the agricultural system to meet food demand [4].

The preventing food loss and waste has become a global issue. Solving this major societal problem is possible by improving education in this area, improving raw material processing technologies, and improving transport and storage facilities. This activity should involve the entire agricultural food production and supply chain.In addition, collecting data, and comparable data across countries, is essential. Data on losses for certain products can be found in various data bases, but for the individual stages of the supply chains of a particular product is very difficult, if not impossible. There are also no scientific studies on the impact of these losses on the nutrition of the population.

The main hypothesis in the study is that per capita losses of wheat and products affect the population's nutrition with a mediating effect on per capita supply.

MATERIALS AND METHODS

The main hypothesis is that per capita losses of wheat and products influence nutrition of population, with mediation effect of per capita supply.

The rationale for this hypothesis is as follows:

• Greater "Losses per capita" will lead to lower per capita supply;

• Greater per capita supply will lead to better nutrition of population;

• And as a result – greater "Losses per capita" will lead to worse nutrition of the population.

The data source is the Food and Agriculture Organization (FAO).

Data from Food Balances from 2010 until now [7], Food Balances until 2013 [8] and Food Security and Nutrition[9] were used. The data refer to the period 2000-2022.

Food losses are measured in metric tons. To achieve comparability between them and supply per capita, the food losses are recalculated in kilograms per capita.

For per capita supply, all four FAO indicators were used:

• "Food Supply Quantity (kg/capita/year)";

• "Food Supply (kcal//capita/day)";

• "Protein Supply Quantity (g/capita/day)";

• "Fat Supply Quantity (g/capita/day)".

Three indicators were used as a measure of population nutrition:

- "Average Dietary Energy Supply Adequacy"
- "Prevalence of Undernourishment"

- "Prevalence of Obesity in the Adult Population"

The prevalence of undernutrition in one direction and the prevalence of obesity in the opposite direction are in fact negative effects of nutrition of the population.

Since the information for "Average Dietary Energy Supply Adequacy" and "Prevalence of Undernourishment"is in the form of 3-year averages, all other indicators were also calculated as 3-year averages. In this calculation, a weighted arithmetic mean was used, with the number of population in the respective year used as weights. As a result, 21 3-year intervals were obtained – from 2000-2002 to 2020-2022.

The particular indicators we have used to measure food losses, per capita supply and nutrition of population, lead to the concretization of the main hypothesis (Fig. 1).

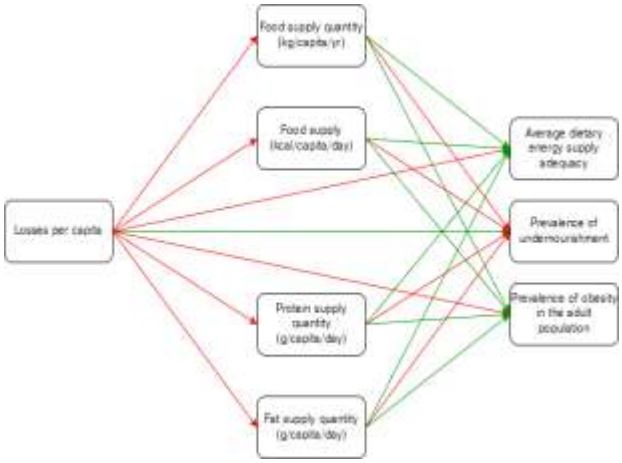

Fig. 1. Relationships between losses per capita and nutrition of population
Source: Authors' own conception.

Expected positive relations are marked in green, while expected negative relations are marked in red.

Mediation analysis was used to model these relationships. This analysis allows the estimation of both the direct and indirect impacts of the independent variable on the dependent variables.Mediation analysis is a statistical method used to understand the mechanisms by which an independent variable influences a dependent variable through a mediator variable. By including the mediator in the analysis, we gain a deeper understanding of the causal chain of events [13].

Mediation analysis involves two types of regression equations. The first one shows the influence of the independent and mediating variables together on the independent variable. The second one shows the influence of the independent variables on the mediator variables. [14]

In our case these two types of equations are:

$$\hat{Y}_i = a_i + b_i X + \sum_{j=1}^{4} c_{ij} M_j \ (i = 1,2,3)$$

$$\hat{M}_j = \alpha_j + \beta_j X \ (j = 1,2,3,4)$$

Where:

Y_1 is "Average Dietary Energy Supply Adequacy"

Y_2 is "Prevalence of Undernourishment"

Y_3 is "Prevalence of Obesity in the Adult Population"

X are "Losses per capita"

M_1 is "Food Supply Quantity (kg/capita/year)";

M_2 is "Food Supply (kcal//capita/day)";

M_3 is "Protein Supply Quantity (g/capita/day)";

M_4 is "Fat Supply Quantity (g/capita/day)"

RESULTS AND DISCUSSIONS

Before the application of mediation analysis, a time series stationarity test was made. For this purpose, the Augmented Dickey-Fuller (ADF) test was used (Table 1), which is the most popular and most commonly used Unit Root test.The test results indicated:

• The time series of "Prevalence of Undernourishment" is non-stationary, but the time series of the first differences are stationary. Therefore, the first differences are used in the analysis;

•The time series of "Losses per capita", "Food Supply Quantity (kg/capita/year)", "Food Supply (kcal//capita/day)", "Protein Supply Quantity (g/capita/day)", "Fat Supply Quantity (g/capita/day)", "Average Dietary Energy Supply Adequacy" and "Prevalence of Obesity in the Adult Population" are non-stationary and the time series of the first differences are also non-stationary. However, the time series of the second differences are stationary, so the second differences are used in the analysis.

Table 1. Augmented Dickey-Fuller test*

Variable	Level – intercept		First differences – intercept		Second differences – intercept	
	Test statistics	***p*-value**	**Test statistics**	***p*-value**	**Test statistics**	***p*-value**
Losses per capita	-2.09	0.252	-2.77	0.084	**-10.65**	**0.000**
Food Supply Quantity (kg/capita/year)	-1.68	0.425	-2.84	0.072	**-3.84**	**0.010**
Food Supply (kcal//capita/day)	-2.10	0.246	-2.20	0.214	**-4.49**	**0.003**
Protein Supply Quantity (g/capita/day)	-2.05	0.264	-2.29	0.185	**-4.42**	**0.003**
Fat Supply Quantity (g/capita/day)	-1.67	0.431	-1.30	0.607	**-3.30**	**0.031**
Average Dietary Energy Supply Adequacy	4.12	1.000	-1.54	0.492	**-5.99**	**0.000**
Prevalence of Undernourishment	0.55	0.984	**-3.23**	**0.034**		
Prevalence of Obesity in the Adult Population	-1.37	0.573	-1.94	0.310	**-4.13**	**0.006**

* Null hypothesis is that time series have unit root, i.e., time series are non-stationary.
Source: Own calculation.

Table 2. Estimations of coefficients of mediation analysis

Independent variable	Dependent variable	Unstandardized coefficient	*z*-statistics	*p*-value
Food Supply Quantity (kg/capita/year)	Average Dietary Energy Supply Adequacy	-0.061	-0.374	0.708
Food Supply (kcal//capita/day)	Average Dietary Energy Supply Adequacy	-0.051	-0.224	0.823
Protein Supply Quantity (g/capita/day)	Average Dietary Energy Supply Adequacy	2.009	0.302	0.763
Fat Supply Quantity (g/capita/day)	Average Dietary Energy Supply Adequacy	-0.841	-0.268	0.789
Losses per capita	Average Dietary Energy Supply Adequacy	0.022	0.637	0.524
Food Supply Quantity (kg/capita/year)	Prevalence of Undernourishment	0.070	1.182	0.237
Food Supply (kcal//capita/day)	Prevalence of Undernourishment	-0.036	-0.441	0.659
Protein Supply Quantity (g/capita/day)	Prevalence of Undernourishment	0.712	0.294	0.769
Fat Supply Quantity (g/capita/day)	Prevalence of Undernourishment	0.552	0.485	0.628
Losses per capita	Prevalence of Undernourishment	-0.003	-0.216	0.829
Food Supply Quantity (kg/capita/year)	Prevalence of Obesity in the Adult Population	-0.004	**-2.631**	**0.009**
Food Supply (kcal//capita/day)	Prevalence of Obesity in the Adult Population	0.013	**5.854**	**0.000**
Protein Supply Quantity (g/capita/day)	Prevalence of Obesity in the Adult Population	-0.394	**-5.970**	**0.000**
Fat Supply Quantity (g/capita/day)	Prevalence of Obesity in the Adult Population	-0.094	**-3.014**	**0.003**
Losses per capita	Prevalence of Obesity in the Adult Population	0.001	**3.126**	**0.002**
Losses per capita	Food Supply Quantity (kg/capita/year)	0.096	0.993	0.321
Losses per capita	Food Supply (kcal//capita/day)	0.095	0.125	0.900
Losses per capita	Protein Supply Quantity (g/capita/day)	0.002	0.097	0.922
Losses per capita	Fat Supply Quantity (g/capita/day)	0.006	1.127	0.260

Source: Own calculation.

The results of the mediation analysis evaluation are presented inTable 2 below.

From the revealed relationships in Fig. 2, several conclusions can be drawn:

• "Losses per capita" influence neither directly nor indirectly "Average Dietary Energy Supply Adequacy" and "Prevalence of Undernourishment".

• "Losses per capita" influence "Prevalence of Obesity in the Adult Population" ($z = 3.13, p = 0.002$), which is contrary to preliminary expectations.

• "Average Dietary Energy Supply Adequacy" and "Prevalence of Undernourishment" do not dependent on mediator variables.

• "Prevalence of Obesity in the Adult Population" depends on all mediator variables.

Obtained statistically significant relationships are presented in Fig. 2.

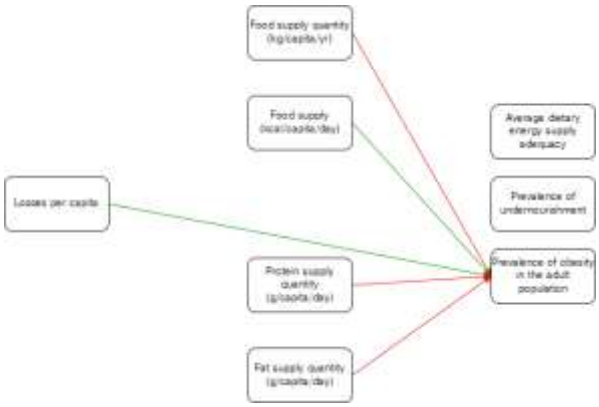

Fig. 2. Statistically significant relationships identified through the mediation analysis

Source: Authors' own conception.

○ Relationships between "Prevalence of Obesity in the Adult Population" on the one hand and "Food Supply Quantity (kg/capita/year)" ($z = -2.63, p = 0.009$), "Protein Supply Quantity (g/capita/day)" ($z = -5.97, p = 0.000$) and "Fat Supply Quantity (g/capita/day)" ($z = -3.01, p = 0.003$) on the other hand are negative – greater values of mediator variables lead to a lower "Prevalence of Obesity in the Adult Population", which is contrary to preliminary expectations.

○ Relationship between "Prevalence of Obesity in the Adult Population" and "Food Supply (kcal//capita/day)" is positive – greater values of mediator variable lead to a higher "Prevalence of Obesity in the Adult Population" ($z = 5.85, p = 0.000$), which coincides with preliminary expectations.

It is noteworthy that all results that contradict preliminary expectations refer to indicators that are measured in kilograms or grams per capita. This is a key to a possible explanation of these contradictions. The change of prevalence of obesity could be related not to the quantity, but to the quality of food, proteins and fats. It is possible that a higher amount of high-quality food, protein and fat does not lead to the prevalence of obesity, as does a lower amount of protein and fat, but of poorer quality. An additional argument in this direction is that a greater supply of food, but measured in kilocalories, leads to a greater prevalence of obesity.

Reducing post-harvest losses of cereals - a way to increase food security

Grain storage on the farm is done in several ways:

•open warehouse - the most traditional, well-known and popular way to store;

•iron silos (personally built premises with different storage capacities) - the second most popular storage method;

•plastic sleeves (big bags) - in recent years a method of storing grain that has gained great popularity;

•quick-installation structures (Crop circles) - widely used in grain-producing countries such as the USA and Canada.

Among the advantages of grain storage warehouses are the possibility of re-equipping and adapting old premises (barns), no significant investments are required, there is a possibility of separate storage of even small quantities of grain. Storing grain in open warehouses poses risks: poor ventilation, the flooring is not always of high quality, additional equipment and labor costs are incurred when transferring, and the inability to fill the warehouse to full capacity.

However, after modernization (equipment with ventilation ducts, sloping floors, etc.), the open warehouse is much more suitable for storage. The risks of storing grain in structures of the quick-assembly type are: poor protection of the product from environmental influences, high percentage of losses during storage, need for live security (when located directly in the

field), and short shelf life. Despite the strong supporters of storage in plastic sleeves, this technology is accompanied by a number of risks: the need for careful preparation of the site, expensive disposable sleeves, the special equipment for loading and unloading grain, the need for protection, control of birds and rodents, seeds lose their germination, workers must have certain skills.Amongtheadvantages of the method, the following can be noted: the technology is relatively affordable for grain producers; it allows for long-term storage without loss of grain quality; the grain is stored tightly; significant cost savings compared to silosOne way to reduce the costs, and therefore the risks of grain storage, is to cool it. Before leaving for storage (after acceptance, further processing, and loading), the grain can be cooled. This will reduce the loss of dry weight, slow down the development of pests, and avoid the development of mold (mycotoxins). Cooled grain can be stored with a humidity of 1-1.5% higher than recommended. The residual moisture will be removed from the grain during the cooling process. Cooled grain does not need to be moved or poured, since it does not heat up. All this allows to avoid grain losses due to injuries, no additional energy consumption is required. In addition, we have additional space in the storage capacities. All types of cereals can be cooled.

CONCLUSIONS

The food production and consumption system is characterized by three dimensions - financial, environmental, and social. This requires measures to overcome food loss to be directed at each of these levels. It is necessary to take measures to change the attitude toward foodloss, this is the only way to ensure sustainable food production for the growing world population. The production and consumption of agricultural products have a significant impact on the environment, as they intensively use limited natural resources, cause the formation of greenhouse gases, pollute with the use of plant protection products and depletes oil nutrients such as nitrogen and phosphorus. Therefore, when the food produced from them is lost or wasted, the natural resources used for its production are also lost, leading to negative economic and environmental impacts. In this regard, it is necessary to turn to the use of organic fertilizers and preparations, and as [11] notes, organically fertilized plants (Vitaorganic) have significant biological potential and lead to the accumulation of amounts of dry matter and total sugars similar to those grown with mineral fertilization.

One of the Sustainable Development Goals - Goal 12.3, requires that by 2030, not only food losses along food production and supply chains but also post-harvest losses be reduced globally.

Short food supply chains(SFSCs) will play an important role in achieving this goal.

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REFERENCES

[1]Adams, R.S., Ishler, V.A., 2009, Trouble-shooting problems with low milk production. Dairy and Animal Science, 4(1), 98–16.www.das.psu.edu/teamdairy, Accessed on June 3, 2024.

[2]Adebisi, O.A., Adebisi, L.O., Ibrahim., F., Omofaiye, A.M., Jonathan, A., 2021, Covid-19 Lockdown:ImplicationonCommodity Food Price and Household Food Security in Kwara State, Nigeria. International Journalof Agricultural Science Research and Technology in Education and Education System, 11(3), pp. 173-179.

[3]Aulakh, J., Regmi, A., Fulton, J.R., Alexander, C., 2013, Estimating post-harvest food losses: developing a consistent global estimation framework. In: Proceedings of the Agricultural & Applied Economics Association's2013 AAEA & CAES joint annual meeting, Washington, DC, USA, 4– 6 August 2013.

[4]Dharmathilake, N.R.D.S., Rosairo, H.S.R., Ayoni, V.D.N., Herath, R.M., 2020, Implications of Post-Harvest Losses and Acreage Response of Selected Up-Country Vegetables from Nuwara-Eliya District in Sri Lankaon Sustained Food Security.The Journal of Agricultural Sciences - Sri Lanka Vol. 15(1), 88-100. http://doi.org/10.4038/jas.v15i1.8674.

[5]Food and Agricultural Organization, 2011, Global food losses and waste: extent, causes and prevention.

[6]Food and Agricultural Organization, 2009, How to Feed the World in 2050. Rome: FAO. http://www.fao.org/fileadmin/templates/w sfs/docs/expert_paper/How_to_Feed_the_ World_in_ 2050.pdf, Accessed on 28 September 2024.

[7]Food and Agriculture Organization. Data from Food Balances from 2010 until now.https://www.fao.org/faostat/en/#data/FBS, Accessed on 5 January, 2025.
[8]Food and Agriculture Organization. Food Balances until 2013. https://www.fao.org/faostat/en/#data/FBSH, Accessed on 5 January, 2025.
[9]Food and Agriculture Organization. Food Security and Nutrition https://www.fao.org/faostat/en/#data/FSAccessed on 5 January, 2025.
[10]Kitinoja, L., 2016, Innovative small-scale postharvest technologies for reducing losses in horticultural crops.Ethiop J Appl Sci Technol 1, pp. 9–15.
[11]Kostadinov, K., Filipov, S., Shopova, N., Chipilski, R.,2024,Vegetativebehaviorofcabbagegrownwithorganicfertilization.VII International Agricultural, Biological & Life Science Conference, Edirne, Turkey, 18-20 September.
[12]Ministry of Agriculture and Food, Bulgaria.
[13]Vo, T.-T., Cashin, A., Superchi, C., Tu, P.H.T., Nguyen, T.B., Boutron, I., MacKinnon, D., Vanderweele, T., Lee, H., Vansteelandt, S., 2022, Quality assessment practice in systematic reviews of mediation studies: results from an overview of systematic reviews. Journal of Clinical Epidemiology.143, pp. 137-148.DOI: 10.1016/j.jclinepi.2021.12.013
[14]Preacher, K.J., Kelley, K., 2011, Effect Size Measures for Mediation Models: Quantitative Strategies for Communicating Indirect Effects. Psychological Methods. Vol. 16, No. 2, pp. 93–115. DOI: 10.1037/a0022658

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DIGITAL TRANSFORMATION IN AGRICULTURE: A COMPARATIVE ANALYSIS OF HUNGARY, ROMANIA AND GREECE AND THE ROLE OF COMPETENCE PROFILING IN THE AGRITECH MANAGER FRAMEWORK

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Abstract

This paper examines the digital transformation of agriculture in Hungary, Romania, and Greece, focusing on national policies, adoption of precision agriculture, and institutional roles. The paper is based on the EU data which have been processed using the following methods: structured desk research, comparative policy analysis, and qualitative triangulation through stakeholder surveys and sector analysis tools, ensuring that findings are both evidence-based and contextually validated. Drawing on data from EU and national sources, there are highlighted significant disparities in technology uptake - Hungary leading with 23% adoption, Romania at 10%, and Greece at 5%. The analysis informed the design of the AGRITECH project, initiated by Austria-based PAMEA, which introduced the AgriTech Manager (ATM) profile. This role integrates green and digital skills aligned with EQF and EU frameworks. The paper outlines how comparative policy research shaped AGRITECH's learning ecosystem and supports competence-based education to drive digital and sustainable innovation in agriculture.

Key words**:** *precision agriculture, digital transformation, AgriTech manager, deep tech, competence-based education*

INTRODUCTION

Even agriculture started few years ago its transformation towards Agriculture 4.0, compelling to respond to converging crises such as the demand for increased productivity, the impact of climate change, and/or the imperative for sustainable practices, in the European context, this transformation is increasingly defined by digitalisation and deep tech integration - core elements of the **EU's Green Deal** (European Commission, 2019) [3], **Digital Europe Programme** (European Commission, 2021) [5], and **European Skills Agenda** (European Commission, 2020) [4], as well as by the growing policy focus on smart farming and technology-driven sustainability [7]..

However, the capacity to achieve real digital competitiveness in agriculture is different across EU Member States, especially in Central and South-Eastern Europe, where countries like Hungary, Romania, and Greece - despite significant agri-food potential [6], [13] - are still facing structural gaps, namely insufficient digital skills in rural areas, fragmented innovation ecosystems, and poor alignment between education, training, and labour market demands in the Agri-tech sectors (1.2 Needs analysis and specific objectives - AGRITECH Application Form, 2024).

To address these challenges, the **AGRITECH project** (*Alliance for Innovative Learning*

Environment in Advanced Agriculture through Technology and Management) appeared as a strategic educational innovation initiative. Its vision: to foster a new generation of professionals equipped to lead digital transformation in agriculture through deep-tech tools like AI, blockchain, and sensor-based systems, all while anchoring learning in sustainability and entrepreneurship.

The initial concept was developed by **PAMEA**, an Austrian organization with a strong track record in interdisciplinary education projects and agricultural innovation. Building on its prior collaborations with the other consortium institutions, PAMEA conducted a needs analysis revealing critical gaps in **digital literacy, interdisciplinary training, and competence validation** [12]. This analysis catalysed the formation of a transnational consortium and culminated in the AGRITECH project proposal under the ERASMUS+ "Partnerships for Innovation" call.

The project's flagship innovation is the creation of the **AgriTech Manager (ATM)** competence profile - an advanced, EQF-aligned role that blends green and digital skills with innovation capacity, project leadership, and high capacity for entrepreneurship. Designed to go beyond traditional agricultural training, the ATM profile responds to future-oriented roles involving data-driven decision-making, sustainability transitions, and smart farming integration.This paper provides a comparative analysis of national support frameworks and digital transformation programmes in **Hungary, Romania,** and **Greece**, exploring how national strategies and institutional actors - such as **MATE, DDTG** and **Gazda Kontroll**in Hungary, **USAMV** and **AgriCloud** in Romania, and **ELGO, AUTH** and **SACT** in Greece - built the context for digital innovation in agriculture, and explaining how the comparative policy insights shaped the **design of the ATM profile** and its related curricula, certification model, and learning environments.

Through this lens, the paper aims to showcase how **cross-border collaboration, policy alignment,** and **competence-based innovation** can catalyse inclusive and resilient digital transformation in the European agricultural landscape.

MATERIALS AND METHODS

This study applied a **comparative qualitative approach** to analyse the national readiness and support mechanisms for digital transformation in agriculture across Hungary, Romania, and Greece, methodology designed to identify key gaps, drivers, and institutional roles that inform the AGRITECH project's design and educational innovation strategy.

Primary data were collected through **desk research**, focusing on official **EU-level policy documents** (e.g. the European Green Deal, Digital Europe Programme, European Skills Agenda) [3],[4],[5], and **national digital agriculture strategies**, including Hungary's Digital Agricultural Strategy [10], Romania's CAP digitalisation initiatives [13], and Greece's Digital Transformation Bible [9]. Further insights were derived from the **AGRITECH project application**, consortium reports, and published research on digital and sustainable agriculture.

Additionally, the study examined **institutional practices and pilot initiatives** through public reports, academic sources, and project documentation (e.g. Erasmus+ project applications and progress reports). Verified statistical indicators on the adoption of precision agriculture and digital tools were retrieved from **Eurostat**, national ministries of agriculture, and recent studies conducted by EU agencies and academic institutions [1], [8], [6], [7].

The methodology adopted a **comparative framework**, evaluating the three countries based on four thematic dimensions:

(1) national policy readiness for digital agriculture,

(2) adoption levels of precision agriculture and deep tech,

(3) the role and capacity of educational institutions, and

(4) alignment among key stakeholders, including public authorities, universities, and agribusiness actors. This structure enabled contextual benchmarking and helped surface

both structural strengths and capacity gaps within each country (Fig. 1).

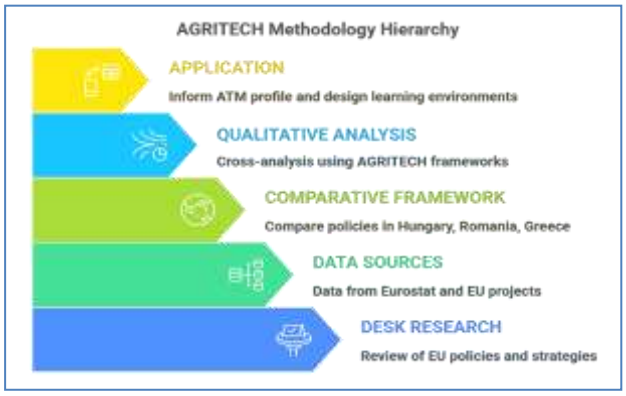

Fig. 1. AGRITECH Methodology Hierarchy
Source: [8] PAMEA, 2023, AGRITECH Preliminary Needs Assessment Report. Berg: Project Advisory and Management Expert Association.

The framework also systematically linked macro-level policy with institutional practices and labour market needs - serving as the analytical foundation for the design of the **AgriTech Manager competence profile.**
The findings were interpreted using a **qualitative analysis model**, combining descriptive synthesis and comparative policy mapping. This was reinforced through triangulation with the AGRITECH project's internal needs analysis and competence framework development, ensuring alignment with EU standards such as EQF, ESCO, and DigComp.

RESULTS AND DISCUSSIONS

National policy landscape and support programmes

The following section provides a concise overview of the national policy landscapes and support programmes in the three countries analysed. Each subsection highlights the key strategic frameworks, institutional actors, and implementation challenges relevant to the digital transformation of agriculture, offering a comparative lens for understanding the context in which the AGRITECH project was developed.

Hungary-Advancing Digital Agriculture through Strategic Academia-Government Synergy

Hungary has demonstrated a strong commitment for digitalising its agricultural sector, primarily through the **Digital Agricultural Strategy (DAS)** [10], adopted in 2019 under the country's **Digital Success Programme 2.0**. This strategy defines a vision for a modern, data-driven agri-food system, emphasizing precision farming, smart farm management, and the digital upskilling of rural stakeholders. Key objectives include enhancing digital infrastructure in rural areas, promoting innovation in agritech, and supporting the uptake of technologies such as IoT, AI, and remote sensing among farmers.
A central academic driver of this transformation is the **Hungarian University of Agriculture and Life Sciences (MATE)**. As the largest agricultural higher education institution in Hungary, MATE plays a very important role in implementing DAS objectives through education, applied research, and professional training. It hosts specialized departments such as the **Department of Precision Agriculture and Digital Farming**, and leads national and EU-funded research and development initiatives in fields like data-driven crop monitoring, decision support systems, and smart irrigation.
MATE is also a **partner in the AGRITECH project**, reflecting its strategic alignment with EU-level objectives for green and digital transition in agriculture. Within AGRITECH, MATE contributes to the definition and piloting of the **AgriTech Manager (ATM) competence framework**, and leads on the integration of practical digital tools and sustainability skills into the curriculum. Its expertise helps bridge policy with practice by ensuring that deep tech competencies - such as AI implementation, geospatial analytics, and blockchain applications - are embedded in formal education and lifelong learning pathways.
In terms of policy support, the **Hungarian Ministry of Agriculture** acts as an associated partner of AGRITECH, providing regulatory insight and facilitating the alignment of project outcomes with Hungary's **Common Agricultural Policy Strategic Plan 2023–2027**, plan which includes measures for the digitalisation of farm management and

advisory systems, further reinforcing the enabling environment for innovations piloted by AGRITECH.

However, barriers remain. According to recent studies, only **23% of Hungarian crop farms currently use precision agriculture technologies** [1], with usage concentrated in large-scale farms (Bai et al., 2022). Major obstacles include high investment costs, fragmented knowledge transfer systems, and a persistent gap in digital skills among older farmers and smallholders.

Hungary's integrated approach - linking government strategies, academic leadership through MATE, and EU-level innovation ecosystems - provides a strong foundation for addressing these gaps. AGRITECH builds on this momentum by contributing to **curricular modernization**, **competence validation**, and **cross-sectoral cooperation**, thus enhancing the long-term digital competitiveness of Hungary's agri-food sector through the definition of **AgriTech Manager profile**.

Romania: Bridging Structural Gaps through Emerging Ecosystems and Educational Innovation

The **National Strategic Plan 2023–2027 of Romania** under the **Common Agricultural Policy (CAP)** serves as the foundation for digital transformation in agriculture by supporting **smart farming solutions** and **data-driven advisory systems** and **agricultural training modernization**. The CAP plan of Romania serves as the main framework for digital agriculture development because it does not have a separate national digital agriculture strategy. The **EU-level SmartAgriHubs** project has Romania as one of its participating members to support digital innovation hubs throughout Member States [6].

Still, the widespread adoption of precision agriculture faces significant obstacles in Romania because of its structural challenges despite having strong policy intentions. The adoption of precision agriculture technology during 2020 reached only **10% of farms which mostly involved large commercial operations**. European Commission (2020) and Romanian Ministry of Agriculture (2023) identify equipment costs as a major barrier together with restricted financing options and insufficient digital competencies especially among small farmers and older farmers [4], [13].

Nonetheless, the digitalisation landscape is evolving through the efforts of both educational and private sector actors. A leading academic institution in this space is the **University of Agronomic Sciences and Veterinary Medicine of Bucharest (USAMV)**, another project partner in AGRITECH. USAMV integrates digital and environmental innovation into its curricula and contributes directly to the **design of the AgriTech Manager profile**, particularly in areas like digital competence mapping, sustainability assessment, and curricular validation.

The emergence of **AgriCloud**, a company listed in the top five deep tech Romanian companies which focuses on cloud-based solutions for agriculture and AGRITECH partner, represents a concrete step forward in linking data science, AI, and blockchain with practical farm management [16], [14]. AgriCloud supports knowledge transfer and facilitates cooperation between tech providers and agri-enterprises, aligning directly with AGRITECH's goals to build smart learning ecosystems and cross-sectoral incubators .

Romania's AGRITECH partners collectively act as catalysts in transforming national strategy into operational models for digital learning and innovation. By co-developing the competence-based profile of the **AgriTech Manager** and piloting modular learning programs, they address existing gaps in skills development and stakeholder coordination. This aligns with broader EU calls for reinforcing the role of **vocational education and training (VET)** and **higher education** in driving the green and digital transition.

Romania's ongoing transformation is therefore marked by both opportunity and urgency. AGRITECH reinforces this trajectory by promoting structured collaboration between universities, private tech actors, and policymakers - contributing not only to educational reform but also to long-term agricultural competitiveness and rural resilience.

Greece: Policy Commitment and Pilot Innovation Towards Smart Agriculture

Greece has started progressively to incorporate the digital transformation into its national development agenda, agriculture being recognized as a priority sector in several policy instruments. The most important strategic plan is the **Digital Transformation Bible 2020–2025** [9], issued by the Greek Ministry of Digital Governance, which explicitly highlights **smart farming** and **digital rural development** as areas of national focus, complemented by Greece's **National Strategic Plan under the Common Agricultural Policy 2023–2027**, which includes provisions for modernising agricultural practices through precision technologies, training, and digital advisory systems.

Despite the strategic alignment, Greece's adoption of precision agriculture remains limited. In 2021, only around **5% of Greek farms** were implementing precision farming tools, mainly used for high-value sectors such as olive groves, vineyards, and greenhouse production (Hellenic Ministry of Rural Development and Food, 2021) [9]. The identified key barriers include **fragmented land holdings**, **financial constraints**, and **low digital readiness** in the rural communities.

However, Greece is also host for promising educational and institutional initiatives that are accelerating digital innovation in the agri-food sector. The coordinator of AGRITECH project is **ELGO-DIMITRA**, the National Agricultural Organization responsible for professional training, innovation dissemination, and agricultural research. ELGO's involvement ensures the practical integration of AGRITECH outputs into national extension systems and lifelong learning pathways. It also serves as a testing ground for piloting the AgriTech Manager training model in real farming contexts.

In parallel, **Aristotle University of Thessaloniki (AUTH)** have led several pilot projects in smart farming, remote sensing, and geospatial analysis, often funded through Horizon Europe and national R&D programmes, projects which have put the groundwork for deploying IoT systems, precision irrigation platforms, and AI-enabled crop monitoring tools, helping to build an innovation-ready ecosystem aligned with AGRITECH's goals.

Through AGRITECH, Greek partners contribute to developing and validating the **AgriTech Manager competence framework**, particularly in areas of smart farming, green transition, and entrepreneurial education. Their experience with modular and digital learning also supports the design of **micro-credential-based learning pathways**, which are crucial for addressing upskilling needs among adult learners and professionals in rural areas.

While Greece still faces structural limitations in scaling digital agriculture, its integration of pilot programmes, academic expertise, and national digital strategy offers a strong foundation. AGRITECH amplifies this trajectory by fostering cross-sectoral collaboration and embedding competence-based learning into the broader policy and innovation ecosystem.

Comparative analysis

The policy and institutional review of Hungary, Romania, and Greece revealed **converging strategic intentions** but **diverging capacities** to implement digital transformation in agriculture (Fig. 2). All three countries have aligned themselves with EU-level priorities under the Green Deal and Digital Europe Programme, yet they differ significantly in adoption levels, stakeholder coordination, and educational integration.

Hungary stands out as the most advanced in both policy execution and institutional engagement. The **Digital Agricultural Strategy (DAS)** provides a clear national framework, supported by the strong involvement of academic institutions like **MATE**, which link research, training, and policy implementation. Hungary also records the **highest adoption rate of precision agriculture at 23%**, with widespread use of GPS systems and line guidance technologies - primarily in large-scale farms [1].

In contrast, **Romania's policy framework**, while formally integrated into its CAP 2023 - 2027 Plan, is less centralized and relies heavily on emerging actors such as **AgriCloud** and **USAMV** to bridge policy with practice.

Romania shows **moderate adoption at 10%** [4], constrained by fragmented advisory services, low investment capacity among smallholders, and insufficient digital training. However, its dynamic innovation ecosystem - particularly in tech-agri partnerships - is a promising vector for growth.

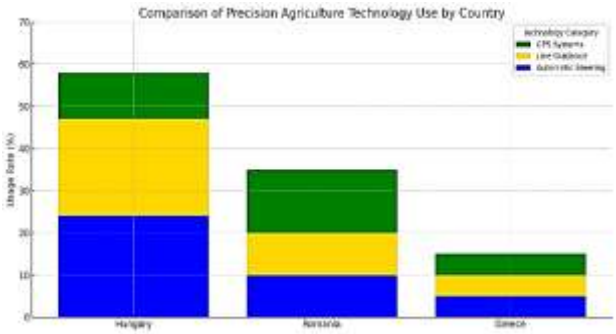

Fig. 2. Comparison of Precision Agriculture Technology Use by Countries
Source: [8] PAMEA, 2023, AGRITECH Preliminary Needs Assessment Report. Berg: Project Advisory and Management Expert Association.

Greece demonstrates strong **strategic alignment** through the **Digital Transformation Bible** and CAP commitments, but **lags in implementation**, with only **5% of farms adopting precision agriculture** [9]. Structural constraints - especially fragmented land ownership and rural digital gaps - hamper progress. Nevertheless, Greek institutions like **ELGO-DIMITRA** and **AUTH** are leading notable pilot projects in smart farming, making Greece an important incubator for scalable innovations.

From an **educational and skills development perspective**, all three countries highlight the need to **modernise agri-education**, **embed digital tools**, and **support lifelong learning**. However, only Hungary demonstrates a systemic link between national strategy and higher education. Romania and Greece rely more on project-based or pilot approaches, which often lack sustained funding or institutional mainstreaming.

A **shared challenge** across all three is the lack of integrated frameworks for **competence validation**, **cross-sector collaboration**, and **micro-credential recognition** - all of which are core pillars of the AGRITECH project. The **AgriTech Manager profile** and related training pathways are thus conceived as direct responses to these structural gaps, informed by the comparative insights gathered here [12], [6].

Table 1. Summary of Comparative Analysis

Country	Strategy Strength	Adoption Level	Main Gaps
Hungary	Strong	23%	Digital equity, older farmer digital skills
Romania	Emerging	10%	Fragmentation, low VET-business alignment
Greece	Aligned, under-executed	5%	Fragmented holdings, rural digital divide

Source: [8] PAMEA, 2023, AGRITECH Preliminary Needs Assessment Report. Berg: Project Advisory and Management Expert Association.

This comparative overview (Table 1) confirms the need for **transnational collaboration**, **competence -based curricula**, and **innovation ecosystems** that link education, technology, and agricultural policy [12] - a mission directly addressed by the AGRITECH project.

AGRITECH PROJECT - bridging gaps through education and innovation

AGRITECH project, conceived as *"**Alliance for Innovative Learning Environment in Advanced Agriculture through Technology and Management",*** was launched in response to the clear, cross-cutting gaps identified in national digital agriculture frameworks across initially in Hungary, Romania, and Greece, and later on Italy, Cyprus and Czech Republic. Initiated by **PAMEA**, the concept (Fig. 3) was rooted in comparative needs analysis and structured to directly address the fragmented integration of **digital tools, innovation skills, and sustainability competences** in agricultural education [12].

Co-funded by the ERASMUS+ programme under **Partnerships for Innovation**, AGRITECH brings together higher education institutions, technology providers, research bodies, and public authorities. The project aims to **strengthen the digital and green**

capacities of agricultural training systems through a multi-level approach:

-**Competence development** through the creation of the **ATM** profile, mapping essential green, digital, and entrepreneurial skills aligned with EQF, ESCO, and EU innovation priorities [3], [4].

-**Curriculum innovation**, including the co-design of learning modules integrating deep technologies such as **AI, block-chain, remote sensing**, and **IoT**, with a strong emphasis on sustainability, business models, and value chain innovation [2].

-**Smart Learning Ecosystems**, where formal education, VET providers, and agribusinesses cooperate to pilot immersive, modular learning, supported by digital incubators and peer-based mentorship.

-**Policy integration and upscaling**, with partners like **MATE**, **USAMV**, **AUTH** and **ELGO-DIMITRA** acting as national multipliers to bridge educational outcomes with national digital transformation agendas.

What makes AGRITECH unique is its **dual vertical and horizontal integration**. Vertically, it aligns local needs with EU frameworks and funding mechanisms [3], [5], [6], and horizontally, it fosters cooperation between countries at different stages of digital readiness - transforming this diversity into a learning asset.

The project's structure facilitates **peer learning and knowledge transfer**, ensuring that promising practices developed in one region can be adapted and scaled across others. Ultimately, AGRITECH does more than create a new professional profile - it builds a **transnational innovation.**

Through evidence-informed design, iterative piloting, and stakeholder co-creation, the project aims to empower a new generation of professionals who can lead the digital transition of Europe's agri-food systems..

Defining ATM - competence profile development

ecosystem for smart, sustainable agriculture.

At the core of the AGRITECH project is the creation of a new, future-oriented role - the **AgriTech Manager**, a new professional profile designed to meet the evolving demands of the agricultural sector, where environmental challenges and technological advancement converge. ATM is envisioned as a **hybrid professional** - equipped not only with deep digital and green competences but also with strategic, entrepreneurial, and innovation management skills.

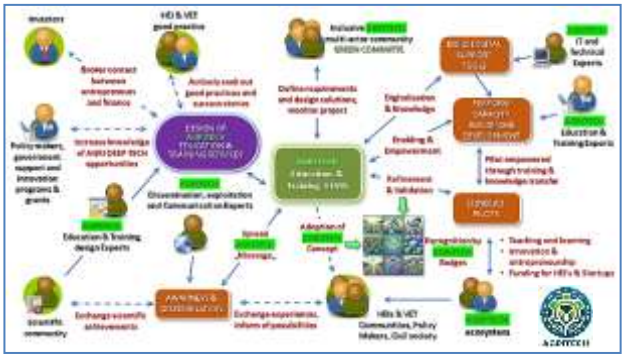

Fig. 3. AGRITECH Concept
Source: PROPOSAL_101187399 - AGRITECH-ERASMUS – EDU - 2024-PI-ALL-INNO.

The competence profile is being developed through a **multi-phase process**, grounded in **EU reference frameworks** such as:

-The **European Qualifications Framework (EQF),**

-The **European Skills, Competences, Qualifications and Occupations (ESCO)** taxonomy,

-The **DigComp** and **GreenComp** frameworks, and

-Sector-specific inputs from **EIP-AGRI** and **CEDEFOP** studies [6].

The development process is **ongoing and evidence-based**, integrating insights from the project's **initial needs analysis**, comparative country review, and practical experience of AGRITECH partners in education, agri-business, and public policy. The competence model covers five core dimensions:

(i)**Smart Agriculture & Deep Tech Integration**

(ii)**Green & Sustainable Value Chain Development**

(iii)**Innovation & Business Model Design**

(iv)**Project and Stakeholder Management**

(v)**Digital Leadership & Lifelong Learning**

To ensure the relevance and adaptability of the profile, AGRITECH has launched a **targeted stakeholder consultation process**, including:

(a) A **Stakeholder Survey** targeting educators, researchers, technology providers, farmers,

and policy experts, aimed at validating competence priorities and identifying potential training formats.

(b) A **Sector Analysis Questionnaire** focusing on business and labor market representatives, to assess digital and green skill gaps, job role forecasts, and learning pathway preferences.

These instruments serve distinct purposes and target groups, but together they support the **triangulation of findings** gathered during the proposal phase. They also reflect the project's commitment to participatory design and policy alignment at both national and EU levels.

Ultimately, the AGRITECH Manager is not conceived as a static role, but as a **dynamic competence cluster** that can be embedded into diverse educational settings - ranging from higher education degrees to VET programs, micro-credentials, and lifelong learning formats. This flexible and modular approach enables the profile to **adapt to national contexts**, while supporting **transnational mobility and international professional recognition** across the EU.

Discussions: Policy and Research implications

The comparative analysis and competence-driven approach adopted by the AGRITECH project reveal a number of actionable implications for both **policy-making** and **future research** in the domain of digital and green transformation in agriculture.

From a **policy perspective**, the fragmented nature of digital adoption in the agricultural sector across Member States highlights the need for **stronger coordination between education, innovation, and rural development strategies** [11]. AGRITECH model demonstrates that targeted investment in **competence-based education**, combined with institutional partnerships and incubator ecosystems, can accelerate transformation even in regions with structural disadvantages. Policymakers at national and EU levels are encouraged to:

-Support the integration of hybrid professional profiles like the **AgriTech Manager** into national qualification frameworks;

-Fund the development and recognition of **micro-credentials and modular training paths** aligned with digital and green competence frameworks;

-Promote the establishment of **agri-innovation hubs** that connect VET providers, HEIs, tech startups, and public bodies in applied learning environments;

-Incentivize **public-private partnerships** to co-design and scale smart agriculture solutions [2], [8], [6], [15].

In terms of **research implications**, AGRITECH offers a replicable methodology for identifying digital skill gaps and validating future job profiles in a sector-sensitive manner. The project's use of **stakeholder surveys**, **sector analysis tools**, and **comparative national assessments** can serve as a reference for other digital transition initiatives within agriculture or adjacent sectors (e.g., forestry, aquaculture, circular bioeconomy). Additionally, the ongoing piloting of the AGRITECH competence profile creates opportunities for longitudinal research on:

-The effectiveness of **deep tech-based learning modules** in agriculture;

-The impact of **cross-sectoral learning ecosystems** on digital uptake and rural employment;

-The feasibility of integrating **AI, blockchain,** and **IoT** into competence-oriented training frameworks [2].

At the European level, AGRITECH reinforces key dimensions of the **Green Deal**, **Digital Europe Programme**, and **Pact for Skills**, showing how transnational cooperation can deliver scalable and context-sensitive educational innovation.

In conclusion, the AGRITECH project contributes not only to solving current educational and skills mismatches in agriculture, but also to **shaping the long-term governance and capacity-building mechanisms** needed for a sustainable digital transition in the sector.

CONCLUSIONS

This paper explored the digital transformation of agriculture in Hungary, Romania, and Greece, expanded before the proposal submission to Italy, Cyprus and Czech Republic too, highlighting both policy-level

commitments and implementation gaps that affect the sector's digital competitiveness.

The findings revealed a shared ambition across all three countries to modernize agriculture through smart technologies and sustainability-driven practices, yet with significant variation in adoption rates, institutional engagement, and educational preparedness.

AGRITECH project emerged as a direct response to these disparities, offering a transnational, competence-based framework to equip a new generation of professionals - **AgriTech Managers** - with the competencies and tools to lead sustainable digital change in the agri-food system. By linking national strategies with EU-level goals and integrating stakeholder feedback through structured research instruments, the project bridges systemic gaps in education, innovation, and rural development.

The **comparative policy analysis**, **competence mapping**, and **learning ecosystem design** presented here provide a replicable model for future projects aiming to align digital skills development with sector-specific needs. As the green and digital transitions accelerate across Europe [3], [4], [6], the AGRITECH experience reinforces the need for cross-border cooperation, flexible learning pathways, and the strategic involvement of both academic and private sector actors.

Finally, AGRITECH approach offers not just a training solution, but a scalable vision for building **resilient, digitally empowered agricultural systems** that can meet the challenges of tomorrow to real AGRICULTURE 4.0 implementation [6], [17].

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REFERENCES

[1]Bai, A., Szakál, D., Török, Á., 2022, The adoption of precision agriculture technologies in Hungary: Patterns, barriers, and perspectives. Hungarian Agricultural Review, 11(3), 45-58.

[2]Chaterji, S., DeLay, N., Evans, J., Mosier, N., Engel, B., Buckmaster, D., Chandra, R., 2020, Artificial Intelligence for Digital Agriculture at Scale: Techniques, Policies, and Challenges. https://doi.org/10.48550/arXiv.2001.09786

[3]European Commission, 2019, The European Green Deal. Brussels: Directorate-General for Environment. https://ec.europa.eu/info/publications/european-green-deal_en, Accessed on 09.01.2023.

[4]European Commission, 2020, European Skills Agenda for sustainable competitiveness, social fairness and resilience. Brussels: Directorate-General for Employment, Social Affairs and Inclusion. https://ec.europa.eu/social/main.jsp?catId=1223, Accessed on 11.01.2023

[5]European Commission, 2021, Digital Europe Programme: Strategic Orientations 2021–2027. Brussels: Directorate-General for Communications Networks, Content and Technology. Retrieved from https://digital-strategy.ec.europa.eu, Accessed on 16.01.2023

[6]European Commission: Directorate - General for Agriculture and Rural Development, Digital transformation in agriculture and rural areas, Publications Office of the European Union, 2023, https://data.europa.eu/doi/10.2762/469898

[7]European Parliament, 2016, Precision Agriculture and the Future of Farming in Europe. https://www.europarl.europa.eu, Accessed on 19.01.2023.

[8]Gabriel, A., Gandorfer, M., 2023, Adoption of digital technologies in agriculture - an inventory in a European small-scale farming region. Precision Agriculture, 24, 68–91.

[9]Hellenic Ministry of Rural Development and Food, 2021, Annual Report on Digital Agriculture Initiatives in Greece. Athens: Government of Greece.

[10]Hungarian Ministry of Agriculture, 2019, Digital Agricultural Strategy of Hungary. Budapest: Ministry of Agriculture.

[11]OECD. 2019. Digital Opportunities for Better Agricultural Policies.

[12]PAMEA, 2023, AGRITECH Preliminary Needs Assessment Report. Berg: Project Advisory and Management Expert Association.

[13]Romanian Ministry of Agriculture and Rural Development, 2022, COM comments on Romania's National Strategic Plan 2023-2027, 35f6906b-74ee-4d9a-8f18-e9e163d41953_en, Accessed on 24.01.2023

[14]Romanian Ministry of Agriculture and Rural Development, 2023, National Strategy for Agriculture Digitization.
[15]Romania – Smart Rural 27, Smart Villages in CAP Strategic plan Romania – Factsheet, RO_SR27 CSP Factsheet
[16]Szalavetz, A., 2023, Agricultural Technology Start-ups - Romania and Hungary Compared. Romanian Journal of European Affairs, 23(1), 34–45.
[17]Șerban, D.-G., Lungu, E., Șerban, F. L., Turek Rahoveanu, M. M., 2024, Digital transformation in Romania's agriculture in the period 2023–2027. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 24(4), 745-752.

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THE ROLE OF RESPONSIBLE CONDUCT IN ACADEMIC ETHICS AND INTEGRITY: A BIBLIOMETRIC PERSPECTIVE

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Abstract

Using a bibliometric methodology, the current study examined the development and worldwide trends in the areas of ethics, academic integrity, and scientific integrity as well as the responsible conduct of researchers, faculty, students, and doctoral students. Analyzing the theoretical and applied contributions from the specialist literature was the goal of the study in order to pinpoint the primary research themes and any gaps that still existed. The discovery of networks of collaboration between authors and institutions demonstrated how responsible behavior supports academic integrity and ethical standards and how interest in addressing these issues is growing. It was also noticed an increase in international collaboration, especially between Asian and European institutions. What stands out, however, is the rather small number of applied studies. The databases that were the basis of the research were Scopus and WOS, the articles published in the period 1992-2024 being analyzed. The bibliometric analysis was carried out with the help of the VOSviewer software, which allowed mapping the links established between authors, institutions, terms or publications, starting from the frequency of keywords, authors, citations and thematic clusters. The research led us to the conclusion that responsible conduct is an important element in ensuring ethics and academic integrity, this being proven by the interest that researchers have shown through its approach in various scientific researches, but we would find that there is still a need of a global and systematic approach to this concept, which could thus contribute to the creation of an ethical and transparent academic and scientific environment.

Key words: *bibliometric analysis, academic ethics, academic integrity, responsible conduct, globalization*

INTRODUCTION

Academic integrity is a important component for preserving scientific values in a worldwide setting characterized by difficulties like rapidly changing technologies (like artificial intelligence) or the demands of quick publication.

Because academic and research ethics and integrity are essential components of creating a rigorous and responsible academic community, encouraging social responsibility, advancing knowledge, and ensuring that the research conducted contributes to the common good, as in other fields governed by ethics, maintaining the caliber, legitimacy, and applicability of scientific activity depends heavily on them [10, 21].

Therefore, one of the purposes of ethics and academic integrity is to guarantee the validity and trust of the scientific community as well as the results of the study that was carried out. By forbidding data manipulation or fabrication, ethical principles protect the reliability and quality of scientific findings so that they can be verified, replicated, and used in subsequent studies.

However, academic and scientific ethics safeguard the rights and interests of all participants in the research process, including avoiding the exploitation of authors and researchers and upholding the confidentiality and welfare of the communities involved.

Through ethical practices, it can be ensured that all collaborators are recognized for their contributions, preventing some unethical phenomena, such as plagiarism or unjustified

authorship, but also conflicts of interest, promoting equity both in international and interdisciplinary collaborations.

Another role of academic ethics and integrity is that of promoting responsible conduct by educating researchers in the spirit of honesty and responsibility, by promoting ethical norms that contribute to the prevention of unethical practices, which are not only related to plagiarism or self-plagiarism, but also to manipulation data or publication in predatory journals. Ethics and integrity encourage researchers to publish their results completely and transparently, even if they are not favorable or contradict certain assumptions from which they started.

The fundamental values of the academic community—integrity, inventiveness, and social responsibility—are upheld by academic ethics, which encourages the development of original ideas and solutions as well as long-term solutions to global issues.

At the same time, academic ethics is what prevents and manages the negative consequences of disrespected integrity, which can compromise both the reputation of researchers and, as it is, that of academic institutions, negatively affecting both individual careers and public trust in science. Without respecting these values, trust in education, research and science could be compromised, and the development of knowledge would be limited by unethical and irresponsible practices.

Analyzing the way in which various researchers have approached these aspects related to ethics and academic integrity, we find that since 1973 Merton K.R. introduces different ethical norms of science, such as universalism, communalism, disinterestedness and organized skepticism, which are essential for scientific progress [20]. In 2005 Resnik B.D. presented various ethical aspects of science, including integrity in research, conflicts of interest and social responsibility of scientists [23], and Krimsky S., in 2004, analyzed conflicts of interest in scientific research, emphasizing that academic integrity is a essential aspect in maintaining scientific objectivity [15]. In 2007 John P.A. Ioannidis highlights various problems related to the reproducibility of scientific research, emphasizing the need to respect ethical standards for the validity of scientific results [14]. In 2003 Steneck H.N. made a comprehensive description of responsible conduct in research, highlighting the role of education in the formation of these qualities for researchers, and in 2009 Fanelli D., through a meta-analysis, tried to estimate the prevalence of fabrication and falsification of data in science, emphasizing the importance of promoting integrity in scientific research [9, 26]. In 2013, Anderson S.M. carried out a comparative analysis of the role that institutional policies have in promoting ethics and integrity in research [1]. In 2022, Eaton S.E. analyzed the impact of emerging technologies on academic integrity and proposed strategies to maintain ethical standards in education, and Lancaster T. identified the need to adapt academic integrity to the challenges brought by artificial intelligence, insisting on the need to update educational policies [6, 16]. In 2023, Else H. analyzed the unethical market of selling authorship in scientific works, highlighting the concerns of publishers and the negative impact on academic integrity, and Chawla D.S. tracked the prevalence of unjustified authorship in science and its effects on the credibility of research, emphasizing the importance of respecting ethical criteria in the attribution of authorship [5, 8].

Additionally, there are national documents that stress the value of academic integrity and ethics in preserving the caliber and legitimacy of scientific research. According to a National Council of Ethics advice on integrity in scientific research, as well as Babes-Bolyai University, the need to respect ethical norms is emphasized, considering that they are essential for ensuring excellence in research and education [19, 27]. In the Good Practice Guide of the "Grigore T. Popa" University of Medicine and Pharmacy in Iasi, ethics is considered essential for the relations between staff and the institution, given also within the interactions with external beneficiaries, thus contributing to the promotion of university values [28]. In turn, the Polytechnic University of Bucharest, through its guide, underlines the

same values [29]. The Center for Research in Applied Ethics of the University of Bucharest assumes the role of promoter in stimulating debates about applied ethics and moral philosophy that can support the growth of an academic integrity culture [25].

These perspectives all emphasize the consensus among researchers that maintaining academic and research integrity and ethics is essential to ensuring the quality and credibility of these fields.

The purpose of the paper is to examine the development and worldwide trends in the areas of ethics, academic integrity, and scientific integrity as well as the responsible conduct of researchers, faculty, students, and doctoral students based on published literature.

MATERIALS AND METHODS

The research methodology involved going through the following stages: identifying the research themes, evaluating the impact that the scientific articles had on the existing literature and graphically representing the evolution of the terms "academic integrity", "academic ethics" and "responsible conduct". The searches were made in the WOS and Scopus databases on 29.11.2024, using 3 keywords. Thus, after the first search with the key term "academic ethics" in the WOS database, a number of 21,514 articles resulted, and there were 332,218 articles found in the Scopus database. When the second term "academic integrity" was added, 1,439 papers from the WOS database and 3,208 articles from the Scopus database were found. We included the third important term "responsible conduct" to our searches in the Scopus database because of the greater quantity of publications there.This resulted in a number of 75 articles (Fig. 1).

The bibliometric analysis, which is a research method that uses statistical and mathematical techniques to study the models and trends in the scientific literature [18] allowed us to highlight both the temporal trends, related to the frequency of publication of articles with the theme of ethics and academic integrity, and and the identification of collaboration networks between authors or institutions, which highlighted the most important centers of excellence. The analysis followed the citations and impact of the publications, allowing the outline of some theoretical bases and concepts that can be the basis of further research.

By creating conceptual maps, made with the help of the VOSviewer software, we were able to offer a much more complex vision of the analyzed subject.

RESULTS AND DISCUSSIONS

Regarding the evolution of scientific research in the field of ethics and academic integrity, we found that since the first article appeared in 1992, their number has increased constantly, reaching 195 articles in 2024, articles that have been cited 2,785 times.

Starting from the 3,208 identified articles, through the bibliometric analysis we sought to obtain a comprehensive picture of the research on ethics and academic integrity, highlighting global trends, essential contributions and existing gaps in the specialized literature. By mapping the collaborative networks between authors, institutions and regions, we sought to identify the strengths and weaknesses of the academic system, as well as the impact of emerging technologies on academic integrity.

The conceptual map between co-authors and countries illustrates the connections and the intensity of cooperation between researchers from various countries, being generated based on bibliometric data from the analyzed publications and providing information about the structure and dynamics of international collaborations.

We find that the USA and the United Kingdom appear as central nodes, having a major influence in global research networks and having intense collaborations with other nations, such as China, Germany or India, which are leaders in global academic production.

China has strong connections with partners in Asia, Europe and North America, underscoring a significant increase in Asian influence in research.

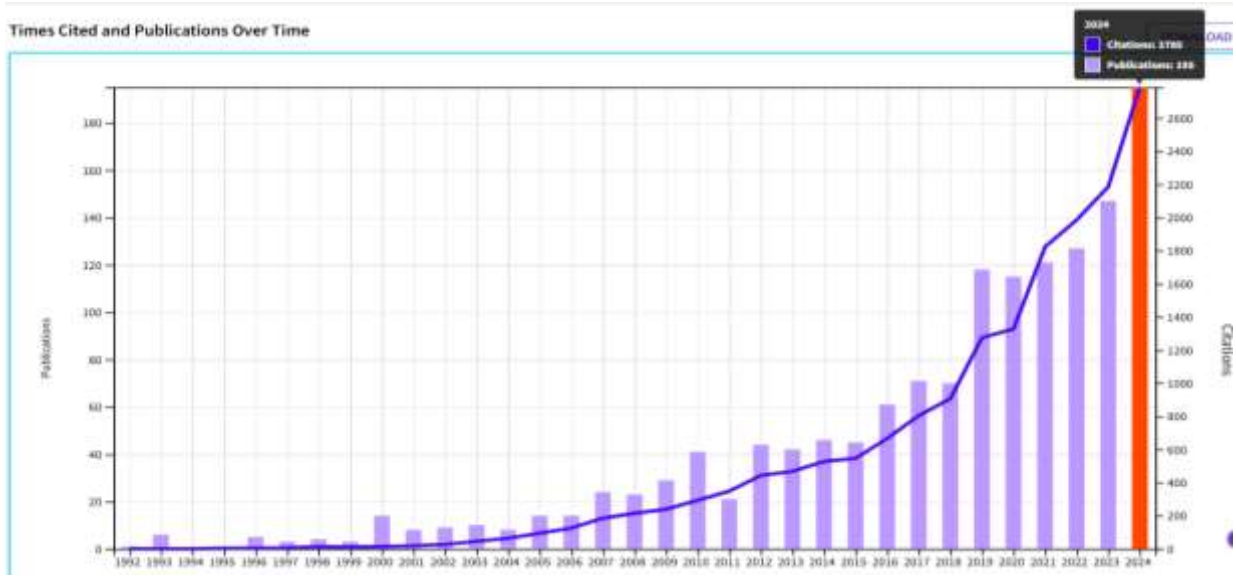

Fig. 1. The evolution of scientific research in the field of ethics and scientific integrity
Source: [30].

The map also highlights distinct thematic and regional clusters. The blue cluster, European, highlights strong collaborations between countries such as Germany, Spain and Belgium due to European funding programs. The green cluster, Asia, includes countries such as India, Malaysia or Indonesia reflecting these significant regional collaborations for research. The red cluster includes countries from East Asia and the Middle East, which constitute another pole of strong scientific cooperation. Countries with fewer connections, such as Nepal, Sri Lanka and Kazakhstan appear on the periphery of the network, due to the low level of integration in global collaborations. Romania is present in this network, but has a smaller number of connections, its participation being a modest one within these networks (Fig. 2).

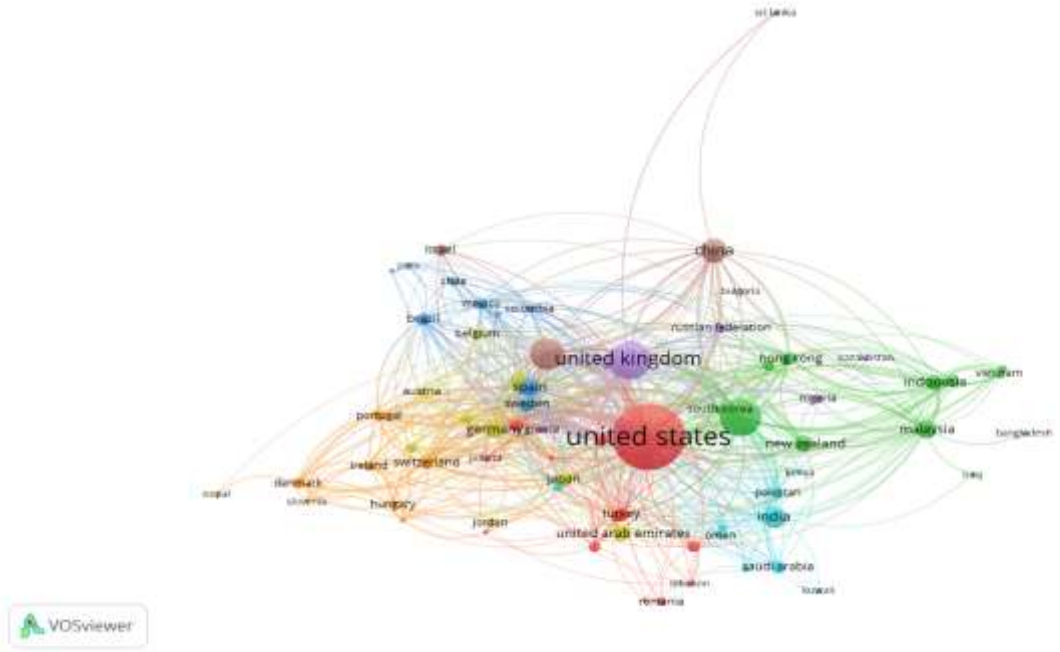

Fig. 2. The relationship between co-authors and countries
Source: own processing VOSwiever [30].

Thus, we find that the general network is dense, demonstrating the significant integration of countries in global collaborations, with a few exceptions. Influential states play an important role in disseminating knowledge and connecting more isolated regions.

The relationship between co-occurrence and keywords allowed us to establish the frequency with which keywords appeared together in the same context, highlighting the dominant topics and the relationships between them within a field of ethics and academic integrity and being essential in understanding the hierarchy and the interdependence between the analyzed subject and for the direction of future studies. Putting as a condition the use of a minimum number of 5 keywords, 869 scientific articles resulted, which were grouped into 7 clusters (Fig. 3).

The red cluster highlights topics such as "academic integrity", "cheating" or "artificial intelligence", demonstrating researchers' concerns related to ethical violations in education and the impact of emerging technologies, such as artificial intelligence, on academic practices. Terms such as "dishonesty" and "cheating detection" show the challenges related to the detection of unethical behaviors, especially in the educational environment. The green cluster is centered on the ethics of scientific and medical research, including terms such as "research ethics", "scientific misconduct" and "medical research" highlighting concerns related to the correctness of publication (publication ethics) and the validity of clinical studies (clinical trials). The blue cluster highlighted the human dimension of ethics, with terms such as "human" and "ethics" emphasizing the social responsibility and ethical aspects of medical research.

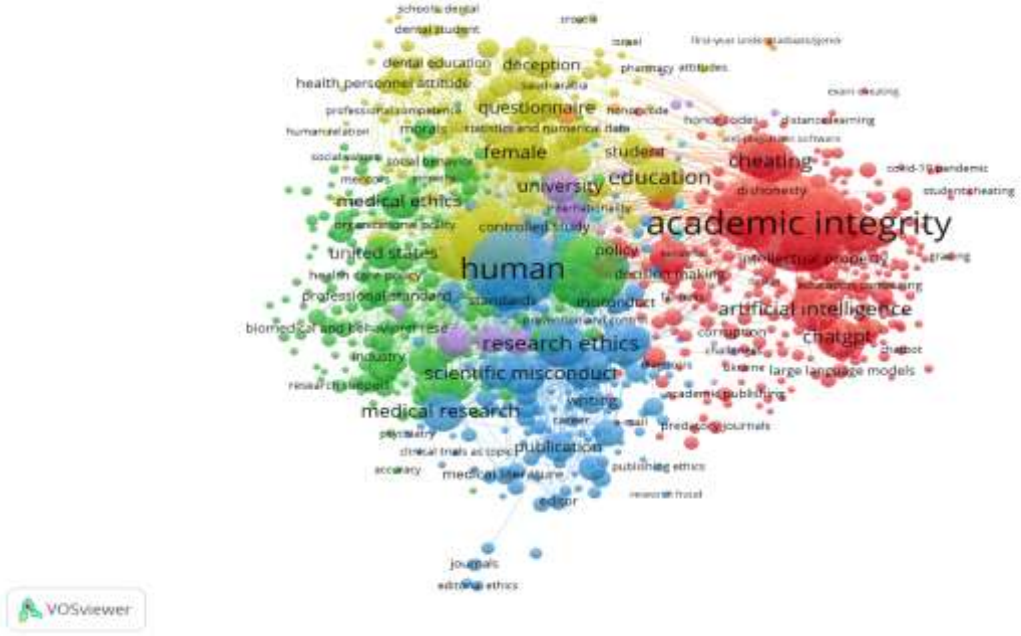

Fig. 3. Co-occurrence relationship - keywords
Source: own processing VOSwiever [30].

The yellow cluster highlighted aspects related to education and demography, including terms such as "education", "student" and "questionnaire" starting from studies focused on the application of academic integrity among students. The connections between the clusters are articulated through central terms such as "academic integrity" and "research ethics" demonstrating the interdependence between education, research ethics and emerging technologies. Thus the analysis demonstrated the interaction between the fields of academic integrity, research ethics and modern technologies, providing a complex perspective on the dominant topics and the relationships between them, pointing out contemporary

issues including the effects of AI and ethical publication, and offering a structure for setting priorities for upcoming studies and regulations. Figure 4 highlights the relationships between co-cited papers and cited references in the field of academic ethics and research integrity, providing insight into the conceptual structure of this field. The dense groupings on the left, dominated by the works of McCabe D.L. and Trevino I.K. shows a well-established subfield focused on the study of unethical student behavior and the implementation of honor codes in education. These works are frequently co-cited, which underlines their importance as fundamental references in this field. Since Fanelli D.'s publications on the right deal with a specific subfield focused on the integrity of scientific research—with a focus on the frequency of data falsification and article retractions—they are separated from the rest of the map. Although less connected to the rest of the network, these works are considered fundamental to the understanding of ethical misconduct in academia, being frequently cited in this context. The connections between the clusters are relatively low, because the subfields of academic ethics, focused on student behavior, and research integrity, focused on researcher behavior, are studied separately, with little conceptual overlap. However, the weak connection between Fanelli's works and those in the educational cluster demonstrates that they could be deepened in future research. Thus, a clear segmentation of the field between two major themes is established: unethical academic behavior in education and the integrity of scientific research. The limited connections between these subfields show the opportunity for conceptual integration needed for a broader understanding of the link between educational and scientific ethics.

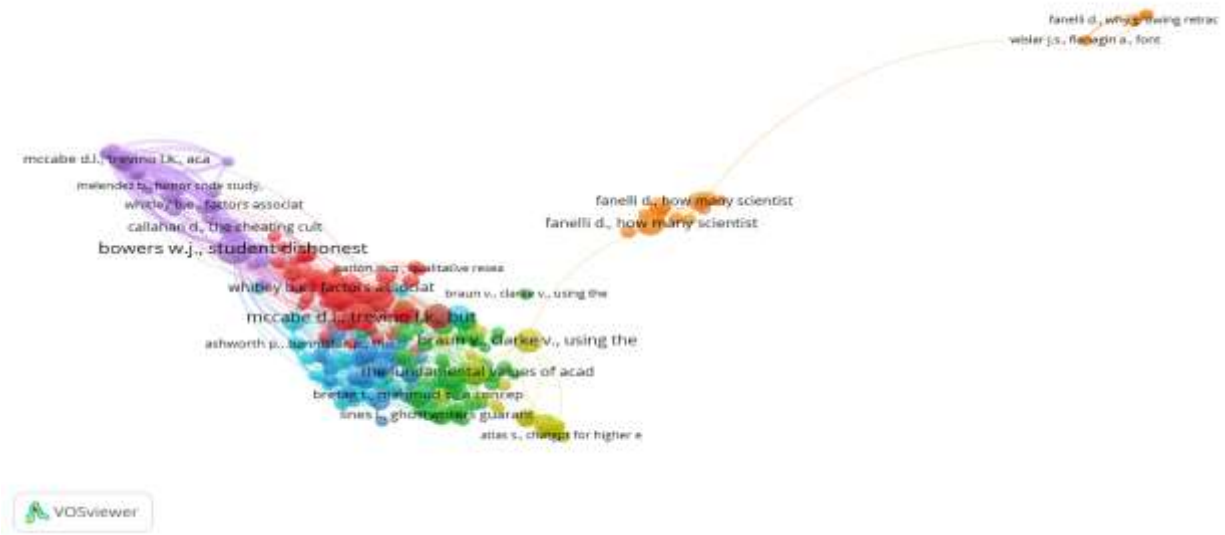

Fig. 4. Co-citations - cited references relationship
Source: own processing VOSwiever [30].

The relationship between citations and cited authors reflects the influence and relevance of individual or collective research on ethics and academic integrity. This relationship highlights how an author's ideas, methods, and findings have been taken up, integrated, and extended by the academic community (Fig. 5). The red cluster which is centered on Mc Cabe D.L. shows the major contributions in the study of unethical student behavior and academic honor codes, being supported by authors such as Trevino I.K. and Harding T.S., dominating research on educational integrity. The blue cluster, with Bretag T. as its central node, analyzes global academic integrity, focusing on plagiarism prevention and institutional policy implementation, with contributions from authors such as Ellis C. and Rowwland S.

The yellow cluster connects interdisciplinary educational and ethical research, through authors such as Bertram G. and Rowland S., emphasizing the application of honor codes and the relationship between education and ethics. The green cluster is dominated by Tan S. and Wang J. who address the issue of educational integrity at an international level, exploring the cultural and global dimensions of academic behavior The purple cluster centered again on Fanelli D. related to ethical misconduct in science such as falsification of data and retraction articles, being connected with authors such as Anderson M.S. and Teixeira da Silva J.A. which analyzes the ethics of publication and research integrity. The separation between the clusters highlights an opportunity for integration between the two perspectives. The central authors are fundamental reference points, having essential works for the understanding and development of the field.

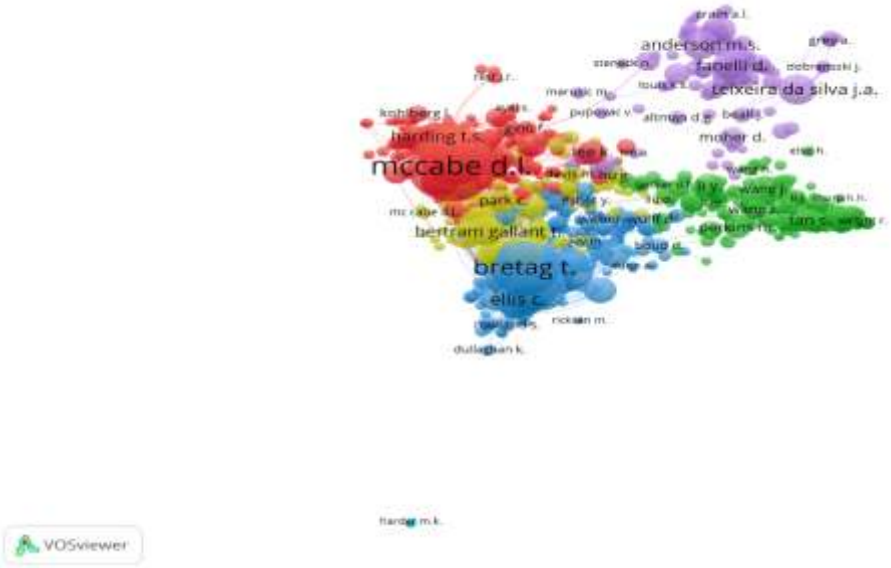

Fig. 5. Co-citations - cited authors relationship
Source: own processing VOSwiever [30].

Next, we analyzed those articles related to the formation of a professional conduct regarding ethics and academic and research integrity. From the 75 articles resulting from the consultation of the Scopus database, putting as conditions the identification of articles published in 2020 that have a minimum number of 5 citations, a number of 10 articles resulted that were further analyzed, both the purpose and purpose being identified research, as well as the results obtained (Table 1).

Table 1. The results of the research in the field of training a conduct related to ethics and academic and research integrity

Author(s)	Title	Year	Number of citations	Main findings
Perrier, L., Blondal, E., MacDonald, H.	The views, perspectives, and experiences of academic researchers with data sharing and reuse: A meta-synthesis	2020	51	The research analyzed the opinions and experiences of researchers regarding the sharing of data resulting from their research and how to reuse it, with the aim of determining the deficiencies and the reasons that prevent this sharing [22]
Haven, T., Pasman, H. R., Widdershoven, G.,	Researchers' perceptions of a responsible research	2020	34	The research analyzes the climate responsible for research by analyzing the opinions of researchers using focus

Bouter, L., & Tijdink, J.	climate: A multi focus group study			groups. The study carried out within 2 research institutions in Amsterdam highlighted both the barriers faced by the respondents, as well as the solutions identified in order to achieve such a responsible climate [12]
Li, L., Ma, Z., Fan, L., Lee, S., Yu, H., & Hemphill, L.	ChatGPT in education: A discourse analysis of worries and concerns on social media	2024	17	The study analyzed the impact of ChatGPT on scientific research, starting from the existing information on Twitter related to education, being identified 5 predominant themes, which refer both to ethics and academic integrity, as well as to the development of skills required by the labor market. The results are considered useful both for political factors, as well as for the scientific and business environment [17].
Huybers, T., Greene, B., & Rohr, D. H.	Academic research integrity: Exploring researchers' perceptions of responsibilities and enablers	2020	13	The study analyzes the perception of researchers regarding the role of individual responsibility in ensuring academic integrity, from the perspective of the Singapore Declaration. This perspective is related to certain factors, namely: university ethics codes, staff training methods, mentoring activity and peer pressure. The results show that the respondents' country of origin, seniority at work or academic position are elements that influence this perception [13]
Armond, A. C. V., & Kakuk, P.	Perceptions of research integrity climate in Hungarian universities: Results from a survey among academic researchers	2022	10	Starting from the fact that individual behavior influences the climate of academic research integrity, the study identifies the weak points and strong points of the organizational climate in 3 Hungarian universities. The research is based on the answers provided by the respondents represented by both doctoral students and representatives of the academic or research environment, in different positions [3].
Elliott, T., Fazeen, B., Asrat, A., Cetto, A. M., Eriksson, S., Looi, L. M., & Negra, D.	Perceptions on the prevalence and impact of predatory academic journals and conferences: A global survey of researchers	2022	10	The study analyzes the perception of 1872 researchers, from different geographical areas, with different academic positions and with different income levels, regarding the publication in journals and scientific conferences of prey, with the aim of raising awareness of these practices and their vulnerabilities. The purpose of the study was to raise awareness of the role that education regarding academic ethics has in preventing these practices [7].
Gopalakrishna, G., Wicherts, J. M., Vink, G., Stoop, I., van den Akker, O. R., Ter Riet, G., & Bouter, L. M.	Prevalence of responsible research practices among academics	2022	9	The study focused on the analysis of wrong behaviors in scientific research, with the aim of preventing these practices, which was based on the application of questionnaires to a number of 6,813 teaching staff from

				universities in the Netherlands. The results obtained showed that the subjects taught, the rank or the publication protocols influence academic behavior differently, so they can be the basis for formulating policies to overcome these obstacles [11].
Arabyat, R. M., Qawasmeh, B. R., Al-Azzam, S. I., Nusair, M. B., & Alzoubi, K. H.	Faculty members' perceptions and attitudes towards anti-plagiarism detection tools: Applying the theory of planned behavior.	2022	8	The research analyzes the opinion of the academic environment in Jordan regarding plagiarism. The study was based on the application of a questionnaire that measured the behavior of the respondents and their attitude regarding the use of plagiarism detection software in scientific papers before their submission for publication [2].
Brown, T., Isbel, S., Logan, A., & Etherington, J.	Predictors of academic integrity in undergraduate and graduate-entry masters occupational therapy students	2020	7	The research identified and analyzed potential predictors of ethics and academic integrity among students and master's students, starting from the application of a scale of dishonesty. The obtained results can thus contribute to the identification of vulnerable students and the implementation of proactive policies [4].
Sarauw, L. L.	The reversed causalities of doctoral training on research integrity: A case study from a medical faculty in Denmark	2021	5	The research is a case study regarding the inclusion of a course on ethics and academic integrity within a Faculty of Medicine in Denmark, which contributes to the training of doctoral students, with the aim of identifying their perception regarding this aspect, as well as its role on the formation of a culture of academic integrity [24].

Source: Synthesis of the consulted literature.

The analyzed research reflects a complex and diversified approach to academic integrity and research ethics, highlighting both the barriers and possible solutions for promoting an ethical and responsible climate in the academic environment.

Data sharing and reuse are limited by organizational and individual barriers, requiring policies that encourage open collaboration. A responsible research climate depends on the balance between individual and institutional responsibility, as evidenced by studies in Amsterdam and Hungary.

The impact of emerging technologies such as ChatGPT on education and research underlines the need to develop skills relevant to the labor market and adapt educational policies.

Global studies on predatory practices highlight the vulnerabilities of researchers and the role of education in academic ethics to prevent them.

Analysis of research misconduct shows the influence of factors such as the discipline taught or publication protocols, underscoring the need for proactive policies.

Regional studies, such as the one in Jordan, show variations in the perception of plagiarism and the use of detection technologies, reflecting the importance of education and technological resources. In addition, identifying predictors of academic dishonesty among students provides opportunities for the implementation of preventive policies.

The introduction of ethics courses, as in the case of the study in Denmark, demonstrates their role in forming a culture of academic integrity and strengthening an ethical environment in education and research.

These findings underscore the need for a comprehensive and integrated approach to promoting academic and scientific integrity.

The main limitations of the research are thematic fragmentation, with educational ethics and research integrity being treated separately, which prevents a unified global perspective. Also, studies are often regional, focusing on Europe or the Middle East, limiting the global applicability of the findings. The impact of emerging technologies such as artificial intelligence is underexplored and the lack of longitudinal analyzes prevents the assessment of the long-term effects of policies and initiatives.

We believe that future research should integrate the themes of educational ethics and scientific integrity in a unified approach, exploring the impact of modern technologies on academic integrity and expanding research at a global level, with an emphasis on cultural and regional diversity.

CONCLUSIONS

The bibliometric analysis of ethics and academic integrity, as well as that of awareness of responsibility, highlights the importance and complexity of the subject, underlining the fundamental role of these fields in maintaining the credibility and quality of the academic environment. Research shows that integrity is central to ensuring ethical behavior in both education and science, but approaches remain fragmented without clear integration between these two dimensions.

Although the review identifies influential authors and clear subfields, the lack of an integrative perspective between educational ethics and research integrity limits the field's progress. Methodological gaps include the absence of longitudinal studies and the neglect of the long-term impact of integrity policies.

Global research emphasizes cultural diversity and technological challenges, but often in a fragmented manner. The influence of emerging technologies, such as artificial intelligence, on academic integrity is underexplored, and studies fail to provide a systematic global approach that reflects cultural and regional differences

The future perspective should integrate these subfields, explore technological and cultural influences more deeply, and use longitudinal methods to build a unified vision of academic integrity that responds to global and interdisciplinary challenges.

REFERENCES

[1]Anderson, M. S., Shaw, M. A., Steneck, N. H., Konkle, E., Kamata, T., 2013, Research integrity and misconduct in the academic profession, Higher Education: Handbook of Theory and Research: Volume 28, 217-261.

[2]Arabyat, R. M., Qawasmeh, B. R., Al-Azzam, S. I., Nusair, M. B., Alzoubi, K. H., 2022, Faculty members' perceptions and attitudes towards anti-plagiarism detection tools: Applying the theory of planned behaviour, Journal of Empirical Research on Human Research Ethics, 17(3), 275-283.

[3]Armond, A. C. V., Kakuk, P., 2022, Perceptions of research integrity climate in Hungarian universities: Results from a survey among academic researchers, Science and engineering ethics, 28(4), 30.

[4]Brown, T., Isbel, S., Logan, A., Etherington, J., 2020, Predictors of academic integrity in undergraduate and graduate-entry masters occupational therapy students, Hong Kong Journal of Occupational Therapy, 33(2), 42-54.

[5]Chawla, D. S., 2023, Unearned authorship pervades science, Nature, 2023

[6]Eaton, S. E., 2022, The academic integrity technological arms race and its impact on learning, teaching, and assessment, Canadian Journal of Learning and Technology, 48(2), 1-9.

[7]Elliott, T., Fazeen, B., Asrat, A., Cetto, A. M., Eriksson, S., Looi, L. M., Negra, D., 2022, Perceptions on the prevalence and impact of predatory academic journals and conferences: A global survey of researchers, Learned Publishing, 35(4), 516-528.

[8]Else, H., 2023, Multimillion-dollar trade in paper authorships alarms publishers, Nature, 613(7945), 617-618.

[9]Fanelli, D., 2009, How many scientists fabricate and falsify research? A systematic review and meta-analysis of survey data, PloS one, 4(5), e5738.

[10]Fouda, T., 2020, Impact of the fourth industrial revolution on the development of scientific research in the field of agricultural engineering in Egypt and Arab world, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Vol. 20(3), 253-258

[11]Gopalakrishna, G., Wicherts, J. M., Vink, G., Stoop, I., van den Akker, O. R., Ter Riet, G., Bouter, L. M., 2022, Prevalence of responsible research practices among academics, The Netherlands, F1000Research, 11.

[12]Haven, T., Pasman, H. R., Widdershoven, G., Bouter, L., Tijdink, J., 2020, Researchers' perceptions of

a responsible research climate: A multi focus group study, Science and Engineering Ethics, 26, 3017-3036.
[13]Huybers, T., Greene, B., Rohr, D. H., 2020, Academic research integrity: Exploring researchers' perceptions of responsibilities and enablers, Accountability in Research, 27(3), 146-177.
[14]Ioannidis, J. P. A., 2007, Why most published research findings are false: author's reply to Goodman and Greenland, PLoS medicine, 4(6), e215.
[15]Krimsky, S., 2004, Science in the Private Interest: Has the Lure of Profits Corrupted Biomedical Research?, Rowman & Littlefield Publishers.
[16]Lancaster, T., 2022, Cheating in the academic environment, Integrity of Scientific Research: Fraud, Misconduct and Fake News in the Academic, Medical and Social Environment, pp. 523-529. Cham: Springer International Publishing.
[17]Li, L., Ma, Z., Fan, L., Lee, S., Yu, H., Hemphill, L., 2024, ChatGPT in education: A discourse analysis of worries and concerns on social media, Education and Information Technologies, 29(9), 10729-10762.
[18]Marcuta, A., Tindeche, C., Tonea, E., Smedescu, C., Smedescu, D., Marcuta, L., 2023, Metaverse and the global economy. Metaverse and agriculture-a bibliometric analysis, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Vol. 23(3), 529-548.
[19]MCDI, 2020, Guide of integrity in scientific research (Ghid de integritate în cercetarea științifică), https://www.old.research.gov.ro/uploads/sistemul-de-cercetare/organisme-consultative/cnecsdti/2020/ghid-integritate-in-cercetarea-stiintifica-cne-2020.pdf, Accessed on 12.11.2024.
[20]Merton, R. K., 1973, The sociology of science: Theoretical and empirical investigations, The University of Chicago.
[21]Mihailovic, B., Cvijanovic, D., 2013, Business ethics and environmental problems, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Vol. 13(3), 147-150.
[22]Perrier, L., Blondal, E., MacDonald, H., 2020, The views, perspectives, and experiences of academic researchers with data sharing and reuse: A meta-synthesis, PloS one, 15(2), e0229182.
[23]Resnik, D. B., 2005, The ethics of science: An introduction, Routledge.
[24]Sarauw, L. L., 2021, The reversed causalities of doctoral training on research integrity: A case study from a medical faculty in Denmark, Journal of Academic Ethics, 19(1), 71-93.
[25]Socaciu, E., Vică, C., Mihailov, E., Gibea, T., Mureșan, V., Constantinescu, M., 2018, Etica si integritate academica (Academics Ethics and Integrity) https://eticasiintegritate.unibuc.ro/wp-content/uploads/2018/11/Etica-si-integritate-academica.pdf, Accessed on 12.11.2024.
[26]Steneck, N. H., 2003, ORI introduction to the responsible conduct of research. Department of Health and Human Services, Office of the Secretary, Office of Public Health and Science, Office of Research Integrity
[27]UBB, 2024, Codul de etică și deontologie universitară (The Code of University Ethics and Deontology), In Romanian, https://www.ubbcluj.ro/ro/despre/organizare/files/etica/Codul-cadru_de_etic%C4%83_%C5%9Fi_deontologie_universitar%C4%83.pdf, Accessed on 12.11.2024
[28]UMF, Redactarea lucrarilor stiintifice si de cercetare. Ghid de bune practici, https://www.umfiasi.ro/ro/universitate/organizare/Documents/Comisia%20de%20etic%C4%83/Ghid%20de%20bune%20practici/2021-2022/Ghid%20pentru%20redactarea%20lucrarilor%20practice%20si%20de%20cercetare.pdf, Accessed on 12.11.2024.
[29]UPB, Ghid practic de îndrumare a Codului de Etică și Deontologie profesională în UPB, https://upb.ro/wp-content/uploads/2020/04/GHID-COD-ETIC-varianta-2.pdf, Accessed on 12.11.2024.
[30]WOS, https://1410qt542-y-https-www-webofscience-com.z.e-nformation.ro/wos/woscc/basic-search, Accessed on 29.11.2024.

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PRESSURE, PERFORMANCE AND UNIVERSITY ETHICS. ANALYSIS OF THE RELATIONSHIP BETWEEN EDUCATION FUNDING AND ACADEMIC INTEGRITY IN E.U. COUNTRIES

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Abstract

The aim of this research was to analyse the relationship between the level of public investment in tertiary education and the structural characteristics of higher education in the Member States of the European Union, with a focus on the indirect implications on academic integrity. In the context in which institutional pressures can affect academic quality and ethics, the study aims to identify whether and to what extent funding influences performance, structural balance and the risk of compromising university standards. The specific objectives included: selecting a coherent set of comparable educational indicators at EU level, assessing the relationships between them through statistical correlations, constructing a composite score of educational pressure and formulating substantiated conclusions regarding the budgetary impact on the academic climate. The methodology used was of a quantitative-comparative type, based on the processing of data available in the Eurostat platform for the period 2015–2023. Only countries for which all the analyzed data were fully reported were included. The analytical tools applied included descriptive analysis, Pearson correlation coefficient and z-score standardization to develop the composite score of educational pressure. The results obtained highlighted significant correlations between the level of expenditure/student and the student/teacher ratio, as well as between education financing and the share of the population with higher education. In addition, the composite score showed that countries with low investment and unbalanced structure (Romania, Bulgaria, Italy, etc.) display increased institutional pressure, which can indirectly affect academic integrity. The overall conclusion of the research is that integrity in the university environment does not depend exclusively on cultural or ethical factors, but is structurally conditioned by the way in which resources are allocated, the academic workforce is balanced and educational transitions are managed. Therefore, a sustainable approach to academic integrity inevitably also requires a strategic vision on funding and institutional architecture.

Key words: *education, performance, ethics, funding, integrity, E.U.*

INTRODUCTION

Academic integrity is the ethical foundation of educational and research activity, supported by values such as honesty, responsibility, fairness and respect for knowledge. This requires compliance with the norms of intellectual conduct by all actors involved – students, teachers, researchers and institutions – in the process of creating, disseminating and evaluating information [2, 10, 12, 16].

One of the most common forms of violation of academic integrity is plagiarism, defined as the taking over of the ideas, formulations or results of other authors without proper citation, including self-plagiarism [18, 20, 9]. Another unethical practice is copying in assessment contexts, through the use of prohibited sources or undeclared collaborations. In recent years, the phenomenon of "contract cheating", the delegation of academic tasks to third parties, has become increasingly present, undermining the veracity of assessments and the meaning of the educational act [3, 24].

Academic pressures, such as workload, institutional competition, and excessive expectations, can lead to opportunistic behaviors, especially in environments where

institutional support is limited. In this context, technology introduces both solutions and risks: artificial intelligence, for example, can be misused to generate content without academic recognition, complicating efforts to maintain standards [13, 19].

Maintaining academic integrity involves not only sanctioning misconduct, but also developing an organizational culture based on ethics, methodological support, and coherent educational policies. In a quality-focused educational system, integrity becomes a condition of institutional legitimacy and an indicator of academic maturity [11, 14].

In the analysis of academic integrity, a comprehensive approach requires recourse to theoretical frameworks that explain not only individual behaviors, but also institutional and systemic conditioning. Among the most relevant are the theory of resources in education, institutional ethics, and modern perspectives on educational management.

The resource theory in education starts from the premise that educational performance and quality are deeply influenced by the volume and type of available financial, human and infrastructural resources [15, 25]. Lack of resources can lead to structural imbalances (overburdening of teaching staff, limited access to educational support), which generate systemic pressures that can weaken the consistent application of academic standards. In this context, integrity becomes not only an ethical choice, but also a function of institutional sustainability.

Institutional ethics constitute a normative framework that regulates the values, practices and organizational culture in the academic environment. This is not reduced to formal codes of conduct, but involves a set of constant practices through which the institution cultivates honesty, transparency and responsibility. In the absence of a coherent institutional culture, ethical norms tend to become symbolic or ineffective. Therefore, academic integrity reflects the degree to which the assumed values are translated into authentic practices.

Educational management, in its modern form, has a central role in strengthening academic integrity. Effective academic leadership not only ensures the implementation of policies and procedures, but also shapes the ethical climate through decisions regarding resource allocation, performance evaluation, and support for professional development [26, 27]. Participatory models of university governance, oriented towards transparency and inclusion, contribute to creating a framework in which unethical behaviors are easier to prevent than to sanction [1, 17, 21].

Therefore, the analysis of academic integrity requires the articulation of these three theoretical perspectives: resources influence operational capacity, institutional ethics determine the value climate, and educational management provides the mechanisms for coordination and intervention. Only through a systemic approach can integrity be understood and cultivated as an integral part of educational sustainability.

On the other hand, the chronic underfunding of the higher education system creates fertile ground for the manifestation of unethical behaviors, both on the part of students and teaching staff. From an institutional perspective, the theory of systemic pressure explains how resource deficits, material, human and organizational, generate internal tensions that compromise the rigorous application of academic norms [23].

The lack of financial resources leads directly to the overloading of teaching staff, large classes and a low capacity to monitor and evaluate student activity in depth. In this context, the quality of academic supervision decreases, and the application of integrity policies becomes more formal than functional.

In parallel, the pressure on students, especially in contexts where academic, psychological or material support is reduced, determines avoidance behaviors, such as copying, illicit collaboration or plagiarism. The need to perform in the absence of resources becomes a catalyst for opportunistic behaviors.

Moreover, the absence of continuous training and professional support for teachers contributes to decision-making fatigue, the uneven application of evaluation criteria and, in some cases, the tolerance of deviant behaviors, in a logic of "institutional survival" [22]. Thus, underfunding not only affects

educational outcomes, but also erodes the ethical culture of the institution, jeopardizing the credibility of the academic process.

Therefore, in the absence of adequate funding, academic integrity cannot be maintained exclusively through regulations or individual will, requiring a sustained institutional framework, capable of providing functional conditions and real support to educational actors.

In this context, the aim of the research is to examine how the level of public investment in tertiary education influences the structure and functioning of university systems in the Member States of the European Union, with a focus on indirect effects on academic integrity, this being done based on the analysis of the link between public financing of higher education and its structural characteristics. At the same time, we also monitored the potential impact on academic balance, but also the risk of compromising university ethical standards in the context of institutional pressures.

MATERIALS AND METHODS

To carry out this research, we used a quantitative, comparative approach, based on data reported by the European Union member countries based on Eurostat. In order to ensure comparative validity, only those states that fully reported the indicators included in the analysis, for the entire period 2015–2023, were selected.

This selection was indispensable for the subsequent application of quantitative statistical methods, ensuring a stable and comparable analytical framework for exploring the relationship between the level of public investment in education and the indirect dimensions of academic integrity. Also, the homogeneity of the sample contributes to limiting systemic errors and increasing the relevance of the interpretations resulting from the correlative analysis.

The analysis was carried out based on the following processed data: Public expenditure on higher education as a share of GDP (ISCED 5–8); Annual expenditure/student (FTE) in higher education (ISCED 5–8); Annual expenditure/full-time equivalent student (FTE); Student/teacher ratio (ISCED 6–8), Share of population with tertiary education (ISCED 5–8), for the age groups 15–64 and 25–34.

Each indicator was analysed both individually and in relation to the others, to identify patterns of statistical association between the level of investment and general educational performance.

Statistical methods used were:

Pearson correlation, which was used to assess was used to analyse the intensity and direction of the linear relationship between public expenditure on education (% GDP) and the rate of population with tertiary education, expenditure/student and the student/teacher ratio; educational expenditure and educational absorption rate (25–34 years old with higher education), using the following formula:

$$r = \Sigma[(x_i - \bar{x})(y_i - \bar{y})] / \sqrt{[\Sigma(x_i - \bar{x})^2 * \Sigma(y_i - \bar{y})^2]} \quad \text{.....(1)}$$

Standardization of indicators for fair comparisons between countries and between years was carried out by applying normalization of values in the form of *z-scores*, thus:

$$z = (X - \mu) / \sigma \quad \text{.....(2)}$$

The creation of the composite score aimed to determine the educational pressure, which was derived by combining the standardized: student/teacher ratio; expenditure/student; percentage of the population with higher education.

Each of the countries was thus positioned in a comparative analysis model to assess the systemic risk of declining academic integrity, in relation to the level of educational investment. The data were processed and analyzed in Excel, and the statistical results were interpreted in correlation with the specialized literature on ethics and financing in education.

RESULTS AND DISCUSSIONS

The level of public expenditure allocated to higher education, expressed as a percentage of gross domestic product, is an essential

indicator for assessing the commitment of states to university and postgraduate education. Beyond its gross economic significance, this indicator directly reflects the strategic orientations of public policies in the field of human capital formation and support for scientific research.

A comparative analysis of this indicator at the level of the European Union allows the identification of significant differences between states in terms of prioritizing education in national budgets (Table 1).

Table 1. Public expenditure on higher education as a percentage of GDP (ISCED 5–8), 2015–2023 (%)

Country	2016	2017	2018	2019	2020	2021
Austria	1.78	1.71	1.70	1.56	1.86	1.85
Bulgaria	0.59	0.81	0.76	0.80	0.83	0.83
Croatia	0.81	0.86	0.86	0.86	0.97	0.88
Cyprus	1.05	1.16	0.95	0.89	0.91	0.89
Czechia	0.70	0.70	0.92	0.93	0.86	0.87
Denmark	2.63	2.39	2.35	2.31	2.41	2.36
Estonia	1.40	1.13	1.18	1.09	1.13	1.12
Finland	1.83	1.66	1.54	1.51	1.59	1.53
Germany	1.26	1.25	1.27	1.28	1.39	1.35
Italy	0.73	0.75	0.77	0.78	0.88	0.85
Latvia	0.76	0.69	0.74	0.82	0.85	0.85
Lithuania	0.82	0.75	0.79	0.80	0.93	0.85
Luxembourg	0.48	0.46	0.41	0.45	0.46	0.46
Malta	1.37	1.21	1.28	1.33	1.49	1.35
Netherlands	1.75	1.59	1.71	1.61	1.68	1.74
Norway	2.13	2.11	2.08	2.15	2.31	1.91
Poland	1.06	1.08	1.06	1.10	1.14	1.08
Romania	0.71	0.72	0.75	0.81	0.81	0.75
Slovenia	0.95	0.95	1.01	1.02	1.16	1.12
Spain	0.92	0.93	0.92	0.94	1.08	1.09
Sweden	1.85	1.79	1.79	1.78	1.88	1.84

Source: own processing, Eurostat [5].

The data presented in Table 1 show a considerable variation between the European Union member states in terms of the proportion of GDP allocated to higher education. Thus, we can see that the Nordic countries (such as Finland, Denmark or Sweden) have maintained a consistently high level of budgetary allocations, frequently above the threshold of 1% of GDP. In contrast, countries in Central and Eastern Europe (such as Romania, Bulgaria or Slovakia) have reported significantly lower levels, often below 0.5% of GDP. This discrepancy is due to a series of structural and political factors. First, the overall budgetary capacity of the state directly influences the volume of resources available for education. Second, the strategic importance given to higher education varies from one government to another, being conditioned by national priorities and the vision of long-term sustainable development.

In terms of temporal dynamics, some states have shown a trend of gradual increase in investments in tertiary education (Ireland, Estonia), while others have recorded stagnation or even reductions in allocations, possibly as a result of post-pandemic fiscal consolidation or the redirection of resources to other critical areas (health, defense).

At the level of consequences, a low and constant level of investment in higher education can generate: overburdening of academic staff (through high student/teacher ratios); limited access to educational

infrastructure and resources; systemic pressures that can negatively influence the climate of ethics and academic integrity (by reducing the capacity for supervision, evaluation and mentoring). On the other hand, adequate funding supports the quality of the educational act, facilitates research and reduces the risk of unethical behavior caused by institutional constraints.

Table 2. Annual expenditure per student (FTE) in higher education (ISCED 5–8) (Euro)

Country	2015	2016	2017	2018	2019	2020	2021
Austria	14,027.7	14,470.3	14,705.6	15,322.8	13,655.7	16,234.8	17,270.2
Bulgaria	2,340.4	2,473.3	3,121.7	3,319.6	3,766.3	3,882.7	4,323.4
Croatia	4,890.5	3,743.5	3,965.7	4,068.9	4,717.2	4,614.3	4,833.3
Cyprus	8,605.4	8,120.1	8,701.7	7,814.0	7,596.0	7,416.2	7,926.9
Czechia	5,198.3	4,742.1	5,399.5	7,789.5	8,589.1	7,648.2	8,465.5
Denmark	:	19,628.3	18,596.0	19,208.9	19,632.6	20,156.6	22,388.1
Estonia	6,938.0	6,924.2	7,768.7	9,420.0	9,250.0	9,391.1	9,947.8
Finland	15,994.4	15,771.5	15,309.5	15,473.3	15,648.8	16,117.3	16,003.7
Germany	13,276.2	13,396.6	13,690.3	14,235.5	14,727.5	15,051.0	15,429.0
Italy	8,360.6	8,272.7	8,393.7	8,366.3	8,254.3	8,202.1	8,469.1
Latvia	5,043.2	3,675.7	4,024.2	4,866.9	5,790.3	6,174.0	6,132.8
Lithuania	4,424.6	3,291.3	3,491.3	4,056.2	4,638.4	5,565.3	5,612.2
Luxembourg	42,134.2	42,855.9	43,594.6	41,245.4	39,897.0	40,990.4	41,891.7
Malta	11,166.4	12,138.2	11,970.4	12,711.7	14,502.1	14,233.0	14,019.2
Netherlands	15,667.4	15,788.2	15,806.1	15,844.0	16,421.4	16,610.2	17,259.2
Norway	22,414.5	22,775.5	23,308.0	23,991.8	24,421.7	21,086.6	22,918.8
Poland	4,317.0	3,897.2	4,212.4	4,687.2	5,276.3	5,378.0	5,768.3
Romania	2,510.7	2,334.6	2,494.2	2,837.3	3,469.6	3,296.9	3,373.2
Slovenia	7,105.7	7,155.2	7,751.4	8,019.1	8,822.5	9,273.8	9,578.1
Spain	8,359.1	8,214.0	8,414.6	8,668.8	8,931.2	8,792.8	9,106.9
Sweden	23,304.6	23,065.2	23,059.6	22,500.6	22,301.0	21,543.3	22,140.0

Source: own processing, Eurostat [4].

The data in Table 2 reflect the amount of public and private expenditure allocated annually for each full-time equivalent (FTE) student in higher education, expressed in euros, being an indicator that provides a detailed perspective on the investment/individual effort and the real level of support that a student benefits from within the tertiary education system. The comparative analysis shows significant differences between EU Member States. Western and Northern European countries, such as Luxembourg, Sweden, the Netherlands and Germany, are consistently at the top of the ranking, with average annual amounts per student that far exceed the threshold of 10,000 euros. This reality is the consequence of an educational model focused on quality, modern infrastructure and adequate remuneration of academic staff. In addition, in these countries, higher education is often correlated with applied research and technological innovation, which justifies the high level of investment. In contrast, Central and Eastern European countries report significantly lower values, in many cases below 3,000 euros/student. This discrepancy reflects not only a lower fiscal capacity, but also a possible subordination of education in the hierarchy of government priorities. At the same time, it indicates a greater dependence on external funding for specific projects, in the absence of a sustainable internal framework.

From a causal perspective, low spending per student leads to: insufficient endowments in educational institutions; limited access to materials, laboratories and digital resources; the impossibility of attracting and retaining high-performing teaching staff; overburdening

staff and compressing the pedagogical relationship.

The indirect effect of these deficiencies can be reflected in increased risks to academic integrity: formal assessments, poor quality control, demotivation of students and staff, as well as institutional tolerance for unethical behavior. Therefore, the analysis of this indicator not only provides a picture of the national financial effort, but also of the structural conditions in which higher education is carried out in each state. The link between the level of investment per student and the academic climate is essential for understanding the dynamics of integrity at the institutional level.

Table 3. Annual expenditure/full-time equivalent (FTE) student in higher education (ISCED 5–8) (Euro)

Country	2015	2016	2017	2018	2019	2020	2021
Austria	14,833.9	15,379.7	15,767.7	16,641.2	17,296.4	17,754.6	18,864.6
Bulgaria	2,092.9	2,150.9	2,839.5	2,979.6	3,479.5	3,555.3	4,027.2
Croatia	5,173.8	4,053.9	4,140.6	4,244.9	4,719.8	4,837.9	5,117.1
Cyprus	13,325.3	13,238.8	15,958.2	14,631.5	15,452.3	15,502.2	16,582.1
Czechia	5,670.5	5,086.5	5,806.5	8,458.7	9,332.7	8,263.0	9,126.0
Denmark	:	19,651.0	18,582.4	19,221.7	19,610.0	20,167.4	22,406.7
Estonia	8,149.2	9,760.1	8,267.0	9,916.4	9,815.4	9,809.4	10,363.2
Finland	22,437.5	23,882.0	23,286.5	23,311.3	23,244.3	23,866.3	23,887.2
Germany	13,769.8	13,946.6	14,313.0	14,961.5	15,847.4	16,261.0	16,820.6
Italy	8,274.6	8,248.6	8,460.2	8,499.3	8,502.1	8,580.3	8,790.3
Latvia	3,641.4	3,119.1	4,257.9	4,895.6	4,350.8	5,705.7	5,389.4
Lithuania	4,614.5	3,375.8	3,594.0	4,201.6	4,883.1	5,958.4	6,027.4
Luxembourg	42,134.2	42,855.9	43,594.6	41,245.4	39,897.0	40,990.4	41,891.7
Malta	11,064.7	12,123.8	11,966.2	13,247.5	15,227.9	15,442.8	16,047.7
Netherlands	15,277.7	15,458.5	15,562.2	15,649.5	16,251.0	16,454.2	17,198.7
Norway	24,766.9	25,307.3	25,879.2	26,757.9	26,942.1	23,328.3	25,456.1
Poland	5,014.8	4,504.8	4,912.4	5,581.8	6,415.7	6,609.3	7,291.3
Romania	2,696.3	2,516.4	2,690.4	3,052.4	3,763.8	3,545.6	3,641.2
Slovenia	7,297.5	7,376.2	7,996.8	8,271.0	9,148.8	9,476.2	9,801.9
Spain	8,657.6	8,500.4	8,786.0	9,091.2	9,457.8	9,512.4	9,945.0
Sweden	23,955.3	23,678.2	23,825.5	23,280.8	23,225.4	22,580.6	23,550.1

Source: own processing, Eurostat [4].

The data in Table 3 provide a detailed and consolidated view of the actual expenditure per student in higher education, adjusted for full-time equivalent (FTE). This calculation method provides a more realistic basis for comparison between countries, eliminating the distortions generated by the presence of part-time students or mixed attendance regimes. The values presented indicate that the differences between European Union countries are not only quantitative, but also structural. In countries where expenditure/student is consistent from year to year, such as Germany, Denmark or Finland, we can observe institutional stability supported by predictable educational policies and a coherent vision of the role of education in national development. These countries invest strategically in academic infrastructure, digitalization, research resources and in the continuous training of teaching staff. In contrast, the values reported by some Member States in Eastern or South-Eastern Europe highlight recurrent underfunding and a lack of budgetary continuity. In such cases, fluctuations in spending per student are symptomatic of the instability of public policies, dependence on external funding or the absence of internal mechanisms for efficient resource allocation.

From a causal perspective, low spending per student leads to a series of negative effects, such as: reduced institutional capacity to

provide quality educational services; limited access to mentoring, tutoring or personal development programs; increased student/teacher ratio, which implies a decrease in direct academic control and time allocated to each student; decreased attractiveness of academic careers, especially for young researchers. All these elements fuel a framework conducive to the deterioration of academic integrity, either through institutional negligence or through tolerance towards unethical practices in the absence of functional prevention and control structures. Therefore, this indicator is one of the most relevant in understanding the real quality of the educational experience and the potential of a university system to maintain high ethical standards, but it must also be viewed in correlation with other variables such as the student/teacher ratio or the percentage of the population with higher education, for a nuanced and substantiated interpretation.

Table 4. Student-to-teacher ratio in higher education (ISCED 6–8) (number)

Country	2015	2016	2017	2018	2019	2020	2021	2022	2023
Austria	16.5	16.6	16.2	15.8	15.3	16.2	15.7	15.5	15.7
Bulgaria	12.9	12.4	12.0	11.5	11.3	11.9	12.4	11.8	11.6
Croatia	:	12.6	12.8	:	:	:	:	:	11.0
Cyprus	18.3	17.7	21.5	23.2	23.8	26.9	27.1	25.2	26.6
Czechia	23.0	18.9	18.4	15.0	16.8	16.2	16.5	16.7	16.7
Denmark	17.3	16.6	15.6	15.3	15.3	15.2	13.7	14.9	13.8
Estonia	14.0	13.7	13.5	12.8	12.9	12.2	12.3	11.3	11.0
Finland	15.1	15.3	15.5	15.3	14.9	14.4	13.4	14.4	15.3
Germany	12.0	12.1	12.1	12.0	11.9	11.7	11.6	11.3	11.2
Italy	20.2	20.2	20.0	20.3	20.2	20.8	20.5	20.2	19.6
Latvia	:	19.6	19.5	18.1	18.1	18.0	15.8	16.3	:
Lithuania	16.5	16.3	16.2	14.4	14.5	15.0	13.4	13.4	13.6
Luxembourg	8.0	7.6	7.1	4.0	4.6	4.5	4.4	4.2	4.2
Malta	9.6	9.7	9.7	9.2	9.2	8.7	9.0	8.4	9.0
Netherlands	15.4	14.8	14.6	14.7	14.8	14.6	14.8	13.9	13.1
Norway	10.4	:	9.4	9.3	9.1	9.1	9.5	9.3	8.9
Poland	14.9	14.6	14.3	13.8	13.5	13.0	12.6	12.6	12.5
Romania	18.7	19.3	19.4	19.8	19.4	19.8	20.7	20.0	19.3
Slovenia	16.8	15.0	14.6	13.7	14.0	13.4	15.1	10.6	11.4
Spain	13.2	12.8	12.8	12.7	12.6	13.1	13.4	13.1	12.6
Sweden	10.4	10.4	10.3	10.2	10.0	9.9	10.2	10.5	10.1

Source: own processing, Eurostat [6].

Table 4 presents an important perspective on the functional structure of higher education, analyzing the ratio between the number of students and that of teaching staff, the indicator reflecting the degree of workload of academic staff, which directly influences the quality of the educational act, the capacity for mentoring and supervision, as well as the level of pedagogical interaction.

The differences between the countries of the European Union are striking. Countries such as Sweden, Finland or the Netherlands present a lower ratio, located below 15 students per teacher, which indicates an educational model oriented towards the direct and individualized relationship with the student. In such contexts, teaching staff have the time and resources for rigorous assessments, personalized support and involvement in research projects alongside students, thus contributing to strengthening the climate of academic integrity. On the other hand, in countries such as Romania, Poland or Bulgaria, the ratio frequently exceeds 20 or even 25 students/teaching staff, creating increased institutional pressure on academic staff. In such cases, the high teaching load

reduces the time available for lesson preparation, individual support, and extracurricular activities essential for student training. In addition, chronic overwork of teaching staff can lead to a decrease in assessment vigilance, weaker control of plagiarism, and, implicitly, a decrease in ethical standards.

From a causal perspective, a high student/teacher ratio can have effects such as: a decrease in the quality of assessments; the use of standardized and impersonal teaching methods; the discouragement of involvement in coordinated research activities; the emergence of a climate of tolerance for superficiality or unethical behavior.

In the long term, these conditions affect both the quality of graduates and the institutional reputation, reinforcing the risk of a systemic erosion of academic integrity. Thus, the student-teacher ratio is not just a technical parameter, but a barometer of educational pressure and a possible indirect indicator of vulnerability to unethical practices in the academic environment.

Table 5. Share of population with higher education (ISCED 5–8), age group 15-64 years (%)

Country	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Austria	28.1	28.9	29.7	30.1	31.1	31.3	31.8	32.5	33.6	34.4
Bulgaria	24.1	24.4	24.5	24.8	24.7	25.8	26.1	26.3	26.7	29.4
Croatia	19.9	20.1	20.7	21.9	22.1	22.3	22.3	22.8	24.9	26.6
Cyprus	36.4	37.6	38.1	39.4	40.5	41.0	42.8	44.0	46.0	46.3
Czechia	19.8	20.6	21.4	21.7	21.6	22.1	23.4	23.5	23.5	23.8
Denmark	30.2	31.1	32.2	32.6	33.4	33.7	34.8	35.0	35.5	37.3
Estonia	32.0	33.1	33.6	34.1	34.7	35.2	36.0	36.7	36.0	36.0
Finland	35.5	35.9	36.4	37.3	38.5	39.8	35.5	35.9	35.7	35.7
Germany	23.8	24.4	24.8	25.2	26.0	27.2	28.0	27.9	29.0	30.1
Italy	15.5	15.7	16.5	17.2	17.5	17.8	17.8	18.1	19.2	19.7
Latvia	28.1	29.5	30.0	30.1	31.4	33.2	34.2	34.5	34.0	34.7
Lithuania	33.2	34.1	34.8	36.1	37.9	38.7	39.8	41.3	41.0	41.7
Luxembourg	35.2	36.4	34.1	38.3	41.0	40.9	44.5	46.0	45.7	48.2
Malta	19.9	20.3	22.1	24.7	27.0	28.2	29.6	29.4	30.8	33.3
Netherlands	30.5	31.0	32.1	33.0	34.8	36.6	37.5	38.8	38.4	38.7
Norway	36.7	36.8	36.8	37.5	37.7	38.8	40.6	41.1	41.9	42.7
Poland	24.4	25.2	26.3	27.2	28.6	29.3	29.4	30.0	33.2	34.3
Romania	15.0	15.1	15.3	15.5	16.0	16.2	16.4	17.1	16.1	16.5
Slovenia	26.6	27.2	28.7	28.7	29.3	31.5	35.4	35.1	29.8	30.5
Spain	32.1	32.7	33.2	34.0	35.1	36.0	36.2	36.5	37.1	37.5
Sweden	34.0	35.3	36.0	37.1	37.8	38.3	39.6	41.1	41.9	42.8

Source: own processing, Eurostat [7].

The data from Table 5 shows the share of the active adult population (aged 15-64) who graduated from higher education, providing an overview of the general educational level of the workforce within each Member State of the European Union. This indicator is often used to assess the degree of access and success in tertiary education in the long term and is correlated with the level of socio-economic development, productivity and innovation capacity. Nordic and Western European countries, such as Sweden, the Netherlands or Luxembourg, report high percentages, reflecting a consolidated history of investment in education and a higher education system well integrated with the labor market. In these countries, university education is perceived as a natural path to professional development, and wide access to education is supported by both coherent public policies and an institutional culture of quality. In contrast, Central and Eastern European countries register lower

values, which may indicate persistent obstacles to access to higher education: socio-economic barriers, limited capacity of institutions or pronounced regional inequalities.

From a cause-and-effect perspective, a low percentage of the adult population with higher education indicates: an underfunded or rigid educational system; difficulties in retaining students in the system (high dropout rate); a poor correlation between labor market requirements and the structure of university programs; a low perception of the value of university education among the active population.

In relation to the issue of academic integrity, an insufficiently educated workforce can exert additional pressure on universities, in the sense of increasing demand for quick degrees, easy access or decreasing academic requirements. This context can create favorable conditions for the emergence of ethical compromise practices (formal assessments, tolerance of plagiarism, reducing curricular requirements). Therefore, this indicator reflects not only the result of a long-term educational investment, but also the resilience of the university system in maintaining ethical standards in the face of the social and economic demands of an adult population in continuous transformation.

Table 6. Share of population with higher education (ISCED 5–8), age group 25–34 years (%)

Country	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Austria	38.6	39.7	40.3	40.5	41.6	41.4	42.4	43.1	43.5	44.1
Bulgaria	31.8	32.8	33.4	34.0	32.6	33.1	33.8	34.0	35.8	40.5
Croatia	30.8	32.8	32.7	35.3	35.4	37.0	36.2	36.0	38.8	39.4
Cyprus	54.7	56.2	57.0	58.5	59.1	57.4	58.8	59.2	61.6	60.1
Czechia	31.0	32.6	33.8	33.3	32.6	33.0	34.9	34.6	33.7	33.5
Denmark	43.0	44.6	45.5	45.8	47.1	47.1	49.1	49.0	49.0	51.2
Estonia	38.5	39.1	40.9	41.1	40.6	40.1	43.2	43.9	43.5	42.7
Finland	40.2	40.7	40.3	40.3	42.0	43.8	40.1	40.7	39.2	39.1
Germany	29.6	30.5	31.3	32.3	33.3	35.3	36.9	36.7	38.4	40.5
Italy	25.2	25.6	26.9	27.9	27.9	28.6	28.3	29.2	30.6	31.6
Latvia	39.9	42.1	41.6	41.6	43.8	44.2	45.5	45.9	45.1	45.0
Lithuania	54.8	54.9	55.6	55.6	55.2	56.2	57.5	58.2	57.4	58.2
Luxembourg	50.3	51.5	51.3	53.7	56.1	60.6	62.6	61.0	60.2	63.8
Malta	31.9	34.3	34.9	40.2	41.0	40.2	42.9	42.5	46.2	46.9
Netherlands	45.1	45.2	46.6	47.6	49.1	52.3	55.6	56.4	54.5	55.1
Norway	49.0	49.2	48.3	48.5	48.4	50.9	55.0	55.6	56.6	56.8
Poland	43.2	43.5	43.6	43.5	44.6	43.7	41.8	41.7	46.3	45.7
Romania	25.5	24.8	25.6	24.9	25.5	24.9	23.3	24.7	22.5	23.2
Slovenia	40.8	43.0	44.5	40.7	44.1	45.4	47.9	47.3	40.7	43.1
Spain	41.0	41.0	42.6	44.3	46.5	47.4	48.5	50.2	52.0	52.6
Sweden	46.5	47.3	47.4	47.6	48.4	49.2	49.3	52.4	54.1	54.4

Source: own processing, Eurostat [7].

The data in Table 6 show the share of the young adult population (25–34 years) that has graduated from higher education, providing an overview of the current efficiency of the tertiary education system and its capacity to respond to contemporary labor market demands. This indicator is frequently used in European statistics to assess the degree of modernization and performance of university education among the new generation.

EU Member States show significant variation. Countries such as Lithuania and Luxembourg have already exceeded the 50% threshold, which denotes a clear orientation of young people towards higher education, supported by wide access policies, financial support for students and a functional link between

universities and employers. These countries invest not only in university infrastructure, but also in the attractiveness of study programs, the quality of teaching and international mobility. At the opposite pole, countries such as Romania or Italy register percentages below the EU average, which reflects structural difficulties such as: limited access to higher education for vulnerable categories; high indirect costs of studies (accommodation, transportation, materials); a poor correlation between the curriculum and the real needs of the economy.

This situation has significant implications for academic integrity, as an education system under pressure to "produce graduates quickly" may be tempted to reduce academic requirements, speed up assessment processes, or tolerate questionable practices in order to maintain favorable graduation statistics. Furthermore, in countries where the percentage of young people with higher education is low, universities may feel pressure to attract and retain students for financial reasons, which can lead to: lowering admission criteria; simplifying study programs; reducing academic control.

Table 7. Share of the population aged 18–24 who are no longer in any form of education (%)

Country	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Austria	7.3	6.9	7.4	7.3	7.8	8.1	8.0	8.4	8.6	8.1
Bulgaria	13.4	13.8	12.7	12.7	13.9	12.8	12.0	10.3	9.3	8.2
Croatia	2.7	2.8	2.9	3.1	3.0	2.2	2.4	2.1	2.0	2.0
Cyprus	5.2	7.6	8.5	7.8	9.0	11.6	9.8	8.2	10.4	11.3
Czechia	6.2	6.6	6.7	6.2	6.7	7.6	6.4	6.2	6.4	5.4
Denmark	8.1	7.5	8.8	10.4	9.9	9.3	9.8	10.0	10.4	10.4
Estonia	13.7	11.4	11.8	12.0	11.2	8.5	9.8	10.8	9.7	11.0
Finland	9.2	7.9	8.2	8.3	7.3	8.2	8.2	8.4	9.6	9.6
Germany	10.1	10.3	10.1	10.3	10.3	10.1	12.5	12.7	12.8	12.4
Italy	14.7	13.8	14.0	14.3	13.3	14.2	12.7	11.5	10.5	9.8
Latvia	9.9	10.0	8.6	8.3	8.7	7.2	7.3	6.7	7.7	7.9
Lithuania	5.5	4.8	5.4	4.6	4.0	5.6	5.3	4.8	6.4	8.4
Luxembourg	9.3	5.5	7.3	6.3	7.2	8.2	9.3	8.2	6.8	7.8
Malta	16.3	15.6	14.0	14.0	14.2	13.0	10.9	10.3	10.2	9.6
Netherlands	8.2	8.0	7.1	7.3	7.5	7.0	5.1	5.6	6.2	7.0
Norway	10.2	10.9	10.4	9.9	9.9	9.9	12.3	13.2	12.5	13.0
Poland	5.3	5.2	5.0	4.8	5.1	5.3	5.8	4.7	3.7	4.1
Romania	19.1	18.5	18.1	16.4	15.3	15.6	15.3	15.6	16.6	16.8
Slovenia	5.0	4.9	4.3	4.2	4.6	4.1	3.1	4.0	5.4	5.0
Spain	20.0	19.0	18.3	17.9	17.3	16.0	13.3	13.9	13.7	13.0
Sweden	7.0	7.4	7.7	7.5	6.5	7.7	8.4	8.8	7.4	7.2

Source: own processing, Eurostat [8].

Therefore, this indicator is particularly valuable for assessing the contemporary performance of university systems and for anticipating ethical risks among emerging generations. Correlated with the level of investment and the student/faculty ratio, it becomes a relevant tool for estimating the pressure exerted on academic integrity.

The data in Table 7 reflect the proportion of young people aged 18 to 24 who left the education system early, without achieving a tertiary qualification and without being involved in any other form of training. This indicator is fundamental for understanding the long-term sustainability of the education system, but also the external pressures exerted on higher education.

Countries such as Romania, Spain, Italy and Malta record persistently high values, consistently exceeding 13–15%. These figures

highlight major dysfunctions in the transition stages between compulsory and post-secondary/university education, which significantly reduces the population base eligible for higher education. On the other hand, countries such as Slovenia, Lithuania or the Netherlands show values below 5%, demonstrating efficiency in educational retention and in supporting the complete educational path. These systems are less exposed to the pressure to "compensate" by relaxing university criteria.

Therefore, high early dropout rates may indirectly contribute to lower academic standards by increasing the dependence of higher education institutions on a fluctuating and vulnerable student population. This indicator therefore becomes a key element in the equation of investment in education and academic integrity.

To better understand the relationships between the level of public investment in education and indicators of efficiency and institutional pressure, a Pearson correlation matrix was constructed using 2021 data selected from the seven tables previously analyzed.

Table 8. Matrix of Pearson correlation coefficients between educational indicators

	Education expenditure/GDP	Expenditure/ student	Full-time expenditure	% higher education 15-64 years old	% higher Education 25-34 years old	Early leavers 18-24 years old
Education expenditure/GDP	1.000	0.347	0.366	0.266	0.198	0.005
Expenditure/student	0.347	1.000	0.966	0.559	0.551	0.083
Full-time expenditure	0.366	0.966	1.000	0.616	0.578	0.100
% higher education 15-64 years old	0.266	0.559	0.616	1.000	0.947	-0.200
% higher education 25-34 years old	0.198	0.551	0.578	0.947	1.000	-0.292
Early leavers 18-24 years old	0.005	0.083	0.100	-0.200	-0.292	1.000

Source: Own processing.

The analysis of the correlations between the main educational indicators for 2021, this being the last reporting year for all the indicators analyzed, highlights a series of significant relationships that contribute to understanding how the level of public investment influences the performance and structure of the higher education system in the European Union (Table 8).

First, a moderate positive correlation is observed between public spending on education as a percentage of GDP and spending/student (r = 0.35), respectively in the normed version (r = 0.36), which shows that more consistent national budget allocations tend to be reflected in higher funding per student, although not in an absolute proportional way, which indicates differences in efficiency in the allocation of resources. The relationship between spending/student and normed FTE spending is, as expected, extremely strong (r = 0.97), confirming the relevance in the analysis of educational investments. Regarding educational outcomes, expenditure/student is positively correlated with the percentage of the adult population (15–64 years) and youth (25–34 years) with higher education (r = 0.56, respectively r = 0.55), demonstrating that systems that invest more at the individual level tend to generate a more educated population, highlighting the positive effects of financing on access to and completion of higher education. The relationship between the proportion of the educated population aged 15–64 and that aged 25–34 is also very strong (r = 0.95), which demonstrates a coherent and efficient intergenerational transition in countries with stable education policies. An important aspect is the relationship with the indicator "Early leavers from education and training", which is negatively correlated with the percentage of the population aged 25–34 with higher education (r = –0.29), confirming that a higher rate of early school leaving affects the capacity of society to form a young generation with a high level of education. Similarly, the weak negative relationship with the overall educational level (15–64, r = –0.20) underlines the persistent risk of educational exclusion. In

contrast, the correlations between investment indicators (spending % GDP or per student) and early school leaving are weak or almost null ($r \approx 0.00–0.10$), demonstrating that budgetary allocations alone are not sufficient to prevent early school leaving, without structural interventions and targeted policies.
Therefore, the results highlight that tertiary education funding contributes significantly to the consolidation of human capital, but it must be correlated with institutional efficiency and integrated strategies to reduce dropout and increase quality. The identified correlations reinforce the idea that the level of investment has a direct impact on performance and an indirect impact on the ethical climate, by configuring the structure and pressure in the higher education system.

Table 9. Composite score of educational pressure in higher education

Country	Student/ Teacher Ratio (Number)	Expenses/student (euro/student/year)	Early leavers	Score Educational Pressure
Austria	15.7	17,270.2		-0.070
Bulgaria	12.4	4,323.4	9.8	0.310
Croatia		4,833.3	9.9	0.629
Cyprus	27.1	7,926.9	6.7	0.884
Czechia	16.5	8,465.5	12	0.664
Denmark	13.7	22,388.1	6.4	-0.606
Estonia	12.3	9,947.8	9.8	0.097
Finland	13.4	16,003.7	12.5	0.223
Germany	11.6	15,429	9.8	-0.153
Italy	20.5	8,469.1	3.3	0.064
Latvia	15.8	6,132.8	3.2	-0.186
Lithuania	13.4	5,612.2	13.3	0.685
Luxembourg	4.4	41,891.7	7.8	-1.826
Malta	9	14,019.2	2.4	-1.028
Netherlands	14.8	17,259.2	12.7	0.294
Norway	9.5	22,918.8	9.8	-0.574
Poland	12.6	5,768.3	7.3	0.019
Romania	20.7	3,373.2	5.3	0.467
Slovenia	15.1	9,578.1	9.3	0.254
Spain	13.4	9,106.9	12	0.426
Sweden	10.2	22,140	10.9	-0.386

Source: own processing.

To assess the degree of systemic pressure exerted on higher education institutions, a composite score was constructed based on three relevant indicators: the student/faculty ratio (internal structural pressure), annual expenditure per student (available resources per capita) and the early educational dropout rate (external pressure on the university recruitment base).
Each indicator was statistically standardized by the *z-score*, and the values were combined into an average score, where a higher level signals a higher educational pressure. Expenditure/student was inverted in the calculation, to reflect its inversely proportional nature to the pressure.The results shown in Table 9 highlight important differences between the Member States of the European Union. Countries with high scores (e.g. Romania, Bulgaria, Italy) simultaneously face: a high number of students per teacher, low investment per student, and a significant rate of early school leaving. These factors create a tense educational environment, in which the risks related to overload, institutional demotivation and ethical vulnerability are more pronounced.

In contrast, countries such as Denmark, Ireland and Finland register low scores, reflecting: a favorable balance between the number of students and academic staff, sustainable financing of education, and an efficient transition system between educational cycles.
The proposed composite score thus provides an integrated picture of the pressure exerted on the academic environment, being a useful tool in assessing the potential risk of degradation of academic quality and integrity in a comparative European context.

CONCLUSIONS

The research findings confirm the central hypothesis that public investment in tertiary education does not have an isolated impact on a single aspect of the university system, but generates cumulative effects on its functioning, influencing the capacity of institutions to sustain a climate of academic performance and integrity. It was also highlighted that recurrent underfunding, combined with a high student/faculty ratio and a significant dropout rate, contributes to the creation of a tense educational environment, in which ethical norms are difficult to operationally sustain.
On the other hand, countries that have allocated consistent and adequate resources in relation to student needs have demonstrated not only administrative efficiency, but also an increased capacity to maintain clear academic standards, implement control mechanisms and encourage a quality-oriented institutional culture. Thus, integrity is not only a component of individual training, but the result of an organizational structure capable of absorbing pressure, managing resources in a balanced way and providing an ethical functional framework.
Furthermore, the use of the composite score of educational pressure has shown that the vulnerability of systems is not the result of a single deficiency, but of an interaction between lack of funding, the imbalance between demand and capacity, and the failure of the transition between educational cycles. This integrative approach allows the identification of countries at systemic risk, not only in terms of educational performance, but also of the gradual erosion of institutional ethics.
Furthermore, discrepancies in data reporting between countries indicate a structural problem in the capacity for comparable monitoring and evaluation.
This statistical deficit limits both the formulation of informed public policies and the strengthening of common European mechanisms for the protection of academic integrity.
In conclusion, the study underlines that academic integrity cannot be guaranteed exclusively through regulations or codes of conduct, but must be supported by consistent investments, structural balance and educational policies focused on prevention and institutional support.
A systemic approach to integrity equally requires resources, absorption capacity and a sustainable administrative vision.

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REFERENCES

[1]Anghel, R. E., Marcuta, A., Tindeche, C., Rosu, M., Traistaru, C., Marcuta, L., 2022, Study on the perception of students of the Faculty of Management and Rural Development regarding the teaching-learning-assessment activity carried out online during the COVID-19 period, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Vol. 23(3), 75-82.
[2]Brezuleanu, C. O., Mihalache, R., Brezuleanu, M. M., Ungureanu, E., Sirghea, A., 2024, adaptation of entrepreneurial education and training in economics for the students of" Ion ionescu de la Brad" University of Life Sciences (IULS) Iași, Romania, in the context of changing labour market needs, Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development, 24(1), 135-146.
[3]Draper, M., Boland, M., 2024, Contract cheating: Legal, regulatory, and policy responses. Second Handbook of Academic Integrity, pp. 729-746, Cham: Springer Nature Switzerland.

[4]Eurostat, Annual expenditure on educational institutions per pupil/student based on FTE, by education level and programme orientation, https://ec.europa.eu/eurostat/databrowser/view/educ_uoe_fini04/default/table?lang=en, Accessed on 1.12.2024.
[5]Eurostat, Public expenditure on education by education level and programme orientation - as % of GDP, https://ec.europa.eu/eurostat/databrowser/view/educ_uoe_fine06__custom_16658639/default/table?lang=en Accessed on 1.12.2024.
[6]Eurostat, Ratio of pupils and students to teachers and academic staff by education level and programme orientation, https://ec.europa.eu/eurostat/databrowser/view/educ_uoe_perp04/default/table?lang=en Accessed on 1.12.2024.
[7]Eurostat, Population by educational attainment level, sex and age (%) - main indicators, https://ec.europa.eu/eurostat/databrowser/view/edat_lfse_03/default/table?lang=en Accessed on 1.12.2024.
[8]Eurostat, Early leavers from education and training by sex and labour status, https://ec.europa.eu/eurostat/databrowser/view/edat_lfse_14__custom_16658720/default/table?lang=en Accessed on 1.12.2024
[9]Gibbons, J., Turell, M. T., 2008, Dimensions of forensic linguistics, John Benjamins Publishing Company, pp. 265-299.
[10]Guerrero-Dib, J. G., Portales, L., Heredia-Escorza, Y., 2020, Impact of academic integrity on workplace ethical behaviour, International Journal for Educational Integrity, 16(1), 2.
[11]Higashijima, M., Loeber, L., Garnett, H. A., James, T. S., 2025, Challenges of electoral integrity in an era of overlapping crises, Election Law Journal: Rules, Politics, and Policy. 12 pp.
[12]Himcinschi, M., 2021, Ethics and Academic Integrity–Conceptual Aspects, SCIENTIA MORALITAS-International Journal of Multidisciplinary Research, 6(2), 164-190.
[13]Jose, J., Jose, B. J., 2024, Educators' academic insights on artificial intelligence: challenges and opportunities, Electronic Journal of e-Learning, 22(2), 59-77.
[14]Kayyali, M., 2025, Ethical Considerations in Higher Education: Accountability Navigating Complexities, Accountability in Higher Education: Navigating Current Issues and Trends, pp. 145-184, IGI Global Scientific Publishing.
[15]Kui, D. O. K., Widjaja, A. W., Pramono, R., 2025, Navigating Christian School Resilience, Lesson Learn from Decline to Survival Strategies, Journal of Posthumanism, 5(4), 794-814.
[16]Liuta, O., Deineka, O., Artyukhova, N., Hrytsenko, L., Daher, K., 2025, Academic integrity as a determinant of higher education quality assurance, Socio-economic relations in the digital society, 1(55), 96-105.
[17]Lo, W. Y. W., 2025, Trust and tension: shared governance in higher education amid student activism, Studies in Higher Education, 1-16.
[18]Louw, H., 2017, Defining plagiarism: Student and staff perceptions of a grey concept, South African Journal of higher education, 31(5), 116-135.
[19]Pedro, F., Subosa, M., Rivas, A., Valverde, P., 2019, Artificial intelligence in education: Challenges and opportunities for sustainable development. Paris, France, UNESCO, 2019, 46 pp.
[20]Ronai, K., 2020, Plagiarism Defined? A multiple case study analysis of institutional definitions, Apples-Journal of Applied Language Studies, 14(1), 25-46.
[21]Rosu, M., Marcuta, A., Tindeche, C., Anghel, R. E., Traistaru, C., Marcuta, L., 2022, Study on the perception of students of the faculty of management and rural development regarding the role of digitalization in the training of competences necessary for the integration of graduates in the labor market, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Vol. 22(4), 627-634.
[22]Savaş, G., Arslan, K., Kılınç, A. Ç., 2025, When teacher leadership backfires: Exploring the unintended consequences of teacher leadership, Educational Management Administration & Leadership, 1-22. 17411432251325356.
[23]Tagbo, S., 2024, A Review And Refocus Of University Education For Good Governance And Sustainable Peace In Rivers State, Development, 4(11), 74-88.
[24]Walker, M., Townley, C., 2012, Contract cheating: A new challenge for academic honesty?, Journal of Academic Ethics, 10, 27-44.
[25]Winarno, A., Aini, D. N., Fuad, M., Salleh, N. H. M., 2025, The Relationship of Entrepreneurial Education, Social Institutions and Business Experience to the Growth of Small and Medium Industries (Malang Regency Case, Indonesia), Journal of Lifestyle and SDGs Review, 5(5), e06432-e06432.
[26]Yaseen, U., Idrees, R. N., Shakil, M. H., Haider, S. Z., Khalil, J., 2025, Influence of academic leadership on organizational commitment of faculty members in private sector universities: mediating role of work engagement, Quality Assurance in Education, 33(1), 17-30.
[27]Yu, Q., Huang, C., Yan, J., Yue, L., Tian, Y., Yang, J., ... Qin, Y., 2025, Ethical climate, moral resilience, and ethical competence of head nurses, Nursing ethics, 32(1), 56-70.

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WINE, CULTURE AND CONNECTION: EXPLORING THE OPPORTUNITIES OF WINE TOURISM IN ROMANIA

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Abstract

Romania, with its millennia-old viticultural tradition, has significant potential to develop wine tourism as a driver of rural development, cultural preservation, and economic growth. While vineyards have long been integral to local culture, wine tourism has only recently emerged as a niche blending heritage, gastronomy, and immersive experiences. Historically, vineyards focused on grape production, but diversification led to complementary activities like tourism. Initially centred on passive observation during vineyard tours, wine tourism is now shifting towards experiential activities, engaging visitors in the stories and culture of winemaking. Despite its potential, the sector lacks in-depth research or a detailed SWOT analysis. This paper traces the sector's evolution from traditional grape cultivation to an industry balancing production and tourism and identifies key opportunities and challenges, emphasizing the need for strategic investments. These include creating cohesive wine routes linking wineries and cultural landmarks, improving infrastructure, and launching targeted campaigns to position Romania as a global wine tourism destination. By addressing these needs, Romania can leverage its cultural heritage and exceptional wines to attract international audiences.

Key words**:** *wine tourism, SWOT analysis, tourism diversification, wine routes.*

INTRODUCTION

Like most other countries, Romania's wine industry was primarily production-focused at its roots. However, recent years saw a shift towards wine tourism, especially incorporating experiential tourism as a key component of economic diversification, both on a global and local level. Traditionally, winemaking in Romania was centred on agricultural output, with vineyards mainly producing wine for domestic consumption and export but, as the tourism sector has expanded globally, wine regions have understood the potential of their cultural and gastronomic assets to attract visitors. Today, wine tourism has emerged as a niche sector capable of blending production with immersive experiences, transforming vineyards into destinations where culture, heritage, and wine intertwine to offer more than just tastings [12], [26].

With a history older than 2000 years, Romania's winemaking industry has been one of the oldest in Europe, with viticultural regions like Dealu Mare, Murfatlar, and Cotnari being central to grape cultivation, contributing to Romania's reputation for producing high-quality wines [2]. State-owned wine enterprises, especially during the socialist period, were primarily geared toward mass production, which limited their capacity for diversification, and even after Romania transitioned to capitalism and a market economy, many established wineries initially struggled to balance traditional production models with modern tourism demands [17].

Globally, wine tourism has experienced rapid growth, driven by the rising demand for personalized and experiential travel. Leading wine-producing regions such as Napa Valley (United States), Tuscany (Italy), and Bordeaux (France) have long capitalized on this trend by offering curated wine tours, luxury accommodations, and cultural events [12]. Keeping pace, emerging wine destinations in Eastern Europe, including Romania, are now

positioning themselves to compete on the international stage profiting from a global shift towards sustainable tourism and the increasing popularity of local, authentic experiences, which further enhance their potential to attract tourists seeking unique wine-related adventures [1]. Wine tourism in today's Romania presents a compelling combination of cultural heritage and gastronomy, offering experiences going beyond wine production, with visitors being able to explore ancient vineyards while learning about traditional winemaking techniques passed down through generations

MATERIALS AND METHODS

The current paper aims to investigate the evolution of wine tourism in Romania, analysing the sector's transition from traditional wine making practices to experiential tourism. As global wine tourism trends emphasize interactive and immersive visitor experiences [12], the research explores how Romanian wineries can capitalize on these trends. The paper's main objectives are:

(1)Identify historical pathways in the sector, from early beginnings to present day;

(2)Identify opportunities and challenges through a detailed SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis;

(3)Propose pathways for sustainable growth, focusing on strategic investments, infrastructure development, and innovative marketing approaches.

We believe the chosen theme and objectives are highly beneficial to understanding the sector because as the wine industry moves beyond production and integrates tourism into its framework there will be a significant impact on the country's rural, economic, and cultural landscapes [24]. Currently, wine regions in Romania are not only centres of agricultural production but also hubs of local culture and history therefore wine tourism can help preserve traditional viticultural practices, folklore, and regional customs, ensuring their transmission to future generations.

Throughout the paper, we employed extraction and analysis of wine-related data from existing statistics databases such as INSS, OIV and EUROSTAT, while also reviewing existing literature and media outlets articles to determine an updated picture of wine tourism's status in Romania. While gathering data and information available for the sector, we were able to identify the need for a comprehensive SWOT analysis of this industry, especially because it will help assess the feasibility of strategic interventions and can be a stepping stone for building a roadmap of addressing key challenges.

RESULTS AND DISCUSSIONS

In Romania, winemaking plays a central role in the cultural and economic life of rural communities, where grape cultivation has traditionally been passed down through generations. The first written mentions of wine-making practices in the region were found to be made during Burebista's reign (around 66 BC) [27]. Archaeological proof shows that wine was a popular product for more than 4,500 years. Ever since, wine has been used as an exchange good, partying aid, and mystical supplement in Romanians' daily lives [27].

Prior to the 21st century, wine production was largely focused on agricultural output, with little to no attention paid to tourism. Producers were more concerned with the quantity and quality of the vineyards' output than with diversifying the farm's income. The peak of productivity in the sector was registered in Romania during the socialist era, when wineries operated under state control, prioritizing large-scale production rather than experiential activities. However, this approach actually endangered the sector because while the main focus was on quantity, the quality factor became non-existent, and Romanian wines dropped in prestige [8].

It wasn't until the post-communist transition and Romania's integration into global markets that wineries realized the need to adapt to newer times and began to explore tourism as a complementary avenue to boost revenue and promote local culture. Early efforts focused on basic vineyard tours, often characterized by passive observation of winemaking processes,

followed by brief wine tastings but these offerings lacked creativity and failed to engage visitors on a deeper level [28]. Repeating the experience held no appeal, because visitors saw everything there was to see during only one trip, and the poor infrastructure didn't help - poor road access and limited accommodations near vineyards hampered the sector's growth. Romania thus came to a position where it was becoming harder and harder to compete with countries like Italy, France or Spain who were already becoming established wine tourism destinations. Realizing that they need to keep up with evolving global trends and changing tourist preferences, Romanian wineries have begun to shift from dull "look but don't touch" tours, to adopting practices that allow visitors to actively participate in the winemaking process, from grape harvesting to wine blending because of the understanding that tourists seek authentic interactions and personalized experiences. Visitors now days have access to a wide range of activities beyond wine tastings: hands-on workshops, vineyard picnics, traditional winemaking demonstrations, and guided storytelling sessions have become increasingly popular and wineries like Crama Țelna [6] and Domeniile Sâmburești [7] have incorporated cultural elements such as folk music performances, regional cuisine, and historical tours to enhance the visitor experience.

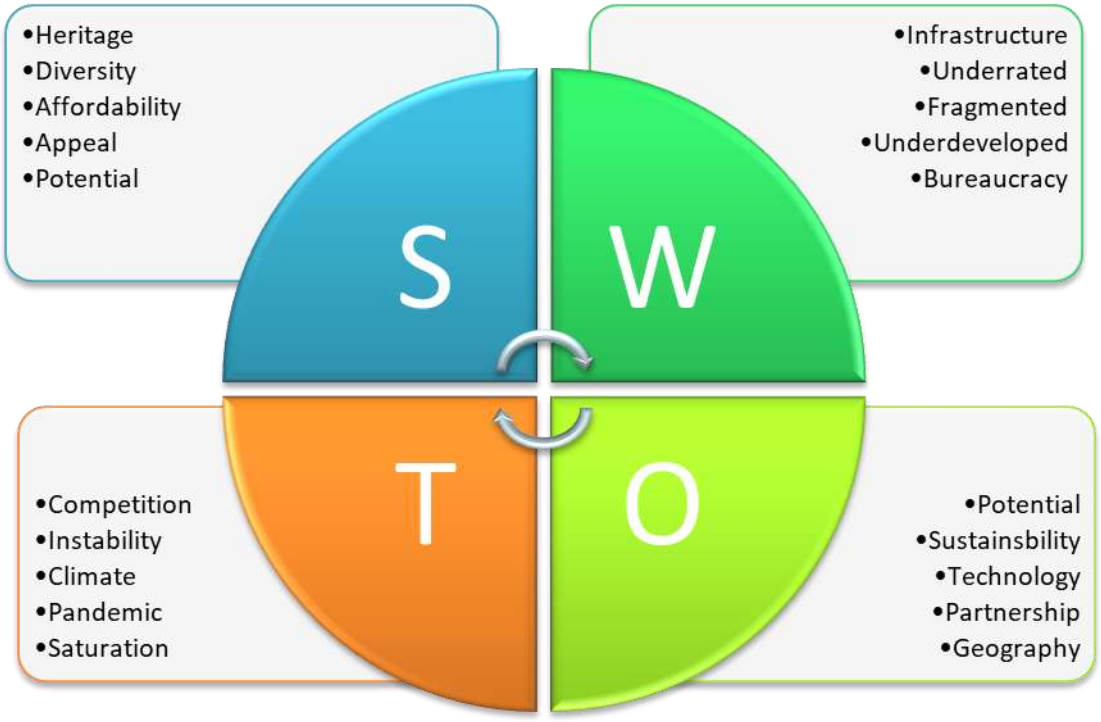

Fig.6. SWOT Analysis of the wine sector in Romania
Source: Own concept.

SWOT Analysis of the wine sector in Romania

While there are numerous research papers and media articles about the sector, in recent years, a comprehensive SWOT analysis of the sector from the perspective of wine tourism as a focal point, is missing. We decided to bring forward such an analysis and emphasize the invaluable potential we see in Romania's wine tourism (Figure 1).

a)Strengths

Rich cultural and historical heritage is the main competitive advantage of Romania on the international wine tourism map.

It's Millennia-old viticultural heritage offers a compelling narrative for attracting tourists, because as we previously mentioned, Romania's winemaking tradition dates back over 2,000 years, with archaeological evidence of ancient vineyards in the south of Romania.

Such an extensive background helps cellars with building a story around the place and helps them differentiate themselves from more industrialized wine regions by highlighting ancient practices, legends, and customs tied to wine production [28].

Testament to this approach are also the festivals like "Vin la Cultura" in Iasi, "WineUp Fair in Transylvania" in Cluj or "Artisan Food Market" in Bucharest, events that are gathering tens of thousands of visitors that are interested in finding more about Romania's wines and stories.

Another strength of Romania when it comes to wine tourism is the fact that the country has very diverse wine regions. Historically, the country has been divided in 9 regions, Banat, Crișana, Maramureș, Transilvania, Bucovina, Moldova, Oltenia, Muntenia and Dobrogea, and naturally, the traditions and practices concerning wine cultivation and winemaking practices shaped according to local influences. Each region holds a significant number of wineries that bring flavour and appeal to Romania's wine bouquet. Using Crame Romania's website, we identified a total of 234 vineyards and cellars split across historical regions of Romania (Table 1).

Romanian law states that only 162 out of the known 10,000 grape varieties are permitted for cultivation on Romanian territory [18].

Table 1. Number of Wineries and Cellars in Romania

Region	Wineries
Crisana & Maramures	48
Transylvania	25
Banat	11
Oltenia & Muntenia	83
Bucharest	3
Moldova	38
Dobrogea	26
Total	**234**

Source: https://www.crameromania.ro/en/regions [5].

However, only 129 varieties are currently cultivated. Out of these, 59 are local varieties and 70 are international varieties.

The country's main wine regions, such as Dealu Mare, Moldova, and Transylvania, benefit from varied microclimates, soil compositions, and altitudes, which result in distinctive wine profiles. For example, the warm, sunny climate of Dealu Mare is ideal for producing full-bodied reds, while the cooler climate of Transylvania favours aromatic whites. Romania's wine landscape and market is shaped by its rich historical regions, each with its own distinct terroir and winemaking traditions [21]. The country's wide variety of wineries and the large number of grape varieties authorized for cultivation contribute to an impressive diversity in its wines. This makes Romania an increasingly attractive destination for both local and international tourists.

With its reputation as one of Europe's most affordable travel destinations, Romania also stands out as a budget-friendly option for wine tourism. Compared to more established regions such as Tuscany, Bordeaux, or Napa Valley, Romania offers similar experiences—wine tastings, tours, and lodging—at significantly lower prices. This makes it especially appealing to budget-conscious travellers like young adults, backpackers, and wine lovers who want quality experiences without breaking the bank. For instance, a two-day wine tour in the Dealu Mare region costs around 230 EUR per person [33] while a similar tour in Bordeaux starts at around 750 EUR/person [10].

Interest in wine tourism is also growing among Romanians themselves. More people are embracing local wines, with events such as festivals, grape harvest celebrations, and wine-pairing dinners gaining popularity, particularly in cities like Bucharest, Cluj-Napoca, and Iași. At the same time, wine consumption is on the rise, reflecting a broader cultural shift in which wine is increasingly seen as a refined and leisurely choice [32].

In this context, the growing domestic interest provides wineries with a reliable market that can sustain their tourism efforts during off-peak seasons when international tourists may be fewer, and wineries, by continuing to engage the domestic audience through events, workshops, and promotional campaigns, can maintain steady visitor flows and revenue. Moreover, the involvement of local tourists helps create a sense of pride in Romania's wine

heritage, further supporting its long-term preservation.

While regions like Dealu Mare or Moldova are already recognized for their contributions to Romanian wine production, several lesser-known regions, such as Crișana and Banat, offer untapped potential for tourism development. These emerging wine regions boast unique landscapes, microclimates, and traditional winemaking practices that have yet to be fully integrated into the national wine tourism strategies [14]. For example, Banat, located near the Serbian border, produces high-quality wines that could attract tourists interested in off-the-beaten-path destinations, since this area is not a very popular destination. At the same time, Crișana, with its rolling hills and family-owned vineyards, offers multiple opportunities for rural tourism, where visitors can experience authentic village life while exploring local wineries. But investing in infrastructure and promotional efforts are the main points of pressure to put on the authorities so that these regions could diversify Romania's wine tourism offerings and help distribute visitor traffic more evenly across the country.

b) Weaknesses

Romania's struggle with underdeveloped infrastructure is well-known, especially when compared to its Eastern European neighbours. Even though there's been some progress in recent years—due to European Union funding that's helped build highways and boost businesses—we still have a long way to go. The infrastructure gap underlines the need for ongoing investments and smarter planning, especially in rural areas where most wineries are located. Many of the major wine regions, such as Dealu Mare and Moldova, suffer from poorly maintained roads, limited transportation options, and inadequate signage leading to wineries, oftentimes made only in Romanian, not in English or other international language. For international visitors, navigating these regions without a private vehicle can be challenging, as public transportation and connections between airports and wine routes are often unreliable or non-existent [13]. Also, the lack of high-quality accommodations near wineries is another major issue, and wine regions have a shortage of hotels, guesthouses, and other facilities that meet the standards expected by international tourists. The bright side is that some wineries have made efforts to provide on-site accommodations, however, the overall availability of comfortable accommodation remains insufficient. Moreover, basic visitor amenities, such as rest areas, restaurants, and tourist information centres, are often lacking, making it difficult for tourists to fully enjoy their experiences. We need to be aware of the fact that without addressing these infrastructure gaps, Romania cannot compete with more established wine tourism destinations.

Despite its rich wine heritage, diverse offerings, and award-winning wines, Romania has very low international visibility and remains relatively unknown on the global wine tourism map [34]. Unlike regions such as Bordeaux, Napa Valley or Tuscany, which have established strong international brands, Romanian wine regions have minimal presence in global tourism guides and wine publications, largely due to insufficient marketing campaigns targeting foreign audiences. While domestic tourism promotions have improved, efforts to attract international tourists are fragmented and underfunded. Romania's low international visibility is also tied to the limited export of its wines because although Romanian wines have started to gain recognition in international competitions, they remain largely unfamiliar to global consumers, which affects their ability to draw tourists. Additionally, the absence of collaborations with major travel agencies, influencers, and wine tourism platforms reduces Romania's reach in key markets such as Western Europe, the United States, and Asia.

Another significant weakness is the lack of coordination and collaboration among key stakeholders, including wineries, local governments, and tourism operators. Unlike established wine regions that operate within well-structured networks such as "Anivin de France" [30] or Consorzio Italia del Vino [4], many Romanian wine regions function independently, resulting in disjointed and inconsistent tourism offerings. Wineries often design their tours and events without collaborating with nearby businesses, leading

to missed opportunities for creating cohesive wine routes and multi-faceted tourism packages. While projects like CrameRomania and Wines of Romania try to gather all wineries together for promotion and cohesive interests, not all cellars are willing to participate. Moreover, there is no unified branding strategy for Romanian wine tourism, and while some regions have attempted to promote themselves individually, a national-level strategy that integrates all regions and presents a consistent message is lacking. This fragmented approach hampers Romania's potential to establish itself as a unified wine tourism destination and also impedes the country's efforts to develop regional tourism networks and launch a national promotional campaign.

While studying this market we observed that many Romanian wineries still rely on traditional tourism models that lack innovation and engagement. A large number of wineries offer simple wine tastings and vineyard tours, which do not meet the expectations of modern tourists seeking immersive experiences, while activities such as grape-picking, winemaking workshops, and food pairings are limited or only available at select wineries. Additionally, few wineries integrate cultural elements such as traditional music, storytelling, or local crafts into their tourism packages limiting their appeal to tourists seeking authentic, culturally rich experiences. To remain competitive, Romanian wineries need to expand their experiential offerings by introducing more interactive activities and collaborations with local artisans, chefs, and cultural performers to bring novelty and excitement to an otherwise simple event. This can be done not only through own funds but also by accessing national and European funding. According to MADR, the funds influx in this sector is of more than 45 million EUR annually [30].

Another obstacle to progress for Romanian wine tourism is the bureaucracy of the system. Wineries that aim to improve their performance by offering tourist experience must navigate a web of complex regulations—not only those related to viticulture, winemaking, and wine sales, but also laws concerning tourism, food services, and hospitality. The process of obtaining the necessary licenses can be slow and confusing, with inconsistent policies and red tape often delaying projects. For instance, wineries may struggle to get permits for hosting events, constructing visitor facilities, or expanding their services. The situation is further complicated by the absence of clear guidelines for rural tourism development, which tends to deter investors and limit the sector's growth. Additionally, Romania's national tourism strategy does not currently prioritize wine tourism as a key element of rural development [20].

c)Opportunities

However, there is significant potential for growth, particularly through the rising global interest in experiential tourism. Today's travellers are increasingly drawn to experiences that allow for authentic engagement with local culture, rather than just passive sightseeing. This trend opens up exciting possibilities for Romanian wineries. Activities like grape harvesting, wine blending workshops, food and wine pairing events, and guided storytelling tours offer immersive experiences that connect visitors with the history and culture of winemaking. By incorporating regional traditions—such as folk music, local crafts, and traditional cuisine—wineries can create more memorable and culturally rich experiences that appeal to both domestic and international tourists. For example, wineries could host events where visitors learn about Romanian folklore related to wine and agriculture while enjoying traditional meals paired with local wines – such experiences could gather many participants.

As global awareness of environmental issues continues to grow, Romania has a significant opportunity to position itself as an eco-conscious wine tourism destination. Many travellers are now seeking destinations that prioritize sustainability and offer eco-friendly experiences and by promoting organic vineyards, sustainable farming practices, and environmentally friendly tourism services, Romania can align itself with this global trend and attract environmentally aware tourists [23].

Wineries can adopt practices such as organic grape cultivation, water conservation, and renewable energy use to enhance their sustainability credential while marketing campaigns highlighting these efforts could help position Romanian wine regions as leaders in green tourism. For example, eco-friendly accommodations, vineyard tours that educate visitors on sustainable winemaking, and farm-to-table dining experiences featuring locally sourced ingredients could become key selling points. Sustainability-themed wine routes could also be developed, offering tourists the chance to explore wineries that prioritize environmental conservation.

The digital era presents a valuable opportunity for Romania to enhance its visibility and attract a broader audience through targeted digital marketing efforts. Social media platforms, wine tourism apps, and virtual tours are effective tools that can help promote Romania's wine regions to both domestic and international audiences because wineries can showcase their offerings through engaging content, such as videos of vineyard tours, behind-the-scenes winemaking processes, and testimonials from visitors.

Additionally, augmented reality (AR) and virtual reality (VR) technologies can be used to create immersive digital experiences that allow potential tourists to explore vineyards and participate in virtual tastings from the comfort of their homes. This strategy would be particularly effective in reaching international tourists who may be hesitant to travel initially but could be enticed by a virtual glimpse of Romania's unique wine experiences. At the same time, collaborations with travel influencers, wine bloggers, and international tourism websites can further enhance Romania's digital presence paired with creating a dedicated online platform for booking wine tours, accommodations, and experiences could make it more appealing for tourists and get them to plan their visits [31].

Developing cohesive and well-marked wine tourism routes is another major opportunity for Romania. The creation of thematic wine routes that connect multiple wineries, cultural landmarks, and local attractions can enhance the overall visitor experience and encourage longer stays. For example, routes could be designed around specific themes, such as local grape varieties, historical vineyards, or eco-friendly wineries. The integration of lesser-known wine regions, such as Crișana and Banat, into these routes would help distribute visitor traffic and stimulate rural development while increasing their popularity at the same time. Collaborating with local businesses along the routes—such as traditional restaurants, craft workshops, and historical sites—would also help to create multi-faceted itineraries that cater to a range of interests, from gastronomy enthusiasts to history or nature buffs [14].

Investments in infrastructure, such as improved roads, signage, and accommodations, will be crucial to the success of these routes. Regional and national tourism boards can collaborate with wineries and local authorities to develop maps, guides, and mobile apps that make it easy for tourists to navigate the routes and discover hidden gems.

While international tourists are an important target, Romania's domestic market and neighbouring countries offer significant growth opportunities [3]. With increasing disposable incomes and a rising interest in weekend getaways among Romanian urban residents, domestic wine tourism is on the rise. Many city dwellers from Bucharest, Cluj-Napoca, Iași and Timișoara are already participating in wine festivals, vineyard tours, and wine-tasting events, providing a reliable year-round audience, while neighbouring countries, such as Hungary, Bulgaria, and Ukraine, represent additional markets where competition is less intense compared to established wine destinations in Western Europe. Regional marketing campaigns that promote cross-border travel could attract tourists seeking short-distance, affordable getaways while collaborations with regional travel agencies, combined with promotional events and wine fairs in nearby countries, could help drive regional tourism growth.

d) Threats

Romania faces intense competition from globally renowned wine tourism destinations, such as Tuscany (Italy), Bordeaux (France), and Napa Valley (United States), which have long-established brands, sophisticated

infrastructure, and strong international visibility and benefit from extensive marketing campaigns, high-profile wine festivals, luxury accommodations, and well-developed wine routes. They also have a loyal base of wine tourists, including high-income visitors willing to pay premium prices for curated experiences. Additionally, Romania must compete with other emerging wine tourism destinations from Eastern Europe, such as Hungary and Georgia. Hungary's Tokaj wine region [9], for instance, is internationally recognized for its sweet wines, while Georgia has gained attention for its ancient qvevri winemaking method [29], attracting tourists seeking authentic and historical experiences. These countries have invested in branding and infrastructure, potentially overshadowing Romania's efforts if strategic actions are not taken. To mitigate this threat, Romania needs to strengthen its branding and marketing efforts, emphasizing its unique indigenous grape varieties, rich cultural heritage, and affordability as differentiating factors.

Economic instability, at both the national and global levels, pose a significant threat to Romania's wine tourism sector. Periods of economic downturn can lead to reduced disposable income, limiting tourists' ability to travel and spend on leisure activities such as wine tours and tastings. Domestic tourists, who form a large portion of the market, may prioritize essential spending over discretionary travel during times of financial uncertainty [16]. Moreover, wineries themselves may face financial difficulties in maintaining or expanding their tourism offerings due to rising production costs, inflation, or fluctuating demand while smaller, family-owned wineries, in particular, may struggle to invest in infrastructure improvements or experiential tourism initiatives during economic downturns. Supportive government policies, such as tax incentives or grants tailored to rural tourism development, could play a crucial role in helping wineries navigate periods of economic uncertainty.

Climate change poses a growing threat to viticulture worldwide—and Romania is no exception. Shifts in temperature, changes in rainfall patterns, and more frequent extreme weather events are already affecting grape production. Heatwaves, droughts, and unexpected frosts can lead to lower yields and alter the flavour profile of wines, which could ultimately damage the reputation of established wine regions [15]. Environmental issues like soil erosion and water scarcity add to the challenges, especially if vineyards don't adopt more sustainable farming methods.

To stay resilient, wineries will need to adapt by implementing eco-friendly practices such as diversifying crops, conserving water, and planting grape varieties that can withstand hotter, drier conditions. But this transition shouldn't fall solely on producers. Government involvement—through education programs and financial support for sustainable initiatives—can ease the burden and encourage wider adoption of environmentally responsible practices. Framing sustainability as a key part of Romania's wine tourism identity could also attract eco-conscious travellers, turning an environmental challenge into a strategic advantage for both tourism and the wine industry.

The COVID-19 pandemic has reshaped travel behaviours, with long-lasting effects on international tourism because although global travel has gradually recovered, lingering uncertainties around health and safety continue to influence tourist preferences [11]. Many travellers are now more cautious, prioritizing destinations that offer robust health protocols, outdoor experiences, and flexible booking options [22]. Given this context, Romania's wine tourism sector, particularly its small and family-run wineries, may struggle to implement the same level of health and safety measures as larger, more established destinations. And without adequate precautions, a segment of tourists may perceive Romania as a less secure travel option compared to destinations with stricter health guidelines and better medical infrastructure. Additionally, the pandemic accelerated the demand for digital and contactless services, including virtual tours and online wine tastings for which Romanian wineries fail to adapt. Failing to implement these new expectations risk losing potential visitors to competitors that offer more tech-savvy solutions.

While Romania currently faces the challenge of low visibility, over-tourism could become a threat if the sector grows rapidly without proper planning. Over-tourism can occur when large numbers of tourists overwhelm local communities, leading to environmental degradation, overcrowding, and a diminished visitor experience [25]. In rural wine regions, over-tourism could strain an already feeble infrastructure, disrupt local life, and contribute to the loss of authenticity, which is a key attraction for wine tourists. In extreme cases, wineries may shift their focus from quality wine production to mass tourism, potentially compromising the integrity of their products and the overall tourist experience. Additionally, the commercialization of cultural elements, such as hand-made objects, traditional festivals or folk performances, could result in their dilution, reducing their appeal to tourists seeking genuine cultural interactions.

To avoid over-tourism, Romania must adopt sustainable tourism development practices, such as visitor caps, zoning regulations, community engagement initiatives, promoting lesser-known wine regions, and distributing tourist traffic more evenly. These actions could help alleviate pressure on popular areas but active collaborative planning among wineries, local authorities, and tourism boards will be crucial to maintaining a balance between growth and sustainability.

CONCLUSIONS

The SWOT analysis of the Romanian wine tourism sector we performed in this current paper highlights its significant potential for growth, driven by its rich cultural heritage, diverse wine regions, and increasing domestic interest in wine tourism. However, several structural and promotional challenges hinder its ability to efficiently compete with more established wine destinations like Tuscany and Bordeaux. To address its challenges and fully capitalize on its opportunities, Romania needs an inter-disciplinary strategy that includes infrastructure improvements, marketing enhancements, and sustainable development initiatives.

First and foremost, Romania needs to address its infrastructure deficiencies. Upgrading road networks in major wine regions to improve accessibility for both domestic and international tourists, enhancing accommodations near wineries by encouraging investments in thematic hotels, eco-lodges, and vineyard stays, or developing better transportation options, such as shuttle services between major cities and wine regions, to facilitate visits would be highly beneficial. Enhancing local infrastructure and accessibility to wineries is a key first step on the route to enhancing sector performance and productivity.

Strengthening international visibility and branding would also be highly beneficial, especially through creating a national branding strategy that highlights Romania's unique wines, indigenous grape varieties, and affordability. This can be done by launching targeted digital marketing campaigns through social media, travel influencers, and international wine publications, participating in global wine tourism fairs and events to promote Romanian wine tourism to an international audience and why not, even out-of-the-box guerrilla marketing campaigns.

To keep up with the international competitors, Romania needs to focus on building high-demand experiences in local wineries. The country as a whole need to expand its experiential offerings such as grape-picking festivals, wine-blending workshops, and traditional food and wine pairing while at the same time integrating cultural and historical elements into wine tours, including visits to historical sites, folk performances, and storytelling. National government programs need to fund projects that encourage wineries to offer personalized experiences like private tours, exclusive tastings, and luxury vineyard stays so that we could cater not only to deal-seeking tourists but also high-end luxury travellers.

Getting all stakeholders at the same table when building the strategies is essential because only through partnerships and collaboration the sector will be able to thrive.

Strengthening of the partnerships can be fruitfully done by establishing regional wine

tourism associations to improve coordination between wineries, local governments, and tour operators, by developing cohesive wine tourism routes linking wineries with cultural landmarks and gastronomy experiences or by facilitating meetings to gather local businesses together that could eventually complement each other.

Promoting Romania as an eco-friendly destination for wine lovers can bank on global sustainability trends while genuinely having a positive impact on the environment. By encouraging sustainable winemaking practices, such as organic farming, water conservation, and biodiversity protection and by developing eco-tourism programs, (including vineyard cycling tours and farm-to-table experiences) wineries can gain a competitive advantage while at the same time making a positive change around them.

Last but not least, no progress can be made without legislative and administrative support. The government needs to simplify regulatory and bureaucratic procedures for wineries and tourism operators to encourage investment and innovation, to provide financial incentives for wineries adopting sustainable practices and investing in tourism infrastructure and to develop national policies that position wine tourism as a key driver of rural economic development.

By implementing this type of development strategies, Romania could transform its wine tourism sector into a globally recognized and competitive industry. A strategic approach that focuses on infrastructure, branding, experience diversification, collaboration, sustainability, and policy support will ensure long-term success while preserving Romania's unique wine heritage.

REFERENCES

[1]Bucur, G. M., Matei, G., 2023, Opportunities for Ensuring the Profitability of a Small Winemaking Holding in Romania. Scientific Papers, Series B, Horticulture, Vol. LXVII(2), 216-223.

[2]Chiurciu, I.-A., Zaharia, I., Soare, E., 2021, Romanian Wine Market and Traditions. Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 21(2), 157-168.

[3]Comănescu, L., 2017, SWOT Analysis of the Romanian Tourism Market Component of the Marketing Plan. Annals of 'Ovidius' University of Constanța, 2, 193–202. https://stec.univ-ovidius.ro/html/anale/RO/2017-2/Section%20IV/23.pdf, Accessed on January 5, 2025.

[4]Consortio Italia del Vino, www.consorzioitaliadelvino.it/en/, Accessed on 24 February 2025.

[5]Crame Romania.ro, 2025, https://www.crameromania.ro/en/regions, Accessed on 24 February 2025.

[6]Crama Telna, 2024, www.cramatelna.ro/, Accessed on 24 February 2025.

[7]Domeniile Samburesti, www.samburesti.com/istoric/, Accessed on 24 February 2025.

[8]Drink Insider, 2020, Analiză Drink Insider: Cum a scos Nicolae Ceaușescu România de pe harta mondială a vinului, https://hotnews.ro/analiza-drink-insider-cum-a-scos-nicolae-ceausescu-romnia-de-pe-harta-mondiala-a-vinului-240005, Accessed on January 5, 2025.

[9]Ercsey, D., Tokaj wine district, www.winesofhungary.hu/wine-tourism/tokaj-wine-district, Accessed on 24 February 2025.

[10]French Wine Adventures, Multi Day Tours, Multi-day wine tours France: Gourmet food and wine-tasting, www.frenchwineadventures.com/multi-day-tours/, Accessed on 24 February 2025.

[11]García-Madurga, M.-Á., Esteban-Navarro, M.-Á., Morte-Nadal, T., 2021, CoVid Key Figures and New Challenges in the HoReCa Sector: The Way towards a New Supply-Chain. Sustainability, 13(12), 6884. https://doi.org/10.3390/su13126884

[12]Gómez-Carmona, D., Paramio, A., Cruces-Montes, S., Marín-Dueñas, P. P., Montero, A. A., Romero-Moreno, A., 2023, The effect of the wine tourism experience. Journal of Destination Marketing & Management, 29, 100793. https://doi.org/10.1016/j.jdmm.2023.100793

[13]Gonda, T., 2024, The Importance of Infrastructure in the Development of Accessible Tourism. Journal of Infrastructure, Policy and Development, 8(2), 2735. https://doi.org/10.24294/jipd.v8i2.2735

[14]Gurgu, A.-E., 2021, Development of Wine Sector – A Way to Sustain Wine Tourism in Romania. Cactus Tourism Journal, 3(1), 46–55. https://doi.org/10.24818/CTS/3/2021/1.05

[15]Jones, G.V., White, M.A., Cooper, O.R., Storchmann, K., 2005, Climate Change and Global Wine Quality. Climatic Change, 73(3), 319–343. https://doi.org/10.1007/s10584-005-4704-2

[16]Kapiki, S., 2012, The Impact of Economic Crisis on Tourism and Hospitality: Results from a Study in Greece. Central European Review of Economics and Finance, Vol. 2(1), 19-30.

[17]Lădaru, R. G., Beciu, S., 2014, Marketing Research On Wine Consumers Preferences In Romania. Scientific Papers. Series "Management, Economic Engineering in

Agriculture and Rural Development", Vol. 14(3), 127-130.
[18]Ministry of Agriculture and Rural Development, MADR., 2024, Order no.253/21.06.2024 - regarding the approval of the Official Catalogue of the plant varieties in Romania for the year 2024. https://istis.ro/wp-content/uploads/2024/07/ISTIS-CATALOG-OFICIAL-2024.pdf, Accessed on 24 February 2025.
[19]Ministry of Agriculture and Rural Development, MADR, Horticulture, Viticulture, www.madr.ro/en/horticulture/viticulture-enology/, Accessed on 24 February 2025.
[20]Monitorul Oficial., Official Gazette, 2017, Decision no. 558 04/08/2017, https://legislatie.just.ro/Public/DetaliiDocument/192301, Accessed on 24 February 2025.
[21]Nedelcu, A., 2014, Wine Tourism in Romania: Case Study: Dealu Mare Vineyard. International Journal of Sustainable Economies Management (IJSEM), 3(2), 16-26. https://doi.org/10.4018/ijsem.2014040102
[22]OIV, 2022, State of The World Vine and Wine Sector. https://www.oiv.int/what-we-do/statistics, Accessed on 24 February 2025.
[23]OIV, 2021, Focus OIV The World Organic Vineyard. https://www.oiv.int/sites/default/files/2022-09/en-focus-the-world-organic-vineyard.pdf, Accessed on 24 February 2025.
[24]Oltean, F. D., Gabor, M. R., 2022, Wine Tourism—A Sustainable Management Tool for Rural Development and Vineyards: Cross-Cultural Analysis of the Consumer Profile from Romania and Moldova. Agriculture, 12(10), 1614. https://doi.org/10.3390/agriculture12101614
[25]Popescu, A., Tindeche, C., Mărcuță, A., Mărcuță, L., Hontus, A., Stanciu, M., 2023, Overtourism in the Most Visited European City and Village Destinations. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 23(3), 718-737.
[26]Santos, V.R., Ramos, P., Almeida, N. and Santos-Pavón, E., 2019, Wine and wine tourism experience: a theoretical and conceptual review, Worldwide Hospitality and Tourism Themes, Vol. 11(6), 718-730. https://doi.org/10.1108/WHATT-09-2019-0053
[27]Strabo, 1933, The geography of Strabo , translated by William Heinemann; New York: G. P. Putnam's Sons, http://data.perseus.org/citations/urn:cts:greekLit:tlg0099.tlg001.perseus-eng2:7.3, Accessed on 5 February, 2025.
[28]Tănase, M. O., Dina, R., Isac, F.-L., Rusu, S., Nistoreanu, P., Mirea, C. N., 2022, Romanian Wine Tourism—A Paved Road or a Footpath in Rural Tourism?. Sustainability, 14(7), 4026. https://doi.org/10.3390/su14074026
[29]UNESCO, 2012, Ancient Georgian traditional Qvevri wine-making method. https://ich.unesco.org/en/RL/ancient-georgian-traditional-qvevri-wine-making-method-00870, Accessed on 24 February 2025.
[30]Vin de France, www.vindefrance.com/wines/pro/anivin-de-france, Accessed on 24 February 2025.
[31]Vîlcea, C., Licurici, M., Popescu, L., 2024, The Role of Websites in Promoting Wine Tourism: An Evaluation of Romanian Wineries. Sustainability, 16(15), 6336. https://doi.org/10.3390/su16156336
[32]WINET, 2020, Studiu privind sectorul vitivinicol din Regiunea Sud-Est, România. https://blacksea-cbc.net/wp-content/uploads/2020/02/BSB638_WINET_Study-on-the-wine-sector-in-the-South-East-region-of-Romania_RO.pdf, Accessed on 24 February 2025.
[33]Wine Industry, Excursions and Events, www.winedustry.ro/excursii-si-evenimente/, drumul-viilor-dealu-mare-2024-excursie-de-două-zile.html Accessed on 24 February 2025.
[34]WoR. 2023, December 19, Romanian wines win over 500 international medals in 2023. https://winesofromania.com/en/romanian-wines-win-over-500-medals-2023/, Accessed on 24 February 2025.

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A DIFFERENTIATED RURAL SETTLEMENT FRAMEWORK FOR LOCAL ECONOMIC DEVELOPMENT RESILIENCE IN RURAL GHANA

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Abstract

Globally, one in every ten rural village indicates a low level of economic growth. The condition is no different in Ghana, which continues to face significant developmental challenges, particularly regarding low socio-economic status of rural community. Local Economic Development (LED) is crucial for promoting sustainable growth, improving livelihoods and reducing poverty in rural Ghana. This paper examines the determinants of LED resilience across agricultural, mining, fishing and forest-based settlements, proposing an integrated framework tailored to each settlement type. Drawing on multiple theoretical perspectives, this study identifies key factors influencing LED resilience: Social, Human, Economic, Cultural, and Environmental resilience. A mixed-methods approach involving surveys, interviews, and focus groups discussions (FGDs) was utilized to gather data from diverse rural Ghanaian communities. Findings indicate that social cohesion, human capital development, and cultural preservation are essential for LED resilience, with distinctive dynamics specific to each settlement type. This study advances existing literature by offering a differentiated framework specific to agricultural, mining, fishing, and forest-based rural settlements in Ghana and presents practical recommendations for implementing localized strategies to foster inclusive economic growth.

Key words**:** *local economic development, rural planning, rural economy, rural development*

INTRODUCTION

Local Economic Development (LED) fosters sustainable growth, improves livelihoods, and reduces poverty in rural Ghana. Rural settlements in Ghana, which include agricultural, mining, fishing, and forest-based communities, face unique challenges and opportunities [1, 25, 26]. These communities are constrained by limited infrastructure, inadequate access to markets, and insufficient social services, all of which hinder resilient economic growth [2, 10, 23, 28]. Despite extensive research into individual determinants of LED, an integrated, context-specific approach tailored to distinct rural settlement types remains underexplored. Addressing this gap, this paper aim to examine key determinants of LED resilience across different settlement types namely agricultural, mining, fishing and forest-based settlements and proposing an integrated framework tailored to each settlement type for promoting sustainable economic development. This study provides a unique framework for assessing Local Economic Development (LED) resilience across different rural settlement types in Ghana, filling a gap by focusing on the specific needs of each type. It combines multiple theoretical perspectives and a mixed-methods approach to offer practical, locally relevant strategies for enhancing economic resilience in Ghana.

Literature review

Theoretical Perspectives on Local Economic Development Resilience

Local Economic Development (LED) resilience in rural Ghana is influenced by a complex interplay of factors that vary by settlement type. The theoretical basis for understanding LED resilience includes Endogenous Growth Theory, the Resource-Based View (RBV), the Livelihood Concept, and Institutional Theory. These theories provide a comprehensive framework for analysing the factors that contribute to LED resilience and have been extensively applied in studies across different geographical contexts.

Endogenous Growth Theory emphasizes the importance of human capital, infrastructure, and innovation as primary drivers of economic growth. Investments in education, skills

development, and infrastructure are crucial for fostering economic resilience, particularly in rural settlements [1, 4, 5, 8, 23, 27]. For instance, targeted investment in rural education and infrastructure in China significantly enhanced the adaptive capacity of local economies, underscoring the universal applicability of this theory [28]. This paper builds on Zhou's findings by applying similar concepts to rural Ghana and adapting them to different types of rural economies, such as agricultural, mining, and fishing settlements [28].

The Resource-Based View (RBV) highlights the role of local resources in building a sustainable competitive advantage. In the context of rural Ghana, natural, social, cultural, and environmental assets are essential to LED resilience. Previous studies in Malaysia [14, 15, 16, 18, 19] and Romania [10] have emphasized leveraging these local resources for sustainable growth. That rural communities that leveraged their natural and cultural assets experienced improved economic resilience [13, 23]. This paper extends RBV to the Ghanaian context, examining how agricultural communities utilize fertile land, mining settlements extract mineral resources, and fishing communities capitalize on marine assets for LED resilience.

The Livelihood Concept by Ian Scoones (1998) takes a holistic approach to rural development, recognizing the interconnection of different types of capital—human, social, natural, financial, and physical—that support livelihoods [12]. Scoones (1998) highlighted the need for diversified livelihood strategies to enhance resilience against economic shocks [21]. Recent studies in sub-Saharan Africa [1, 17, 25, 26] have shown that integrating multiple forms of capital such as human and social capital enhances livelihood resilience in rural communities. In this study, we apply Scoones' framework to rural Ghana, focusing on how diverse livelihood strategies can strengthen the resilience of different types of rural settlements.

Institutional Theory emphasizes the importance of governance structures, community participation, and supportive policy frameworks in fostering LED. Institutions play a crucial role in shaping economic performance by defining the rules that govern local economies [9, 11, 25]. This theory has been applied in several studies, such as [8], who highlighted the role of local institutions in building community resilience in rural Sweden. This paper expands on these ideas by examining how effective governance and community participation in Ghanaian rural settlements contribute to LED resilience, ensuring equitable benefits from economic activities and fostering community trust [25].

In comparing rural economic resilience across different regions, studies such as China [28], Malaysia [18, 19], Ghana [1], Romania [10], and Sweden [8] highlight that LED resilience is significantly influenced by local contexts, including resource availability, governance, and socio-cultural factors. By comparing these international contexts with Ghana, this paper seeks to provide a broader understanding of how various determinants shape LED resilience in different settings. This comparative analysis helps to illustrate the generalizability of the findings and emphasizes the importance of contextualizing resilience strategies to fit local conditions. The similarities, such as the importance of community participation and resource leveraging, provide a strong argument for adapting successful strategies from other regions to the Ghanaian context. Conversely, the differences underscore the need for localized solutions that account for specific socio-economic and cultural factors inherent in rural Ghana.

Determinants of Local Economic Development Resilience in Differentiated Rural Settlements

Rural communities in Ghana face persistent challenges in achieving economic resilience and socio-economic sustainability. These challenges significantly affect the ability of rural households to adapt and thrive amidst changing environmental, economic, and social conditions. Understanding the determinants that contribute to enhancing Local Economic Development (LED) resilience is essential for developing effective policies that can foster growth, reduce poverty, and improve livelihoods in rural areas [12, 22, 27]. The

determinants that influence LED resilience are multifaceted and span across social, human, economic, cultural, and environmental domains [6, 20, 24].

Each determinant plays a vital role in shaping the overall resilience and capacity of rural communities to withstand and recover from adversities.

In this context, LED resilience is conceptualized as the ability of rural communities to cope with economic shocks, adapt to changes, and seize new opportunities to ensure sustainable economic development [3, 6, 25].

The concept of resilience in rural Ghana is not just limited to economic growth but also encompasses the capacity to maintain social cohesion, preserve cultural heritage, and sustainably manage natural resources [1, 17, 25, 26]. Therefore, an integrated approach that considers the interaction of multiple resilience factors is crucial for understanding the complexities of rural development. This approach aligns with existing theories, such as the Territorial Innovation Model, which emphasizes the interplay between internal and external factors in shaping rural economic performance [18, 19].

Over the past decade, there has been increasing interest in understanding the disparities in resilience across rural communities. The literature has shown that the capacity of rural communities to respond to economic challenges is not uniform, and it varies significantly depending on local context and resources [2, 7, 10, 18, 23]. This differentiation underscores the importance of identifying key resilience determinants that can enhance LED and contribute to reducing vulnerability in rural Ghana [25, 26].

Table 1 presents the determinants of LED resilience identified in this study, including social, human, economic, cultural, and environmental factors. These determinants and their respective indicators serve as the foundation for assessing the factors that influence LED resilience in rural Ghana.

The identification of these determinants is essential for developing effective interventions to strengthen the resilience of rural communities. By understanding how each determinant contributes to the adaptive capacity of rural households, policymakers can design targeted programs that address specific needs, ultimately promoting sustainable economic development in rural Ghana [1, 25, 26].

Table 1. LED resilience determinants in rural Ghana based on the studied literature

Resilience Determinant	Indicators	References
Social Resilience	Collective Action	[11][19][24]
	Community Membership	[15][18][23]
	Trust & Norms	[2][19][28]
	Social Networks	[10][11][19]
	Partnerships	[11][18]
Human Resilience	Health	[2][13][19]
	Education	[2][18][26]
	Skills	[2][18]
	Leadership	[11][18][28]
	Technological Application	[11][12][19]
Economic Resilience	Occupation & Income	[8][10][18]
	Entrepreneurship	[9][14][19]
	Economic Diversification	[3][5][8][10][15][18]
	Household Employment	[16][18]
	Agriculture Dependency	[7][19][20][22]
	Access to Market	[10][18]
	Government Assistance	[6][18][26]
	Family Remittance	[13][14][18][25]
	Innovation	[11][12][19]
	Asset & Property Ownership	[8][13][18]
	Financial Management	[8][10][15][18]
Cultural Resilience	Attitudes	[14][17][18]
	Religion	[1][14][17][19][23]
	Culture	[1][14][17][18][23]
	Heritage	[17][18][23]
Environmental Resilience	Natural Environment	[4][13][19]
	Climate Change	[4][13][19]
	Soil Fertility	[3][18][20][22]
	Environmental Quality	[4][18][27]
	Accessibility to Facilities	[9][18]
	Location	[18][25]

Source: Own structured ideas based on the studied literature.

Rural Settlement Types in Ghana

Agricultural-based settlements rely primarily on farming and livestock, with resilience driven by sustainable farming practices, market integration, and education on modern agricultural techniques. Collective action through cooperatives and sustainable land use practices plays crucial roles in enhancing social and environmental resilience [11, 19].

Mining-based settlements depend on mineral extraction, facing vulnerabilities related to resource depletion and market fluctuations. Economic resilience in these settlements is shaped by income derived from mining, while human resilience focuses on health interventions and skills development for alternative livelihoods [3, 10].

Environmental resilience is also critical, requiring effective reclamation and sustainable management of the mining areas [4, 13].

Fishing-based settlements rely on fishing and related activities, with resilience influenced by sustainable fishing practices, market access, infrastructure like cold storage, and education on modern fishing techniques [2]. Strong community networks enhance social resilience, while environmental resilience focuses on tackling overfishing and pollution challenges [10, 24].

Forest-based and historical settlements are characterized by their cultural heritage and reliance on forest resources.

Cultural resilience in these communities supports eco-tourism and traditional crafts, while economic resilience is promoted through non-timber forest products, such as handicrafts and beekeeping [14]. Environmental and social resilience are strengthened through sustainable forest use and community participation in conservation efforts [13].

Table 2. Resilience determinants across settlement types

Resilience Determinant	Analysis	Type of Settlement			
		Agricultural	Mining	Fishing	Forest-Based
Social Resilience	Mean	4.1	3.5	4.0	4.3
	SD*	0.7	0.9	0.8	0.6
Economic Resilience	Mean	3.8	3.2	3.6	3.9
	SD*	0.8	1.1	0.9	0.7
Environmental Resilience	Mean	3.9	2.8	3.5	4.2
	SD*	0.6	1.2	0.8	0.5
Cultural Resilience	Mean	3.5	3.1	3.7	4.5
	SD*	1.0	0.8	0.9	0.4
Human Resilience	Mean	3.9	3.4	3.8	4.1
	SD*	0.7	0.9	0.8	0.7

Note: SD (Standard Deviation).
Source: Authors' analysis of primary survey data.

Table 2 shows that forest-based settlements consistently demonstrate higher resilience scores across social, economic, environmental, cultural, and human dimensions compared to other settlement types, with particularly strong performance in cultural and environmental resilience.

Mining settlements, on the other hand, generally have the lowest mean scores for resilience determinants and higher variability, indicating significant challenges in social cohesion, economic diversification, and environmental sustainability.

Agricultural and fishing settlements fall between these two extremes, with relatively balanced scores, though agricultural settlements slightly outperform in areas such as social and economic resilience.

These findings highlight the distinct strengths and weaknesses of each settlement type, emphasizing the need for targeted interventions to address specific challenges in mining and other lower-scoring communities.

MATERIALS AND METHODS

This study employed a mixed-methods research design, combining both quantitative and qualitative approaches to investigate the factors influencing Local Economic Development (LED) resilience in rural communities in Ghana.

The mixed-methods approach was selected to provide a comprehensive understanding of LED resilience by integrating numerical data with in-depth insights from community members, thereby enhancing the depth and reliability of the findings.

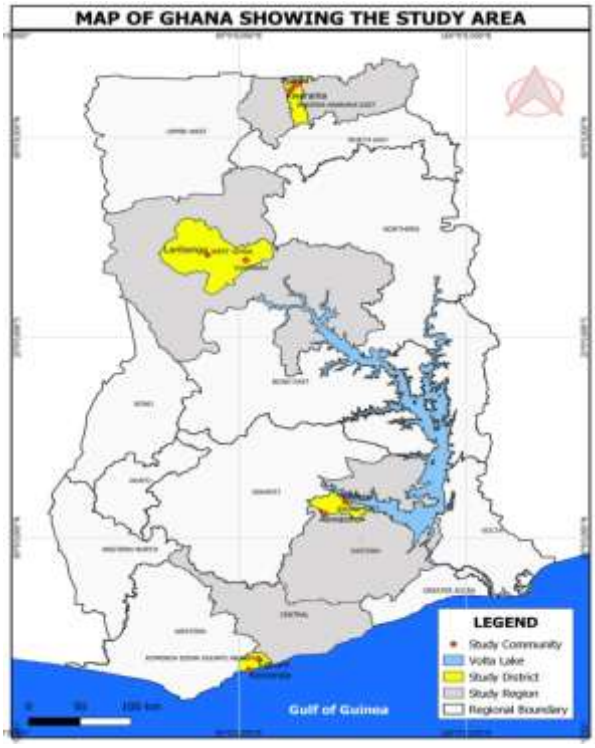

Fig. 1. Location of eight rural settlements in four different regions in Ghana
Source: [25].

The study was conducted across four regions (Figure 1): Upper East (Kassena Nankana Municipality), Eastern (Kwahu East District), Central (Komenda-Edina-Eguafo-Abirem Municipality), and Savannah (West Gonja Municipality).

These regions were chosen to ensure comprehensive representation of diverse rural settlement types, encompassing a variety of geographical, cultural, and economic characteristics. This diversity allows for a broader generalization of the findings to rural settlements across Ghana.

A stratified random sampling method was used to select two communities from each region, resulting in the inclusion of eight communities: Komenda, Eguafo, Pungu, Korania, Akwasiho, Kotoso, Busunu, and Laribanga. Stratified random sampling was chosen to ensure that the sample represented different settlement types (agricultural, mining, fishing, and forest-based) and to minimize bias by ensuring that all subgroups within the population were adequately represented.

This method provides a more precise estimate of the population parameters compared to simple random sampling, especially when dealing with heterogeneous populations.

The research sample consisted of 377 participants, calculated using Cochran's formula for sample size determination to ensure statistical power and representativeness. The stratification helped achieve a balanced representation of demographic and economic characteristics across the selected communities, enhancing the credibility of the findings.

Data were collected using structured surveys, interviews, and FGDs. The structured questionnaire gathered data on household income, education, market access, credit availability, and other factors. The questionnaire was pretested with a small group similar to the target population to ensure clarity, reliability, and relevance. Cronbach's alpha was calculated to assess the internal consistency of the questionnaire items, with a value of 0.80 indicating good reliability. Revisions were made based on the pretesting feedback to improve the quality of the data collection instrument.

Qualitative data were gathered through in-depth interviews with key stakeholders, including local government officials, community leaders, and business owners. A semi-structured interview guide was used to ensure consistency while allowing participants to elaborate on their experiences and perspectives. To validate the qualitative findings, member checking was conducted, where participants reviewed and confirmed the accuracy of the interview transcripts. FGDs were also conducted to explore community dynamics affecting LED resilience, with participants selected to ensure diversity in age, gender, and economic activities. The discussions were facilitated by experienced moderators, and ethical considerations, such as informed consent and confidentiality, were strictly observed. Quantitative data were analysed using both descriptive and inferential statistical methods. Descriptive statistics summarized demographic characteristics, while inferential methods, including regression analysis and chi-square tests, were used to assess the relationships between LED resilience and various independent variables. Factor analysis was employed to identify underlying determinants contributing to LED resilience across rural communities. The hypotheses formulated for this study were tested using ordinal logistic regression, with a significance level of 0.05 set as the threshold for hypothesis acceptance or rejection. This approach allowed for an assessment of the impact of multiple resilience factors (social, human, economic, cultural, and environmental) on LED outcomes. For qualitative data, thematic analysis was conducted to identify patterns and themes emerging from interviews and FGDs. Thematic coding was carried out independently by two researchers to ensure inter-coder reliability, and discrepancies were discussed and resolved to reach consensus. This analysis provided a nuanced understanding of LED resilience, offering insights into the contextual realities of the communities studied. The mixed-methods approach facilitated triangulation, enhancing the validity and reliability of the findings by cross-verifying data from multiple sources.

The reliability and validity of the data collection methods were ensured through several measures. For the quantitative component, Cronbach's alpha was used to assess the reliability of the questionnaire items, with a value above 0.70 indicating acceptable internal consistency. Construct validity was addressed by aligning the questionnaire items with established theoretical constructs related to LED resilience. For qualitative data, validity was ensured through member checking and peer debriefing, where another researcher reviewed the analysis process and findings to ensure they accurately represented the data.

Demographic Characteristics of Study Participants

Table 3 presents the demographic characteristics of the study participants, including age, gender, education level, average farm income, and household size. The age group with the highest representation was 41-50 years, followed by 31-40 years. Participants were predominantly male (74.8%), with educational attainment ranging from no formal education to undergraduate degrees. Most participants (60.4%) had household sizes of five or fewer members, and the majority reported an average farm income between GHS10,001 and GHS15,000.

Table 3. Demographic information

Characteristics	N	Percentage (%)
Age (years)		
26-30	42	11.1
31-40	87	23.1
41-50	184	48.8
Above 50	64	17.0
Gender		
Female	95	25.2
Male	282	74.8
Education Level		
None	102	27.1
Primary	98	26.0
Junior High School	107	28.4
Senior High School	41	10.9
Diploma	12	3.2
Undergraduate Degree	17	4.5
Average Annual Income (GHS)		
1,001-5,000	18	4.8
5,001-10,000	61	16.2
10,001-15,000	143	38.0
More than 15,000	154	41.0
Household Size (Number of people)		
<5	228	60.4
5-10	119	31.5
11-15	30	7.9

Source: Primary survey data collected during the study.

Understanding these demographic characteristics is crucial for interpreting the factors influencing LED resilience in rural Ghana. The classification of communities by settlement type provides insights into their economic characteristics, which is essential for understanding the unique LED dynamics within each community.

RESULTS AND DISCUSSIONS

Factor Analysis

Factor analysis was conducted to determine the underlying dimensions among variables related to Local Economic Development (LED) resilience. This analysis aimed to identify key latent constructs namely Social Resilience, Human Resilience, Economic Resilience, Cultural Resilience, and Environmental Resilience that contribute to LED resilience. The results, summarized in Table 4, provide insights into the relationships and variances explained by each factor.

Table 4. Results of factor analysis

Factor Name	Variables	Factor Loading	% of Variance Explained	Cronbach's Alpha
Local Economic Development	LED1 LED2 LED3	0.791-0.871	67.576%	0.757
Social Resilience	SR1 SR2 SR3 SR4	0.731-0.914	78.215%	0.833
Human Resilience	HR1 HR2 HR3 HR4	0.816-0.939	75.473%	0.836
Economic Resilience	ER1 ER2 ER3	0.744-0.971	81.601%	0.885
Cultural Resilience	CR1 CR2 CR3	0.791-0.972	81.722%	0.886
Environmental Resilience	ENR1 ENR2 ENR3	0.526-0.914	63.552%	0.883

Source: Factor analysis results computed from the survey data.

Each determinant showed distinct loadings, indicating that the variables were grouped well into meaningful factors. Cronbach's alpha values, ranging from 0.757 to 0.886, indicated an adequate level of internal consistency for each factor. Specifically, all factors exceeded the commonly accepted threshold of 0.7, demonstrating high reliability. The Kaiser-

Meyer-Olkin (KMO) values ranged from 0.667 to 0.746, suggesting adequate sampling adequacy, while Bartlett's test of sphericity was significant ($p < 0.001$), confirming that the dataset was suitable for factor analysis.

The factor analysis identified five resilience dimensions that account for a substantial proportion of variance in LED resilience: Social, Human, Economic, Cultural, and Environmental. This comprehensive approach ensures that the constructs used in the study are representative and suitable for regression analysis.

Regression Analysis and Robustness Checks

To assess the impact of the identified resilience factors on LED, an ordinal logistic regression model was employed. The ordinal nature of the dependent variable (LED) made this model appropriate for examining the relationship between LED and independent variables such as Social Resilience, Human Resilience, Economic Resilience, Cultural Resilience, and Environmental Resilience.The ordinal logistic regression model used is represented as follows:

logit(P(LED≤k)=αk+β1SR+β2HR+β3ER+β4 CR+β5ENR+εαk+β1SR+β2HR+β3ER+β4 CR+β5ENR+ε….......................................(1)

where:

-logit(P(LED≤k) represents the log odds of LED being less than or equal to the threshold category k.

-αk represents the threshold-specific intercept, capturing differences in the baseline log odds between the threshold categories.

-β1,β2,β3,β4,β5 are the coefficients that indicate the effects of Social Resilience (SR), Human Resilience (HR), Economic Resilience (ER), Cultural Resilience (CR), and Environmental Resilience (ENR) on LED.

-ε represents the error term.

Assumptions and Diagnostic Checks

To ensure the validity of the regression model, several diagnostic checks were conducted (Table 5, 6, 7):

(1)*Multicollinearity:* Variance Inflation Factors (VIF) were calculated for each independent variable, with all VIF values being below 5, suggesting that multicollinearity was not an issue.

(2)*Normality:* Residuals were evaluated for normality using the Shapiro-Wilk test and Q-Q plots, which confirmed that deviations from normality were within acceptable limits.

(3)*Homoscedasticity*: The Breusch-Pagan test was used to check for homoscedasticity of residuals, and the results indicated no significant heteroscedasticity, validating the model's consistency.

Table 5. Assumptions and diagnostic checks

Assumption	Method Used	Test Statistics / Result	Interpretation
Multicollinearity	Variance Inflation Factor (VIF)	All VIF values < 5	No significant multicollinearity detected; independent variables are not highly correlated.
Normality	Shapiro-Wilk Test and Q-Q Plot	Shapiro-Wilk p-value > 0.05; Q-Q plot close to reference line	Residuals follow an approximately normal distribution, ensuring valid inferential results.
Homoscedasticity	Breusch-Pagan Test	p-value > 0.05	No evidence of heteroscedasticity; residual variance is constant, supporting model consistency.

Source: Diagnostic tests (VIF, Shapiro-Wilk, Breusch-Pagan) performed on the study data.

Table 6. Normality check

Method	Test Statistic / Plot	Result Interpretation
Shapiro-Wilk Test	W = 0.98, p-value = 0.12	Residuals are approximately normal
Q-Q Plot	Residuals closely follow reference line	No substantial deviation from normality

Source: Results from the Shapiro-Wilk test and Q-Q plot analysis conducted by the authors.

The p-value of the Breusch-Pagan test is greater than 0.05, indicating that there is no significant evidence of heteroscedasticity. This means that the residuals have a constant variance, supporting the consistency of the model's predictions.

Table 7. Breusch-Pagan test results

Test Name	Test Statistic	p-value	Interpretation
Breusch-Pagan Test	BP = 5.21	0.18	No heteroscedasticity detected

Source: Authors' statistical analysis using the Breusch-Pagan test.

These diagnostic checks provide confidence that the regression model used in the study is statistically valid and reliable, ensuring that the inferences drawn regarding the impact of Social, Human, Economic, Cultural, and Environmental Resilience on Local Economic Development are robust and dependable.

Robustness Checks

To verify the robustness of the findings, an ordinal probit regression model was applied as an alternative to the ordinal logistic model. This alternative estimation method aimed to validate the reliability of the findings and yielded results consistent with the ordinal logistic regression. However, to further enhance robustness**,** bootstrapping was performed with 1,000 replications to estimate confidence intervals for the regression coefficients. Bootstrapping results confirmed the statistical significance of all five resilience factors, supporting the robustness of the model (Table 8).

Table 8. Robustness checks-bootstrapping

Variable	Coefficient Estimate	Bootstrapped Standard Error	95% Confidence Interval
Social Resilience (SR)	1.779	0.134	[1.520, 2.045]
Human Resilience (HR)	1.655	0.143	[1.379, 1.917]
Economic Resilience (ER)	0.293	0.076	[0.145, 0.441]
Cultural Resilience (CR)	0.975	0.102	[0.775, 1.180]
Environmental Resilience (ENR)	0.189	0.055	[0.081, 0.295]

Source: Bootstrapping analysis with 1,000 replications conducted by the authors.

Overall, Social and Human Resilience have the strongest influence on LED resilience, followed by Cultural, Economic**,** and Environmental Resilience. The bootstrapped confidence intervals confirm the statistical significance of all factors, underscoring their relevance in enhancing LED resilience in rural Ghana.

Regression Results

The results from both the ordinal logistic regression model and the ordinal probit model are summarized in Table 9.

Table 9. Ordinal Logistic and Probit Regression results

Dependent Variable:	Variable	Ordered Logistic Coefficients	Ordered Probit Coefficients
LED Resilience	Human Resilience (HR)	1.655***	0.889***
	Economic Resilience (ER)	0.293***	0.211***
	Social Resilience (SR)	1.779***	0.837***
	Cultural Resilience (CR)	0.975***	0.621***
	Environmental Resilience (ENR)	0.189***	0.476***

Note: ***p<0.001, **p<0.05. The coefficients represent the influence of each independent variable on LED.
Source: Results from the ordinal logistic and ordinal probit regression analyses performed on the study data.

These models examined the impacts of Social, Human, Economic, Cultural, and Environmental Resilience on LED resilience.

Interpretation of Findings

The regression analysis showed that all resilience determinants significantly affect LED resilience. Specifically, Social Resilience (SR), Human Resilience (HR), and Cultural Resilience (CR) had the most substantial positive effects on LED resilience, indicating that enhancing these forms of capital contributes significantly to improving local economic resilience. Economic Resilience (ER) and Environmental Resilience (ENR) also had positive effects, but to a lesser extent. The findings highlight the importance of a multifaceted approach to improving LED resilience in rural Ghanaian communities. The significant positive effects of Social Resilience and Human Resilience align with previous studies that emphasize the role of social cohesion, education, and skills development in fostering local economic stability [2, 11, 18].

Investments in social cohesion, human capital (such as education and skills development), and cultural preservation were identified as key areas for policymakers to focus on to enhance LED resilience. Economic resilience, although significant, was not as influential as social or human resilience, suggesting that local economic development strategies should prioritize community networks, skills development, and cultural assets over purely economic diversification efforts.

LED Resilience Framework in Settlement Types

The comprehensive framework for enhancing Local Economic Development (LED) resilience in rural Ghana focuses on five key determinants: social, human, economic, cultural, and environmental resilience. This integrated approach is aimed at addressing the unique needs of agricultural, mining, fishing, and forest-based settlements in Ghana.

Social resilience is fostered through community cohesion, collective action, and trust-building, which are crucial for enabling local collaboration and reducing economic shocks. Human resilience involves improving health, education, and leadership, empowering

rural communities to enhance productivity and governance capability.

Table 10. LED resilience framework in settlement types

Resilience Determinant	Indicator	Settlement Type Relevance	Targeted Interventions for Enhancing Resilience	Potential Outcomes
Social Resilience	Collective Action	All settlement types	Develop cooperative models, community-based action programs.	Enhanced social cohesion, increased adaptive capacity
	Community Membership	All settlement types	Promote collective identification with local development initiatives.	Strengthened community ties, improved collective efficacy
	Trust & Norms	All settlement types	Facilitate community dialogues, trust-building workshops.	Reduction in transaction costs, increased local participation
	Social Networks	All settlement types, but critical in fishing and mining	Foster inter-community collaboration, cross-sectoral networks.	Improved information flow, collective problem-solving capacity
	Partnerships	All settlement types	Encourage public-private partnerships, NGO collaborations.	Enhanced resource mobilization, diversified funding sources
Human Resilience	Health	Agricultural, Mining, and Fishing Settlements	Improve healthcare accessibility, community health education.	Increased productivity, reduced absenteeism
	Education	All settlement types	Establish rural educational infrastructure, mobile schools.	Human capital enhancement, reduction in youth migration
	Skills	All settlement types	Launch vocational training, skill-specific development programs.	Increased employability, diversified economic opportunities
	Leadership	All settlement types	Leadership development programs for local officials and community heads.	Effective community governance, enhanced initiative mobilization
	Technological Application	Particularly important for Agricultural and Mining settlements	Technological transfer projects, access to digital tools.	Improved efficiency in agricultural and extractive processes
Economic Resilience	Occupation & Income	Agricultural, Mining, Fishing	Create micro-financing opportunities, promote income diversification.	Increased household income, reduced economic vulnerability
	Entrepreneurship	All settlement types	Support start-ups via micro-loans, entrepreneur incubators.	Boost in local enterprise, job creation
	Economic Activity Diversification	Agricultural-based, Mining-based	Offer incentives for alternative livelihood ventures beyond main activity.	Reduced over-reliance on single sector, stability during shocks
	Market Access	Agricultural and Fishing Settlements	Upgrade transport links, establish rural marketplaces.	Enhanced economic integration, higher market prices for produce
	Government Assistance	All settlement types	Design targeted subsidies, social safety nets for vulnerable groups.	Economic safety during shocks, enhanced financial security
	Asset & Property Ownership	Agricultural and Historical Settlements	Formalize land tenure systems, support legal ownership structures.	Economic security, increased investment in land improvement
Cultural Resilience	Attitudes	Forest-based and Historical Settlements	Conduct awareness programs that enhance collective cultural identity.	Cultural continuity, enhanced community pride
	Religion	Agricultural, Fishing, and Historical Settlements	Engage religious leaders in community-led programs.	Foster moral accountability, enhanced mobilization capacity
	Heritage	Forest-based and Historical Settlements	Promote eco-tourism, heritage site preservation.	Revenue from cultural tourism, enhanced cultural conservation
Environmental Resilience	Climate Change Adaptation	Agricultural and Mining Settlements	Develop local climate resilience action plans, adaptation funds.	Reduced climate vulnerability, sustainable resource use
	Natural Disasters	All settlement types	Community disaster preparedness training, risk management frameworks.	Improved readiness, reduced disaster impact
	Soil Fertility	Agricultural-based Settlements	Implement organic farming techniques, soil conservation practices.	Enhanced agricultural yield, long-term soil health
	Environmental Quality	All settlement types	Introduce strict pollution control and local recycling initiatives.	Improved public health, increased land productivity
	Access to Facilities	Fishing and Forest-based Settlements	Develop infrastructure for healthcare, water supply, and education.	Reduced inequality, enhanced standard of living
	Location	All settlement types	Targeted regional infrastructure projects to improve market access and resource allocation.	Increased geographic equity, improved logistics

Source: Adapted from reviewed literature and authors' conceptual framework.

Economic resilience emphasizes income diversification, market access, and asset ownership, promoting financial stability and reducing vulnerabilities in local economies.

Cultural resilience focuses on heritage conservation and community engagement, ensuring the preservation of traditions while supporting economic activities like tourism.

Environmental resilience addresses climate adaptation, disaster management, and environmental conservation, aiming to sustain natural resources critical to rural livelihoods.

The framework promotes an integrated approach where social, human, economic, cultural, and environmental factors work together to strengthen rural community resilience. The goal is to enhance rural

livelihoods, reduce vulnerability to shocks, and promote sustainable, inclusive growth across diverse rural settlement types in Ghana (Table 10).

The findings reveal that Social Resilience (e.g., community cohesion, collective action), Human Resilience (e.g., education, skills, health), and Cultural Resilience (e.g., cultural heritage preservation) have the most significant impact on LED. Social resilience was highlighted as a critical factor, emphasizing the importance of community collaboration in overcoming economic shocks. Human resilience, particularly through education and skills development, is essential for adaptability and productivity enhancement. Economic Resilience (e.g., income diversification, asset ownership) and Environmental Resilience (e.g., sustainable practices, environmental quality) also contribute but have a comparatively lower impact.

The study underscores the need for a multifaceted approach that integrates these resilience factors. For instance, policies should prioritize human capital enhancement, community networks, and sustainable environmental practices to strengthen LED resilience across all settlement types. The findings suggest that relying solely on economic diversification without addressing social and human resilience may not yield sustainable outcomes.

Comparative Analysis of Resilience Determinants

Table 11 indicates statistically significant differences in social, economic, environmental, and cultural resilience ($p < 0.05$), with respective F-values suggesting variations across these domains. However, human resilience did not show a statistically significant difference, with a p-value of 0.342.

Table 11. Comparative analysis of LED resilience determinants

Resilience Determinant	F-Value	p-Value	Significant Difference ($p < 0.05$)
Social Resilience	3.56	0.018	Yes
Economic Resilience	4.21	0.012	Yes
Environmental Resilience	5.09	0.005	Yes
Cultural Resilience	2.87	0.039	Yes
Human Resilience	1.12	0.342	No

Source: Authors' statistical analysis comparing resilience determinants across settlement types.

This implies that while certain resilience determinants differ meaningfully across settlement types, the human resilience factor may have common characteristics across these communities. These results underscore the necessity of tailored resilience-building strategies that consider unique differences across settlement types for factors such as economic and environmental resilience.

CONCLUSIONS

To enhance LED resilience in rural Ghana, policymakers must adopt an integrated approach tailored to the unique characteristics of each settlement type. Strengthening social cohesion, investing in education and health, promoting economic diversification, preserving cultural heritage, and implementing sustainable environmental practices are all critical to supporting LED resilience. Specific interventions, such as vocational training centers for skill development, cooperative models for community engagement, and climate adaptation funds, can help rural communities adapt to economic shocks and foster inclusive growth.

Detailed policy recommendations for each settlement type include:

(i)Agricultural-Based Rural Settlements: Establish vocational training centers focused on modern agricultural techniques and sustainable farming practices. Provide subsidies for agricultural inputs and promote cooperatives to enhance collective bargaining power and improve market access.

(ii)Mining-Based Rural Settlements: Implement community health programs to address occupational hazards and promote alternative livelihood programs to reduce dependency on mining activities. Develop local governance structures to manage revenue from mining operations transparently, ensuring equitable distribution of benefits.

(iii)Fishing-Based Rural Settlements: Introduce sustainable fishing practices and provide training on fish processing and value addition. Establish cooperatives to facilitate access to credit and market linkages and invest in infrastructure such as cold storage facilities to reduce post-harvest losses.

(iv)Forest-Based/Historical Rural Settlements: Promote eco-tourism and cultural heritage preservation by providing training on hospitality and tourism management. Support initiatives that protect forest resources while creating alternative income opportunities, such as beekeeping or handicraft production, to reduce dependence on forest exploitation.

The findings of this study aligned with several United Nations Sustainable Development Goals (SDGs), enhancing its global relevance. Specifically, the proposed LED resilience framework contributes to SDG 1 (No Poverty) by promoting income diversification, SDG 8 (Decent Work and Economic Growth) through skills development, and SDG 11 (Sustainable Cities and Communities) by preserving cultural heritage. Furthermore, the focus on environmental resilience and climate adaptation supports SDG 13 (Climate Action), offering a holistic approach to enhancing sustainable development in rural Ghana while addressing global sustainability challenges.

REFERENCES

[1]Antwi, E. K., Otsuki, K., Osamu, S., Obeng, F. K., Gyekye, K. A., Boakye-Danquah, J., Takeuchi, K., 2014, Developing a Community-Based Resilience Assessment Model with Reference to Northern Ghana. IDRiM Journal, 4(1): 73-92.

[2]Benhabib, J., Spiegel, M. M., 1994, The Role of Human Capital in Economic Development: Evidence from Aggregate Cross-Country Data. Journal of Monetary Economics, 34(2): 143-173.

[3]Breul, M., Atienza, M., 2022, Extractive Industries and Regional Diversification: A Multidimensional Framework for Diversification in Mining Regions. The Extractive Industries and Society, 11: 101125.

[4]Chirisa, I., Nel, V., 2022, Resilience and Climate Change in Rural Areas: A Review of Infrastructure Policies Across Global Regions. Sustainable and Resilient Infrastructure, 7(5): 380-390.

[5]Cochrane, L., Cafer, A., 2018, Does Diversification Enhance Community Resilience? A Critical Perspective. Resilience, 6(2): 129-143.

[6]Dobre, L., Mocuța, D. N., 2023, The National and International Importance of the Development and Planning of Rural Space - A Vital Pillar of Sustainable Development. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 23(1): 163-169.

[7]Duma Copcea, A., Mihuț, C., Mateoc-Sîrb, N., Niță, L., Okros, A., Lațo, I., Mateoc, T., Popa, D., 2023, Studies on Minimum Wheat Tilling. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 23(2): 217-223.

[8]Folke, C., 2016, Resilience (republished). Ecology and Society, 21(4): 44.

[9]Harvey, D., 1989, From Managerialism to Entrepreneurialism: The Transformation in Urban Governance in Late Capitalism. Geografiska Annaler: Series B, Human Geography, 71(1): 3-17.

[10]Iova, R. A., Crețu, D., Crețu, O. R., 2023, Impact of Rural Development Programs Implementation on the Economic and Social Evolution of the Rural Communities in Călăraşi County, Romania. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 23(2): 325-333.

[11]Jørgensen, A., Fallov, M. A., Casado-Diaz, M., Atkinson, R., 2020, Rural Cohesion: Collective Efficacy and Leadership in the Territorial Governance of Inclusion. Social Inclusion, 8(4): 229-241.

[12]Judijanto, L., Wahab, W., 2024, The Role of Information Technology in Improving Local Economic Resilience. International Journal of Financial Economics, 1(1): 139-150.

[13]Kamarudin, K. H., Rashid, M. F., Chong, N. O., 2022, Local Community Knowledge for Flood Resilience: A Case Study from East Coast Malaysia. International Journal of Built Environment and Sustainability, 9(2): 21-34.

[14]Kamarudin, K. H., Untari, R., Rashid, M. F., 2020, Sustaining Rural Livelihood through Entrepreneurship and Creative Village Development: Malaysia and Indonesia Experience. Scientific Papers: Management, Economic Engineering in Agriculture & Rural Development, 20 (3): 303-309.

[15]Kamarudin, K. H., Rashid, M. F., 2020, Factors for Smallholders Persistence in Rural Malaysia: Evidence from Rice Farming Community in Selangor State. Scientific Papers: Management, Economic Engineering in Agriculture & Rural Development, 20 (1): 261-268.

[16]Kamarudin, K. H., Hassan, A. A. G., Rashid, M. F., 2022, The Socio-Economic Impacts of Movement Control Order on Rural Households during COVID-19 Pandemic in Malaysia. Scientific Papers: Management, Economic Engineering in Agriculture & Rural Development, 22 (4): 295-302.

[17]Njoh, A. J., 2016, Tradition, Culture and Development in Africa: Historical Lessons for Modern Development Planning. Routledge.

[18]Rashid, M. F., Ngah, I., Misnan, S. H., 2019, Framework for Economic Performance of Rural Areas in Malaysia: A Territorial Approach. International Journal of Built Environment and Sustainability, 6(1-2): 1-6.

[19]Rashid, M. F., Ngah, I., Misnan, S. H., 2019. Revitalizing Rural Areas in Malaysia: A Framework for Economic Revitalization. IOP Conference Series: Earth and Environmental Science, 385(1): 012004.

[20]Rosenbaum, P., Smith, A., 2010, Soil Fertility and Its Implications for Local Resilience. Agricultural Sciences Journal, 32(4): 501-514.

[21]Scoones, I., 1998, Sustainable Rural Livelihoods: A Framework for Analysis. Brighton: Institute of Development Studies.
[22]Thampapillai, D., Ruth, M., 2019, Soil Fertility Management and Economic Resilience in Rural Areas. Journal of Environmental Management, 41(3): 123-133.
[23]Thompson, P., Bordelon, B., 2017, Cultural Identity and Economic Resilience: Lessons from Indigenous Communities. Community Development Journal, 52(4): 543-558.
[24]U.S. Department of Commerce, 2016, Community Resilience Planning Guide for Buildings And Infrastructure Systems. National Institute of Standards and Technology.
[25]Vorodam, J. B., Rashid, M. F., Misnan, S. H., 2022, Settlement as a Determinant for Community's Resilience to Local Economic Development in Ghana. IOP Conference Series: Earth and Environmental Science, 1082(1): 012005.
[26]Vorodam, J. B., Rashid, M. F., Misnan, S. H., 2023, Exploring the Multidimensional Determinants of Local Economic Development in Rural Communities in Ghana: A Comparative Analysis. IOP Conference Series: Earth and Environmental Science, 1274(1): 012017.
[27]Young, N., 2016, Responding to Rural Change: Adaptation, Resilience and Community Action. In Routledge International Handbook of Rural Studies. Routledge.
[28]Zhou, Q., Qi, Z., 2023, Urban Economic Resilience and Human Capital: An Exploration of Heterogeneity and Mechanism in the Context of Spatial Population Mobility. Sustainable Cities and Society, 99: 104983.

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ECOTOURISM AND ORGANIC FARMING

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Abstract

Organic farming plays a vital role in supporting rural areas, improving quality of life and contributing to the development of ecotourism. Offering new products with higher quality also has the potential to attract tourists and enhance regional attractiveness. This study aims to explore the relationship between organic farming and ecotourism, focusing on how their interaction can benefit the sustainable development of rural areas. The study focuses on the economic, social and environmental benefits of linking these two sectors, while addressing key challenges such as market access and the need for training in sustainable practices. Analysis in the study allows us to give certain recommendations to strengthen cooperation between farmers and tourism stakeholders, ultimately promoting sustainable growth and expanding economic opportunities for local communities.

Key words**:** *bio-agriculture, ecotourism, sustainable development*

INTRODUCTION

Modern global trends in the development of sustainable economies place increasing emphasis on environmentally friendly practices in agriculture and tourism. Organic production and ecotourism represent two key directions that contribute to the ecological, social and economic sustainability of the regions.

This article examines the interrelationship between these two sectors and their potential for synergistic development.

Ecotourism and organic farming are interconnected fields that promote sustainability and local economies. Ecotourism focuses on responsible travel to natural areas with the goal of protecting the environment and improving the well-being of local communities [39]. The World Ecotourism Conference in Quebec in 2002 accepted that "ecotourism encompasses all forms of tourism focused on nature where the principal motivation is to observe and appreciate nature and traditional cultures living in natural areas" [41].

The International Ecotourism Society [35] defines ecotourism as "ethical travel to natural areas that help the well-being of local people and conserves the environment". Global Biodiversity Protection [34] said that "ecotourism (also known as ecological tourism) is responsible travel to fragile, pristine, and usually protected areas that strive to below impact and (often) small scale".

In Bulgaria, many organizations, such as the Bulgarian Association for Rural and Ecological Tourism [32] and the Bulgarian Association for Alternative Tourism [33], offer their own definitions of ecotourism. Ecotourism encourages local economic development through small-scale entrepreneurial ventures which is helping to boost the socio-economic vitality of local communities and ensures a fair sharing of responsibilities and benefits.

Another important part is the environmental education that is directly related to the sustainable tourism and social responsibility [29].

Ecotourism helps to minimize the environmental impact and contributes to the conservation of natural resources. From the other hand the organic farming is very important for the healthier lifestyle and that includes the next benefits: soil health and biodiversity, lower emissions and pollution, boosts product value by label it as organic [19].

In addition to these benefits, organic agriculture promotes the sustainability of agroecosystems by integrating agronomic, biological and physical-mechanical management methods [5]. It also takes into account local natural conditions, aiming to maintain soil fertility and optimize biological cycles. The regulatory framework in Bulgaria follows EU guidelines and includes specific requirements for organic products controlled by certification bodies.

Impact of organic production on sustainable development

Organic production has a significant impact on the economic, environmental and social aspects of sustainable development. The application of environmentally sound agricultural practices not only improves soil and water quality, but also creates new economic opportunities for small and medium farms [13].

Socially, organic farming promotes the development of local communities by stimulating job creation and supporting traditional agrarian practices. Incorporating ecotourism into organic production also has a positive effect, contributing to the promotion of local crops and ways of life [14].

Both sectors – ecotourism and organic farming – share a common commitment to sustainable practices that contribute to environmental protection. Ecotourism has the potential to increase demand for organic products, thereby stimulating farmers to adopt environmentally friendly production methods [39], [21].

MATERIALS AND METHODS

A number of methods are used in this study such as: statistical analysis, induction, deduction and systematization/classification of data.

A SWOT analysis of bio-production has been made, which provides clarity on the strengths and weaknesses in this field, along with the possible opportunities and risks facing the sector.

In order to support the analysis, data from Eurostat have been utilised to illustrate and highlight the main trends in the organic farming land usage for some countries in EU.

RESULTS AND DISCUSSIONS

Benefits and challenges

Organic farming practices are vital for the environment and give economic stimulation to the local communities. Ecotourism plays an important role in the implementation of organic farming practices by promoting economic leverage, increasing environmental awareness and stimulating the commitment of local communities. The relationship between ecotourism and organic farming manifests itself through various dimensions, but economic motives are among the leading factors. Ecotourism provides farmers with additional sources of income by encouraging them to implement organic practices that are in sync with the principles of sustainable tourism. The integration of ecotourism with agritourism provides farmers with the opportunity to sell organic products directly to consumers, which increases their profitability and strengthens the motivation to switch to organic production methods. Additional income from rural tourism allows farmers to diversify their income, thus reducing their dependence on traditional agriculture and providing greater financial stability. In addition, ecotourism creates new job opportunities in rural areas, which not only strengthens local economies, but also encourages farmers to adopt sustainable organic practices. These practices are key factors because they match the expectations of modern tourists, who often prefer environmentally friendly manufactured products. Organic products often command higher market prices, and ecotourism opens up direct sales opportunities that further increase farmers' economic viability. Thus, ecotourism not only provides financial support for local communities, but also promotes sustainable development by promoting environmentally responsible agricultural practices [29].

Engagement with organic farming within ecotourism plays an important role in preserving local cultures and landscapes by promoting a sense of community and preservation of cultural heritage [29], [21]. The link between ecotourism and organic farming supports environmental care, as tourists often

look for sustainable practices and products that meet their environmental expectations [29].

On the other hand, the application of biological farming techniques, such as those in conservation agriculture, reduces costs and improves soil health, making these methods particularly attractive to farmers seeking to benefit from ecotourism [20]. Promoting ecotourism can also increase farmers' understanding of ecological practices, thereby making them appreciate more the benefits of organic farming and its contribution to the conservation of natural resources [1]. Farmers involved in ecotourism initiatives are often driven by a desire to protect the environment, which is fully consistent with the principles of organic farming [6]. Voluntourism initiatives create additional opportunities for the exchange of knowledge and experience by stimulating a community-oriented approach within organic agriculture [22]. Social pressure and community support play a key role in encouraging farmers to adopt organic farming practices, as highlighted by the Theory of Planned Behavior [17]. In addition, organic farms have the potential to become educational centers, providing visitors with hands-on experience in sustainable farming practices and highlighting the importance of organic farming [21]. Tourists can deepen their understanding of food production processes and environmental protection, making this educational value an essential part of their experience. However, some critics argue that the commercialization of agritourism can lead to a loss of authenticity in the experience, with an over-focus on profit compromising the sustainability of the practices. It is therefore crucial to maintain a balance between economic and environmental objectives to ensure that agritourism initiatives remain true to their ecological roots.

Among the main obstacles are resource management, impact on local ecosystems, limited access to markets and the need for training in sustainable practices. These barriers make it very difficult for rural communities to fully benefit from the synergies between ecotourism and organic farming. Among the main challenges is the uneven distribution of benefits, which may discourage some farmers from adopting organic practices. This inequality of benefits is particularly critical for sustainable rural development and requires careful management to be overcome.

Good practices and innovations in bioproduction

In Europe and many other places around the world, there are a number of successful examples of organic farming that is linked to ecotourism practices that focus on sustainable partnerships and the active participation of local communities. The key aspects include three main elements: sustainable partnerships, community engagement and environmental protection.

Among the successful examples of organic agriculture and ecotourism can be mentioned:

- **Organic farms with their own tourist infrastructure** – Farms in France and Italy offer accommodation, tastings and hands-on workshops for visitors. For example, in the Tuscany region of Italy, farms such as Podereil Casale combine organic production with agritourism, offering opportunities to participate in farming activities and tastings of local organic products [27].
- **Certified bioregions** – Some regions of Austria and Germany are being designated as bioregions, attracting tourists and investors. An example is the Wertheim bioregion in Germany, where local farmers are working together for the sustainable development of the region through organic farming and ecotourism [11], [37].
- **Agrotourism with participation in agricultural activities** – In Bulgaria, some farms provide different organic activities, like participating in animal husbandry, dairy production, and nature walks [36].
- **High-tech organic farms** – The introduction of automated crop monitoring and management systems increases the productivity and quality of organic products [16], [7]. In the Netherlands, for example, some organic farms use robots for weeding, which reduces reliance on manual labour and increases production efficiency [15].
- **Educational and demonstration centres** – In some European countries there are farms that are specifically set up as educational centres. For example, in Sweden, organic

farms such as Skärvångensbymejeri offer training in organic farming, including courses in traditional cheese and animal husbandry [30].

●**Collaborate with restaurants and hotels** – Many organic producers are creating partnerships with local restaurants and hotels that offer only certified organic products. In Spain, for example, some hotels in Andalusia use only organically produced food on their menus, thus promoting organic production and increasing interest in local products [12].

In regions such as Nepal, organic farming strengthens ecotourism by promoting sustainable practices, improving local produce, and attracting visitors who value a healthy lifestyle [2].

Eco-agritourism combines the principles of organic farming and ecotourism, promoting sustainability, biodiversity and the preservation of local culture, significantly improving the economic opportunities of local communities, especially in less developed areas such as the island of Korčula [38]. The Center for Environmental Education in Indonesia demonstrates how ecotourism can increase the economic and social empowerment of local farmers through organic rice farming [40]. The Subak Uma Lambing project in Bali also highlights the synergy between organic farming and ecotourism, highlighting the need for legal frameworks to support these initiatives [4].

In order to have the benefits from the ecotourism in Romania there is need of implementation of coherent policies and active involvement of local communities [9]. According to different research the funds from the European Union are vital in the support of agritourism especially due to the period of COVID-19 period [31].

In Bulgaria we can see that there is ecotourism and organic farming, but a lot of improvements can be done in these sectors, like enlarging the markets which will affect the revenue for the farmers [28]. Efficiency and environmental waste can be optimized [8]. New skills and networks can be also helpful in this process [3][18].

Government support is also key to promoting initiatives related to organic farming and ecotourism, and providing funding and resources can accelerate the development of the sector [26]. Certainly, there are difficulties for the producers to have equal access to the market and fulfil all requirements of the authorities. However, with innovative approaches, flexible policies and promoting the sustainable growth of organic farming, there could be an improvement in this sector. [3].

Institutional support for bioproduction

Organic production in Bulgaria is supported through various programs and regulations targeting the rural areas and their sustainable development. We can list a number of mechanisms related to rural development:

●**Rural Development Programme (RDP)** – This program is allowing to the beneficiaries to receive funding for their production transformation and invest to the modernisation and sustainable technologies [23];

●**European Union funding** – The EU supports organic production through policies such as the European Green Pact and the Farm to Table Strategy, which aim to reduce chemical pesticides and boost organic farming [10];

●**Certification schemes and control bodies** – organic producers in Bulgaria have to go through strict controls in order to obtain the relevant organic certificates that increase their competitiveness on the international market;

●**National and local initiatives** – various organisations and associations work to promote organic farming, provide training and support farmers through advisory services;

●**Tax breaks and grants** – some organic producers can benefit from tax breaks and grants for investing in sustainable practices.

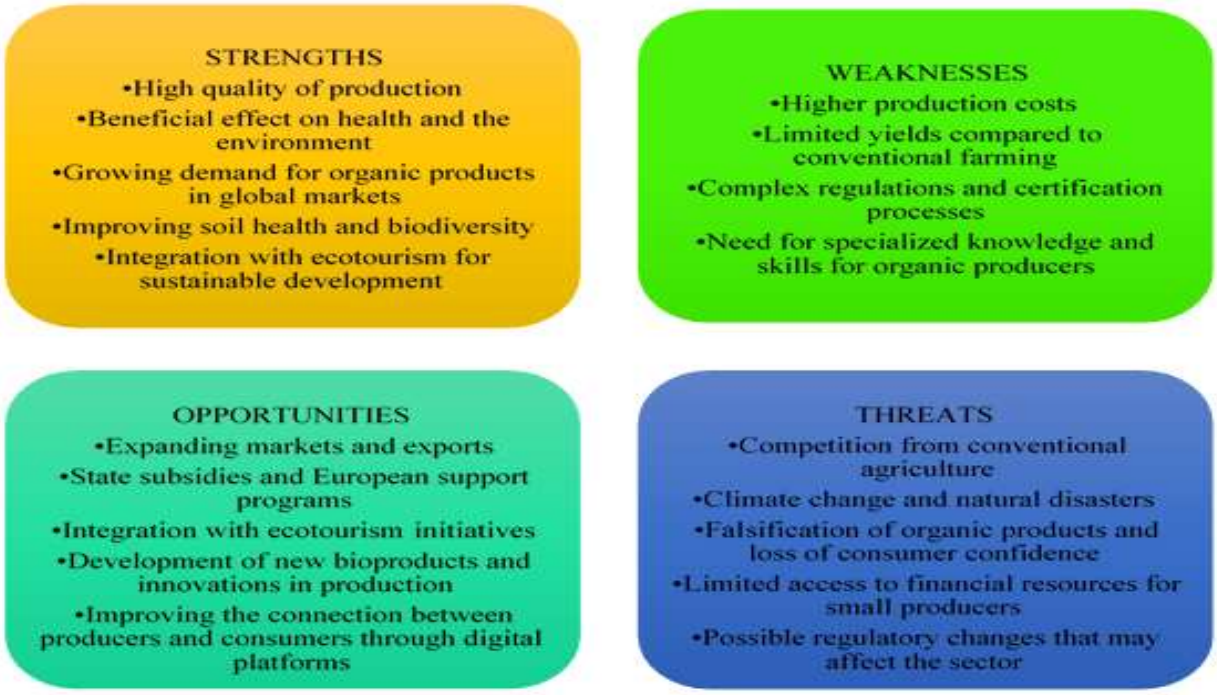

Fig. 1. SWOT analysis of biomanufacturing
Source: Authors' vision.

The SWOT analysis of organic production in the context of ecotourism reveals deep structural prerequisites for sustainable growth, but also highlights key constraints that require a strategic approach. The combination of high ecological value, growing demand for organic products and opportunities for integration into ecotourism models creates a foundation for the development of innovative and diversified business models in rural areas. Such models can unite production, tourism and education in sustainable local economies.

Strengths, such as the high quality of production and its ecological value, can be a catalyst for building premium market segments oriented towards healthy eating and sustainable consumption. This opens up opportunities not only for direct sales, but also for the creation of territorial brands that would unite producers, tourism services and institutions.

At the same time, however, weaknesses in the sector – most notably high production and certification costs, as well as the lack of market culture and access to distribution networks – hinder the large-scale expansion of organic agriculture. Of particular concern is the dependence of many producers on subsidies without a sustainable business logic, which makes the sector vulnerable to political and market shocks.

Threats related to the regulatory environment and the lack of young and trained farmers can lead to stagnation and the withdrawal of potential participants in the sector, especially in remote and demographically aging areas. Without active state participation in simplifying procedures, reducing the administrative burden and stimulating young agricultural entrepreneurs, the potential of the biosector will remain untapped.

Therefore, the key lever for overcoming weaknesses and neutralizing threats lies in the opportunities for integration - both horizontal (between farmers and tourism operators) and vertical (inclusion in value chains, from production to the end consumer). Examples from France, Italy and Germany show that by creating bioregions, combined with training centers, tourism infrastructure and digital logistics, real sustainability can be achieved.

In conclusion, the synergy between organic production and ecotourism should be perceived not simply as a niche opportunity, but as a strategic tool for the social and economic revitalization of rural areas in Bulgaria. This requires a coordinated national policy based on territorial planning, investments in human

capital, public-private partnerships and digital transformation.

In 2022, the share of agricultural land used for organic production in Bulgaria amounted to only 2.2%, according to Eurostat data, which places it among the last in the EU in this indicator. In comparison, Sweden (23.42%), Austria (26%) and Estonia (22%) demonstrate a significantly higher commitment to organic farming. This clear discrepancy is not due to natural constraints – on the contrary, Bulgaria has a variety of climatic zones, little polluted land and a tradition of natural production. The main differences stem from systemic and structural factors – primarily the lack of a long-term strategy, unstable institutional support, as well as low motivation of farmers, who often perceive organic certification as expensive, bureaucratic and opaque.

The reports of the Ministry of Agriculture and Food (MAF) show that since 2019, the area under organic production has been decreasing, and in 2021 they are 86,310 hectares, compared to over 100,000 hectares two years earlier [24]. This is a clear indicator of the difficulties in retaining already certified farms, especially due to the unpredictability of subsidies and the insufficient realization of production. An additional factor is the limited domestic market - studies show that only about 8–10% of Bulgarian consumers regularly buy organic products, with the main reasons for refusal being the price and doubts about the authenticity of the certification. Against this background, ecotourism is an alternative channel for market integration of organic producers. In regions with well-developed agrotourism practices - such as Smolyan, Stara Zagora, Gabrovo and parts of Northwestern Bulgaria, producers manage to sell their production directly, with higher added value. According to the Bulgarian Association for Alternative Tourism [32], over 60% of tourists in rural areas actively seek out organically certified products, being willing to pay up to 20% higher prices, especially when the product is combined with local history, tasting or participation in agricultural activities. This highlights the need for closer integration between agricultural producers and tourism operators, as well as the creation of regional quality and origin labels. In addition to the economic value, this relationship has the potential to stimulate local employment, social entrepreneurship and cultural identity, especially in vulnerable and depopulated areas. This outlines not only a market but also a social logic of the synergy between organic agriculture and ecotourism, which can be capitalized on through targeted policies and regional initiatives.

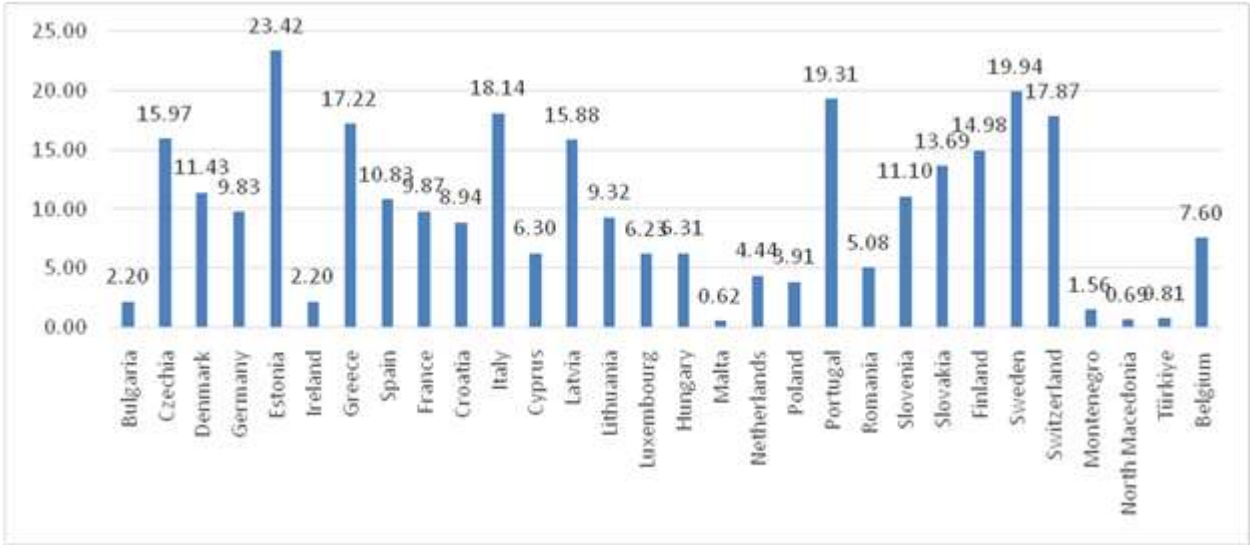

Fig. 2. Area under organic farming, 2022, %
Source: Eurostat, [42].

In animal husbandry, the number of biologically raised cattle reached 10,408, and sheep – 19,873. Biological beekeeping is also actively developing, and in 2021. 218,949

certified bee colonies were registered. Despite the favorable natural conditions for the development of the sector, a number of challenges such as regulatory complications, high production costs and low consumer awareness hinder the progress of organic producers [24].

Link between organic production and ecotourism

Ecotourism promotes responsible travel to natural areas to protect the environment and improve the well-being of local communities [25]. Organic farms offering tourism services such as agritourism, tastings and educational programs can create additional revenue opportunities and promote sustainable agricultural practices. Interactions between ecotourism and organic production include:

•Development of farmers' markets and direct sales;

•Organisation of tourist routes including visits to organic farms;

•Conducting courses and seminars on sustainable agriculture and ecological nutrition;

•Introducing sustainable practices in tourist sites through the use of organic products.

CONCLUSIONS

The synergy between bioproduction and ecotourism opens up new perspectives for sustainable development, balancing economic benefits with nature conservation and cultural heritage preservation. Innovative business models are outlined when there is combination between organic production and tourism. The synergy can improve the quality of life in these areas and also support the sustainability.

We can conclude that both sectors – organic farming and ecotourism are connected and they contribute to the sustainable growth in rural areas. They not only help protect the environment, but also stimulate economic growth, create jobs and strengthen the social well-being of local communities. Through their synergistic development, sustainable models can be built that bring benefits to both nature and people, affirming an ecologically and socially responsible way of life.

Despite these mechanisms, a number of challenges such as bureaucratic procedures, a complex certification system and insufficient awareness of farmers hinder the wider spread of organic farming.

Based on these aspects, the following SWOT analysis presents the main strengths and weaknesses, opportunities and threats for biomanufacturing. Despite government support and various types of funding to improve and accelerate the development of this sector, challenges such as limited access to markets and regulatory barriers still exist. The resolution is in the innovative approaches, new policies, and continued support for the sustainable development of ecotourism and organic agriculture in Bulgaria.

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REFERENCES

[1]Adesope, O.M., Matthews-Njoku, E.,-C., Oguzor, N.S., Ugwuja, V.C., 2012, Effect of Socio-Economic Characteristics of Farmers on Their Adoption of Organic Farming Practices. doi: 10.5772/30712 In Crop Production Technologies, Edited by P. Sharma and V. Abrol. Intechopen.

[2]Aoki, M., 2014, Motivations for organic farming in tourist regions: a case study in Nepal. Environment, Development and Sustainability, A Multidisciplinary Approach to the Theory and Practice of Sustainable Development, Springer, Vol. 16(1), 181-193 doi: 10.1007/S10668-013-9469-6

[3]Arabska, E., Dimitrova, S., Kolaj, R., Borisov, P., 2024, Challenges and opportunities for development of organic production in Bulgaria. Vide. Tehnoloģija. Resursi, 1:39-47. doi: 10.17770/etr2024vol1.7952

[4]Astara, I., W. W., Budiarta, I. W., Wijaya, K.M., Sanjaya, I.G.A.M.P., Subrata, T., Sukmadewi, D.K.T., Miyazawa, N., 2023, The Potential of Subak Uma Lambingin Sibangkaja Abiansemal Village, Badung

Basedon Organic Farming Culture as Ectourism. Journal of Legal and Cultural Analytics (JLCA) Vol. 2(3), 191 - 202 doi: 10.55927/jlca.v2i3.5829.
[5]Blagoev, A., 2024, Vazdeystvienastrip-tilltehnologiyatavarhusistemitenazemedelieto (Effects of Strip-till Technology on Agricultural Systems). Economic Thought Journal, 69(3), 388-400 (in Bulgarian). https://doi.org/10.56497/etj2469306
[6]Brodt, S., Klonsky, K., Tourte, L., Duncan, R., Hendricks,L., Ohmart, C., Verdegaal, P., 2004, Influence of farm management style on adoption of biologically integrated farming practices in California. In: Renewable Agriculture and Food Systems, 19(4), 237-247, doi: 10.1079/RAFS200488
[7]Bușu, M., Dragomir, V., Bădan (Voicila), D. N., Romania's Rural Digital Transformation and Implications for Agriculture, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol. 24(3), 125-130.
[8]Dimitrov, K.D., Ivanova, M., 2017, Trends in Organic Farming Development in Bulgaria: Applying Circular Economy Principles to Sustainable Rural Development. Visegrad Journal on Bioeconomy and Sustainable Development, Vol.6(1), 10-16. doi: 10.1515/VJBSD-2017-0002
[9]Dragomir, L., Mazilu, M., 2021, Paradigms and Paradoxes in the Metamorphosis of Ecotourism. Quaestiones Geographicae, 2021, Adam Mickiewicz University, 40(4), 71-84. https://doi.org/10.2478/quageo-2021-0034.
[10]European Commission (EC), 2020, European Green Pact and Farm to Table Strategy. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_bg, Accessed on 05.01.2025
[11]Federal Ministry Republic of Austria (FMRA), 2024, Organic Farming in Austria, https://info.bml.gv.at/service/publikationen/landwirtschaft/organic-farming-in-austria.html, Accessed on 05.01.2025
[12]Food and Agriculture Organization (FAO), 2024, Codex Alimentarius, International Food Standards, https://www.fao.org/fao-who-codexalimentarius/en/, Accessed on 05.01.2025
[13]Georgieva, V. D., 2024, Impact of global value chains on the innovation potential of enterprises and regions. MBBU Publishing House. 128, (in Bulgarian).
[14]Georgieva, S., 2020, The impact of block chain technologies on the financial sector. Economic development and policies: realities and prospects. Prof. Marin Drinov Publishing House of BAS. pp. 827-837.
[15]Government of the Netherlands, Ministry of Agriculture, Fisheries, Food Security and Nature, 2024, https://www.government.nl/ministries/ministry-of-agriculture-fisheries-food-security-and-nature Accessed on 12.12.2024
[16]Harizanova-Bartos, H., Kabadzhova, M., 2024, Development of Bulgarian Agriculture Production Structures, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol. 24(3), 411-421.
[17]Hattam, C., 2006, Barriers to the adoption of organic agriculture. An investigation using theTheory of Planned Behaviour. Aspects of Applied Biology 79. International Association of Agricultural Economists, Annual meeting, August 12-18, 2006, Queensland, Australia.25269.
[18]Hvizdova, E., 2018, Organic farming as a key pillar of sustainable tourismdevelopment – ruraltourism, agro-tourism and eco-tourism. Ekonomika, 1(51), Setion 4 Enterprises and Industries Economy, doi: 10.24144/2409-6857.2018.1(51).197-200
[19]International Federation of Organic Agriculture Movements (IFOAM), 2008, Definition of Organic Agriculture. https://www.ifoam.bio/why-organic/organic-landmarks/definition-organic, Accessed on 05.01.2025
[20]Kassam, A., Brammer, H., 2013, Combining sustainable agricultural production with economic and environmental benefits. The Geographical Journal, 179(1), 11-18., doi: 10.1111/J.1475-4959.2012.00465.X
[21]Liu, S.-Y., Yen., C.-Y., Tsai, K.-N., Lo, W.-S., 2017, A Conceptual Framework for Agri-Food Tourism as an Eco Innovation Strategy in Small Farms, Sustainability, 2017, 9(10), 1683.
[22]Miller, C.M., Mair, H., 2015, Organic farm volunteering as a decommodified tourist experience. Tourist Studies, 15(2), 191-204. doi: 10.1177/1468797614563436
[23]Ministry of Agriculture and Food, MZH, 2025, Rural Development Programme (RDP) of Bulgaria (2014-2020, 2021-2027). https://www.mzh.government.bg/bg/politiki-i-programi/programi-za-finansirane/programa-za-razvitie-na-selskite-rayoni/, Accessed on 05.01.2025
[24]Ministry of Agriculture and Food (MAF). Annual Agricultural Reports 2014-2021. https://www.mzh.government.bg/bg/statistika-i-analizi/. Accessed on 12.12.2024
[25]Pavlov, A., 2024, Theoretical aspects of migration - neoclassical migration theory. Proceedings of the Twentieth National Youth Scientific and Practical Conference 2023. 181-184. Federation of Scientific and Technical Unions in Bulgaria.
[26]Petrova, M., Nikolova, M., Pavlov, P., 2023, An Innovative Organic Agriculture Model for Sustainable Development of Rural Areas in Bulgaria. IOP Conference Series: Earth and Environmental Science, Vol. 1126, 2nd International Conference on Environmental Sustainability in Natural Resources Management 31/10/2022 - 01/11/2022 Riga, Latvia doi: 10.1088/1755-1315/1126/1/012034
[27]PodereilCasale, 2024, https://podereilcasale.com/en/, Accessed on 12.12.2024
[28]Popov, H.V., 2014, Partnership of organic farming, eco-tourism and wilderness conservation – experiences of the pilot project "New Thracian Gold" in Bulgaria. Paper at: IFOAM Organic World Congress 'Building Organic Bridges', 13-15 Oct. 2014, Istanbul, Turkey.
[29]Privitera, D., 2010, The importance of organic agriculture in tourism rural. Applied Studies in

Agribusiness and Commerce, AGRIMBA, vol. 4(01-2), pages 1-6. doi: 10.19041/APSTRACT/2010/1-2/8
[30]Skärvångens Bymejeri, 2024, https://www.bymejeriet.se/om-oss/ Accessed on 27.01.2025
[31]Stanciu, M., Popescu, A., Stanciu, C., 2023, Rural tourism, agrotourism and ecotourism in Romania: current research status and future trends. Scientific Papers SeriesManagement, Economic Engineering in Agriculture & Rural Development, 23(1), 745-757.
[32]The Bulgarian Association for Rural and Ecological Tourism, 2025, https://www.en.baret-bg.org/Structure2_e/enstructure.html, Accessed on 05.01.2025
[33]The Bulgarian Association for Alternative Tourism, 2025, A step forward responsible tourism, https://www.baatbg.org/en/%D0%BD%D0%B0%D1%87%D0%B0%D0%BB%D0%BE/1/, Accessed on 27.01.2025
[34]The Global Biodiversity Protection. org., 2025, Eco-tourism, The responsible travel, https://globalbiodiversityprotection.org/en/cause-view/eco-tourism/ , Accessed on 07.02.2025
[35]The International Ecotourism Society, 2025, Wjay is ecotourism, https://ecotourism.org/what-is-ecotourism/, Accessed on 05.01.2025
[36]TheWildFarm, 2024, 100% Bio beef meat, https://divataferma.com/, Accessed on 07.02.2025
[37]Tourismus region Wertheim, 2024, https://tourismus-wertheim.de/#filter=r-fullyTranslatedLangus-,sb-sortedBy-0&zc=12.,9.52051,49.75998, Accessed on 07.02.2025
[38]Vrsaljko, A., Turalija, A., Grgić, I., Zrakić, M., 2017, Organic agriculture as a precondition for development of eco-agrotourism on the islands - a case study of Korčula Island. Journal of Central European Agriculture, 18(3), 733-748. doi: 10.5513/JCEA01/18.3.1947
[39]Wight, P., 1993, Sustainable ecotourism: balancing economic, environmental and social goals within an ethical framework. Journal of Tourism Studies, 4(2):54-66.
[40]Wiyono, S.H., Subianto, A., Nuhman, N., 2023, Sustainable Ecotourism Development and Community Empowerment: A Case Study of the Center for Environmental Education in Seloliman Village, Indonesia. 11(2), 310-328. doi: 10.33019/society.v11i2.528
[41]World Ecotourism Summit Quebec City, Canada, 19-22 May 2002, Final Report.