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C O N T E N T

FACTORS AFFECTING INCOME LEVELS OF OIL PALM FARMERS AFTER CREDIT UTILIZATION IN AKWA IBOM STATE, NIGERIA

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Abstract

The study analyzed factors affecting the income levels of oil palm farmers after credit utilization in Akwa Ibom State. In addition, the study examined the constraints faced by oil palm farmers in obtaining credit. To select 145 respondents, a multi-stage sampling procedure was used. The data were collected and analyzed using descriptive statistics and multiple regressions. The finding reveals that three factors: household size (0.148), interest rate (-0.205) and non-farm income (0.218) significantly influenced the income level of the farmers. Almost all the identified constraints (10 out of 13) were seen as serious constraints faced by the respondents with lack of funds (4.24), high cost of input (4.19), inadequate farmland (3.71), Lack of agrochemicals (3.67) and lack of planting materials ranked(3.44) emerging as the first five major constraints. This gave a Grand mean of 3.29. For oil palm producers to maintain and improve their economic performance, financial facilities at reasonable interest rates should be made available to them by the federal and state governments. Planting materials, agrochemicals and other farm inputs that will boost oil palm production should be made available to the farmers at a subsidized rate.

Key words: *income level, factors, constraints, oil palm, farmers, credit utilization*

INTRODUCTION

Oil palm plantations are one of the plantations which have made quite a unique contribution to the economic activities in Nigeria because of the produce gotten from it that is much needed industrially and domestically [7]. The oil palm tree crop is incredibly important and versatile, with every component of it having a purpose [8]. Palm fruit is majorly processed to obtain palm oil, palm kernel oil and palm kernel cake [13]. The oil extracted from oil palm is utilized for a variety of purposes, such as industrial oil, culinary oil, and fuel (biodiesel) [18].

West African palm oil consumption has grown domestically at a rate that is faster than its output in recent decades. Now, West Africa is a net importer of palm oil, having been the primary producer and exporter of the oil for centuries. Nigeria produced 43% of the 1.5 million tons of oil palm produced worldwide between 1961 and 1965. But since Nigeria's oil palm output has all but stopped, things have altered. Currently, 14.4 million tons of oil palm are produced worldwide; Nigeria, one of the major producers in West Africa, produces only 7% of this total.

[14] affirmed that while yield of palm oil is at a constant level, output supply depends much more on cultivated area. Imports deeply affect palm oil farmers in Nigeria, while exports are not enough stimulated.

[5] Acknowledges that in order to sustain oil palm production there is need to provide credit facilities.

According to [20] who compared the features of the oil palm industries in Malaysia and Nigeria, plantation management and processing in sizable, contemporary mills are the foundations of Malaysia's success. The production method known as plantations is characterized by a vast monoculture managed by a single entity. In contrast, dispersed smallholders in Nigeria account for 80% of production; they gather semi-wild plants and employ manual processing methods. In the southern region of Nigeria, there are millions of smallholders dispersed over an estimated area of 1.65 million hectares. Other environmental and coordination issues include poor standards and quality control, monopoly of the marketing board, low provision of market information, low use of contemporary inputs, and low extension services [1].

Since the state of the global market prices affects smallholder oil palm farmers' income, their financial future is unpredictable [16]. Oil palm producers may find it difficult to make ends meet for their families due to price fluctuations in palm fruit. Oil palm farmers' well-being often correlates with the level of business of the farmer which is reflected by the income of the farmer. [10] states that income is the sum of money that members of society get as payment for the factors of production over a specific period. The return on the use of labour, equity, and agro-processing expertise on the farm is often how farm income is expressed.

[19] asserts that external and internal factors can be distinguished among the several variables suspected to have an impact on oil palm farmers' income levels. Input, which includes its price and availability, and output, which includes its price and demand, are examples of external factors. The amount of labour, capital (capital ownership level, which may keep some farmers' incomes low), and land area (the more land area cultivated, the higher the production and income per unit area) are examples of internal factors. According to [16], it is reported that labour and working capital have a positive relationship to income whereas price and land area have a negative relationship to income and this disagrees with the findings of [19]. [15] assert that expenditure is a major factor affecting the income level, In other words, higher incomes are associated with higher levels of expenditure. Accordingly, [17] found income levels to significantly influence household expenditure. This is also the case for oil palm farmers in Akwa Ibom; hencethe need to access credit so as to increase output bolstered by factors of production which ultimately boost incomes.

[11]. The riverine communities in Akwa Ibom hold strong claims to the origin of oil palm business particularly Eket and Ikot Abasi Local Government areas, however the business is now wide spread across the state [6].

Production of palm oil, a significant economic activity for the state's population, is primarily done by women and other rural residents with traditional methods [21].

[9] used production function analysis to examine efficiency in resource use in the production of palm oil in Abak local government area; findings revealed that palm oil production is influenced by labour (hired and family), chemicals, oil palm stands, fertilizer, and farm size. Most of the empirical reviews as it concerns Akwa Ibom State have focused on factors influencing and economic analysis of palm oil production. Studies that have examined the factors influencing the income of oil palm farmers after utilizing credit in Akwa Ibom State appear scarce in the literature.

Therefore, to develop appropriate policies that would support oil palm production, enhance farm productivity and the involvement of farmers and ultimately raise food production in the nation, it is necessary to investigate the factors influencing oil palm farmers income following access to credit in Akwa Ibom State. Specifically, the objectives of the study are as follows:

(1) determine factors influencing oil palm farmers income levels after accessing credit.

(2) examine constraints by oil palm farmers in accessing credit.

MATERIALS AND METHODS

Study Area

Abak Agricultural Zone, make up the study area. It is located at latitude 40591 North and longitude 70 and 471 East of the Greenwich meridian, with a total size of 190 square kilometres. The population of Abak as of 2023 was estimated to be 211,642, and 111,958 were males while 99,684 were female based on a 2.5% constant annual growth rate from the last census of 2006. Before the civil war, the main source of income for the

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residents of this area was the export of palm produce via the river port at Ekpene Okpo, Ntak Ibesit, which is located about 8 kilometres from Abak town. The Abak division was the primary producer of palm oil and kernels exported through the river ports at NtakIbesit and Ikot Okoro. Traditional dances from Abak, like Ekpe, Ekpo, and Idiongitals, showcase the region's cultural legacy; nevertheless, the majority of these dances are Christian in nature. Abak Agricultural Zone comprises five local Government areas which include: Abak, Oruk Anam, Etim-Ekpo, Ukanafun and Ika. It has nine blocks with each block comprising eight cells (villages).

Sampling Procedure and Data Collection

The study adopted a multistage sampling procedure. The first stage involved purposive selection of Abak Agricultural Zone from the existing six (6) Agricultural Zones in Akwa Ibom State, because of its high oil productivity, for the second stage, out of the nine blocks in the zone five were randomly selected out of which three cells (villages) were randomly selected to give a total of 15 cells for the third stage. In the fourth stage, three oil palm cooperatives were selected per cell giving a total of 45 cooperatives, after which four oil palm farmers were selected per cooperative to give a total of 180 oil palm farmers. However, 145 oil palm farmers participated in the study. Primary data were obtained using a well-structured questionnaire given to the respondents who were credit beneficiaries.

Analytical Techniques

Ordinary least square (OLS) regressions were used to analyse the data in objective one which was to analyse the factors affecting the income levels of oil palm farmers after credit utilization while a 5-point Likert scale rating technique was to examine the constraints faced by oil palm farmers in obtaining credit. The data gathered to measure and identify the efficiency of the factors determining income level from oil palm production throughout a farming season were analyzed using multiple regression analysis. These factors were selected in light of previous research on comparable interactions concerning farmers' income. Our general regression equation is expressed implicitly as follows:

The implicit form is:

$$INC = f(\mathrm{HHS}, \mathrm{FAE}, \mathrm{VOC}, \mathrm{INR}, \mathrm{OPC}, \mathrm{NFI} + \mu$$

where:

INC = Income level of oil Palm farmers from oil Palm production (Naira)

HHS = Household size

FAE = Farming experience (years)

VOC = Volume of credit obtained (naira)

INR = Interest rate (%)

OPC = Operating cost (naira).

NFI = Non-farm income (naira)

μ = Error term

Objective 2 was analyzed using the 5-point Likert scale rating technique, [2]:

VS = 5, S = 4, P = 3, NC = 2, NS = 1

Likert Scale = ∑W/N = Sum of Weights (W1+W2+----Wn)/N

where:

W = Weights assigned by the respondents to each statement ranging from 1 to 5, with 1 being less significant and 5 being very important.

N = Total number of respondents

Weighted score = <u>No of VS x 5 + No of S x 4 No of P x 3+ No of NC x 2+ No of NS x 1</u>
N

where:

VS =Very serious constraint

S= Serious constraint

P= Partial constraint

NC = Not a constraint

NS=Not sure .

The benchmark was 3.0 obtained by adding all respondents' weights and dividing by 5. <u>[5+4+3+2+1]/5</u> = 3.0

RESULTS AND DISCUSSIONS

Analysis of Factors Affecting Income Levels of Oil Palm Farmers after Credit Utilization

Multiple regressions are conducted to examine if certain factors like (household size, farming experience, volume of credit, interest rate, operating cost and non-farm income) of the respondents can affect their farm income level.

Table 1 shows that all six (6) independent variables taken together have some level of influence on the variance in the income level of the respondents, $R^2 = 0.440$. From the table also, 19.4% variance (adjusted $R^2 = 0.194$) in the income level of the respondents is accounted for by the six (6) independent variables. Nevertheless, the joint influence of these independent variables on the income level of the respondents is statistically significant at $F = 5.251$; $P < 0.05$.

A critical examination of the Beta coefficients in Table 1 shows that three factors (household size, interest rate and non-farm income) significantly influenced the income level of the farmers. Household size is significant at 10% with a coefficient of 0.148. This implies that a unit increase in the household size will likely increase the availability of farm labour eventually leading to more production which increases the income level of the farmers by 0.148 units.

[3] also observed household to be a significant determinant of cassava production among famers. The coefficient of interest rate is -0.205. This means that a unit increase in the interest rate charged to the farmers for obtaining credit decreases the income level of the farmers by 0.205 units. More income through sales will increase the business level of the farmers. Sadly, these farmers have to be giving out some portion of the additional income to their creditors as interest on credit. This reduces their income level, [4] obtained similar results in their study on determinants of loan repayment performance among cooperative beneficiaries in South-south Nigeria. The coefficient of non-farm income is significant at 0.218. This means that a unit increases in the non-farm income increases income levels of oil palm farmers by 21.8%. This finding aligns with [16] wherein working capital and labour positively and significantly influenced income.

Table 1. Factors influencing income Levels of Oil Palm Farmers

S/N	Variables	Coefficients (Double Log)
1	Household Size	0.148 (1.838)* [0.039]
2	Farming Experience	0.087 (1.088) [0.355]
3	Volume of Credit	-0.143 (-1.496) [0.186]
4	Interest rate	-0.205 (-2.110)** [0.131]
5	Operating Cost	0.061 (1.774) [0.173]
6	Non-farm income	0.218 (2.679)** [0.128]
	Constant	13.548**
	R^2	0.440
	Adjusted R^2	0.194
	Standard error of Estimate	1.17570
	F-value	5.251
	Significant	0.000
	Remark	Significant

Source: Computed from Field Survey, 2021.

Note: Values in the middle represent t-values while values in the last parenthesis represent standard error. ** Significant at 5% level of significant; * Significant at 10% level of significant.

Analysis of the Constraints Faced By Oil Palm Farmers in Obtaining Credit

The researchers make an effort to examine the constraints the respondents are facing in their bid to obtain credit for their farming activities. Thirteen (13) possible constraints are pooled from the literature and the respondents are asked to indicate if they have experienced the constraints by indicating how serious such constraint is to them. The mean responses of the respondents are calculated (Table 2).

Any mean score greater than 3.0 is considered a significant constraint, however, mean scores less than 3.0 are considered as not significant constraints of that particular statement since the maximum response score for each item is 5 and the minimum is 1. From the results in Table 2, almost all the identified constraints (10 out of 13) are seen as serious constraints by the respondents.

Lack of funds is agreed to by the respondents as the highest form of constraint faced. It attracts a mean response of 4.24 and is ranked 1st. Funding is very important to the farmer for meeting farming, physiological (feeding) and even security (housing) needs. These needs are rated high, given prominent positions as described as basic needs in Maslow's hierarchy theory of needs. Unless these basic needs are fulfilled, it would be difficult for the farmers to meet higher needs such as business expansion, and self-actualization which, in this situation, is a sound achievement in farming. If the funding needs of the farmers are not met, the implication is that their farming activities are inefficient. The result supports [9] claim that oil palm growers were limited to small-scale, subsistence-level producers due to a lack of financing options. Other constraints faced by the respondents are; high cost of input (4.19), inadequate farmland (3.71), lack of agrochemicals (3.67) and lack of planting materials (3.44). This result connotes the findings of [12] and [21] that the high cost of input, lack of planting materials and ongoing reliance on labour-intensive manual labour and primitive instruments were major challenges to oil palm production in Akwa Ibom State. Poor transportation system (3.24) and poor market structure (3.32) are also found as a constraint by the farmers. A good marketing structure will allow the farmers to expose their cassava products to potential buyers for more income. A grand mean of 3.29 indicates that the respondents are seriously constrained as they embark on their farming endeavours.

Table 2. Distribution of the Respondents on Constraints Faced in the Study Area

Constraints	VS	S	PC	NC	NS	Mean	MR
Planting material	31.7	17.9	23.4	17.2	9.7	3.44	5th
Processing facilities	17.2	20.7	18.6	34.5	9.0	3.02	9th
Storage facilities	6.9	15.9	28.3	38.6	10.3	2.70	12th
Soil fertility	14.5	18.6	24.8	24.8	17.2	2.88	10th
Incidence of pest and disease	19.3	19.3	24.8	25.5	11.0	3.10	8th
Lack of fund	66.2	13.8	8.3	1.4	10.3	4.24	1st
Lack of information	1.4	15.2	36.6	33.1	13.8	2.57	13th
Inadequate farmland	44.8	18.6	10.3	15.2	11.0	3.71	3rd
Lack of agrochemicals	28.3	31.7	28.3	2.8	9.0	3.67	4th
Labour scarcity	3.4	19.3	32.4	34.5	10.3	2.71	11th
Poor market structure	13.8	37.2	29.0	7.6	12.4	3.32	7th
Poor transportation system	24.1	21.4	26.2	11.0	17.2	3.24	6th
High cost of input	55.2	26.9	9.0	0	9.0	4.19	2nd
Grand mean						3.29	

Source: Field survey, 2021.
Note:
VS = Very Serious Constraint
S = Serious Constraint
P = Partial Constraint
NC = Not a Constraint
NS = Not Sure
MR = Mean Ranking

CONCLUSIONS

This study has been able to establish that household size, interest rate and non-farm income are the potent factors affecting income levels. The study showed that there is a positive influence of household size and non-farm income on oil palm farmers' income. On the other hand, interest rate negatively influenced income. Nevertheless, the respondents were besieged with several constraints such as lack of funds, high cost of input, inadequate farmland, lack of agrochemicals and lack of planting materials, etc.

Thus, the study recommends the followings:

-To maintain and boost oil palm producers' economic performance, the federal and state governments should provide easily accessible loan facilities at affordable interest rates.

-Planting materials, agrochemicals and other farm inputs that will boost oil palm production should be made available to the farmers at a subsidized rate.

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FARMERS' AWARENESS CONCERNING THE INFLUENCE AND MANAGEMENT OF CLIMATIC CHANGES ON ENVIRONMENTAL ECONOMY AND CROPS NUTRITIONAL STATUS

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Abstract

In our days, climate changes are globally recognized as one of the most challenging pressures on agriculture. They may have consequences not only on crop yields, but on the whole agrifood sector. A survey was conducted on 383 subjects, which own farms and confront with possible extreme phenomana as consequences of climatic changes. The questionnaires were distributed in rural areas of Bistrița-Năsăud County in autumn and early winter of 2024. The aim of our scientific approach was to identify the farmers'perceptions on the existence of climatic changes, and their particular effects on agriculture sector. The raw data were statistically processed using basic statistics and multivariate analyzis. Simple Spearman correlation between variables were established, and factorial analyzis through its component PCA (Principal Components Analysis) was implemented for emphasizing the main factors affecting the farmers awareness on climatic changes and their effects with which they may confront. The results of our study show that only part of the questioned farmers are fully aware of the presence of climatic changes, and of their effects on soil nutritional status, water availability, or productivity. This suggests the importance of implementing training programs targeted to support farmers to improve their knowledges in the field.

Key words: *farmer, item, questionnaire, soil, water.*

INTRODUCTION

Beginning with last two decades of the former century, climate changes have beign a constant preoccupation for people working in different economy sectors, including those invlved in environmental economy [4, 25]. Effective management of these changes requires a strategic approach that integrates both adaptive and proactive measures [8, 18, 24].

Farmers' awareness of how climate change impacts crop nutritional status bridges the gap between environmental sustainability and agricultural economic resilience, fostering adaptive practices that enhance both ecological health and food security. A key point in successful fight against consequences of climate change in agriculture is the adaptation of decision-making process to specific requirements, incorporating climate management strategies that address regional variations and local challenges [1, 3, 7, 8, 11, 15, 25, 26]. The quality and quantity of crops, which are the bascic raw materials for food and fodder is the result of contribution of several complex factors, from plant genotype, soil type and its nutritional status, cultivation technlology, to, which are added environmental factos, as sun radiation, temperature, air humidity, dew point, nebulosity, or wind velocity and direction also contribute. Those are the premises that represent continous preoccupations for farmers, also considering the necessity for adaptation to climate changes realities [11, 20, 24].

Overall, crop yields have increased worldwide in the last decades. Thus, for exemplification between 1980 and 2023, cereal yield doubled worldwide, increasing from 932.9 kg/ha in 1980, up to 1,914.5 kg/ha (with 1,137.5 t/ha in average), with different evolutions by continents, as follows: 928.8 kg/ha (1980) – 1,914.2 kg/ha (2023) in Africa, 848.6 kg/ha (1980) – 881.1 kg/ha (2023) in Americas, 564.4 kg/ha (1980) – 2,009.3 kg/ha (2023) in Asia, 2,587 kg/ha (1980) – 1,904.6 kg/ha (2023) in Europe, 2,434.1 kg/ha (1980) – 5803.3 kg/ha (2023) in Oceania [32]. The reason for spectacular yield increases in some regions like Oceania, or Asia, and low increase as in Americas, or even decreases as in Europe, is the result of different factors. Among them we can mention technological evolutions, different agricultural policies, and not least climate changes. Thus, even though the crops yield has increased considerably worldwide, climate changes affecting this important economic index are a reality.

The average temperature increases of only 1.3°C from 1981 up to 2023 [13], have real consequences on accentuation of climatic changes translated into effects on agriculture (Table 1).

Table 1.The economic aspects of climatic changes worldwide

Parameter	Reference year, 1981	Reference year, 2023	References
Average annual temperature increase (°C)	0.437	1.737	[13]
Total yields	Stable	Fluctuating	[13], [14], [32]
Average yields	Stable	Fluctuating	[13], [14], [32]
Uncover of production costs	Casual	Frequent	[17]
Production looses	Casual	Significant	[13], [14], [31]
Financial looses	Very low	Significant	[14], [10], [31]

Source: Own synthesis based on the studied literature.

A study performed by FAO (2023) concerning the loss and damages produced at global level by climate change, emphasizes that agriculture is severely impacted with almost 39% crop losses and/or specific infrastructure [13]. Another FAO report (2021) show for the case of a country of South America, where FAO statistics emphasizes very low increase of cereal yields in the last 40 years, Uruguay respectively, increasing tendency of losses in cereal production, from 1980 to 2014, from less than 0.1 tonnes within the time interval 1980 - 1984, up to 1 tonne within 2010 – 2014, with maximum losses per 2000 – 2004 period of almost 3 tonnes for rice, and about 1.3 tonnes for maize [14].

All European Union countries are affected to different extent by clime evolution. In particular case of Romania, the effects of climate change are mainly manifested through the occurrence of drought and floods, which make Romanian agriculture vulnerable [16].

According to a feasibility study carried out in Romania (2021), the agricultural areas affected by extreme phenomena as result of climate changes decrease from 1,752,506 ha in 2015 to 171,720 ha in 2019. According to Vânătoru et al. (2013), crop losses due to drought, are observed for winter wheat, maize, and sunflower [31]. Thus, from 2004 up to 2012, maize crop losses are reported, with a maximum of over 75% in 2007, while in the same time interval for sunflower, the losses the highest share of 50.3% also corresponds to the year 2007. The same study shows that winter wheat crop was less affected by drought, losses being lower in this case, with a maximum production decrease of 44.5% observed, the same in 2007.

Frequent uncovering production costs are reported because of climate change effects upon agricultural systems [17]. Diffenbaugh et al. (2021) studied the financial impacts of climate changes expressed as global warming on crop production in the USA [10]. In terms of financial impacts expressed by crops national insurance sector, they show that global warming caused to crop insurances system losses in amount of 27 billion (19%), for a 27 years period, between 1991 – 2017. In ”least developed” and ”low-middle-income” countries drought costs the agricultural sector about 37 billion $ (of which, in African continent causing about 14 billion $), while floods about 21 billion $ from 2008 to 2018 [14]. In South Romania, variable financial losses are reported due to climate changes expressed by drought installation, from 2006 up to 2012. Expressed in Romanian currency, the losses are within specific intervals, function of culture type, as follows: 474.3 RON (2004) – 1,522.5 RON (2012) for winter wheat; 1,011.5 RON (2004) – 2,502.5 RON (2012) for winter maize, and 428.4 RON (2004) – 1,492.2 RON (2012) for sunflower [31].

In recent years, much effort has been made by researchers to improve agricultural technologies to reduce the effects of climate change, including through precision agriculture practices [6, 8, 19, 21, 25]. An essential issue for obtaining crops of high quality and promoting modern farm managerial approaches is the correct perception of the challenges represented by a climate in continuous change [9, 22, 23, 28].

A very useful approach for understanding farmers' degree of knowledge and their atitude against climatic changes and their implications in farm management is the use of surveys. If appropriately conceived they can emphasize the key points of interest, but also misconceptions, and/or gaps in farmers' knowledge [2, 5, 18, 27].

The aim of our study is to inquire into farmers' perceptions about their current knowledge about major issues connected with climate changes effects on agriculture, as water access, soil nutrients, or growth cycle of plants.

MATERIALS AND METHODS

A survey was conducted during September – December 2024 in rural area of Bistrița-Năsăud County, on farmers actively engaged in crop production. 383 farmers were surveyed to assess their awareness and perceptions of the influence of climate change on crop nutritional status, water availability, soil health, and agricultural productivity. The Cochran formula [29] was used to establish the sample size. The rural population of Bistrița-Năsăud County was considered as 180,568 inhabitants [30].

The questionnaire was developed to address key themes concerning the managerial approach of climate changes. It concerns water availability (farmers' perceptions of how climate change affects water resources), soil health and nutrient composition (farmers' understanding of climate change impacts on soil erosion, nutrient depletion, and heavy metal accumulation), agricultural productivity (farmers' views on the primary causes of declining productivity), and plant growth and growing seasons (farmers' perceptions of how increased temperatures and shifting climatic conditions influence plant growth cycles and the length of the growing season).

Informed consent was obtained from all participants before administering the questionnaire. Farmers were assured of the confidentiality of their responses and their right to withdraw from the study at any time.

The data were analysed using both descriptive and inferential statistical methods. Spearman's correlation coefficients were computed to explore relationships between variables. Principal Component Analysis (PCA) was conducted.

Five principal components explain a significant portion of the variance in the dataset. The loadings of each variable on the principal components were analysed.

RESULTS AND DISCUSSIONS

Our survey shows that 48.04% of respondents (184 farmers) believe that climate change reduces the available one, which is the dominant and correct perception (Fig. 1). This aligns with scientific findings that highlight how rising temperatures and shifting precipitation patterns contribute to increased water scarcity in many agricultural regions. Research shows that there is a need to improve the assessment of climate change impacts by using updated strategies, like hydrological simulation models [12].

A significant portion of farmers (28.20%, 108 respondents) believe that climate change has no effect on water availability, suggesting that some may not yet perceive or experience significant changes in their local water conditions.

Meanwhile, 20.63% (79 respondents) think that climate change might increase water access, possibly due to changes in rainfall patterns in specific areas.

Lastly, a small fraction (3.13%, 12 respondents) associate climate change with an increased risk of flooding, reflecting concerns about extreme weather events.

Given that the correct response is 48.04% (reduction in water resources), the findings emphasize the pressing challenge of water scarcity in agriculture due to climate change. This highlights the need for adaptive water management strategies and sustainable agricultural practices to mitigate risks and ensure long-term food security (Fig. 1).

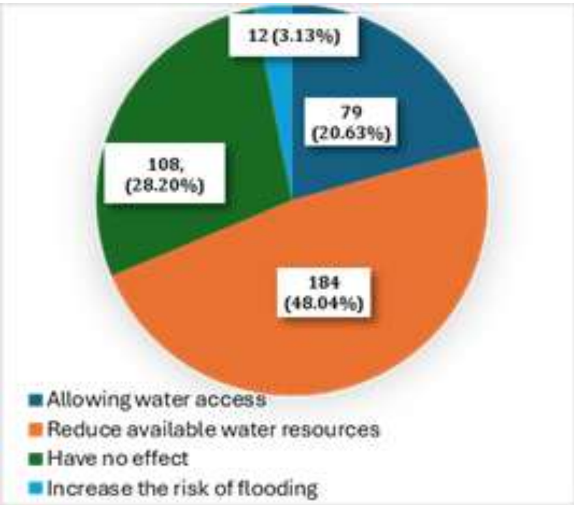

Fig. 1. The farmers' opinions concerning water access for agriculture
Source: Own processing based on field survey.

17.23% (66 farmers) pointed to a lack of fertilizers as a key issue, possibly due to rising costs or reduced availability of essential nutrients needed for crop growth, while the majority of respondents (42.04%, 161 farmers) identified soil erosion and drought as the main factor, which aligns with scientific research indicating that climate change exacerbates soil degradation and water shortages, directly impacting crop yields (Fig. 2). This emphasizes the urgent need for climate-adaptive soil conservation techniques, sustainable irrigation practices, and policies that address the increasing risks of land degradation in European agriculture.

A considerable proportion (34.99%, 134 farmers) attributed the decline to intensive agricultural practices, highlighting concerns about overexploitation of soil, monocultures, and unsustainable farming methods that deplete natural resources. A much smaller fraction (5.74%, 22 farmers) considered pesticides as a major cause, indicating that their impact on productivity is perceived as less significant compared to other factors.

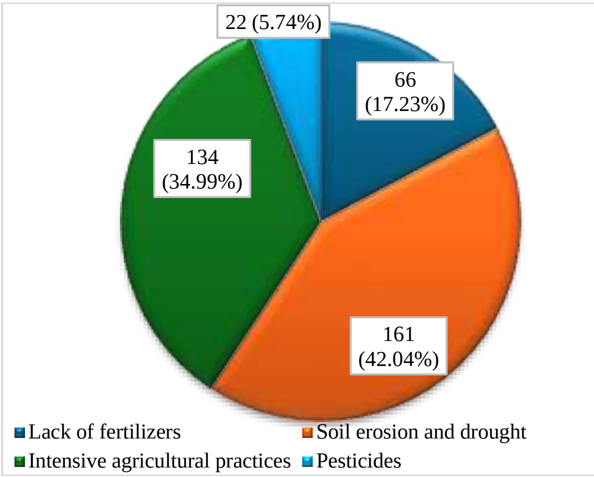

Fig. 2. The farmers' opinions concerning the main cause of the decline in agricultural productivity in the EU, in the context of climate change
Source: Own processing based on field survey.

Majority of subjects, 169 farmers, respectively (44.13%), have a correct perception meaning that climate changes promote soil nutrients depletion. 51 of the respondents representing 13.32% of the total (Fig. 3), have the misconception that climate changes contribute to the enhancement of soil nutritional status.

This approach aligns with scientific evidence, as climate change-induced factors such as soil erosion, extreme rainfall, increased leaching, and higher temperatures accelerate the depletion of vital nutrients like nitrogen, phosphorus, and potassium from the soil. It also emphasizes the urgent need for soil conservation strategies, such as cover cropping, organic amendments, precision fertilization, and reduced tillage, to counteract nutrient depletion and sustain soil fertility in the face of climate change.

A significant proportion (39.43%, 151 farmers) consider that climate change causes the accumulation of heavy metals in the soil. While this can occur in certain environmental conditions, such as increased soil acidification leading to metal mobilization, it is not the primary effect compared to nutrient depletion.

Lastly, 3.13% (12 respondents) think climate change has no effect on soil nutrient composition, which contradicts the well-documented impacts of changing climate patterns on soil health.

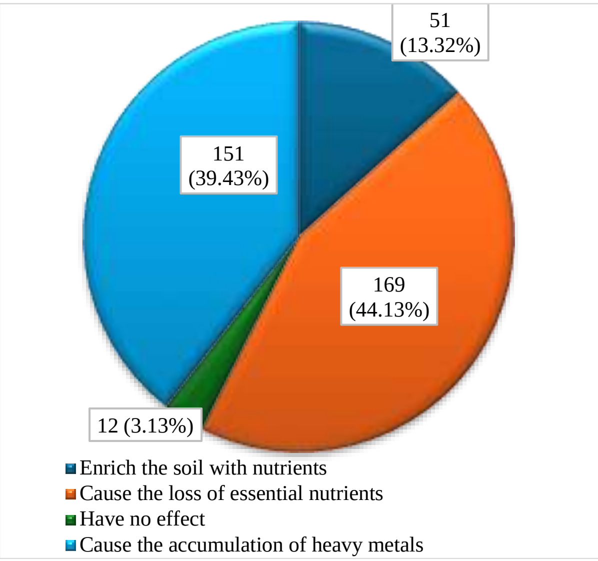

Fig. 3. The farmers' opinions concerning the way in which climate change affects the composition of soil nutrients
Source: Own processing based on field survey.

Most farmers (41.25%, 158 respondents) believe that increased temperatures enhance water access, which may reflect the perception that warmer conditions could lead to increased precipitation or improved irrigation efficiency in some regions (Fig. 4). However, this viewpoint may overlook the risk of heightened evaporation rates, which could negate any perceived benefits in water availability.

A significant portion (31.85%, 122 respondents) suggests that higher temperatures cause more vigorous plant growth.

While certain crops might benefit from extended growing seasons or increased photosynthesis, excessive heat can also lead to heat stress, reduced yields, and greater water demand.

Approximately 24.80% (95 respondents) think that increased temperatures have no effect on plant growth, possibly due to a lack of observed changes in their local context or reliance on resilient crop varieties.

Only 2.09% (8 respondents) believe that higher temperatures slow down plant growth, which is counterintuitive given that extreme heat often hinders plant development and reduces agricultural productivity (Fig. 4).

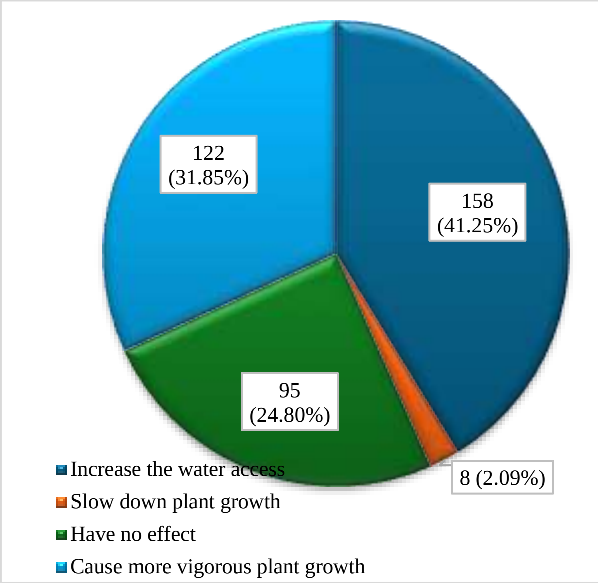

Fig. 4. The farmers' opinions concerning the effect of increased temperatures on the growth cycle of plants
Source: Own processing based on field survey.

The discrepancy between the farmers which have the correct response, and the others suggests a potential misalignment between farmers' perceptions and the scientifically established effects of temperature increases on plant growth.

The correct perception was observed at 37.08% (142 respondents), indicating that most farmers believe that the growing season is extended due to climate change (Fig. 5). This perception aligns with scientific research showing that rising temperatures and milder winters have lengthened the growing period in many European regions, allowing for longer or additional crop cycles. However, an almost equal percentage of farmers (36.81%, 141 respondents) believe that the number of crops is reduced due to climate change (Fig. 5).

While an extended season could theoretically allow for more crop cycles, increasing droughts, heat stress, and unpredictable weather patterns may limit the variety and productivity of crops, forcing farmers to focus on more resilient but fewer crop types. A smaller group of respondents (22.45%, 86 farmers) think that the growing season remains the same, which may reflect experiences in areas where climate change impacts have been less pronounced or offset by other environmental factors.

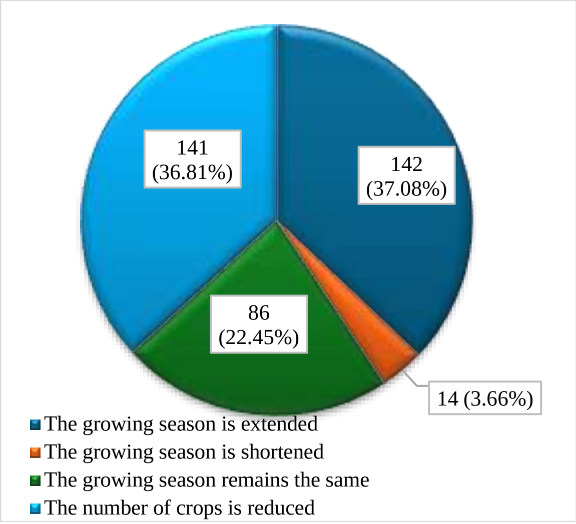

Fig. 5. The farmers' opinions concerning the changes occurring in the European agricultural season due to climate change
Source: Own processing based on field survey.

Only 3.66% (14 respondents) believe that the growing season is shortened, which is the least chosen response. While this can happen in specific cases (e.g., extreme heat accelerating plant maturity too quickly), the general trend in Europe has been toward an extended season. The correlations between farmers' awareness concerning the influence of climatic changes on crops nutritional status variables emphasize key perceptions and misconceptions about the impacts of climate change on agricultural productivity and soil health (Table 2).

One of the strongest positive correlations is observed between "Increase the risk of flooding" and "Cause the accumulation of heavy metals" with a value of 0.53, suggesting that farmers who associate climate change with flooding are also likely to believe it leads to increased heavy metal accumulation in the soil. "Soil erosion and drought" is highly negatively correlated with "Cause the accumulation of heavy metals" (-0.91), with "Cause more vigorous plant growth" (-0.91), and with "Enriches the soil with nutrients" (-0.46) indicating that farmers have a correct perception on factors affecting the influence of climatic changes on crops nutritional status.

Table 2. The simple Spearman correlations between farmers' awareness concerning the influence of climatic changes on crops nutritional status variables

Issue	Var11	Var12	Var13	Var14	Var15	Var16	Var17	Var18	Var19	Var20
Var1	-0.15	-0.53	-0.35	0.80	0.03	-0.09	0.63	-0.26	-0.63	-0.14
Var2	0.32	0.23	0.14	-0.41	0.66	0.71	-0.28	-0.26	-0.06	0.24
Var3	0.12	-0.63	-0.04	0.28	-0.84	-0.40	0.65	-0.08	-0.34	-0.59
Var4	0.29	0.53	-0.15	-0.53	0.47	0.12	-0.49	-0.29	0.51	0.45
Var5	-0.03	-0.53	-0.39	0.75	0.14	0.02	0.64	-0.41	-0.67	-0.10
Var6	0.10	-0.29	0.63	-0.38	-0.91	-0.04	0.12	0.46	-0.05	-0.66
Var7	0.31	0.10	-0.64	0.14	0.69	0.10	0.08	-0.79	-0.03	0.45
Var8	-0.95	0.66	-0.19	0.38	0.15	-0.74	-0.61	0.76	0.74	0.56
Var9	0.35	0.44	0.29	-0.84	0.07	0.25	-0.52	0.02	0.49	0.12
Var10	0.35	-0.25	0.35	-0.20	0.32	0.85	0.15	-0.19	-0.56	-0.20

Var 1-Increase the water access; Var 2-Reduce available water resources; Var 3-Have no effect; Var 4-Increase the risk of flooding; Var 5-Lack of fertilizers; Var 6-Soil erosion and drought; Var 7-Intensive agricultural practices; Var 8-Pesticides; Var 9-Enrich the soil with nutrients; Var 10-Cause the loss of essential nutrients; Var 11-Have no impact; Var 12-Cause the accumulation of heavy metals; Var 13-Accelerate the growth cycle; Var 14-Slow down plant growth; Var 15-Have no effect; Var 16-Cause more vigorous plant growth; Var 17-The growing season is extended; Var 18-The growing season is shortened; Var 19-The growing season remains the same; Var 20- The number of crops is reduced.
Source: Own results.

A notable negative correlation is found between "Pesticides" and "Increase the water access" (-0.95), implying that farmers who see pesticides as a major issue are less likely to believe that climate change improves water availability. There is a moderate positive correlation (0.66) between "Reduce available water resources" and "Cause the accumulation of heavy metals", highlighting that farmers who recognize water scarcity as a major effect of climate change are also more likely to associate it with increased heavy metal content in soils. Below et al. (2012), analysing socio-economic variables expected to be significantly correlated with adaptation to climate changes identified weak, positive and negative correlations [5].

According to PCA, there are five principal factors (Table 3). The first principal component is associated with the influence of climate change on water availability for agriculture in a national context, where the strongest positive loadings are observed for "Increase the water access" (0.647) and "Have no effect" (0.646), while "Increase the risk of flooding" (-0.671) has a notable negative loading. It Is responsible for the greatest part of variance, 34.66% respectively.

This suggests that farmers' perceptions regarding water availability are polarized, with some believing that climate change improves access while others associate it with risks such as flooding. The second component represents the main cause of the decline in agricultural productivity in the EU due to climate change, explaining 27.70% of the variance. "Lack of fertilizers" (0.626) emerges as the most influential factor, followed by "Soil erosion and drought" (0.276), while "Pesticides" (-0.544) has a strong negative loading, indicating that some farmers perceive it as less critical to agricultural decline compared to other factors. The third principal component focuses on how climate change affects soil nutrient composition, accounting for 20.65% of the variance.

A strong negative loading for "Cause the accumulation of heavy metals" (-0.983) suggests that farmers who recognize this impact strongly associate it with nutrient degradation rather than enrichment.

The fourth principal component, explaining 10.00% of the variance, examines the effect of increased temperatures on plant growth cycles. "Have no effect" (-0.630) has the strongest negative loading, suggesting that the belief in temperature-induced changes dominates among farmers.

Table 3. The PCA conducted for identifying farmers perception on climatic changes effects on crops nutrition

Eigenvalue	Variance, %	Factor	Item	Factor loading
6.933032	34.66516	Ease water access for agriculture and climate changes	Allowing water access	0.647428
			Reduce available water resources	-0.290922
			Have no effect	0.646140
			Increase the risk of flooding	-0.671334
5.540028	27.70014	The main cause of the decline in agricultural productivity in the EU, in the context of climate change	Lack of fertilizers	0.626288
			Soil erosion and drought	0.275732
			Intensive agricultural practices	-0.176756
			Pesticides	-0.544304
4.129992	20.64996	How climate change affects the composition of soil nutrients	Enrich the soil with nutrients	-0.583665
			Cause the loss of essential nutrients	0.257862
			Have no impact	0.489864
			Cause the accumulation of heavy metals	-0.982765
2.000432	10.00216	The effect of increased temperatures on the growth cycle of plants	Accelerate the growth cycle	0.156860
			Slow down plant growth	0.216460
			Have no effect	-0.629967
			Cause more vigorous plant growth	0.278934
1.396516	6.98258	Changes occurring in the European agricultural season due to climate change	The growing season is extended	0.949203
			The growing season is shortened	-0.393149
			The growing season remains the same	-0.936300
			The number of crops is reduced	-0.820968

Source: Own processing.

"Cause more vigorous plant growth" (0.279) and "Slow down plant growth" (0.216) both contribute positively but to a lesser extent, indicating varied perspectives on how heat influences plant development.

The final component, covering 6.98% of the variance, captures changes in the European agricultural season due to climate change. "The growing season is extended" (0.949) has the strongest positive loading, indicating widespread agreement that climate change is lengthening the farming season. Conversely, "The growing season remains the same" (-0.936) and "The number of crops is reduced" (-0.821) exhibit strong negative loadings, reflecting the perception that seasonal shifts are occurring rather than remaining static or reducing overall crop diversity.

CONCLUSIONS

The present study reveals that nearly half of the surveyed farmers recognize that climate change reduces available water resources, confirming the scientifically established trend of increasing water scarcity due to rising temperatures and altered precipitation patterns. Regarding agricultural productivity, soil erosion and drought are identified as the primary causes of decline, aligning with scientific research that points to land degradation and water shortages as key threats. Farmers also acknowledge the role of intensive agricultural practices, which suggests that many understand the long-term risks associated with soil overexploitation and monoculture systems. The strong recognition of nutrient loss due to extreme weather, erosion, and leaching reinforces the urgent need for soil conservation strategies, including cover cropping, organic amendments, and precision fertilization. The results also highlight discrepancies in perceptions regarding temperature increases and plant growth. While some farmers believe that higher temperatures enhance plant growth or increase water access, these perceptions may overlook the negative effects of heat stress, increased evaporation, and water scarcity. The varied responses suggest a misalignment between observed impacts and scientific evidence, emphasizing the need for more awareness-building initiatives on the true consequences of climate change for crop production. Most respondents correctly perceive an extension of the growing season, which is consistent with longer frost-free periods and warming temperatures in Europe.

The correlation analysis shows both correct perceptions and misconceptions about climate change effects on agriculture. The PCA allows us to emphasize the hierarchization of the main factors of climate changes affecting the crop nutrition in the perception of the respondents.

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TECHNICAL EFFICIENCY AMONG THE FISH FARMERS IN OSUN STATE, NIGERIA

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Abstract

This study used the stochastic frontier production function analysis to assess the technical efficiency of fish producers in Osun State, Nigeria. A series of structured questionnaires was used to gather primary data from 90 fish producers in Nigeria's Osun State. According to the computed stochastic frontier function for the 90 respondents, the average efficiency value was 0.801. From this, it can be inferred that 82.22% of the population of fish farmers had above-average fish production performance, while 17.78% of the farmers performed below-average. The coefficients of years of experience, household type, age, and educational attainment were found to be strongly correlated with the degree of inefficiency. This demonstrated that these elements either increased technical efficiency or decreased technical inefficiency. The distribution of findings also revealed that, while not using all the inputs, fish farmers in Osun State are more efficient in their utilization. In order to fulfil the common knowledge gap among fish farmers, it is advised that seminars and worship be held in order to increase the efficiency of the fish farmers in the study area.

Key words*: *aquaculture, Stochastic Frontier, input and output, Osun State, Nigeria

INTRODUCTION

Fish production in Nigeria is currently obtained through two main sources, namely, the capture fishery (capture) and aquaculture fishery (aquaculture). However, empirical evidence has shown that there is a wide disparity between fish supply from all these sources and fish demand. As reported by [60], the Nigerian Minister of Agriculture and Rural Development revealed that, Nigeria's total fish production is estimated at 1.123 million metric tonnes while put the fish demand of the country at 3.6 million metric tonnes of which the country only meet up about 31.19%.

[6] also reported a shortfall of about 1.3 million tons in the fish supply of Nigeria. This deficit in the demand-supply gap may increase fish prices and fish importation bills. For example in 2020 alone, the country spent over $876,081,485.00 million on the importation of frozen fish (excluding fish fillets and other fish meat) and only generated $106,964.00 thousand in export [59]. This is why Nigeria is considered a net importer of fishery products. The hidden truth of the importation is development in the fishery sector in Nigeria will be hindered because a huge amount of money that ought to have been committed to its development is being spent on fish importation.

The situation on fish demand and supply gap is surprising and the rate is alarming when one considers the fisheries resources potential the country is blessed with which could serve as an avenue for economic growth if well harnessed. It was revealed by [36] that Nigeria has a continental coastline length of 853 km [36] and a continental shelf area of 43,514 km^2 [50]. Its extensive network of inland waters, including rivers, flood plains, lakes, and reservoirs, both natural and man-made, was also disclosed by [51].

In 2020, the fisheries subsector accounted for 1.09% of the nation's GDP, and in the third quarter of 2021, it contributed 0.9% [34]. According to estimates, the inland water mass is around 12.5 million hectares, with the capacity to produce 512,000 metric tons of fish each year. All these are great sources for fish cultivation and the evidence that Nigerians can produce enough fish to meet its demand and export excess, provided the vast aquatic resources are harnessed and utilized with a high level of productivity.

Ironically, despite the aforementioned inadequate fish supply in the country, Nigeria is the largest fish consumer in Africa and among the largest fish consumers in the world [2] with about 3.2 million metric tons of fish consumed annually [57]

Catfish production increased fast with a high rate since 2000 till present at the global level exceeding 6,000,000 Metric Tons. Catfish is largely cultivated in Europe, Asia, Africa and America [58]. Nigeria is currently the largest producer of African catfish in the world [20]. The aquaculture subsector is thought to be a very good substitute for supplying the country's demand for fish production self-sufficiency. This is because, in comparison to capture fisheries, it has a low capital intensity and a good return on investment [29]. Fish culture is the main focus of aquaculture in Nigeria, where the most often cultivated fish species are Heterotis niloticus (slap water), Cyprinus carpio (common carp), Tilapia spp. (tilapia), and Clarias and Heterobranchus spp. (catfish) [43]. Nonetheless, a lot of fish farms concentrate on catfish because their market value can be two to three times that of tilapia [23].

Fishery production is of great importance in Nigeria given its ability to provide a relatively cheap source of animal protein, income, and employment. Fish accounts for nearly 40% of Nigeria's protein intake, as fish consumption hovers between 11.2 and 13.3 kg/person/per year [4].

In Nigeria, over 1.477.651 people were reported to have been engaged in the fisheries sector of Nigeria in 2014 ([21], [61]). Fish consumption has come to play the role of supplying quality protein, in contrast to protein supply by red meat consumption which scientists have proven to be a source of bad cholesterol, a deadly health issue in the human body which can lead to hypertension. [49] undertook a systematic review and dose-response meta-analysis of prospective studies and reported a positive association between red meat intake and hypertension. Fish functions to protect a human being from a variety of diseases in the world, [55]. The moisture, protein, lipids, vitamins and minerals in fish are important macro and micronutrients, responsible for implying nutritional value to the fish meat [31]. The dietary support of fish is crucial in terms of animal protein, as a portion of 150 g of fish provides about 50-60 percent of the daily protein rations for an adult. As a result, fish can be used as a primary protein source in many underdeveloped nations. Fish made up over 17% of the world's animal protein intake and 6.5% of all protein intake as recently as 2010 [22].

There is widespread hunger and malnutrition in Nigeria, which could be attributed to fish supply gap in Nigeria, because lack of adequate protein intake both in quality and quantity to feed the nation's ever-growing population has been one of the greatest problems confronting millions of Nigerians today. This inadequacy results in the problem of malnutrition.

Most people consider fish and fish products to be acceptable, which contributes to the constantly rising demand for them. Consuming foods high in protein is becoming more and more popular, as noted by [13].

However, the supply side has not been given the appropriate attention to create an equilibrium point with demand. In order to meet the nation's enormous demand for fish, Nigerians must expand aquaculture and fish production using all of the inland water that is accessible.

Interestingly, there is an increasing trend and high level of awareness of farm-raised fish production in Nigeria and farmers are keen on fish farming. Fish farming is expanding rapidly throughout the world and has a high potential for the provision of valuable protein in less developed countries [32].

[47] opined that in most small-scale agricultural production, advanced technology has not enhanced output simply because a lot of such technologies are exhausted without giving a proportionate increase in output. In other words, there is a need to optimise the use of resources and input to enhance profitability and productivity. Optimum yield should be based therefore on full capacity utilization of resources through efficient use of existing technology and policies made bearing in mind this necessity of full capacity [15; 47].

Moreover, it is sufficient to point out that the early model of aquaculture production focused on the biological and technical aspects of aquaculture production with little emphasis on economic performance. For instance, [48] and [8] developed models for different components of aquaculture relating to the design and operation of aquaculture facilities. In Indonesia, [54] found that catfish cultivators had implemented good and correct technical cultivation activities, farming in ponds was financially feasible, and the catfish marketing system was running efficiently in Banjar Regency, South Kalimantan province, In Southwest Nigeria, [7] investigated the profitability of small-scale catfish farming, and in Osun State, Nigeria, [30] examined the economics of catfish farming.

Also, attention has been focused on the optimal harvesting strategies and lots of bio-economic models have been developed to determine the optimal time of harvest based on a number of different cost and price assumption [26] with little or no emphasis on economic efficiency.

Literature review

The majority of empirical studies on efficiency and productivity are grounded in the economic theory of production.

Efficiency is defined as the achievement of a production objective with no waste. The fundamental principle of "no waste" served as the foundation for the several theories of efficiency that economists have developed. But the fundamental concept behind all efficiency indicators is the amount of goods and services per unit of input. Accordingly, if a production unit produces too little from a given bundle of inputs, it is considered technically inefficient.

Efficiency can be measured using two fundamental approaches: the frontier approach and the classical way. The traditional method, known as a partial productivity measure, is predicated on the ratio of output to a specific input. This strategy does have certain drawbacks, though, thus more sophisticated econometric and linear programming techniques were created to analyze production and efficiency. Businesses that operate on the production frontier are said to be efficient, according to the frontier measure of efficiency. Inefficiency is defined as the degree to which a corporation falls below its production frontier. The frontier approach was first discussed in [19].

[19] distinguished three categories of efficiency: economic efficiency (total efficiency), allocative efficiency (price efficiency), and technological efficiency. The ability of a Decision Making Unit (DMU) to generate the most possible output from a specific bundle of inputs or the smallest conceivable quantities of inputs to create a particular level of output is known as technical efficiency (TE). While the latter definition is known as input-oriented TE, the former is known as output-oriented TE. The ability of a technically efficient DMU to use inputs in proportions that minimize production costs given input prices is known as allocative efficiency (AE).

The result of combined TE and AE is economic efficiency (EE) [19]. Accordingly, if a DMU is both technically and allocative efficient, then it is economically efficient. Economists contend that a key factor in determining priorities should be the attainment of (higher) efficiency from limited resources.

The problem of balancing the expanding demand for different services with the resources at hand is becoming more and more difficult for decision-makers. Farrell originally suggested an innovative method of efficiency frontier calculation from actual production measurements in 1957, arguing that the firm's efficiency could be experimentally calculated. The frontier planned form, the estimate method used to obtain it, and the nature and purported characteristics of the gap between the observed production and the ideal production are the three categories into which the frontier estimation techniques can be divided. The frontier form classification makes it possible to differentiate between parametric and nonparametric techniques. A function with explicit parameters (Cobb-Douglass, CES, Translog, etc.) is presented via the parametric approach.

According to [3], the parametric method is the one that shows a function with clear parameters. Numerous econometrical and non-econometrical methods, such as the maximum likelihood method and the least-squares method, allow for the estimation of the production or cost border parameters in the case of a parametric function.

The unique feature of nonparametric frontiers is that they don't force any predetermined form on them [14]. When a functional form is unable to identify the production process, the nonparametric technique is employed. The sole factor that distinguishes the nonparametric techniques is the production's convexity. It allows one to differentiate between that non-convex and the convex nonparametric technique. Farrell utilized the former for the first time in 1957. Farrell's production frontier imposes certain constant outputs at the scale and is linear.

The aim of this article is to use the stochastic frontier production function analysis to evaluate the technical efficiency of fish farmers in Osun State, Nigeria, as well as the factors that influence fish production. This is critical since it would greatly influence the creation and application of policies in the state and the country of Nigeria overall.

MATERIALS AND METHODS

Osun State is where the study was conducted. 9,125 km² make up the total landmass of Osun state. Kwara State borders it to the North, Kogi State borders it to the Northeast, Ondo state borders it to the East, and Ogun State borders it to the South. It is located between latitudes 700 and 800 N.

The rainfall pattern of Osun state is wide and diverse ranging from 125 mm (minimum in the dry season). Thus, there are two rainfall peaks. The average rainfall ranges from 1,125 mm in derived savannah to 1,475 mm in the rain forest belt. The mean annual temperature ranges from 27.2°C in the month of June to 39.0°C in December. The soil types are varied but most contain a high proportion of clay and sand, and are mainly dominated by laterite. Osun state is well drained with some rivers which the indigenes of the area used for domestic purpose and fish cultivation. The region is home to an agrarian community that produces crops, fish, and poultry. Among the states in southwest Nigeria, Osun has the largest percentage of fish producers. With 300 fish farmers, Osun State had the most of the 906 fish farmers in the Southwest, followed by Oyo, which had 234 fish farmers overall [9]. Administratively, Osun state is divided into 30 local government plus 1 area office with an estimated population according to 2006 census of 3423,535. But going by the Osun state Agricultural Development Programme (ADP) method of administration, the state is divided into three zones: Iwo, Oshogbo and Ilesha zones. Ido-Osun and Ofatedo towns are located in Egbedore Local Government while Owode-Ede is in Ede North Local Government of Osun State.

The study areas was chosen from Iwo zone, because it had a higher concentration of fish farmers relative to the other two zones according to the information from Ministry of Agriculture, Fisheries and Aquacultures Department Osun State. Iwo zone comprises of Egbedore and Ede Local Government areas of Osun State. The study was then undertaken in Ido-Osun, Ofatedo and Owode-ede. Ninety catfish fish producers across Iwo zones were randomly selected using a list obtained from Ministry of Agriculture, Fisheries and Aquacultures Department Osun State.

Primary data was used for this study. The data was collected on 2024 catfish production activities using a well-structured questionnaire in a multi-stage sampling technique. Purposive selection was used in the first stage to choose Ido-Osun, Ofatedo (Egbedore Local Government Area), and Owode-Ede (Ede-North Local Government Area) because catfish farming is one of the primary sources of income for the locals. The Second Stage was to obtain the list of catfish farmers in the selected locations from the Fisheries Department of Osun State Ministry of Agriculture, Osogbo and Blossom Vine Catfish Farmers Cooperative Society.

Finally, a total of 90 catfish farmers were randomly selected using proportionality factor adopted by [1].

$$S = \frac{p}{P} x \frac{Q}{1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where:
S =Total number of respondents sampled
p = Number of catfish farmers in each location
P = Total population of catfish farmers
Q = Total number of questionnaires administered.

A total of 40, 20 and 30 respondents were selected from Ido-Osun, Ofatedo, (Egbedore Local Government Area) and Owode-Ede respectively. Ido Osun had a higher concentration of fish farmers relative to other local governments

Data were of primary origin aimed at investigating socio-economic characteristics of the fish farmers as well as efficiency of production. Thus, age of the farmers, household size, educational status, years of experience, number of fish stocked, various cost items necessary for production were among the various variables solicited for using questionnaire.

Catfish farmers' socioeconomic characteristics were described using descriptive statistics. This study examined the technical efficiency (TE) of catfish farmers using the Stochastic Frontier Production Function (SFPF). We employed the SFPF, which was separately proposed by [3] and [33] for the analysis. It has been demonstrated that estimating using the stochastic frontier production function allows one to determine whether variances in technical efficiencies from the frontier output are caused by random external causes or by farm-specific factors [27; 46; 40].

The general implicit form of the model is stated below:

$$LogY = \beta_0 + \beta_1 logX_1 + \beta_2 logX_2 + \beta_3 logX_3 + \beta_4 logX_4 + \beta_5 logX_5 + \beta_6 logX_6 + (V_1 - U_1)) \ldots\ldots\ldots\ldots\ldots (2)$$

where:
Log= Natural logarithm
Y = Output of catfish in kilogramme
X_1 =Number of fingerlings in number
X_2 = Quantity of feed in kilograms
X_3 = Labour in hours
X_4 = Lime (kg)
X_5= Fertilizer (kg)
X_6 =Capital input in naira (₦)
β_0. β_1 , β_2. β_3, β_4, β_5, β_6 = Regression Coefficients

Assumed to be identical, normally distributed, and independent of Ui, Vi= are random variables with a constant V variance N (0,sv2) and zero mean.

To account for technical inefficiencies in production, Ui= are non-negative random variables that are frequently assumed to be independent of Vi. In this way, U is the non-negative truncated (at zero) U of half-normal distribution with | N (0,su2)| The inefficiency of production, Ui was modelled in terms of the factors that are thought to affect farmers' production efficiency. These elements are connected to the socioeconomic characteristics of farmers.

The following defines the determinant of technical inefficiency:

$$U = \delta_o + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + e \ldots\ldots\ldots\ldots\ldots (3)$$

The factor that determines technical where:
U stands for technological inefficiency.
Z_1 = Farmers' age (years)
Z_2 = sex dummy, where female = 0 and male = 1.
Z3 = dummy marital status (married=0, single=0)

Z_4 = Years of education
Z_5 = Size of household
Z_6 = Experience Years
o = Constant 1 – 6 = Estimated parameters
e is the error term.
It is believed that these factors affect the farmers' technical efficiency. They also calculated the gamma (= o2 / 2) u, which is the ratio of the variance of U (o2) to the Sigma squared (2), which is a summation of variances U and V (o2+ 2). The parameters of the SFPF were estimated using the Maximum Likelihood Estimate Method with the computer FRONTIER version 4.1 [17].
Because it has been scientifically proven to be the most effective for agricultural studies of this kind, the Cobb Douglas form of the frontier model was employed. A mathematical expression for technical efficiency, which is the ratio of the observed output (Y1) to the equivalent frontier output (Y1*) contingent on the farmer's input levels, is as follows in the context of the stochastic frontier equation specified as:

TE = Y_1/Y_1^* .... (4)

= f (X ;B) exp (V_1 -U_1) / f (X;B) exp (V_1) .... (5)

= exp (-U_1) ………………………….. ...(6)

where:
Y_1 = observed value of output and
Y_1^* = the frontier output.

The frontier production function is estimated by the Maximum Likelihood Technique. Any farmer who is fully technically efficient will have the value of one. Thus farmers having value lying between zero and one are described as being technically inefficient.

The production function model of the aquaculture production functions was algebraically specified by the Cobb-Douglas function form because of its unique characteristics that are very useful in empirical analyses. These characteristics include: the elasticities of production used in the productivity analysis are equal to the estimated coefficients of the parameters (βi) of the production function and the summation of these elasticities of production gives the types of returns to scale obtained, that is, (Σβi) = RTS.

• When RTS = 1 there is constant return to scale.

• When RTS is between zero and one, that is, 0 < RTS < 1, there is a positive decreasing return to scale. Here, input allocation and output production are optimal and efficient. Any increase in allocation of input will result in increase in the total output but at a decreasing rate. This is known as stage II of production function that the aquaculture farm strives to attain.

• When RTS > 1, there is an increasing return to scale, where output increases at increasing rate with any increase in input. This is the stage I of the production function. The farmer needs to expand production by allocating more of the variable input to get to stage II where production is optimal and efficient.

• When RTS < 0, this is a negative decreasing returns to scale or stage III of the production function where any increased allocation of input for output production results in the decrease in the total output. Here the farmer needs to reduce the allocation of inputs so as to get back to stage II.

RESULTS AND DISCUSSIONS

Socio-economic and production factors

The averages of various production and socio-economic factors of interest are shown in Table 1. Fish farmers in Osun State are middle aged. The mean value for age indicated that the average age of the farmers was 40.8 years. [44] observed that the age bracket of 30-50 years represents an active productive age bracket in agriculture. There is no age restriction in going into catfish farming in the study area. An average fish farmer in the study area has an educational status of about 3 and a household size of 5. Catfish farming operations require a great deal of human effort from stocking, routine management to harvesting. Thus households with increased labour supply are more likely to adopt and participate in labour-intensive new technologies than those with fewer persons per household [35];[11]. The mean stocking capacity (fingerlings) of fish farmers is 56,945.78.

Table 1. The averages of various production and socio-economic factors of interest

Variable	Measure Unit	Mean	Standard deviation	Min	Max
Age	Years	40.8	9.49	18	65
Education	Years	2.79	.50	1	4
Household size	Number	5.18	1.65	2	10
Fingerlings	Number	32,570.12	22,636.12	5,000	90,000
Feed	Kilogram	56,945.78	100,559.1	6,600	800,000
Labour	Man-days	6.74	1.98	2	10
Lime	Kilogram	835	622.22	0	3,000
Fertilizer	Kilogram	371.61	253.04	0	950
Transportation	Naira	2,959.16	1,546.90	700	6,300
Depreciation cost	Naira	2,637.92	1,935.35	770	82,206.74

Source: Authors' computation.

$1 is equivalent to ₦ 1,590.69 as of October 2024 [16].

Determinants of Technical Efficiency

The maximum likelihood estimate of the stochastic frontier production function of fish production in Osun State is shown in Table 2. The results demonstrated that, at the 10% level, the sigma square (δ2) is 0.201 and statistically significant. This shows that the specified distribution assumption of the composite error term is true and fits the data well. Additionally, the estimated gamma (λ) variance ratio, which is significant at the 10% level, is 0.870, indicating that fish farmers in the study area are producing inefficiently. It indicates that variances in fish farming methods were the primary cause of variability in fish yield. Therefore, output can be optimized if the inefficiency effects among the fish producers are minimized. The result shows the relative importance of the variable inputs in fish production.

There are two components to the stochastic production function: the efficiency model and the technical efficiency model The technical efficiency model results show the direct contribution of each fish input employed to the total fish output. While the inefficiency model revealed the indirect influence of some intrinsic attributes of fish farmers on the total fish output

Thus, the result of technical efficiency shows that the estimates of the number of fingerlings stocked, quantity of feed, labour (man-days) and depreciation value of the fixed asset used in the fish production were statistically significant at 1% and 5% respectively. This means that they were directly related to the output that is, output increased as they were increased and vice versa.

The coefficient of fingerling was estimated to be 0.060 and positive. This implies that catfish fingerlings or fish seeds stocked, ceteris paribus, have a positive and significant contribution to the magnitude of fish output derivable on a typical farm. Similar studies by [41] and [18] discovered that the cost of fingerlings was significant in Benue and Cross River states, Nigeria respectively. The significance of fingerlings to table fish production is empirically based on the component of a particular breed or species, type of fish, hatchery management and fish characteristics that determine how the fish would respond to further production input such as fish feeds and other environmental factors within the farm site. Therefore, fish farmers should procure species of fish that are adaptive and responsive to fish feed and other farmers’ management.

The quantity of table fish produced by farmers in the study area was strongly influenced by the positive feed coefficient (0.056). A farmer's purchase of fingerlings dictates how much feed he will buy. This is consistent with [42] and [37]. Most often fish feed cost is usually considered very high, [28] reported that feed accounts for at least 60% of the total cost of fish production in Africa, which to a large extent determines the viability and profitability of fish farming enterprise. However, in the study it was noted that the coefficient of feed (0.056) is moderate compared to the estimated coefficient of fingerling (0.060).

Based on the general fish farming practices among the farmers the feed produced and used widely in Africa are categorized into conventional and non-conventional feed stuff [24]. The conventional feeds are formulated and branded fish feeds and oftentimes are costly beyond the economical capacity of most fish farmers. While the non-conventional fish feed is generally organic waste materials such as maggots, insects, hatchery waste, etc. These alternative fish feeds that are used as fish feed supplements aim at reducing the cost of production. But most often, most fish farmers do not weigh and factor these into their production cost and technically the effect of such feed supplement is difficult to capture and measure as fish input.

The majority of farmers who were interviewed in-depth also disclosed that the organic materials used to enhance fish feed are mostly used in their raw state, with little processing or treatment, and that the amount used on a given stock of fish is unpredictable due to inconsistent supplies. Furthermore, a common limitation mentioned by at least 89% of the fish farmers in the study area was the high cost of fish feed.

The coefficient of labour (0.423) is positive and significant. [52] observed that cost of labour had positive effect on production. [53] obtained similar result for the South Tripura district of Tripura State, China. Fish farming operations among small-scale farmers are generally labour-intensive and these small-scale fish farmers constitute 80% of fish aquaculture in Nigeria [12]. According to the analysis's results, labour was also shown to favourably and significantly increase the fish farmers' production of table fish. Fish management typically involves a high level of labor intensity for daily, infrequent, and routine procedures. In the study area, the hourly and strength engagement for scavenging for maggots and other sources of cheap feed materials are magnums to quantify. Therefore, there is a trade-off of labour man-day for the cost of feed that is required to nurture stocked fish seeds to table fish. Aside from this, labour requirements of pond maintenance and other daily fish farm operations are very crucial and are contributory factors for total table fish output.

The depreciation (0.645) value of the fixed fish farming equipment and machines is considered in this analysis because it is believed that these fixed assets do enhance the ease of fish farm operations which normally improves technical efficiency. As a result, the analysis's findings were deemed favourable and noteworthy in relation to the quantity of table fish produced by an average fish farmer in the study area. This is consistent with what [5] found.

The socioeconomic characteristics of fish farmers, which may enhance the efficacy and efficiency of aquaculture management techniques, are the inefficiency factor taken into account in this study. Age, sex, marital status, educational attainment, household size, and years of experience in fish farming are some of the socioeconomic traits of the fish farmers taken into account (Table 2). Years of experience, household size, and educational attainment all had negative coefficients, suggesting that these variables either increased or decreased technical inefficiency.

The outcome of the analysis shows that old age contributes to the inefficiency of aquaculture management. This implies that as the fish farmers are ageing, they might be deficient in the strength required for efficient management of daily fish farm operations. Whereas young fish farmers with able bodies would have the capacity to withstand the daily energy-sapping of fish production. Therefore, for such a typical ageing farmer to still be in fish operations, it would require the employment of able-bodied labour to carry series of tasking fish farm management. The result is in agreement with the studies of [56]; [35]; [25].

The model revealed that the educational attainment of fish farmers enhances fish farm management efficiency. This underscores the multiplier effects of improved knowledge and skills quotient of fish farmers could be tremendous as a determinant of the total fish produced. From this result, it could be deduced that educated and elite fish farmers tend to be more efficient when compared with less educated fish farmers. This supports the a priori prediction that TE should rise as education increases because experience and education are thought to be favorably connected with the adoption of better production methods and technology. This outcome aligns with [39], [38], and [25].

Table 2. The Stochastic Production Frontier Estimates Maximum Likelihood Estimates of the Stochastic Frontier Production Function for Catfish Farmers

Variables	**Parameters**	**Coefficients**	**St. Error**
Constant	β_0	4.576	0.421
Fingerling (number)	β_1	0.060***	0.016
Feed (kg)	β_2	0.056**	0.024
Labour (man-days)	β_3	0.423**	0.201
Lime (kg)	β_4	0.027	0.291
Fertilizer (kg)	β_5	0.123	0.112
Depreciation cost (₦)	β_6	0.645**	0.278
Inefficiency Function			
Constant	δ_0	0.177	0.203
Age	δ_1	0.024***	0.006
Sex	δ_2	-0.009	0.440
Marital status	δ_3	0.003	0.004
Education level	δ_4	-0.032***	0.007
Household size	δ_5	-0.021***	0.005
Experience	δ_6	-0.031***	0.012
Diagnostic Statistics			
Sigma square	δ^2	0.201*	5.973
Gamma	Γ	0.870*	10.053
Log likelihood function	148.855		

Source: Field Survey Data, 2024.
Note: *Significant at 10% level; ** Significant at 5% level; *** Significant at 1%

Additionally, among the respondents in the study area, the size of the fish farmers' households was statistically significant in relation to the efficient production of fish. The variable is said to increase efficiency if the coefficient is negative. This is consistent with what [10] found. According to the inefficiency model's relevance of household size, most fish producers used their own family members to work in fish farms instead of hiring workers. The implication is that households with mature family members would find daily fish farm operations easier and timely and this may not be so for the fish farmers who solely depend on hired labour for major fish farm operations.

Years of farm experience was another significant variable in the inefficiency model. The experience of the farmers on the proper management of fish farms is usually built up over time. The daily routine maintenance of fish farm operations such as feeding, monitoring water quality (water turbidity, aeration), and prevention of predators required prerequisite experience. Proper handling of these ponds and routine maintenance could be difficult for an inexperienced farmer.

Production Elasticities

When all other factors are maintained constant, production elasticities show the percentage change in output in relation to a percentage change in input. The regression coefficient, sometimes referred to as the estimated parameters of each variable in Table 3, represents the elasticity of production of the variables based on the nature of the Cobb-Douglas production function fitted. The number of fingerlings stocked, the total amount of feed, the total amount of labor, and the depreciation cost on fixed costs were all positive decreasing functions to the factors, according to the estimated elasticities of the explanatory variables. This suggests that the variable allocation was in the stage of economic relevance of the production function.

This implies that allocation and utilization of each of the factors (variables) was in stage II of the production functions or positive decreasing return to scale. Then allocation and utilization are efficient.

The Return to Scale (RTS) which is the summation of the elasticity of production inputs involved in fish production is 0.80. Fish production is in stage II (the rational stage) of the production function, as indicated by the fact that it is positive and less than unity.

This means that if all the variables are each increased by a unit, the profit will increase by 0.80. The return to scale (RTS) which is the summation of the elasticities of production of the production function is used to determine the stage of overall production in the production functions. From this study, RTS is < I implies, there is a positive decreasing return to scale. However, this result is not in agreement to those of [38] and [45] who reported the existence of increasing returns to scale but inefficient or irrational stage of production in catfish production in Oyo and River States of Nigeria, respectively

Table 3. Elasticity of production and Return-to-Scale of catfish farmers

Inputs	Elasticity
Fingerling (number)	0.060
Feed (kg)	0.056
Labour (man-days)	0.423
Depreciation cost (₦)	0.645
RTS	0.80

Source: Field Survey Data, 2024.

Productions are quite optimal and efficient among the fish farmers in the study areas according to Table 3. Any increase in the allocation of input results in an increase in total output at a decreasing rate. This is the best stage of production that any producer (aquaculture farmer) strives to attain.

Distribution of Fish Production Efficiency

The level of production efficiency varies with individual fish farmer’s intrinsic ability, edaphic and environmental factors, water quality, feed and feeding regime. In order to assess the respondents' performance level in the study area, the distribution of fish production efficiency was examined. Table 4 shows the decile range of the Technical Efficiency frequency distribution.

The average fish production efficiency of typical farmers in the study area is 0.801, and the least or minimum and maximum fish production efficiency values are 0.378 and 0.962.

Table 4. Range of Technical Efficiency

Decile Range of TE	Frequency	Percentage
< 0.40	6	6.67
0.40 – 0.49	10	11.11
0.50 – 0.59	12	13.33
0.60- 0.69	8	8.89
0.70 – 0.79	6	6.67
0.80- 0.89	38	38.89
0.90 and above	10	11.11

Source: Field Survey Data, 2024
Mean Technical Efficiency 80.1%
Minimum Technical Efficiency 37.8 %
Maximum Technical Efficiency 96.2 %

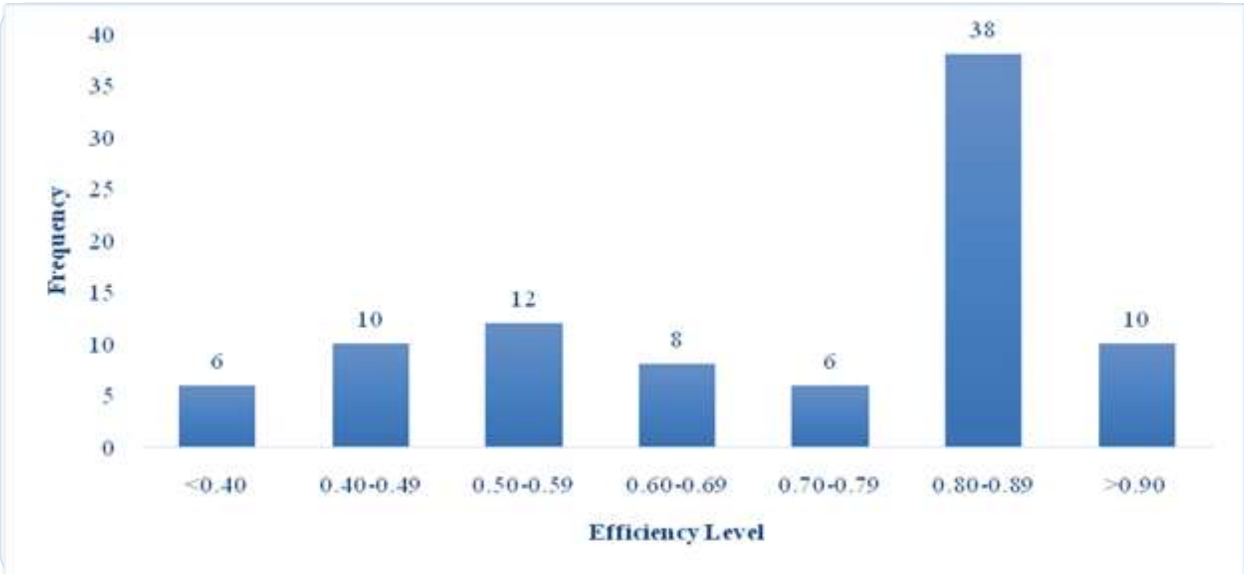

Fig. 1. Frequency Distribution of Technical Efficiency for fish culture in Osun State
Source: Author’s Computation.

According to the distribution of fish production efficiency, 11.11 percent had an efficiency between 40 and 49 percent, while 6.7% had an efficiency below 40 percent. Additionally, it was discovered that 13.33% of the respondents had production efficiency between 50 and 59 percent, 8.9% of the fish farmers had 60 to 69 percent, at least 6.67%

of the respondents were operating between 70 and 79 percent, and 50% of the fish farmers had production efficiency above 80 percent.

Summarily, it can be deduced that about 17.78% of the fish farmers were found to perform below average while 82.22% of the fish farmers' population had their fish production performance above average. Detail analysis further indicated that those farmers with less than 50% fish production efficiency were mostly young graduates or beginners who had inadequate experience in fish production.

Therefore, these set of fish farmers should endeavour to either interact with experienced fish farmers or attend fish production seminars or workshops to acquire adequate skills and knowledge to improve fish production efficiency.

The frequency distribution of technical efficiency for fish culture in Osun State is shown in Fig. 1.

CONCLUSIONS

This study aimed to determine the input and output technical efficiencies of fish producers in Osun State. The maximum likelihood estimate of the frontier production showed clearly that the Number of fingerlings, the quantity of feed, labour and depreciation on fixed cost are the most important inputs in fish production. The mean efficiency value of the 90 respondents' estimated stochastic frontier function was 0.801. It may be inferred that 82.22% of the population of fish farmers had above-average fish production performance, while 17.78% of the farmers performed below-average. The factors of age, years of experience, household type, and educational attainment were found to be strongly correlated with the degree of inefficiency. This suggested that either technical inefficiency decreased or technical efficiency increased as a result of these factors. Therefore, seminars and workshops should be held to train and close the knowledge gap among fish farmers in order to boost their efficiency in the study area.

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MANAGEMENT PRACTICES AND FINANCIAL PERFORMANCE OF AGRI-BASED ENTERPRISES IN PHILIPPINE STATE UNIVERSITIES AND COLLEGES

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Abstract

This paper used a descriptive-correlational research approach to investigate the agriculture-based enterprises' management practices and financial performance of within Philippine state universities and colleges (SUCs) in Leyte and Biliran islands. This study assessed the SUCs' management practices using eight dimensions: strategy, execution, culture, structure, leadership, innovation, talent, strategic linkages and partnerships, and net profit margin in measuring the financial outcomes of these enterprises. Findings revealed that managing talents, innovation, strategic linkages, and partnerships were practiced slightly among SUCs. Findings showed that level 4 SUCs exhibited better net profit margins for agri-based ventures. Moreover, strategy, culture, structure, talent, innovation, and strategic linkages and partnerships are significantly correlated to the financial performance of SUCs agri-based enterprises. This paper offers another perspective for stakeholders to create focused strategies and assistance frameworks, fostering the success and expansion of SUCs' agricultural enterprises.

Key words: *essential management practices, financial health, public universities, agri-focused ventures, SUCs*

INTRODUCTION

In the Philippines, government-funded higher education institutions frequently struggle to obtain sufficient financial resources, prompting them to look for extra income beyond what the state offers [7, 28, 30, 40, 49]. Numerous public colleges and universities have adopted income-generating projects (IGPs), particularly in agriculture, to tackle this issue [11, 49, 54]. These ventures include farms, livestock operations, and aquaculture, which help fund essential needs like infrastructure, faculty salaries, student scholarships, and research and offer students and faculty hands-on training and research opportunities [7, 28]. The income from these projects improves educational outcomes, lessens reliance on unpredictable government funding, and boosts local and regional development [1, 15].

Several studies have explored the management practices and financial performance of IGPs in higher education institutions, focusing on various sectors and settings [7, 28, 54]. Research has highlighted the critical role of effective management in ensuring the sustainability and profitability of IGPs, emphasizing strategic planning, resource allocation, and stakeholder engagement [30]. Studies specific to agri-based enterprises have demonstrated the potential for these ventures to enhance educational outcomes and provide practical training opportunities while generating additional revenue [49].

While research explores IGPs in higher education and their link to financial health, a significant gap exists regarding agri-based enterprises within Philippine SUCs. Existing studies often focus on the financial performance and sustainability of IGPs [1, 7, 11, 15, 28, 30, 35, 49, 54].

This study fills this gap by analyzing the management strategies and financial sustainability of agri-based businesses in SUCs. In particular, it sought to accomplish the following objectives:

(i)Examine the SUCs' practices in managing agri-based enterprises;

(ii) Assess the financial performance of these agriculture-based businesses; and

(iii) Evaluate the correlation between management practices and financial outcomes.

This research intends to offer specific and actionable insights for enhancing the performance of SUC agribusiness ventures in the country by examining management practices and their influence on financial performance. Recognizing efficient management practices for SUCs agri-focused IGPs can improve operational efficiency, inform training programs, and guide policy decisions to strengthen the financial health of agri-based enterprises.

Literature review

Impact of management practices on the financial performance of agri-based enterprises in higher education institutions

Understanding how management practices influence the financial performance of agri-based enterprises is a complex but essential topic [53]. Strong management practices are the backbone of financial success for agri-businesses [34]. Every aspect needs to be well-managed, from financial planning and efficient production processes to strategic marketing, risk management, and a skilled workforce [18]. Embracing technologies like precision agriculture and digital marketing can further optimize resources, boost yields, and expand the customer base, leading to long-term financial stability [21].

The leadership style in agri-based enterprises is also important and can significantly affect how well these businesses do financially [14]. A visionary and inspiring leader always looks for innovative ways to improve and pushing for the adoption of new technologies [2, 46]. Transformational leadership can boost productivity and cut costs by encouraging sustainable practices [6]. On the other hand, a leader who focuses on routine operations and efficiency, known as a transactional leader, ensures that everything runs smoothly and standards are consistently met [52]. Both styles have their strengths, but the right choice can significantly affect employee morale, innovation, and operational efficiency, which are essential for financial success [5].

How resources are allocated also plays a crucial role in the financial health of agri-based enterprises [30]. When these enterprises carefully manage their finances, workforce, and equipment, they can produce more while spending less [20]. It might mean investing in cutting-edge farming technologies, upgrading facilities, or continuously training their team to stay ahead of the curve [26]. Such thoughtful allocation leads to better harvests, higher quality products, and a stronger position in the market, which all boosts financial performance. In universities, aligning these resource decisions with research goals and educational objectives can create powerful synergies, enhancing the enterprise and the institution [55].

Meanwhile, operational efficiency is essential for the financial health of agri-based enterprises [30]. Streamlining processes, cutting waste, and fine-tuning supply management can save money and increase profits [19]. Advanced techniques like precision agriculture, integrated pest management, and sustainable practices can significantly boost crop yields while protecting the environment [22]. Universities are crucial in this progress, leveraging their research to develop and improve these innovative methods [4]. This work paves the way for a more productive and eco-friendly future in farming [41]. By continuously striving for improvement and utilizing academic expertise, agri-based enterprises can greatly enhance their financial performance [47].

On-campus agricultural enterprises must be flexible, embracing changes such as market trends and regulations and adopting new technologies [13]. Universities act as crucibles for innovation and adaptability, equipping businesses to thrive in a competitive landscape [32]. Strong leadership, strategic planning, and efficient resource allocation – these effective management practices are the bedrock of long-term success [38]. By fostering such a foundation, universities empower businesses to achieve sustainability and prosperity.

Measuring the financial performance of IGPs in Philippine SUCs

Monitoring the financial health of state universities and colleges income-generating projects (IGPs) is crucial to ensure long-term success [10, 28, 30, 43]. These diverse projects, ranging from farms to shops and services, are essential for boosting SUCs' financial resources [15]. By analyzing key metrics like profitability, return on investment, and efficiency, we can understand each IGP's economic viability and make informed future decisions [7].

Profitability is a key indicator of financial performance for IGPs [49]. This measure involves calculating the net income generated by the project after accounting for all expenses, including operational costs, labor, and materials. Profitability shows SUCs if the project brings in enough money to cover expenses and contribute to the university's budget [40]. It helps identify areas where they can cut costs or find ways to make more money. With this information, SUCs can make better decisions about the future of each IGP. On the other hand, return on investment (ROI) is like a scorecard for IGPs. It shows SUCs how much profit they get back for every peso they invest. A high ROI means the project uses its money well and generates a good return [7]. SUC administrators can easily compare different IGPs, see which ones are the most successful, and decide where to put their money and resources for the biggest impact by looking at ROI [45]. It helps them pick the winning projects to bring the most money for the university.

SUCs can also monitor the health of their IGPs, like financial fitness trackers. Tools like cost-to-revenue and asset turnover ratios help us see how efficiently these projects turn resources into income [51]. The cost-to-revenue ratio reveals expense control (lower is better), while the asset turnover ratio shows how much revenue each peso invested in equipment generates. These tools clearly show how well the projects are performing financially. By monitoring these ratios, SUCs can spot areas where they can do better and make informed decisions to keep their income-generating projects financially healthy and contribute significantly to the university's budget [30].

Another measurement tool is the cash flow analysis. It tracks incoming and outgoing money to see if there is enough for daily operations and future investments [33]. Positive cash flow means the project is healthy, generating enough to grow smoothly [12]. However, negative cash flow indicates potential financial trouble needing attention to ensure the IGP's long-term success [16]. By regularly analyzing cash flow, SUCs can maintain economic stability and avoid cash shortages that could threaten the success of their projects [35].

Benchmarking against similar projects and industry standards is crucial for contextualizing the financial performance of IGPs [24]. Institutions can gain valuable insights into their relative strengths and weaknesses by comparing their performance metrics with those of other SUCs or private sector equivalents [25]. Benchmarking helps identify best practices, set realistic performance targets, and drive continuous improvement [48]. It also provides a broader perspective on the competitive landscape, enabling SUCs to adapt their strategies to enhance the financial results of their IGPs [15].

MATERIALS AND METHODS

This study employed a descriptive-correlational research approach to explore the management practices and the financial performance of agri-based enterprises of SUCs in the Leyte and Biliran islands of the Philippines. These SUCs are engaged in animal, crop, and fish production enterprises. In determining the management practices of these agri-based enterprises, the researchers utilized an adopted research instrument [42, 44], drawn from Nohria et al.’s [36] concept of eight essential management practices that must be exhibited among firms to achieve business success (Table 1).

Each dimension contains eight describing statements to which respondents rated its extent of manifestation as management practice on their enterprises with the following categories: (1) not practiced, (2) moderate extent, (3) great extent, and (4) very great extent.

Table 1. Description of the dimensions of management practices

Dimensions	Description
Strategy	is a clear plan that aligns resources and goals to adapt to market changes and achieve objectives.
Execution	is the alignment of leadership, employee participation, and efficient processes to implement strategies, meet market demands, and boost productivity.
Culture	reflects shared beliefs, values, and norms that drive teamwork, encourage learning from mistakes, and promote a customer-focused, results-oriented environment.
Structure	defines roles, responsibilities, and processes to enhance productivity, foster collaboration, streamline decisions, and deliver value by placing key personnel close to critical operations.
Talent	refers to skilled individuals whose recruitment, development, and retention through training, fair compensation, and meaningful roles are vital for achieving goals and ensuring success.
Leadership	is the ability to inspire innovation, guide teams with knowledge and support, and foster a culture of commitment and creativity to drive performance and sustainability.
Innovation	is the creation of value through new ideas and practices that improve adaptability, strengthen partnerships, and seize opportunities for competitive advantage in a changing market.
Strategic linkages and partnerships	are collaborations that enhance governance, provide training access, and foster alliances to boost productivity and profitability.

Source: Authors' preparation (2024).

The mean rating for each indicator was obtained and interpreted with the following guidelines: not practiced (μ=1.00-1.75), slightly practiced (μ=1.76-2.50), moderately practiced (μ=2.51-3.25), and highly practiced (μ=3.26-4.00). They were administered to 40 participants who are IGP directors, coordinators, and project managers of the covered SUCs (Table 2).

Table 2. Distribution of respondents

SUC level	SUC	Campus	IGP directors and coordinators	Project managers	Total
4	A	A	1	5	6
4	A	B	1	4	5
4	A	C	1	3	4
3	B	D	1	4	5
3	B	E	1	4	5
3	C	F	1	4	5
2	D	G	1	4	5
2	E	H	1	4	5
Total			8	32	40

Source: Authors' preparation (2024).

To evaluate the financial health of the agri-businesses, the researchers analyzed net profit margins from the annual financial reports provided by each enterprise. Additionally, they obtained institutional approval from all participating SUCs and ensured the anonymity of both respondents and institutions.

RESULTS AND DISCUSSIONS

Management practices of SUCs engaged in agri-based enterprises

Table 3 shows how state universities and colleges (SUCs) manage agricultural enterprises. It analyzes eight key areas of management practices.

The data reveals that most dimensions fall under "moderately practiced," indicating these practices are generally implemented to a moderate extent, but there is room for improvement.

A significant weakness identified is 'talent,' with all SUC levels scoring around 2.45. This underscores the urgent need to focus on attracting and retaining skilled personnel for these agricultural ventures. On the other hand, 'structure' appears to be a relative strength, with scores around 2.71, indicating a somewhat established organizational framework across SUC levels. Interestingly, both 'leadership' and 'strategy' fall under 'moderately practiced' despite their crucial role in success. It highlights the potential for strengthening leadership and developing clearer strategic direction for these businesses. Furthermore, the areas scoring the lowest, 'innovation' and 'strategic linkages and partnerships', present significant opportunities for growth. Encouraging a culture of innovation and fostering partnerships with other institutions or businesses could be key drivers of success for SUC agri-businesses, inspiring hope and a sense of possibility.

Table 3. Manifestation of management practices among SUCs engaged in agri-based enterprises

Dimensions	SUC level 2		SUC level 3		SUC level 4		Mean	Descr.
	Mean	Descr.	Mean	Descr.	Mean	Descr.		
Strategy	2.73	MP	2.50	SP	2.80	MP	2.68	MP
Execution	2.68	MP	2.59	MP	3.02	MP	2.76	MP
Culture	2.54	MP	2.63	MP	3.05	MP	2.74	MP
Structure	2.85	MP	2.47	SP	2.83	MP	2.71	MP
Talent	2.30	SP	2.21	SP	2.85	MP	2.45	SP
Leadership	2.58	MP	2.52	MP	2.98	MP	2.69	MP
Innovation	2.43	SP	2.38	SP	2.62	MP	2.48	SP
Strategic linkages and partnerships	2.38	SP	2.43	SP	2.62	MP	2.47	SP

Source: Authors' calculations (2024).

There are some observations specific to SUC levels. SUC Level 4 consistently scores higher in most dimensions, suggesting a stronger management emphasis. On the other hand, SUC Level 2 scores the lowest in "talent" and "strategic linkages and partnerships," highlighting areas for targeted improvement. Addressing these weaknesses and capitalizing on strengths, SUC agri-businesses can enhance their overall project and strategic management practices, leading to a brighter future for these agricultural enterprises.

Financial performance of SUCs engaged in agri-based enterprises

Figure 1 presents the financial performance of SUCs engaged in agri-based enterprises from 2014-2018 by SUC level. The financial viability of these agri-based ventures is measured using the net profit margin. It is worth noting that the financial performance of these agri-based enterprises has consistently shown a positive net profit margin, a promising sign for their financial health.

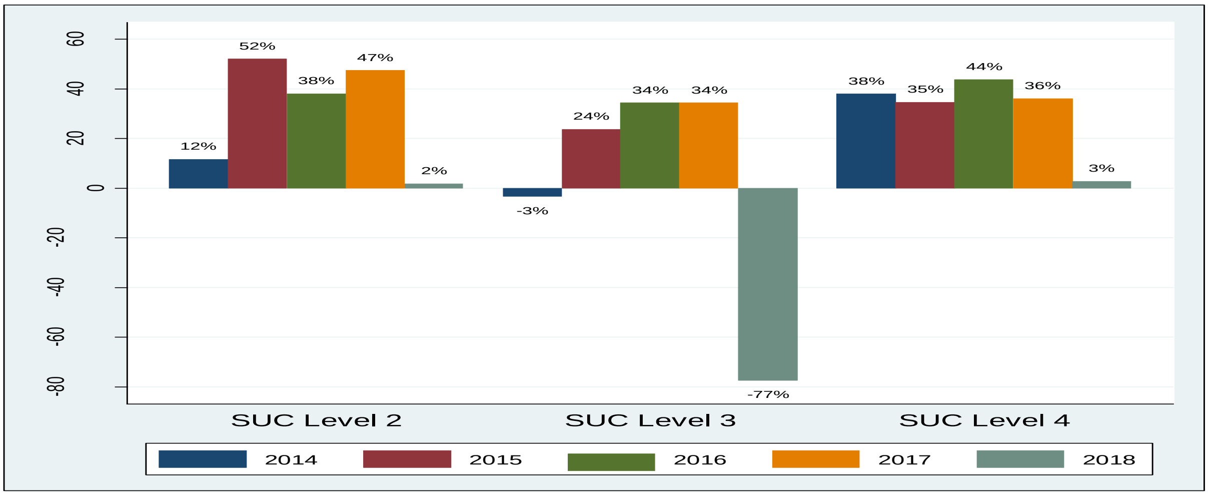

Fig. 1. Financial performance of SUCs engaged in agri-based enterprises from 2014-2018
Source: Own results.

Figure 1 reveals that SUC level 4 presents a stable net profit margin for the last four years among all the SUCs in the region. It shows that the agri-based enterprises under this SUC are relatively stable and mature, considering their income stream level is consistently within the SUC's average. Meanwhile, SUC level 3 agri-based enterprises show negative net profit margins in 2014 and 2018. These enterprises are operating negatively. On the other hand, SUC level 2 agri-based enterprises show the highest net profit margin among the SUCs in the region. This implies that these enterprises provide significant income to their respective SUCs, thereby augmenting their income levels, which will reduce the need for more resources to address the demands and services of the university.

Relationship between management practices of SUCs engaged in agri-based enterprises and their financial performance

Table 4 provides correlation statistics examining the relationship between net profit margin and management dimensions among SUCs engaged in agri-based enterprises. Several key findings emerge from the analysis:

Firstly, the analysis highlights the significant positive correlations between strategic aspects such as strategy, culture, and net profit margin. These correlations, specifically a moderate positive correlation for strategy (*r*=.312, *p*=.0497) and a strong correlation for organizational culture (*r*=.312, *p*=.0497), underscore the importance of well-defined strategies and strong cultures in achieving higher profitability.

Furthermore, the analysis underscores the importance of an effective organizational structure in driving profitability. The significant positive correlation (*r*=.363, *p*=.0215) between structural elements and net profit margin highlights the role of structure in supporting operational efficiency and strategic alignment. Moreover, dimensions related to human capital management, such as talent, demonstrate a notably strong correlation with a net profit margin (*r*=.463, *p*=.0026). It highlights the critical role of recruiting, retaining, and developing skilled employees in driving organizational success and financial performance.

Conversely, dimensions like execution and leadership show non-significant correlations with net profit margin. Execution, while positively correlated (*r*=.276, *p*=.0843), does not meet the threshold for statistical significance, suggesting that effective implementation of strategies may not consistently translate into higher profitability in this context. Similarly, leadership exhibits a negligible correlation (*r*=.034, *p*=.8375), indicating that leadership qualities assessed in this study do not significantly impact net profit margin.

Beyond core management practices, the study found innovation and strong partnerships to be key drivers of profitability. Analyzed data revealed a significant correlation between innovative practices (*r*=.440, *p*=.0045) and strategic linkages (*r*=.344, *p*=.0297) with higher financial returns. It underscores the crucial role of fostering a culture of creativity and collaboration for SUCs' agri-businesses to thrive in the competitive landscape.

Table 4. Correlation statistics between net profit margin and project and strategic management dimensions

Management dimensions	Correlation coefficient	p-value	Description
Strategy	0.312	0.0497^{*}	Significant
Execution	0.276	0.0843^{ns}	Not significant
Culture	0.312	0.0497^{*}	Significant
Structure	0.363	0.0215^{*}	Significant
Talent	0.463	0.0026^{**}	Significant
Leadership	0.034	0.8375^{ns}	Not significant
Innovation	0.440	0.0045^{**}	Significant
Strategic linkages and partnerships	0.344	0.0297^{*}	Significant

Note: * p<.05; ** p<.01; *** p<.001; ^{ns} not significant
Source: Authors' calculations (2024).

Discussions and implications

Building on the results of this empirical study, we highlight critical areas that contribute significantly to our attempt to provide an understanding of the financial viability and management practices of agri-based enterprises of Philippine public higher educational institutions. This understanding not only identifies current challenges but also paves the way for potential growth and improvement in the future.

First, it is crucial to recognize that managing talent requires attention among SUCs' agri-based enterprises. The existing scenario calls for immediate action to actively recruit, develop, and retain skilled personnel involved in agri-based enterprises within these institutions [11]. It can harm the overall efficiency of agricultural projects and initiatives undertaken by these [54]. Managing farm workers in SUCs' agri-based enterprises faces several challenges [30]. A key issue lies in the limited talent pool and heavily employing occasional workers [15]. This situation can weaken the talent management within SUCs as they will not invest in capacity buildings for temporary workers. This talent management issue could lead to a need for more skilled workers. However, finding individuals with the necessary experience and knowledge for these jobs is daunting, especially when compensation remains challenging for SUCs engaged in agri-enterprises. This situation could result in decreased productivity and financial outcomes. Thus, SUCs should prioritize retaining the right talent while ensuring the profitability of these IGPs.

Further, motivation and retention issues can plague SUCs' agri-businesses. Unclear compensation structures or limited career advancement opportunities make attracting and retaining qualified individuals easier [29]. It creates a cycle of constantly training new staff, hindering long-term progress in agricultural endeavors [37]. SUCs, being government institutions, can also face bureaucratic hurdles in hiring and managing personnel [50]. Stricter regulations and slower processes might make these jobs less attractive for farm workers who prefer more flexible or faster-paced environments. The core mission of SUCs, which is often focused on academics and research, can lead to a lack of dedicated resources or management focus on the day-to-day operations of the agri-based enterprise. It can negatively impact farm worker support and morale, hindering the smooth running of agricultural projects.

Second, managing innovations is practiced slightly among SUCs' agri-based enterprises. Stagnation in innovation can lead to outdated practices, hindering productivity and potentially reducing the overall yield or quality of agricultural products. A lack of focus on innovation can make SUCs less sustainable in the agricultural sector [11]. SUCs might struggle to keep pace with private enterprises or research institutions at the forefront of agricultural advancements without actively exploring and adopting new technologies and methods. The limited innovation management can stifle the growth of a culture of creativity and problem-solving among staff and students involved in agri-based enterprises [3]. Without actively encouraging the exploration of new ideas, valuable opportunities for local adaptations or unique solutions to agricultural challenges might be missed.

Third, strategic linkages and partnerships are practiced slightly among SUCs' agri-based enterprises. Beyond talent management and innovation, SUCs' agri-based enterprises often need help with establishing strategic linkages and partnerships [27, 28]. This lack of collaboration with external organizations, industries, and stakeholders hinders their access to crucial resources like equipment or funding [15, 39]. Moreover, it limits knowledge exchange, preventing SUCs from learning from experienced players and sharing their research findings [8]. This isolation restricts their growth potential, limiting access to new markets and hindering the ability to scale up successful projects for a wider impact on the agricultural sector.

Fourth, level 4 SUCs managed their agri-based enterprises positively, reflecting their consistent positive margins. Level 4 SUCs' consistent positive margins in agri-businesses are promising, indicating efficient resource management. Established universities with stable resources and capabilities tend to have better financial outcomes compared to lower level SUCs [49]. The SUC level itself reflects an institution's developmental phase against set standards [9]. The highest level signifies comparability to top Asian universities and colleges [9], along with stronger institutional performance [31].

Lastly, managing strategy, culture, structure, talent, innovation, and strategic linkages and partnerships are significantly correlated to the financial performance of SUCs agri-based enterprises. SUCs that excel in strategic planning, fostering a positive and innovative work environment, and establishing a well-defined organizational framework are more likely to achieve financial success. Developing and retaining skilled talent allows them to leverage expertise for better decision-making [23]. Encouraging innovation fosters the development of new and efficient practices while building strong partnerships with external stakeholders opens doors to valuable resources and knowledge exchange [17]. Focusing on these interconnected elements, SUCs can significantly enhance their financial performance in agri-based enterprises, leading to greater overall success and a stronger contribution to the agricultural sector.

CONCLUSIONS

This empirical study has shed light on critical areas influencing the financial viability and management practices of agri-based enterprises within Philippine SUCs. We identified weaknesses in talent management, innovation, and strategic partnerships, which significantly impact financial performance. These weaknesses manifest as needing help attracting and retaining skilled personnel, requiring more cutting-edge technology adoption, and limited access to resources and knowledge exchange. Meanwhile, the positive financial margins in Level 4 SUCs are promising, signifying that high SUC level tends to have better management practices and improved financial outcomes.

On the other hand, SUCs can lay a robust foundation for their agri-based enterprises by concentrating on strategic planning, fostering a positive and innovative culture, establishing a well-defined structure, developing and retaining talent, and building strong partnerships. This interconnected approach allows SUCs to unlock a future of financial success and a more sustainable and impactful presence within the agricultural sector. Moreover, this research offers policymakers, university administrators, and stakeholders with valuable insights to develop targeted interventions and support systems. These efforts will pave the way for the continued success and growth of SUCs' agri-businesses.

Limitations and future studies

This study offers valuable insights, but some limitations are worth considering. First, relying on respondents' self-reported data can introduce response bias and social desirability effects. Respondents may unintentionally misreport information or be influenced by a desire to present their practices favorably. Second, applying cross-sectional design limits our ability to establish cause-and-effect relationships. We can observe correlations between management practices and financial performance, but we cannot definitively say that one causes the other. Moreover, focusing on a specific region in the Philippines restricts the generalizability of the findings to different areas or educational environments. Finally, the analysis does not account for potential confounding variables such as SUCs' budget allocations and the overall business environment, which could influence the observed correlations.

Future studies may integrate mixed methodologies utilizing both quantitative and qualitative approaches to better describe management practices' impact on the financial performance of agri-based enterprises in Philippine state universities and colleges. Researchers may further investigate the effect of state universities' level and innovation index on the performance of their agri-based enterprises.

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FORECASTING HONEY PRODUCTION IN ROMANIA AND THE EUROPEAN UNION: ANALYSIS OF HISTORICAL TRENDS (1961-2022) AND PROJECTIONS UNTIL 2035

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Abstract

Honey production in Romania and the EU is essential for agriculture, food security, and economic sustainability. Romania, a leading producer, benefits from favourable conditions but faces challenges such as climate change, habitat loss, and market competition. This research analyses historical honey production trends and forecasts production until 2035 using FAOSTAT data and an exponential smoothing (ETS) model. Statistical evaluation confirms a strong predictive accuracy ($R^2 = 0.8918$), projecting Romania's honey production to reach 250,000–300,000 tonnes by 2035. While the outlook is positive, environmental and economic factors may influence actual trends. Sustainable beekeeping, policy support, and market strategies are crucial for ensuring long-term viability. Future research should integrate climate and economic variables to enhance predictive accuracy.

Key words**:** *honey production, forecasting, Romania, European Union, sustainability*

INTRODUCTION

Honey production in Romania and the European Union (EU) is crucial for agriculture and food security, enhancing the economy and promoting ecological balance through pollination. Along with countries like Spain, Hungary, and Germany, Romania is regarded as one of the top producers of honey in the EU. These nations all enjoy climates that are conducive to beekeeping [2, 3, 4]. The country's varied flora and conventional beekeeping methods resulted in numerous honey varieties, each possessing distinct flavours and health advantages, hence improving its marketability domestically and globally [25]. The significance of honey production beyond commercial worth; it is essential for agricultural sustainability. Honeybees are essential pollinators, and their contribution to pollination markedly enhances crop yields and biodiversity [26]. The reduction in bee numbers, attributable to factors such as pesticide application and habitat destruction, jeopardises food security, hence necessitating the preservation of beekeeping methods [11, 27]. The beekeeping sector in Romania bolsters the agricultural economy and serves as a source of income for numerous rural households, therefore aiding rural development and food security [25, 8, 14, 23]. Romania's honey production has experienced variability due to climatic shifts and environmental problems. Research demonstrates that honey produced in Romania typically exhibits high quality, characterised by minimal contaminants, including heavy metals and pesticide residues, in accordance with EU food safety regulations [6, 10]. The European Union enforces rigorous standards for honey quality, encompassing restrictions on hydroxymethylfurfural (HMF), a key indicator of honey freshness and quality [30]. Adherence to these criteria is essential for preserving customer confidence and guaranteeing the health advantages linked to honey consumption [21, 15]. Consumer behaviour about honey in Romania illustrates a multifaceted terrain. Although Romania is a prominent honey producer, its consumption remains comparatively low relative to other European nations, due to cultural influences and insufficient awareness of its health advantages [22].

Demographic characteristics affecting honey intake encompass education level and age, with increased consumption rates noted among persons with higher levels of education. The health advantages of honey are extensively documented, with numerous research emphasising its antioxidant, antibacterial, and therapeutic properties [9,20]. Honey serves as both a natural sweetener and a potential treatment for several health issues, including respiratory and digestive problems [9]. Moreover, the therapeutic properties of honey, especially in traditional applications, highlight its cultural importance in Romania [24]. The trade dynamics inside the EU further impact honey production in Romania. The nation exports a substantial quantity of its honey, predominantly to other EU member states, so bolstering its economic viability [25]. Nonetheless, competition from imported honey, especially from non-EU nations, presents difficulties for local honey producers. The uniqueness of Romanian honey by branding and quality assurance can alleviate these obstacles and enhance the promotion of local products in the worldwide market [25,16]. Environmental conditions significantly influence honey production. The influence of climate change on floral availability and bee health is an increasing issue for beekeepers in Romania and throughout Europe [26]. Sustainable beekeeping practices, such as organic farming and minimising pesticide application, are crucial for the lasting viability of honey production [11].

Incorporating environmental sustainability into agricultural methods is essential for preserving honey production and ensuring food security.

This study aims to analyze historical honey production trends in Romania and the European Union and develop a predictive model to forecast production levels up to 2035, considering key environmental, economic, and agricultural factors.

MATERIALS AND METHODS

Data collection

The data used in this study was obtained from the FAOSTAT database, covering honey production statistics in Romania and the European Union from the earliest available records up to the year 2022. The dataset included annual production values measured in metric tons.

Data Preprocessing

Missing data points were filled using linear interpolation to maintain trend continuity.

In cases where duplicate records existed, values were aggregated using the average to obtain a single representative value for each year [11].

Forecasting Methodology

The forecasting of honey production up to 2035 was performed using Microsoft Excel, leveraging built-in time series forecasting tools.

The seasonality of the data was automatically detected, ensuring that recurring patterns were incorporated into the forecast.

The model accounted for trend, seasonality, and error components in the time series data.

Forecast Model Selection

The forecasting algorithm used exponential smoothing (ETS) with parameters Alpha (level), Beta (trend), and Gamma (seasonality) optimized based on historical data [11].

The forecast was extended until 2035, with a 95% confidence interval to assess prediction uncertainty.

Model Evaluation Metrics

The accuracy of the forecast was evaluated using, Mean Absolute Scaled Error (MASE),

Symmetric Mean Absolute Percentage Error (SMAPE), Mean Absolute Error (MAE), and Root Mean Square Error (RMSE).
These metrics were computed to assess the performance of the forecasting model and ensure reliability in the prediction results.

RESULTS AND DISCUSSIONS

The statistical assessment of the forecasting model for honey production in Romania offers significant insights into the precision and dependability of the predictions. The model employs smoothing parameters, specifically an Alpha value of 0.25, signifying that recent observations have a minor impact on the forecast. The Beta parameter is established at 0.00, indicating the model lacks a substantial long-term trend correction, whilst the Gamma value of 0.25 signifies the identification and integration of seasonal fluctuations with moderate emphasis. The parameter configurations indicate a reliable forecasting method that incorporates both level and seasonality, however, does not explicitly include trend dynamics.
Various error metrics were computed to evaluate the model's performance. The Mean Absolute Scaled Error (MASE) is 1.22, signifying that the forecast error marginally exceeds that of a naïve model, implying a relatively good forecasting method. The Symmetric Mean Absolute Percentage Error (SMAPE) is remarkably low at 0.06 (6%), indicating a high degree of accuracy and minimal divergence from actual data. The Mean Absolute Error (MAE) of 13,035.99 tonnes and the Root Mean Square Error (RMSE) of 17,698.47 tonnes offer additional insight into forecast accuracy, with RMSE highlighting greater variations due to its squared-error calculation. Although these values exhibit some variance, they remain within an acceptable range, so maintaining the trustworthiness of the projected production trends.
The statistical results support the reliability of the forecasting model, indicating that honey production in Romania is projected to exhibit a consistent increase trajectory. The minimal forecast errors and optimal smoothing parameter selections demonstrate that the model effectively captures production trends while accommodating mild seasonal fluctuations. Nevertheless, although the forecast exhibits considerable precision, external variables such as environmental alterations, climatic fluctuations, and economic circumstances may still influence actual production results. Consequently, ongoing surveillance and model modifications may be essential to enhance future forecasts and uphold predictive precision. The projection of honey production in Romania from 2022 to 2035, as depicted in the graph, demonstrates a consistent increase trajectory. The historical data, covering 1961 to 2022, indicates a steady rise in honey output, albeit with periodic volatility. The linear trend equation, $y = 2,615.7x + 86,262$, indicates that yearly honey output is increasing at an estimated rate of around 2,616 tonnes per year. The coefficient of determination, $R^2 = 0.8918$, indicates a robust connection between time and production, signifying that almost 89% of the variance in honey output can be accounted for by the linear trend.
The projected values shown in Figure 1, indicated by the prolonged dark green line past 2022, imply sustained rise in honey output. The confidence interval, depicted as coloured areas surrounding the projected numbers, offers an estimation of possible fluctuations in production levels. The narrow boundaries signify a high level of confidence in the predictions, hence enhancing the model's reliability. The projection indicates that by 2035, honey production in Romania is anticipated to attain roughly 250,000 to 300,000 tonnes, contingent upon external variables including environmental circumstances, beekeeping methodologies, and market demand.
The data indicates that honey production in Romania is increasing, bolstered by conducive beekeeping circumstances and consistent output trends. Nonetheless, although the projection indicates an optimistic perspective, external factors like as climate change, agricultural methodologies, and policy determinations may still affect actual output trends. Ongoing surveillance and

modifications to predictive models will be essential to enhance future forecasts and accommodate unexpected alterations in the business [5].

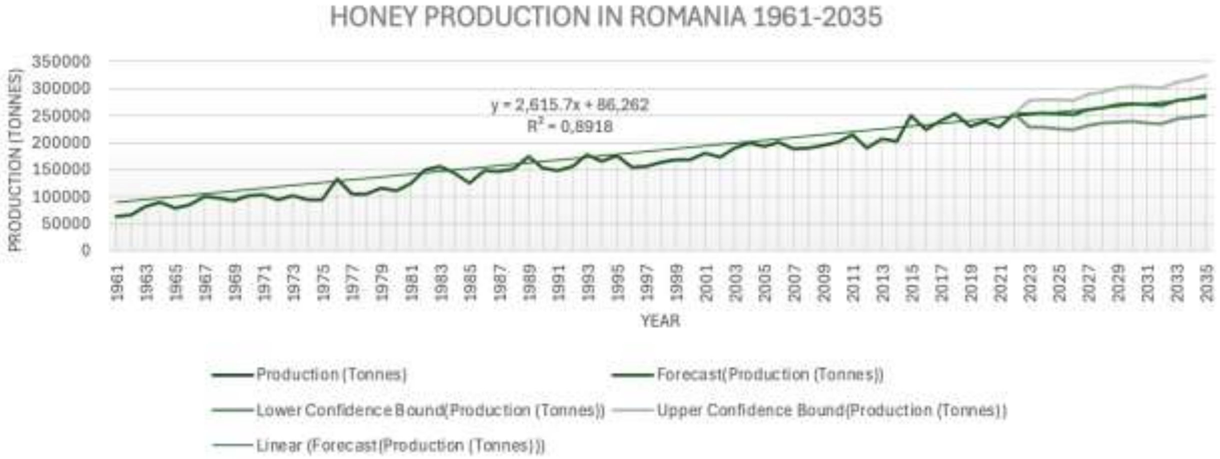

Fig. 1. Honey production forecast in Romania (1961-2035)
Source: FAOSTAT [13].

The statistical analysis of the forecast model for honey production in the European Union offers insights into the model's precision and predictive efficacy. The Alpha parameter, established at 0.25, signifies that current observations exert a moderate impact on the predicted values, indicating that the model incorporates recent trends without overly responding to short-term variations. The Beta parameter, noted as 0.00, indicates that the model lacks a substantial long-term trend correction, suggesting that the forecast relies predominantly on level and seasonal components rather than a defined trend. The Gamma value, set at 0.25, indicates the existence of seasonality in the dataset, attributing modest significance to seasonal fluctuations.

To assess the dependability of the forecast, various error metrics were examined. The Mean Absolute Scaled Error (MASE) is 1.22, showing that the forecast error is somewhat more than that of a naive benchmark model, reflecting a relatively accurate predictive performance. The Symmetric Mean Absolute Percentage Error (SMAPE) is 0.06 (6%), indicating a minimal percentage error and confirming that the model provides very precise forecasts in relation to actual output values. The Mean Absolute Error (MAE) is 13,035.99 tonnes, indicating that, on average, the forecast diverges from actual values by this magnitude. The Root Mean Square Error (RMSE) is 17,698.47 tonnes, indicating the range of mistakes, with more errors receiving more significant weight in the computation.

The projection for honey production in the European Union from 2022 to 2035, as illustrated in Figure 2, shows a persistent increase trajectory. The historical data from 1961 to 2022 demonstrates a steady rise in honey output, albeit with occasional variations. The linear regression equation y = 4,266.9x+1,551.2 indicates an estimated annual increase in honey production of approximately 4,267 tonnes. The coefficient of determination (R^2 = 0.918) suggests a strong correlation between time and production levels, with 91.8% of the variation in honey output explained by the linear trend. This high predictive reliability supports the assumption that production will continue to grow under similar conditions.

The projected values for the period 2022–2035, depicted by the extended dark green line, demonstrate a consistent increase in production, underpinned by a comparatively small 95% confidence range, illustrated by the shaded areas. The projection indicates that by 2035, honey production in the European Union is anticipated to fluctuate between 250,000 and 300,000 tonnes, contingent upon external variables like climatic conditions, apicultural practices, and regulatory policies.

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The existence of upper and lower confidence bounds signifies possible fluctuations; nonetheless, the model's robust correlation implies that departures from the anticipated trend are expected to be minimal.

The sustained rise in honey production within the EU corresponds with advancements in beekeeping methodologies, agricultural policies that bolster apiculture, and an escalating consumer appetite for honey and bee-derived items.

The model delivers a dependable prediction of EU honey output, indicating a consistent growth trend with negligible uncertainty. The results underscore the necessity for ongoing investment in sustainable beekeeping techniques, research on pollinator health, and regulatory initiatives to guarantee the long-term stability of honey production. Nonetheless, due to possible external factors, consistent monitoring and modifications to predictive models will be essential to uphold prediction precision and facilitate informed decision-making in the apiculture industry [17,19].

Fig. 2. Honey production forecast in the European Union (1961-2035)
Source: FAOSTAT [13].

The future of honey production in Romania and the European Union (EU) will be shaped by various factors, including environmental sustainability, technological innovations, market dynamics, and customer preferences. Romania's honey sector, a prominent producer within the EU, is at a pivotal point where it must adjust to challenges and opportunities to sustain its competitive advantage and guarantee food security. A primary challenge in honey production is the reduction of bee populations, attributed to reasons such pesticide application, habitat destruction, and climate change [18]. The EU has acknowledged the significance of pollinators in agricultural productivity and has launched various initiatives to save bee populations and encourage sustainable beekeeping methods [18]. In Romania, enhancing the resilience of bee colonies by selective breeding and improved management procedures is crucial for preserving honey production amid these problems [29]. Incorporating ecological knowledge into agricultural operations can improve crop pollination, benefiting both beekeepers and farmers [18]. Technological innovations are anticipated to significantly influence the future of honey production. Advancements in beekeeping apparatus, including automated hive monitoring devices, enable beekeepers to manage their colonies more efficiently and address possible problems proactively [12, 28]. Furthermore, the application of data analytics and artificial intelligence can enhance honey production operations, encompassing hive health monitoring and market trend forecasting [22]. These methods enhance efficiency and promote the sustainability of honey production by reducing resource waste and improving product quality. Market dynamics are evolving, characterised by a rising consumer demand for premium, organic, and locally derived honey. In Romania, increasing awareness of the health benefits of honey consumption may elevate demand for domestically produced honey [9]. Nevertheless, Romania's present consumption rates are inferior to those of other EU nations, signifying a necessity for focused marketing efforts to establish honey as a dietary staple. Educational initiatives that emphasise the nutritional and medicinal benefits of honey may substantially impact consumer behaviour and enhance market demand [9].

The quality of honey is essential for sustaining competitiveness in the EU market. Romanian honey is known for its varied flower origins, which enhance its distinctive flavours and health advantages [2].

Subsequent investigations are to concentrate on the characterisation of honey varieties utilising advanced analytical methodologies, including high-performance liquid chromatography (HPLC) and mass spectrometry, to guarantee authenticity and quality [7]. Implementing stringent quality assurance processes will be crucial for Romanian honey producers to comply with EU regulations and effectively compete with imported honey, especially from nations with reduced production costs [1]. Moreover, the future of honey production in Romania will probably be shaped by the growing focus on sustainability and environmental conservation. The EU's Green Deal and Farm to Fork Strategy seek to advance sustainable agriculture practices by minimising pesticide usage and augmenting biodiversity [18]. Romanian beekeepers can synchronise their operations with these activities by implementing organic agricultural techniques and participating in habitat restoration projects that benefit pollinator populations [12]. This connection benefits the environment and boosts the marketability of honey products, as customers increasingly want sustainable solutions. Alongside environmental factors, the socio-economic dimensions of honey production must be acknowledged. The beekeeping industry in Romania sustains numerous rural people and enhances local economies [25]. Consequently, assisting small-scale beekeepers via training initiatives and financial resources will be essential for the sector's viability [12]. Collaborative programs linking beekeepers with agricultural producers can bolster the resilience of both sectors, fostering a symbiotic relationship that enhances food security [18]. Honey's contribution to food security is complex; it serves as a healthy food source and is vital for pollination, which is crucial for crop development [22]. As global food systems encounter escalating challenges from climate change and population expansion, the significance of preserving robust bee populations and sustainable honey production methods will intensify [18]. Romanian and EU policymakers must prioritise the safeguarding of pollinators and the advancement of sustainable farming methods to guarantee long-term food security.

CONCLUSIONS

The forecasted honey production trends in Romania and the European Union through 2035 suggest a sustained upward trajectory, indicating consistent growth in the apiculture sector. Statistical analysis and time series forecasting utilising the Exponential Smoothing (ETS) model indicate a consistent increase in honey production, corroborated by historical trends and minor seasonal fluctuations. The model's accuracy, demonstrated by low error values and a high coefficient of determination, indicates that the forecast is dependable, with limited uncertainty over future output levels.

The results indicate that Romania and the European Union will gain from enhanced honey output, propelled by improvements in beekeeping techniques, advantageous agricultural policies, and persistent market demand. Nonetheless, exogenous factors such climate variability, habitat destruction, use of pesticides, and economic variations may influence actual production trends. Although the model offers a strong prediction based on past data, ongoing monitoring and modifications are essential to address unexpected difficulties that may emerge in the future.

To guarantee the continued sustainability of honey production, authorities, academics, and beekeepers must cooperate to mitigate potential hazards, improve bee health, and adopt adaptive strategies in response to environmental and economic fluctuations. Subsequent research ought to concentrate on integrating additional factors, including meteorological and ecological data, into forecasting models to enhance forecasts and bolster resilience against future uncertainty.

The anticipated rise in honey production offers substantial prospects for the beekeeping sector, emphasising the necessity for data-informed decision-making and sustainable apiculture methods. Utilising technical breakthroughs and forceful regulatory measures, the honey producing sector can continue to thrive, aiding both economic development and ecological balance within the European Union.

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PROJECTED TRENDS IN FRESH OR CHILLED RABBIT AND HARE MEAT PRODUCTION IN ROMANIA AND THE EUROPEAN UNION THROUGH 2035

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Abstract

Romania and the European Union (EU) have encountered significant declines in recent decades, driven by changing consumer tastes, economic limitations, and changed attitudes towards rabbit meat. This study aims to forecast production trends in Romania and the EU until 2035 by utilizing historical data from FAOSTAT, employing exponential smoothing methods, and assessing model accuracy through statistical error metrics such as Mean Absolute Scaled Error (MASE), Symmetric Mean Absolute Percentage Error (SMAPE), Mean Absolute Error (MAE), and Root Mean Square Error (RMSE). The findings reveal an ongoing decline in production, with Romania anticipated to sustain near-zero levels, while the EU is forecasted to encounter additional output losses. The study indicates that economic challenges, evolving dietary preferences, and heightened competition from other protein sources are factors contributing to the sector's collapse. Opportunities for revival are there through the development of value-added goods, enhanced marketing strategies, sustainable agricultural techniques, and advancements in genetics and nutrition. The findings highlight the need for regulatory interventions and industry adjustments to conform to changing market demands and guarantee the long-term sustainability of rabbit and hare meat production in Romania and the EU.

Key words*: *rabbit, hare, forecasting, Romania, European Union, sustainability

INTRODUCTION

In Romania and across the European Union, the production of rabbit and hare meat is shaped by various factors, including consumer preferences, production techniques and health considerations. The production of rabbit meat has experienced variations in demand and supply, affected by economic conditions and evolving dietary preferences. In Romania, like various regions in Europe, rabbit meat is acknowledged for its nutritional value, characterised by low fat content and high protein levels, rendering it a desirable option for health-conscious consumers [36, 4]. Historically, rabbit production in Romania has been defined by small-scale farms and backyard operations, which play a crucial role in local meat supplies. The industrialisation of rabbit farming is progressively developing, as larger farms implement more intensive production techniques to satisfy increasing demand [25]. The EU rabbit meat industry is primarily characterised by intra-EU trade, with Italy as a significant contributor, virtually achieving self-sufficiency in rabbit production [35]. This tendency is seen in Romania, where domestic production is progressively augmented by imports to meet consumer demand. The quality of rabbit meat is influenced by multiple factors, such as the animal's food, pre-slaughter environment, and processing techniques. Research indicates that the incorporation of feed additives, including synbiotics and botanical extracts, could improve meat quality by enhancing growth rates and carcass characteristics [18, 17, 23]. The incorporation of fresh alfalfa in rabbit diets has been associated with enhanced meat quality, influencing both the chemical composition and sensory characteristics of the meat [9]. Additionally, the pH levels of rabbit meat, which might impact softness and shelf life, are influenced by dietary choices and processing methods [30, 21]. Chilled rabbit meat is more susceptible to microbial contamination, presenting difficulties for preservation and storage. Studies demonstrate that natural antioxidants, including plant extracts, can reduce lipid oxidation and extend the shelf life of refrigerated rabbit meat [18, 6]. The addition of these compounds boosts the meat's nutritional profile and sensory attributes, increasing its attractiveness to customers [1, 11]. This is essential in a market where consumer preferences are increasingly preferring healthier, minimally processed meat products. Rabbit meat consumption in Romania has been shaped by socio-economic factors, including economic downturns and the growing perception of rabbits as companion animals rather than livestock [35]. This transition has resulted in a decrease in rabbit meat consumption, compelling producers to investigate innovative marketing tactics to rekindle interest in rabbit meat products. The development of processed rabbit meat products, including sausages and ready-to-eat meals, has emerged as a viable strategy in response to customer desire for convenience and diversity [4, 25]. Hare meat, although less frequently consumed than rabbit meat, has potential for production and marketing in Romania. The nutritional analysis of hare meat reveals it as a superior protein source, abundant in polyunsaturated fatty acids, consistent with contemporary dietary preferences for lean meats [13]. The production of hare meat is frequently constrained by hunting rules and seasonal availability, impacting supply consistency. Health issues associated with meat eating, particularly the possibility of zoonotic illnesses, have impacted consumer perceptions of rabbit and hare meat [29]. The future of rabbit and hare meat production in Romania and the EU will likely hinge on producers' capacity to adapt to evolving customer expectations, elevate meat quality through refined production procedures, and address health and safety issues. The incorporation of sustainable practices in rabbit farming, including organic methods and ethical animal treatment, is essential for appealing to a health-conscious consumer demographic [4].

The aim of this study is to forecast the production of fresh or chilled rabbit and hare meat in Romania and the European Union up until 2035 using historical data from FAOSTAT, applying exponential smoothing techniques, and evaluating model accuracy through statistical error metrics.

MATERIALS AND METHODS

Data Collection

The data used in this study was obtained from the FAOSTAT database, which offers statistical data regarding agricultural production trade. The dataset comprises production statistics for fresh or chilled rabbit and hare meat in Romania until 2018 and in the European Union (EU) until 2023. It is important to note that some of the EU data consisted of estimations rather than official figures, as reported by FAOSTAT.

Data Processing

Absent values were addressed by linear interpolation, maintaining a continuous time series without artificial distortions. In cases of duplicate values within the dataset, data was consolidated by computing the average of the existing entries to ensure consistency. The seasonality component of the time series was identified automatically to address reoccurring patterns in production trends.

Methodology for Forecasting

The forecasting analysis was performed via Microsoft Excel, employing its built-in statistical and forecasting functions.

The forecast utilised an exponential smoothing model incorporating parameters Alpha (α), Beta (β), and Gamma (γ) to enhance trend and seasonality adjustments.

The subsequent error metrics were calculated to evaluate the model's accuracy and reliability: Mean Absolute Scaled Error (MASE), Symmetrical Symmetric Mean Absolute Percentage Error (SMAPE), Mean Absolute Error (MAE), Root Mean Square Error (RMSE)

Additionally, a 95% confidence level was used to assess the uncertainty of the projected values, outlining a range in which the actual values are are expected to fall.

RESULTS AND DISCUSSIONS

The forecasting model used to produce fresh or chilled rabbit and hare meat in Romania exhibited a strong responsiveness to recent trends, evidenced by an Alpha value of 0.9, which assigns considerable weight to the latest observations.

The Beta value of 0.001 indicates a negligible impact of long-term trends, suggesting that the historical trend is largely steady or only marginally changing over time. The Gamma value, approximately zero (2.22×10^{-16}), suggests that seasonality was either minimal in the dataset or significantly mitigated throughout the forecasting procedure.

The model's accuracy was assessed by various statistical error indicators. A Mean Absolute Scaled Error (MASE) of 0.0609 indicates that the forecasting model outperformed a naive model, hence affirming its robust prediction accuracy.

A Symmetric Mean Absolute Percentage Error (SMAPE) of 15.07% suggests that, on average, the predicted values deviated by approximately 15% from the actual production data, which is generally regarded as an acceptable accuracy level in time series forecasting.

The Mean Absolute Error (MAE) of 33.38 indicates that, on average, the predicted values deviated from actual production figures by about 33.38 metric tonnes, while the Root Mean Square Error (RMSE) of 58.26 underscores infrequent larger inconsistencies, although not excessively high, thereby affirming the model's overall reliability.

The results demonstrate that the employed forecasting method effectively captures short-term variations while preserving overall predictive consistency. The model's minimal error values demonstrate its reliability in predicting trends in fresh or chilled rabbit and hare meat production in Romania, making it a valuable tool for future policy development and market strategy in the sector.

Figure 1 presents the historical and projected production of fresh or chilled rabbit and hare meat in Romania from 1961 to 2035.

The historical data indicates a consistent trend until the late 1980s, followed by a significant surge in production, reaching its peak in the early 1990s. This apex is succeeded by a slow descent, ultimately approaching negligible levels in the 2000s and remaining static in subsequent years.

The projected trend (2018-2035) indicates that production will remain nearly negligible, with no substantial rise anticipated. The linear regression equation ($y = -9.3723x + 647.37$) with $R^2 = 1$ signifies an excellent linear correlation, underscoring the consistent decrease in productivity (Figure 1).

The upper and lower confidence ranges indicate an expanding range of uncertainty as the projection progresses into the future, implying heightened variability and possible discrepancies in output forecasts.

The estimate indicates that rabbit and hare meat production in Romania is improbable to return to prior levels and will likely remain limited or absent soon.

This trend may be ascribed to economic, regulatory, or market-related concerns, necessitating additional examination of the causes underlying the industry's downfall.

The statistical analysis for fresh or chilled rabbit and hare meat production within the European Union offers insights into the model's precision and predictive efficacy.

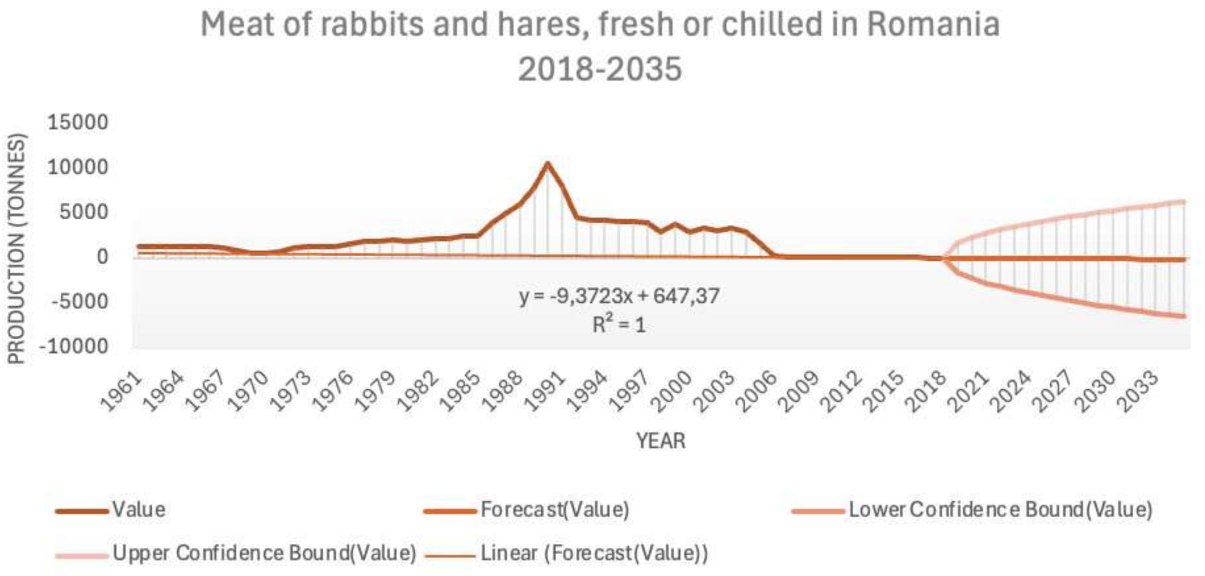

Fig. 1. Meat of rabbits and hares' production forecast in Romania (2018-2035)
Source: FAOSTAT [12].

An Alpha value of 1.00 indicates that the model assigns complete weight to the most recent observations, rendering it highly responsive to current trends while neglecting previous data. A Beta value of 0.10 indicates minimal influence of trend components, suggesting that long-term trends are minimally incorporated into the forecast. A Gamma value of 0.00 indicates that no seasonal fluctuations were identified or incorporated in the model.

The precision of the prediction was evaluated utilising multiple error metrics. A Mean Absolute Scaled Error (MASE) of 0.61 suggests moderate forecasting accuracy, demonstrating that the model performs better than a naive forecast but still has some limitations in capturing variations. Meanwhile, a Symmetric Mean Absolute Percentage Error (SMAPE) of 5% signifies a minimal average percentage deviation between predicted and actual values, indicating a high level of predictive accuracy.

The absolute error metrics—Mean Absolute Error (MAE) of 9,369.92 tonnes and Root Mean Square Error (RMSE) of 13,229.06 tonnes—demonstrate significant variations between expected and actual production levels, suggesting potential volatility or uncertainty in production trends.

The model indicates that, although the forecast accurately reflects recent production trends in the EU, the elevated MAE and RMSE values suggest possible variations and uncertainty in the data. This underscores the necessity for careful interpretation of the projections, especially regarding market dynamics, policy changes and economic impacts on rabbit and hare meat production in the European Union. Figure 2 illustrates the historical and projected production of fresh or chilled rabbit and hare meat within the European Union from 1961 to 2035. The historical data indicates an initial phase of stability, succeeded by a progressive rise in production until the late 1980s, followed by a sudden decrease in the early 1990s. This drop continues at a reduced rate, with production stabilising at diminished levels in the 2000s and subsequently maintaining a somewhat steady trajectory.

The projection from 2023 to 2035 predicts a sustained decrease in productivity, as evidenced by the descending trend line (y = -9,437.8x + 706,432). An R^2 value of 1 indicates that the linear model fits the historical data very well, corroborating the anticipation of a consistent decreasing trend. The upper and lower confidence intervals expand as the projection continues, signifying heightened uncertainty in the long-term prognosis.

The data indicates that rabbit and hare meat production in the EU is anticipated to further drop in the forthcoming years, with no indications of recovery based on past trends. This drop may be attributed to multiple sources, such as changes in customer tastes, legislative changes, economic impacts, or structural modifications within the rabbit meat sector. The expanding confidence intervals underscore the necessity for ongoing surveillance, as external variables may affect the true course of production.

Fig. 2. Fresh or chilled rabbit and hare meat production forecast in the European Union (2023-2035)
Source: FAOSTAT [12].

In recent years, the production of fresh or chilled rabbit and hare meat in Romania and the European Union (EU) has significantly decreased. This trend can be attributed to a mix of causes, including evolving consumer tastes, economic challenges, and health concerns. Understanding these dynamics is essential for stakeholders in the meat production sector to adapt and innovate in response to the changing market environment. The decline in rabbit and hare meat production is primarily attributed to changing customer preferences for alternative protein sources. As customers increasingly prioritise health, there is a rising trend in the consumption of lean meats, such as chicken and fish, which are frequently regarded as healthier alternatives than rabbit meat. Research demonstrates that although rabbit meat is acknowledged for its nutritional benefits, such as low fat and high protein levels, it frequently remains eclipsed by more prevalent meats that possess greater market visibility and consumer recognition [26, 31]. The shift in consumer behaviour has resulted in a decrease in demand for rabbit meat, thereby impacting production levels. Economic issues significantly contribute to the reduction of rabbit and hare meat production.

The expenses related to rabbit farming, especially for feed and veterinary services, have increased, rendering it less economically viable for several small-scale producers [28, 24, 14, 15]. In Romania, where several rabbit farms operate on a small scale, economic pressures are especially intense. Producers frequently encounter difficulties in competing with larger agricultural enterprises that capitalise on economies of scale, resulting in industry consolidation and a decline in the number of small farms [24]. The economic pressure is further heightened by the overarching challenges affecting the agricultural industry in Romania, such as restricted access to financing [24]. Health issues associated with meat intake have also led to a decrease in rabbit and hare meat production. Consumer and producer knowledge of zoonotic diseases, such as coccidiosis affecting rabbits, has risen [16]. This has resulted in increased analysis of meat processing methods and a call for elevated food safety regulations. As a result, producers might face supplementary expenses related to complying to health laws, so affecting their profitability and desire to maintain production [24]. The idea of rabbits as companion animals rather than livestock has notably affected consumer attitudes towards rabbit meat [26]. Consequently, businesses face a diminishing market base, affecting the maintenance of production levels. The marketing and branding of rabbit meat provide obstacles that exacerbate its falling production. In contrast to other meats, rabbit meat exhibits a weak brand presence and is frequently inadequately promoted to customers [5]. The limited availability of processed or semi-processed rabbit products intensifies this problem, as customers increasingly need convenience in their dietary selections [5]. The incorporation of circular economy principles into rabbit husbandry has not been entirely achieved in Romania and the EU. Despite the potential for sustainable methods to improve production efficiency and minimise waste, numerous producers remain either uninformed or unable of efficiently implementing these techniques [32]. The deficiency in knowledge dissemination and innovation within the sector constrains rabbit producers' capacity to adjust to evolving market needs and enhance their economic viability.

The future of fresh or chilled rabbit and hare meat production in Romania and the European Union (EU) is set for transformation, driven by changing customer demands, sustainability efforts, and technical progress. As consumers increasingly emphasise health and environmental sustainability, rabbit meat, recognised for its low fat and high protein content, is garnering interest as a viable alternative to conventional meats such as beef and pork [10, 20]. The transition to more sustainable protein sources is essential, as rabbit production exhibits a markedly lower environmental impact than larger animals, with diminished greenhouse gas emissions per kilogramme of meat produced [22, 7, 33, 8]. Novel methodologies for rabbit meat production are crucial for rejuvenating the sector. Creating innovative, healthier rabbit meat products can appeal to health-conscious consumers and expand the industry [34]. Furthermore, incorporating circular economy ideas into rabbit farming—such as leveraging by-products and optimising feed efficiency—can enhance sustainability and profitability [2, 3]. Consumer desire for transparency and humane treatment of animals is rendering the emphasis on animal welfare and ethical agricultural techniques increasingly significant [27, 19]. Furthermore, progress in genetics and nutrition is anticipated to improve the productivity and health of rabbit populations, increasing their resilience to illnesses and enhancing overall meat quality [20]. Investigating alternate feed sources, such marine macroalgae, may improve the sustainability and nutritional quality of rabbit meat [2].

CONCLUSIONS

This study's findings indicate a notable and ongoing decrease in the production of fresh or chilled rabbit and hare meat in Romania and the European Union. The anticipated trends suggest that Romania's production will stay minimal, whereas the European Union is expected to continue its decline. This decline can be ascribed to multiple factors, including shifting customer preferences, economic constraints, and changing conceptions of rabbits as companion animals instead than livestock. The challenges caused by elevated costs in rabbit farming, escalating regulatory demands, and competition from alternative protein sources have exacerbated the sector's decline.

Notwithstanding these hurdles, prospects persist for the revival of the rabbit and hare meat sector by innovation and adaptability. The creation of value-added and processed rabbit meat products, coupled with enhanced marketing methods, could revitalise consumer interest. The implementation of sustainable agricultural practices and the incorporation of alternative feed sources may improve the economic and environmental sustainability of rabbit farming. Progress in genetics and nutrition, along with heightened focus on ethical and animal welfare standards, may enhance the sector's resilience and potential for recovery.

Considering the present forecasts, governments, industry stakeholders, and producers must cooperate to address the elements leading to reduced production while investigating methods to adapt to changing customer preferences. A coordinated initiative to modernise production techniques, elevate meat quality, and augment marketability will be crucial in shaping the future direction of rabbit and hare meat production in Romania and the European Union.

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WHY ARE LOCAL AND TRADITIONAL FOOD PRODUCERS NECESSARY IN ROMANIAN RETAIL?

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Abstract

The article analyzes the impact that local and traditional producers have on retail in Romania. The analysis we conducted reflects the presence of a relatively small number of producers in the Romanian market, being divided only into certain product categories, mainly food items. Therefore, to become known, the most important option available to them is to collaborate with major retailers in the market. Of course, the limited number of producers restricts the selection options for customers. From a methodological perspective, to complete this article, we conducted documentary research on the number of existing producers and their segmentation and qualitative research. Thus, we interviewed people working with the retailer with the largest number of employees in the Romanian market to find out the number of producers they collaborate with and the criteria these producers must meet to be selected. Additionally, for the analysis part, we examined the most important digital platform that promotes local producers, aiming to connect the rural and urban environments.

Key words**:** *local producers, traditional producers, Via Profi, Romanian Retail*

INTRODUCTION

Local producers play an essential role in retail and society, contributing to market diversity, local economic development, and the promotion of sustainability [8], [6]. According to some studies [5], local products provide benefits through the conservation of biodiversity and traditional knowledge, giving them unique value. [13] emphasizes the importance of local partnerships between producers and consumers, which serve to enhance trust and transparency in supply chains.

Some researchers [2] argue that integrating local producers into regional and global value chains is crucial for improving competitiveness and developing communities in developing countries. However, in emerging markets, some studies suggest that small producers need to adopt survival strategies to cope with global competition [10]. Thus, increasing competitiveness can threaten small businesses both in terms of the costs required to achieve production and the discounts received for raw materials and supplies. In numerous economies, local producer markets offer fresh food and support the local economy, positively impacting communities by creating local production and consumption networks [7], [9], [4], [11].

Some research over time [19], [1] suggests that consumer perception of local products is influenced by emotional values and perceived quality. Consumers are more open to small producers, seeing them as family businesses, which often choose to market their surplus products or start small businesses to survive [15].

However, some studies [12] highlight major challenges for small producers, such as infrastructure barriers and access to large markets. Therefore, to reach consumers and meet their needs, small producers find it imperative to collaborate with market retailers, who provide them with the opportunity to showcase their products in specially designated areas within large stores.

In this context, the purpose of the study ist o analyze the importance of local and traditional food producers in Romanian Retail and the analysis of the adopted measures with the aim of supporting small producers.

In this case, the research novelty is represented by the Via Profi analysis, a platform that brings together producers from all over the country.

MATERIALS AND METHODS

Design of the Research

Based on these aspects, in our research, we examined the relationship between local producers and major retailers, particularly those operating in the food sector.

In our study, we considered the retailer with the largest number of employees, selecting it based on the assumption that care for external customers would also be reflected in the relationship with end consumers (Profi.ro, 2024)[17].

The research questions were: “How do retailers support small producers and facilitate consumer access to traditional products?”, "What conditions should a local producer meet to be considered by retailers on the market?", and "What are the areas in the country where local producers are more visible in stores?". To answer these questions, we conducted qualitative research focusing on the benefits provided by the selected retailer to producers, considering their selection process and the criteria required for collaboration.

Equally, we analyzed the Via Profi platform, which brings together numerous local producers in the digital environment, supporting consumers by facilitating their selection decisions.

RESULTS AND DISCUSSIONS

Depending on their coverage area, producers are divided into the following categories: local, regional, national, and artisanal.

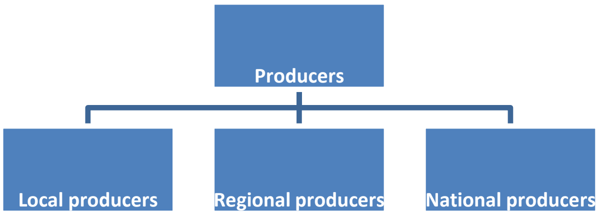

Fig. 1. Producers' Classification
Source: Information provided by the analyzed retailer.

Local producers are those who serve stores/retailers located within a distance of up to 70 kilometers around the analyzed geographic area. In turn, local producers may also include artisanal producers. Represented by small and very small businesses, they often have collaboration contracts with only one store. Artisanal producers do not always choose to collaborate with a retailer, as they may not have the production capacity to meet the retailer's demands.

Regional producers operate within a specific region: Moldova, Muntenia, Transylvania, etc. In contrast, national producers have coverage across the entire country.

Another segmentation of local producers divides them into two categories: traditional local producers and certified producers. When choosing producers to collaborate with, retailers consider their number, type, the areas in which they operate, the products they can offer, and the fulfillment of the necessary criteria to be considered.

Based on interviews with representatives of the retailer, several conditions were established that producers must meet to be considered for collaboration: they must produce traditional products rather than industrial ones, have legal operating status, possess sanitary-veterinary authorization, ensure that products are properly packaged and labeled, and be able to arrange for product transportation.

This section presents the situation regarding the number of producers the analyzed retailer considers. According to Figure 1, as of 2023, the majority of producers were from Suceava and Alba.

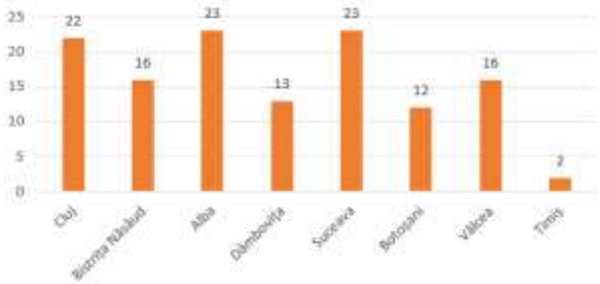

Fig. 2. Local producers by county in 2023
Source: Authors' Research based on the data from the retailer analyzed.

We note that Figure 2 reflects only the number of producers with whom the analyzed retailer collaborates and not the total number of producers existing in Romania. Among the producers listed in Figure 1, some have certified products (traditional/ mountain/ organic) (Figure 3).

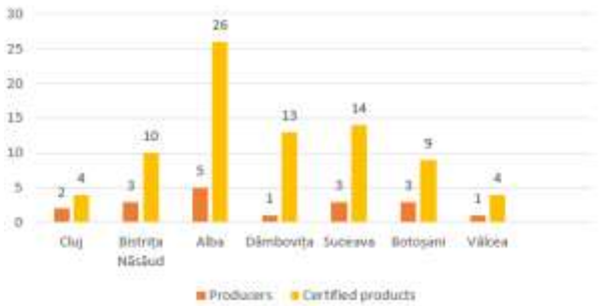

Fig. 3. Certified products from local producers by county
Source: Authors' Research based on the data from the retailer analyzed.

Under these conditions, certifications represent an added layer of trust for consumers and an additional opportunity for retailers to guarantee the seriousness of small producers.

Of course, in recent years, especially with the onset of the pandemic, consumers have placed increasing importance on local products, trusting small producers. Thus, purchasing local products and supporting family businesses has become a trend adopted across the European Union and beyond.

In comparison with Romania, in Italy, consumers are much more familiar with the items offered by local producers. A large portion of them opt for local products, even when it comes to purchasing dairy products.

According to Fig. 4, the next in the order of preferences are food products, with consumers placing increasing importance on health.

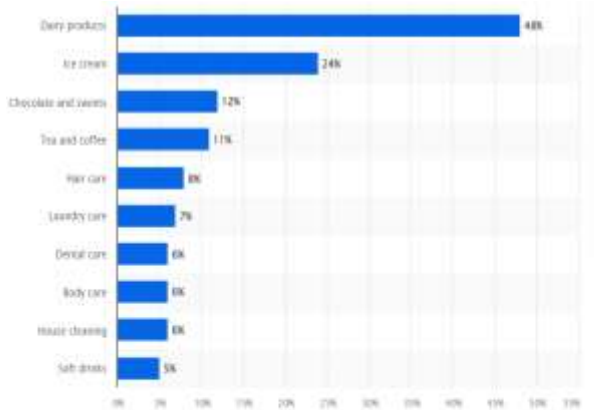

Fig. 4. Goods purchased locally in Italy
Source: [16].

Similarly, consumers in Russia prefer purchasing local products they regularly consume, such as eggs and meat. By comparison, they don't pay as much attention to the origin of tea, coffee, and spices [14].

Unlike Italy, in France, 26% of respondents prefer food products from local producers, thus supporting small family businesses and the implementation of sustainable practices in these businesses [18].

In Belgium, approximately 50% of respondents opt for local products from local markets, while a further 44% of respondents buy products from farm stores [20]. Similarly, in the United Kingdom, around 60% of the interviewed individuals purchase products from local producers [3].

Following the interview conducted with the company representatives, we identified two approaches they take in their relationship with local producers. The first approach involves creating a digital platform aimed at promoting local producers and informing the public about their existence. If customers wish to purchase products from these producers, they need to travel to the producer's location. The second approach involves selling the products offered by producers in the retailer's own stores. The second part of the research focused on the platform that brings together producers from across the country: Via Profi. Emerging as an initiative carried out following a social responsibility campaign, this website promotes small local producers in Romania, providing a platform for discovering and purchasing authentic and traditional food products.

Organized by counties and categories such as vegetables, fruits, dairy products, preserves, honey products, and more, the site facilitates users' access to high-quality local products [21]. Thus, the offers available to the customer are diverse, allowing them to choose the best products from small producers.

Additionally, it provides guides and recipes, promoting a close connection between producers and consumers.

Among the benefits of the site for consumers is easy access to authentic local products purchased directly from producers. At the same time, the platform supports the local economy and reduces intermediaries, ensuring product freshness.

For producers, a major benefit of this platform is that it allows promotion without requiring the payment of a fee. As a result of a social responsibility campaign, producers featured on this platform are not required to pay fees for their promotion. Based on interviews conducted with representatives of the retailer in question, a five-step process is carried out for a local producer to be promoted on the Via Profi platform.

In the first step, producers are identified. The retailer has a dedicated marketing team division that researches local producers in various regions, leveraging information gathered from previous projects. Additionally, producers can self-register to be considered. In this case, the producer must complete a form on the Via Profi platform.

The second step involves contacting producers (most often by phone) to gather information about them, the products they sell, and the conditions of production, manufacturing processes, etc.

The third step, **Verification**, entails analyzing the information obtained and determining which producers are eligible. This includes evaluating whether they are family businesses, or small-scale producers, what processes they use to produce goods, and whether they meet the previously mentioned conditions.

The fourth step, **Presentation**, involves a team from the retailer visiting the producers to conduct a photo session aimed at promoting their products.

Finally, the last step is the **Registration** of the producers on the platform.

In practice, the costs of travel, filming the producers and their products, as well as uploading the information onto the website, are covered by the retailer.

Based on the research question, we can conclude that the analyzed retailer supports local producers by creating a platform that removes spatial boundaries, providing a means to match supply with demand.

CONCLUSIONS

Based on the two conducted studies, we can affirm that the analyzed retailer prefers to collaborate with local, traditional producers who meet certain standards, such as certifications and sanitary-veterinary regulations. These producers must be capable of properly packaging and transporting their products, indicating a clear preference for quality and legal compliance.

Similarly, when considering the regions from which they originate, we observe that most producers are from Suceava and Alba. This could suggest an uneven distribution of local producers in Romania or a preference of the retailer for these areas, either due to logistical reasons or local production traditions.

According to the documentary research conducted, it was observed that consumers' preference for local products is found in most European Union countries and beyond. Whether it’s about food products or daily care items, consumers support small businesses, and the certifications that producers hold provide them with added trust and assurance.

The Via Profi platform plays an essential role in promoting local producers by offering a diverse range of products and providing easy access for consumers to traditional products.

Additionally, the platform contributes to strengthening the connection between producers and consumers, encouraging more conscious and sustainable consumption of local products.

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ACHIEVING HIGH STANDARDS IN ECONOMY AND MANAGEMENT RESEARCH: THE CONTRIBUTION OF FORMAL AND INFORMAL NETWORKS

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Abstract

This paper empirically examined the role of formal and informal networks in building innovation attitudes and an environment for conducting quality research in economics and management in Bulgarian universities. It highlighted some of the key issues not yet explored in the academic literature – the behavioral attitudes and expectations of researchers towards the institutional environment in universities, and the extent to which it was supportive for the development of quality research. An empirical study was conducted with 74 respondents from Bulgarian universities working in the field of economics and management. The analysis of the results showed that respondents appreciated the perceived support from the organization they worked in. Support aimed at stimulating innovative environments for conducting innovative research in economics and management was also highly valued. Two of the research hypotheses were not supported: 1) that informal relationships were more important than formal relationships and 2) that having support from the immediate supervisor stimulated innovative behavior. On this basis, insights were derived in the discussion of the empirical results. The contribution of the publication is in the interdisciplinary approach where behavioral science was linked to network theory. The aim was to discover and identify more clearly those behavioral motivations and constraints that, analyzed through the lens of network theory, provided tools to improve collaboration in research organizations and universities.

Key words*: *formal and informal networks, proactive research management, academic innovative environment

INTRODUCTION

The development of innovation has been part of the universities’ mission, and one of the most topical areas in the HEI’s policies. Stimulating breakthrough research requires a supportive organizational environment for innovation and building a culture that encourages appropriate researcher behavior.

The research process is a collective effort, especially when it involves complex and interdisciplinary work, and requires effective communication between different units to create an environment for knowledge sharing. Organizational theory viewed this as building a good meta-contingent relationship [8], i.e., as an organizational design that facilitated knowledge transfer within and across units and organizations [1]. Network theory extended the understanding of the role of communications and developed ideas about formal and informal networks in the innovation process. While formal relationships were confined within certain boundaries regulated by rules and procedures, informal ones crossed the delineated boundaries and expanded the field of relationships between professionals in search of new knowledge. This complementary role of the two sets of communications, which had different potentials, deserved more attention when designing university policies related to innovation interventions in research.

To explore the role of formal and informal networks in fostering innovative attitudes and an environment conducive to quality research in economics and management, this paper highlighted some of the key issues not yet explored in the research literature – the behavioral attitudes and expectations of researchers towards the institutional environment in universities, and the extent to which it was supportive of the development of high-quality research. The study was limited to the research environment in Bulgarian HEIs, which had been carrying out training and research in economics and management. There were several reasons for narrowing the scope of the study:

1)The topic of behavioral attitudes of lecturers in Bulgarian universities had been sidelined from the attention of researchers. It was an object of study in policy development, but the research did not sufficiently extend beyond the general analyses of the higher education system in strategic documents.

2)There were some differences in policies to stimulate research in different scientific fields. Priority was given to the natural sciences, that made a visible contribution in improving the quality of people's lives and were at the forefront of research. This could be seen both in the results achieved (number of publications, number of patents), and in the funds allocated for their development in national programs. However, when considering the social aspects of development, the contribution of the social sciences was equally indispensable. At the same time, they remained underfunded and were underperforming in terms of scientific output in Bulgaria.

The crucial moment here was access to knowledge in a wider research network that went beyond traditional organizational constraints and required a combination of formal and informal communication approaches.

3) The importance of formal and informal networks in the development of innovation varied across the research topics. In the natural sciences, formal networks could be complemented by informal ones in the initial stages of research but required the presence of formal structures later, e.g., to comply with technical standards in testing [25].

In contrast, social research has been characterized by observational errors, considerable uncertainty, and little agreement on decisions. There, contact with stakeholders could validate results better than trials in a laboratory, and communication with stakeholders therefore became key to confirm or reject hypotheses.

These features provoked the authors to conduct an empirical study of a systematically neglected aspect of research management – the extent to which the organizational structure was adequate to the communication needs of researchers working in economics and management in Bulgarian universities.

The main thesis with which we started this study was that the formal environment had its limits and couldn’t cover all the knowledge needs in a scientific organization, so it needed to be complemented by informal networks, which should not be seen as an alternative to formal ones.

Literature review

Organizational development had been the subject of numerous studies since the first half of the 20th century, but research related to universities emerged after the 1970s [2] and was relatively scarce. In most cases, changes in university organizational models had been seen as part of the movement towards post-bureaucratic and neo-bureaucratic models [27], and more broadly as an attempt to bring the new public management into university governance [14] in an entrepreneurial manner.

Organizational theory views universities as institutions that should be reformed for the sake of greater efficiency, but this conflicted with Humboldt's core values of freedom of inquiry [14]. A different perspective on this conflict was provided by the new institutionalists who explored the importance of culture in contemporary organization [9] and in particular the confrontation between hierarchy and individualism.

While hierarchy was associated with attitudes of a compact group (employees in an organization) to follow rules and everyone's place in this hierarchy, individualism was the opposite – weaker ties (the opposite of compactness in the hierarchy) and compliance with fewer rules [14]. The main difference between the two approaches was the attitude towards control and, respectively, trust. Hierarchical structures presumptively considered that employees should be controlled and therefore set up control units to monitor compliance with the rules.

Individualism, on the other hand, relied on fair play, a fair chance for everyone to enter the game, but also on the responsibility of everyone for their own results, including failure.

University organizational structures were prime example of the dilemma between the two poles of cultural theory. Their goals and perceived academic values required a balance between hierarchy and individualism. Modern universities were not only providers of educational services. They were parts of different research networks in the context of concepts such as the triple helix, which justified the contribution of universities to local development in collaboration with government and business, and the quadruple helix model of innovation, where civil society was included in the model alongside the three actors [11].

The strategic goals of modern universities were aimed at being an equal and even leading partner in broad cooperation with business, public authorities and civil society in the implementation of supra-institutional development strategies and programs. This is why most universities were developing hybrid forms of organizational structures, combining networks and leadership on the one hand, with hierarchical control and accountability [16] on the other. Sometimes, even within the same organization, project planning combined with cross-functional integrative teams took place, leading to parallel and temporary hierarchical structures [7].

These hybrid organizational forms of governance that blend hierarchy and individualism resonated in a huge variety of communication patterns in universities that remained outside the attention of researchers.

Networks within an organization were understood as a social system that consisted of dynamic ever-changing flows of members, flows of information, and availability of social reinforcement [5]. The concept of social reinforcement was defined as "the situation in which an individual requires multiple prompts from neighbors before adopting an opinion or behavior" [30].

Studying social groups in an organization through the lens of network analysis could provide an explanation why one group (cluster) was more interconnected than other groups [19] and how it evolved over time.

Formal network structure referred to rules, processes, roles, and responsibilities, while informal structure described the social network in terms of recurring patterns of any interactions or instrumental and emotional relationships [24].

Since formal organization and ranks in the hierarchy affected the communication network in an organization [24], based on the tracking of formal and informal communications, a conclusion could be drawn about how adequate the organizational structure was to the communication needs of researchers in a university.

In the research literature, barriers between different research units were viewed as functional obstacles or silos [12]. The idea was that clustering, or the presence of isolated groups (researchers, staff, etc.) that had a barrier to information exchange, suffered the negatives of poor communication when performing their functional duties. Silos (barriers) were considered part of the hierarchical management model, where units got their tasks well controlled vertically, but horizontal linkages were not addressed. In research, this could be a major problem when such functional silos limited the opportunities for collaborative complementarity between different structures of the organization.

Overcoming various silo-type barriers (budgetary, geographic, strategic, etc.) had a direct bearing on how we operationalized the concept of systems complexity. As we knew, one of the consequences/characteristics of complex systems was the emergence – of new structures, new functions, etc. This meant that we should view organizations as continuously evolving patterns of interaction. They couldn't be fully understood if they were viewed only as formal structures and processes [5].

Often the occasion for changing structures in universities were new research projects, which might provoke the creation of a new network or other type of structure – both internal and mixed, with the participation of external partners, but in any case, complementing the current organizational structure. If the two diverged (e.g., the new one was of the self-organizing unit type or simply more flexible, while the traditional one was more hierarchical), this could create tensions in terms of rights and responsibilities and in terms of roles within the university and the project. For example, a researcher taking on administrative roles, or a university supervisor being a researcher alongside other junior colleague. These types of structural changes also could lead to changes in communication and the creation of complementary networks.

MATERIALS AND METHODS

In this study, we apply a conceptual framework based on transdisciplinary research, where we link behavioral science with network theory. The aim is to discover and identify more clearly those behavioral motivations and constraints that, when analyzed through the lens of network theory, provide tools to improve collaboration in research organizations and universities. The questionnaire included five main research topics, each of them operationalized in several questions.

1)How respondents rated the importance of formal and informal relationships in the research process. Controversy in the research literature about the importance of formal and informal communications did not give a clear preponderance to one type or the other. Opinions on the complementary nature of the two approaches in knowledge management dominated, with informal relations most often used to bridge high power distances within chains of command [18].

2)What's the opinion of the respondents regarding resource support from the organization. Resourcing for research might seem like an inappropriate subject of analysis in relation to networks, but only at first glance. Material resources were considered as non-human in networks according to Actor-network theory [29]. The concept stated that even technologies that were so commonplace that we did not even think about them could shape the decisions we made, the effects of our actions and the way we moved through the world [23]. People were not the only ones who shaped their world; material elements could also have (sometimes unexpected and unintended) effects and influences on other elements in the network, including people [29].

3)What's the respondents' opinion regarding the perceived support from colleagues and especially the direct supervisor. These questions were relevant to the concept of social capital in organizations [21], which was formed through reciprocal relationships between members [26]. Social capital supported innovative behaviors of individuals in several ways. First, good connectedness, frequency of contact with other researchers within and outside the organization, and good collegial relationships supported innovation [15]. Secondly, shared values, vision, and culture as part of social capital were also supportive factors [22]. They contributed to shaping behaviors and implementing practices valued in the college as desirable and productive.

4)What's the respondents' views on the drivers of innovative behavior. Stimulating research to create innovative products, processes required a complex of factors that at the organizational level included both the availability of adequate resources and organizational support, support from the direct supervisor.

5)What's the respondents' evaluation of the culture of building proactive behavior in academic research.

To explore the relations among the topics nine hypotheses were formulated:

H1: Informal relationships are more important than formal relationships.

H2: Perceived organizational support is based on the resourcing.

H3: Perceived organizational support is based on relationships with colleagues.

H4: Perceived organizational support is based on the relationship with the direct supervisor.

H5: Availability of adequate resources supports innovative behavior.

H6: The presence of organizational support stimulates innovative behavior.

H7: The presence of support from the line manager stimulates innovative behavior.

H8: Having an organizational culture supports innovative behavior.

H9: Organizational support is expressed in/builds a culture of proactive research management.

From the perspective of network theory, H1 examined the respondents' attitudes towards the network of researchers in the respective HEIs and, more specifically, towards those nodes in the network which, by virtue of the organizational hierarchy, should occupy a central position. The questions were aimed at exploring informal relationships with indirect supervisors.

Confirming or rejecting hypotheses H2-H4 would shed light on the research environment in the universities under study. The third and fourth hypotheses were inspired by the concept of social reinforcement [30] mentioned above, which considered the informal encouragement of colleagues, friends, and associates to certain behaviors. When everyone around was working hard on a research topic, it engaged those who were more passive in the process, created confidence, and they changed their behavior.

Confirming hypotheses H5-H8 would mean that there were so-called work process catalysts in the organization. This was a term that had emerged in the debate about management change, particularly around the ideas of post-bureaucracy, [16] neo-bureaucracy and various other hybrid forms of management [27]. The changing role of managers that provoked organizational change was associated with more expertise, consulting, partnering with, providing advice whereby hierarchical boundaries were reduced and an organizational culture was created that supports innovative behavior.

The testing of these hypotheses was done through a survey among 74 researchers, specialists in the field of economics and management, lecturers in Bulgarian HEIs that were instructing students in bachelor's and master's degrees. The analysis of the information collected by means of the survey was carried out with the tools of the statistical method [20].

In summarizing and visualizing the data, the tools of the graphical method (graphical images), grouping, statistical series and tables were used.

The data's nature (Likert scale) determined the use of summary numerical characteristics like means, ratios, shares, and indices.

Since the questions were grouped into topics with similar content, it was necessary to construct a summary indicator for each topic to represent the respondents' opinions about the topics.

The extraction of the common, unobserved content was done with the method of "principal component analysis" [20].

It reduced the dimensionality of the responses and represented the main part of the variation in a new indicator, calculated based on the respondents' answers.

Key to this was the first principal component, which contained most of the total variance of the responses.

Its calculation was done by:

$$z_{k,1} = x_k \times w_{k,1} \qquad (1)$$

where:

$z_{k,1}$ was the first principal component (vector) for topic *k*;

x_k – were the respondents' answers for the questions in topic *k* (matrix);

$w_{k,1}$ – vector of weights for topic k.

Weights $w_{k,1}$ for the formation of the first principal component are established based on:

$$w_{k,1} = \arg\max_{\|w_k\|=1} \left\{ \sum \left(z_{k,1}\right)^2_{(i)} \right\} = \arg\max_{\|w_k\|=1} \left\{ \sum \left(x_{i,k} w_k\right)^2 \right\} \qquad (2)$$

Table 1. Hypotheses Formalization

Hypotheses	Formal definition
H1	$\overline{z_V} > \overline{z_{IV}}$ or $\mu_V > \mu_{IV}$
H2	$r_{z_I z_{III}} > 0$
H3	$r_{z_V z_{III}} > 0$
H4	$r_{z_{IV} z_{III}} > 0$
H5	$r_{z_I z_{VI}} > 0$
H6	$r_{z_{III} z_{VI}} > 0$
H7	$r_{z_{IV} z_{VI}} > 0$
H8	$r_{z_{II} z_{VI}} > 0$
H9	$r_{z_{III} z_{II}} > 0$

where:
$\overline{z_k}$ or μ_k was the mean of the first principal component for the respective topic;
$r_{z_i z_j}$ – the correlation coefficient between the first principal components of topics i and j.

It was worth noting that for a positive semidefinite matrix the weights were equal to the corresponding eigenvector.
The hypotheses testing was realized by means of statistical methods, and the hypotheses themselves were expressed in formal way as shown in Table 1.
The first hypothesis was tested with a standard paired t-test:

$$t_{em} = \frac{\mu_V - \mu_{IV}}{\sqrt{\frac{\sigma_{IV}^2 + \sigma_V^2}{n}}} \quad (3)$$

where: σ_k^2 was the variance of the first principal component for the corresponding topics;
n– the number of participants in the survey.
The remaining eight hypotheses were tested using a test for the statistical significance of the correlation coefficient r, which was first transformed (Fisher transformation):

$$r^* = \frac{1}{2} ln\left(\frac{1+r}{1-r}\right) \quad (4)$$

The empirical value was calculated as:

$$t_r = \frac{r^*}{\sqrt{\frac{1}{n-3}}} \quad (5)$$

All computational operations in the paper were performed with MS Excel and Gretl software.

RESULTS AND DISCUSSIONS

The questionnaire was completed by 74 people. A small proportion of responses were missing (less than 1% of responses), with missing values being imputed into the database with a neutral response. In coding the data, a strongly positive response was assigned a value of 2, a partially positive response a value of 1, a neutral response a value of 0, a partially negative response a value of -1, and a strongly negative response a value of -2.
In the sample, men had a higher relative share than women – 53.4% were men, 46.6% were women. Habilitated lecturers outnumbered non-habilitated lecturers more than twice – 68.5% were habilitated lecturers, 31.5% were non-habilitated lecturers. Lecturers with extensive experience and tenure outnumbered lecturers with little experience almost four times – 21.9% had up to 10 years of experience, 39.7% had between 10 and 20 years of experience and 38.4% had more than 20 years of experience.
The predominance of habilitated lecturers and of those with research and lecturing activity for more than 10 years gave reason to conclude that the sample included highly qualified specialists (economists and managers), habilitated lecturers with a high scientific competence, with sufficient time available to come into direct contact with practice, to participate in the development and publication of scientific works (independently and in interdisciplinary teams), to implement work in scientific networks (formal and informal). Their opinion could be considered as representative and leading in terms of the development of practice in the field of knowledge management, knowledge transfer, culture of sharing and development of research potential in Bulgarian HEIs.

Table 2. Principal component analysis

Topics	**1st PCA Component Share (%)**
I. Adequacy of resources	64.54
II. Organizational Culture for Active Management of Scientific Research	72.52
III. Organizational Support	76.38
IV. Interactions with Immediate Supervisor	80.47
V. Informal Relationships with Indirect Supervisors	69.08
VI. Innovative Behavior	52.87

Source: Authors calculations.

The individual questions within the six topics showed a strong consistency among themselves. Principal component analysis showed (Table 2) that within each group there was a dominant principal component that captured a sizable proportion of the variance in responses to the questions.

The highest degree of consistency was observed in the topic "IV. Relationship with my direct supervisor", where the variance of the first component was 80.47% of the total variance. The lowest degree of consistency was shown by the answers in the topic "VI. Innovative behavior", where the share of variation of the first component was 52.87% of the total variation.

For each group, the isolated first component covered more than half of the group variance of the questions, being positively correlated with all questions (there were no exceptions in this respect).

Thus, the first component for each topic represented their commonality, provided a description of the hidden (unobserved) variables expressing the attitude of the respondents towards all the topics. We constructed these variables based on the weight of the individual questions (factor loadings).

The first working hypothesis related to respondents' involvement in formal and informal relationships and suggested that informal relationships matter more.

The mean value of the isolated variable for topic "IV. Relationship with my immediate supervisor" was 2.920 and the mean value of the latent variable for topic "V.

Informal relationships with indirect supervisors" was 2.816.

Respondents preferred formal relationships over informal relationships, although the difference was small.

Testing the assumption of equality of variances of the two unobserved variables yielded:

$$F_{em} = \frac{\sigma_{IV}^2}{\sigma_V^2} = \frac{7.954}{4.534} = 1.754,$$

where:

$F_{em}$was the Fisher ratio;

σ_{IV}^2 – was the variance of the unobserved variable for topic IV (the larger variance);

σ_V^2 – the variance of the unobserved variable for topic V (the smaller variance).

With degrees of freedom of the numerator and denominator equal to 73, the theoretical limit of the Fisher distribution was 1.473 at 5% risk and 1.733 at 1% risk.

The observed significance level of the empirical characteristic was 0.0563. Therefore, the data suggested that the variances of the two unobserved variables could be assumed to be equal at both 1% and 5% significance.

In testing the hypothesis H1, we defined the formal null and alternative hypotheses as follows:

$$H1_0: \mu_V = \mu_{IV} \text{vs.} H1_A: \mu_V > \mu_{IV} \quad ....(6)$$

where:

μ_{IV} was the mean value of the unobserved variable for topic IV;

μ_V– was the mean value of the unobserved variable for topic V.

The way the null hypothesis was defined implied a one-sided critical domain. The testing of the null hypothesis was based on the Student's t-criterion, which had the value:

$$t_{em} = \frac{\mu_V - \mu_{IV}}{\sqrt{\frac{\sigma_{IV}^2 + \sigma_V^2}{n}}} = \frac{2.816 - 2.920}{\sqrt{\frac{7.954 + 4.534}{74}}} = -0.255.$$

The critical value of the t-distribution at one-sided critical region and 1% risk was 2.379, and at 5% risk was 1.666. The empirical response was smaller (in absolute value) than the critical values, which did not provide a reason to reject the null hypothesis.

The two means could be assumed to be equal, which meant that formal and informal ties were equally important to respondents – no preference was given to one over the other.

Hypotheses H2, H3 and H4 were related to the reasons for perceived organizational support, and the estimated linear correlation coefficients based on the unobserved variables were presented in Table 3.

Table 3. Correlation between 1st principal components

Topics	Correlation	*t*-stat	*p*-value
I. and III.	0.829	10.057	0.0000
V. and III.	0.346	3.063	0.0045
IV. and III.	0.790	9.098	0.0000

Source: Authors calculations. *t*-stat was computed after the Fisher's transformation of the correlation coefficients.

All three correlation coefficients had positive values that were statistically significant at both 5% and 1% risk of error. They predictably indicated a strong influence of resource availability (0.829) and interaction with immediate supervisor (0.790) on perceived organizational support. The influence of informal contacts within the organization was weak (0.346) but significant, which meant that respondents perceived the informal contact opportunities created by the organization as support. All three hypotheses, H2, H3, and H4, were supported by the available data.

Table 4. Correlation between 1stprincipal components

Topics	Correlation	*t*-stat	*p*-value
I. and VI.	0.524	4.942	0.0000
III. and VI.	0.504	4.702	0.0000
IV. and VI.	0.286	2.500	0.0190
II. and VI.	0.618	6.118	0.0000

Source: Authors calculations. *t*-stat was computed after the Fisher's transformation of the correlation coefficients.

Hypotheses H5, H6, H7 and H8 were related to identifying the main drivers of the respondents' innovative behavior. The linear correlation coefficients were calculated based on the unobserved variables (Table 4). All correlation coefficients had positive values, with three being statistically significant at 1% and 5% risk, and one statistically significant only at 5% risk but not at 1%. The three significant coefficients showed a significant influence on innovative behavior, with the most pronounced influence being in building an organizational culture for proactive research management (0.618), followed by adequate resources (0.524) and organizational support (0.504). The influence of direct supervisors was weak (0.286) and at the limit of statistical significance. It could be pointed out that three of the hypotheses considered, H5, H6, and H8 found support from the data, while hypothesis H7 was not sufficiently supported and could not be accepted.

Table 5. Correlation between 1stprincipal components

Topics	Correlation	*t*-stat	*p*-value
III. and II.	0.845	10.510	0.0000

Source: Authors calculations. *t*-stat was computed after the Fisher's transformation of the correlation coefficients.

Hypothesis H9 concerned the relationship between organizational support and building a culture of proactive management (Table 5). The resulting correlation coefficient had a value of 0.845, which was the highest of all correlation coefficients calculated and indicated a strong correlation between the second and third topics. The coefficient was statistically significant at both 1% and 5% risk. The result showed that organizational support was a key factor in the formation of a proactive research management culture in Bulgarian HEIs. Hypothesis H9 was strongly supported by the available data.

The fact that the first research hypothesis H1 had not been proven can be interpreted in two ways. On one hand, formal and informal ties could be considered equally important for respondents, where they did not oppose but complement each other. Informal relationships did not displace but built on the main lines of communication in the research process. Such a finding reinforced the results of other authors [13] [28]. However, the insufficient weight of informal ties could be due to the underdeveloped self-leadership. In it, individuals self-guided the motivational process with a strong desire to achieve a goal and directed their behavior and abilities toward it [21], and therefore self-organized and used multiple informal channels of knowledge and communication in the research process. Key for the individual innovativeness was access to non-overlapping sources of knowledge through social connections [3], which was why most new knowledge acquisition processes in the workplace were informal [4]. In any case, the issue deserves further investigation to address collaboration needs and attitudes more clearly within and outside organizations.

Respondents rate positively the perceived broad support from their direct supervisor (H4) but do not endorse their contributions to innovative behavior (H7). This result could be interpreted as a lack of expectation for the direct supervisor to stimulate innovative behavior. At the same time, such a response might signal a certain lagging of the middle level of research management in economics faculties from participation in the development of the faculty or university strategy. When decisions were not made where the problem arose (i.e., a flexible approach was not applied), but only at a higher level, the middle and lower levels lack clarity about the full picture and especially about the organization's strategy. Particularly problematic was the issue of the role of so-called middle management in universities. Typically, these were directors of sub-structures who summarized several specialized units. The units had managers, but there was an intermediate level of reporting, and when it was not authorized to make decisions, it could be skipped informally.

Respondents' final assessment was of the proactive organizational culture, which they viewed positively. The question related to the extent of researchers' access to resources and whether they must look informally for ways to get their projects approved and to access the resources they need [6]. The overall assessment was clearly positive, which might reflect the attitudes of researchers in economics and management towards funding research projects.

CONCLUSIONS

This paper empirically examined the role of formal and informal networks in building innovation attitudes and an environment for conducting quality research in economics and management in Bulgarian HEIs. It highlighted some of the key issues not yet explored in academic literature – the behavioral attitudes and expectations of researchers towards the institutional environment, and its supportive role for the development of quality research. The contribution of the publication is in its interdisciplinary approach, where behavioral science is linked to network theory. The aim was to discover and identify more clearly those behavioral motivations and constraints that, when analyzed through the lens of network theory, provided tools to improve collaboration in research organizations and universities focused on economics and management research.

One of the important implications related to the original thesis, that the frustration of accessing information through formal channels led researchers to informal ones for knowledge enrichment and collaborative research beyond formal established boundaries. However, we concluded that even the most perfect organizational environment had its limitations as far as knowledge was vast and the possibilities for achieving it were equally impossible to grasp. Therefore, in an ideal research world, informal contacts would always be important. How they will complement formal ones depends both on what the internal formal environment offered in terms of opportunities and what researchers were looking for. There is rarely a balance between these, which is why universities need to be careful about setting boundaries in the research process.

Among the possible avenues for good collaboration is the approach called "relational agency" by Edwards and Mackenzie [10]. The presence of relations means that many people are involved (i.e. it is not an individual task). In the context in which the participants are placed, they continuously set themselves innovative tasks and, in this sense, a dynamic way of interacting is applied/practiced, with each successive task building on the previous one. Thus, a contradiction between structure and relational agency arises here, but it is resolved during the dynamic relationship because the object of activity is constantly expanding [17].

Such a flexible approach is appropriate for research in economics and management because of the holistic nature of decisions in the social sciences.

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METHANISATION IN AGRICULTURE: ECONOMIC, ENVIRONMENTAL, SOCIAL BENEFITS AND INTERNATIONAL EXAMPLES

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Abstract

Methanisation is the process of anaerobic digestion of organic materials, including animal manure and plant residues, resulting in the production of biogas. In agriculture, methanisation provides sustainable waste management solutions, reduces the carbon footprint and contributes to energy independence for farmers. This article explores the economic, environmental and social benefits of methanation, presenting detailed examples from Germany, France, Bulgaria, Italy and Sweden where this technology has been successfully implemented at different levels. It highlights the challenges of using methanisation, namely high initial costs and the need for regulatory support. It also looks at prospects for future development, such as the establishment of cooperative structures for centralised methanisation, the expansion of financing and opportunities for integration with other renewable energy technologies. The findings show that methanisation is a key to sustainable agricultural development and has the potential to reach new areas with appropriate policy and financial support.

Key words: *methanisation, agriculture, economic benefits, environmental benefits, sustainable development*

INTRODUCTION

Agriculture is one of the most important sectors for feeding the population, but it is also a source of significant environmental challenges. The large amount of organic waste generated by agricultural activities, as well as emissions of greenhouse gases such as methane, require urgent measures for sustainable management. Methanisation reduces methane emissions compared to traditional manure management [13]. In this context, methanisation is emerging as an innovative solution that not only addresses these environmental problems but also offers significant economic and social benefits.

Methanisation is defined as the process of anaerobic decomposition of organic materials in the absence of oxygen, which generates biogas composed mainly of methane (CH_4) and carbon dioxide (CO_2). This process occurs in four main steps: hydrolysis, acidogenesis, acetogenesis and methanogenesis. Methanisation is an integral part of the circular economy and contributes to sustainable waste management and the energy transition to renewable sources. This renewable source of energy can be used to generate electricity, heat or fuel vehicles. The residual product of methanisation, known as digestate, is rich in nutrients and finds application as a high-quality organic fertiliser.

Methanisation not only helps to recover waste but also plays an important role in the transition to a circular economy where waste is turned into a resource. It contributes to reducing the carbon footprint of agriculture, increases the energy independence of farmers and promotes the sustainable management of natural resources.

In the face of growing global challenges such as climate change, the energy crisis and the need for sustainable development, methanisation is emerging as a key technology. Examples from Germany, France, Bulgaria and other countries show that with appropriate policies and investment, this technology can be successfully deployed and lead to significant economic and environmental benefits such as job creation and increased awareness of sustainable practices [17]. Methanisation was developed as an industrial technology in the 20th century, when the possibilities of producing energy from waste attracted attention. The first anaerobic digesters were designed for wastewater treatment, but over time the technology found application in agriculture [18].

An important role in the development of methanisation has been played by the European Union, which through directives and funding programmes such as Horizon 2020 has encouraged the deployment of this technology in Member States.Experts believe that Europe has the most developed biogas infrastructure, with countries such as Germany and France leading the way.

Methanisation is a multi-layered technology with economic, environmental and social dimensions. The main challenges identified in the literature include high initial costs and lack of technical capacity in some regions. However, with increasing investment in research and support from international programmes, methanisation has the potential to play a key role in sustainable agricultural development.

MATERIALS AND METHODS

The goal of this paper is to analyze the impact of methanisation on agriculture through a review of international practices, to explore the economic, environmental and social benefits, and to outline the challenges and opportunities for its development.

The paper will examine specific examples from countries with advanced methanisation programmes and from countries that are just introducing the technology to highlight diverse approaches and successful models.

RESULTS AND DISCUSSIONS

To identify concrete conclusions, the benefits of methanisation are divided into economic, environmental and social. The economic benefits of methanisation are: reduced energy costs; additional revenues from biogas sales; more efficient waste management. Environmental benefits of methanisation include: reduction of greenhouse gases; production of organic fertiliser (digestate); improvement of environmental quality. Social benefits of methanisation are: job creation; specific education and awareness of sustainable practices; improved quality of life.

Economic benefits of methanisation

Methanisation allows farmers to meet their energy needs by producing biogas that can be used for heating, electricity and other needs. For example, farms in Germany use biogas to heat greenhouses, reducing costs and increasing energy independence [9]. Excess biogas can be sold to the national grid or processed into biomethane and injected into the gas transmission system. In France, farmers receive subsidies and feed-in tariffs for the biogas they produce, giving them a stable additional income [6]. Methanisation allows farms to manage their waste in a sustainable way. It enables organic waste to be used as a raw material for energy production, which reduces pollution and alleviates removal costs.

Environmental benefits of methanisation

Methanisation prevents the uncontrolled release of methane and reduces the greenhouse footprint of farms. Through the controlled decomposition of organic waste, the technology reduces emissions of methane, which is up to 25 times more potent a greenhouse gas than carbon dioxide.

The residual product of methanisation, digestate, is a valuable organic fertiliser rich in nutrients that contribute to soil fertility. In Denmark, digestate is a major substitute for chemical fertilisers, which improves the ecological status of soils and water resources [4]. The establishment of centralized methanation facilities allows waste to be handled on a more controlled scale. This leads to a cleaner environment in regions with intensive agriculture, reducing soil and water pollution [8].

Social benefits of methanisation

Methanisation facilities require skilled personnel to build, maintain and manage, which contributes to rural economic development and reduces migration to cities [1]. Methanisation reduces odours and pollution from traditional organic waste management. This improves living conditions in settlements close to large farms and livestock centres [11]. By introducing methanisation facilities, awareness is raised about the benefits of sustainable waste management, which motivates farms and communities to implement environmentally friendly practices [2].

Opportunities and challenges for methanisation deployment

The establishment of methanisation cooperatives, in which several farms share biogas production facilities, is a promising option. In Denmark and the Netherlands, cooperatives allow pooling of resources and lower costs as waste from different sources is processed. By incorporating organic waste from the food industry and cities, methanisation can provide a sustainable solution for dealing with organic waste outside agriculture as well, while providing additional resources for farmers [14]. Creating hybrid energy hubs by combining methanisation with solar and wind provides additional security and sustainability for farms [15]. Expanding government and EU funding programs for methanisation projects will encourage more farmers to adopt the technology. Subsidies, interest-free loans and tax breaks can make methanisation more affordable for smaller farms [12]. Expanding research and education programs will provide farmers and students with greater knowledge about methanisation technologies and sustainable waste management. Digestate, which is a residual product of methanisation, can be used as organic fertiliser for sale or export. This will provide an additional source of income for farms and promote environmentally friendly practices. Methanisation facilities require significant investment, which can be a constraint for smaller farms. Subsidies and financial support from the government are needed for successful implementation of this technology [7]. The maintenance and management requirements of methanisation plants require specific skills and experience that are sometimes lacking in smaller areas. Training and education programs could alleviate this problem. Regulatory requirements in different countries can make methanation difficult to implement. The introduction of unified legislative frameworks would facilitate the deployment of the technology locally and internationally [10].

Examples of international practices

In Bulgaria, methanisation is at an early stage of development but has significant potential, especially in livestock areas. With the support of European programmes and national initiatives, pilot methanisation facilities are starting to be built. Methanisation is gaining popularity in the country as an effective method for organic waste management and renewable energy production. Several municipalities, including Sofia, Gabrovo and Blagoevgrad, are implementing projects in this area. The Agricultural Methanisation Unit project aims to introduce methanisation at national level. The pilot farms involved report significantly improved energy efficiency and reduced waste costs. A farm in the Plovdiv region produces 200 kW of electricity per day from animal manure, covering all its energy needs.

Sofia Municipality is taking steps to improve waste management by introducing innovative technologies. Although specific methanisation projects have not been widely publicised, the municipality is actively working on energy efficiency and sustainability programmes, which may include methanisation initiatives.

Gabrovo Municipality is among the leading municipalities in Bulgaria in terms of sustainable waste management. Since 2015, an infrastructure has been built to separate waste into dry and wet fractions. There are 138 sites with binary collection bins on the territory of the municipality, with specialised vehicles collecting waste according to a set schedule. In addition, Gabrovo has implemented a deposit system project, with vending machines for packaging waste placed in public places.

Blagoevgrad Municipality is also taking steps towards implementing methanisation technologies. Under the Operational Programme "Environment" (2014-2020) anaerobic digestion plants for biodegradable waste have been financed in Blagoevgrad, Burgas and Ruse. The municipality of Blagoevgrad is planning to start separate collection of food waste from households, and a contract with a selected operator of the installation is foreseen. Information campaigns to raise awareness among citizens are also planned [3].

These examples show the commitment of Bulgarian municipalities to sustainable waste management and the implementation of methanisation technologies. Although the challenges are significant, local efforts demonstrate the potential of methanation to improve the environmental and energy efficiency of the country.

With more than 9,000 biogas plants, Germany is the European leader in the deployment of methanisation technologies. The country offers government support and subsidies to encourage farmers to invest in methanisation facilities and contribute to the energy transition towards renewable energy. The biogas plant in Bavaria, for example, produces enough energy to power nearly 1 500 households a year using animal manure and vegetable waste.

France has also played a key role in the development of methanisation in Europe. The country is actively developing methanisation through national programmes and EU funding, such as the Fléville project, which produces 200 Nm^3/h of methane. Regions with developed agriculture, such as Bretagne, rely on methanisation for sustainable waste management and to power local grids In Bretagne, one of France's most agriculturally intensive regions, farmers use methanisation to recycle animal waste, which reduces greenhouse gas emissions and generates energy for the local community [5].

Italy is among the leading countries integrating methanisation with the national gas grid. The country provides subsidies for methanisation projects, allowing farmers to produce biogas for sale or domestic use. Italian farmers often work in cooperatives to optimize costs and increase efficiency. Biomethane production is a key component of Italy's energy transformation strategy.

In the Lombardy region, farmers produce over 300 Nm^3 of biomethane per day, which is used for domestic and industrial purposes.

Sweden uses biogas produced by methanisation to power public transport. The main objective is to reduce urban pollution and protect the environment. Biogas from rural areas is transported to cities where it is used as fuel for buses and other vehicles.

Biogas is the main fuel for public transport in Stockholm. In the city of Malmö, over 60% of public transport uses biogas produced by methanisation of agricultural waste and food residues [16] (Table 1).

Table 1. Examples of methanisation implementation by country

Country	Number of installations for biogas	Main economic benefits	Main environmental benefits
Germany	Over 9 000	Energy reduction costs	Reduction of emissions greenhouse gas emissions
France	~ 500	Additional revenue from sale	Organic fertilizer production
Bulgaria	< 50	Waste management	Carbon footprint reduction
Italy	200	High quality organic fertilizer	Water resources protection
Sweden	150	Powering public transport	Clean air and reduced pollution

Source: Own calculation on the basis of data from European Biogas Association, 2023.

Denmark is known for its cooperative approach to methanisation. Small and medium-sized farmers pool resources to build centralised digestion plants that serve several farms simultaneously. This model reduces the cost of technology implementation and maintenance. Centralized facilities process large volumes of waste, increasing efficiency and reducing the environmental footprint.

At a centralised plant in Jutland, waste from 50 farms is processed, generating energy for over 5,000 households.

The examples from these countries show a diversity of approaches to methanation. While Germany and France focus on individual and cooperative models, Denmark relies on centralised facilities, and Sweden and Italy demonstrate innovative ways to use biogas in urban environments and the national energy system. These approaches can be adapted and applied in other regions, taking into account specific conditions and needs.

Examples of methanisation outside Europe

India is among the leading countries outside Europe to use methanisation as part of its rural development and sustainable waste management strategy. The country has over 5 million small-scale biogas plants operating in rural areas. They use animal manure and vegetable waste as their main feedstocks. Biogas produced through methanisation is used for cooking and lighting, replacing traditional sources such as wood and coal. The technology reduces household air pollution, which is key to improving health, especially of women who traditionally engage in cooking. India's National Biogas Programme (NBP) has created an infrastructure for the deployment of small and medium-scale biogas facilities that serve millions of rural households.

China is a world leader in biogas production, using methanisation on a large scale for waste management in agriculture and industry. There are over 30,000 large biogas plants in the country that process waste from livestock, food and wastewater systems. The Chinese government subsidises the construction of digestion facilities and their integration into the country's energy system. Methanisation plays a key role in reducing pollution of soil and water resources, which is of great importance for a country with intensive agriculture.

The biogas plant in Shandong province produces more than 10 000 Nm³ of biogas per day using waste from pig farming. The biogas produced is used to power power plants.

The United States uses methanisation as a way to manage waste from large farms and to produce renewable energy. There are more than 2,000 biogas plants in the country, most of them focused on processing waste from dairy farms and large livestock complexes. The biogas is processed into biomethane and injected into the gas grid or used as fuel for transport. Municipal programs use organic waste from the food industry and households to produce biogas, which is then used for electricity and heating.

In California, the CalBio project uses methanisation to process waste from dairy farms and produce biomethane that powers the state's buses and trucks.

Brazil uses methanisation as part of the waste management associated with ethanol and sugar production. Biogas plants in the country treat wastewater and residues from ethanol production, which are the main pollutants. The biogas produced is used to generate electricity that powers the plants themselves and local communities. Through biogas projects, local communities gain access to cheap energy, which improves quality of life.

The biogas plant in São Paulo treats wastewater from ethanol production, producing energy to power 20,000 households.

Australia is integrating methanisation as part of efforts to reduce carbon emissions from agriculture. Methanisation plants are used to manage waste from dairy farms and livestock production. Australian farmers use digestate as an organic fertiliser to restore soil fertility. Biogas is used to generate electricity that supports rural communities.

In the Victoria region, farmers have established a cooperative digestate project that processes waste from several farms and generates electricity for over 5,000 households.

Examples from India, China, USA, Brazil and Australia show that methanisation is a universal technology that can adapt to different economic, social and environmental conditions. While in Europe methanisation often focuses on sustainable agricultural management, outside Europe the technology plays a key role in addressing challenges related to energy access, pollution and environmental protection. These examples highlight the global potential of methanisation as a solution for sustainable development.

CONCLUSIONS

Methanisation is a technology with huge potential to transform agriculture into a more sustainable and environmentally responsible sector. By deploying methanisation facilities, farms can not only reduce their dependence on conventional energy sources, but also manage their waste in a way that minimises environmental pollution. Methanisation contributes directly to reducing greenhouse gas emissions by processing waste in controlled conditions and using the biogas produced for energy purposes. This sustainability makes methanisation an important tool in the fight against climate change and the transition to a green economy.

Examples from countries such as Germany, France and Bulgaria show that the deployment of methanisation technologies not only improves the energy independence of farmers but also provides additional sources of income through the sale of biogas and organic fertilisers. Establishing cooperative structures for centralised methanisation provides an opportunity to reduce costs and scale up operations. The integration of methanisation with other renewable energy sources such as solar and wind further increases the efficiency and sustainability of farms. At the same time, methanisation also offers significant social benefits for rural communities. By creating jobs and improving quality of life, the technology contributes to the social and economic development of rural regions. One of the major opportunities for methanisation relates to the education and training of new professionals, which will enable farms to implement the most efficient technologies and maintain sustainable waste management in the long term. Looking ahead, the development of financial programmes and subsidies, as well as an improved regulatory framework, will make methanisation more accessible to more farmers. This will allow even more farmers to switch to greener and more efficient practices, which in turn will help build a circular economy and a sustainable future for agriculture. Successful implementation of methanisation requires collaboration between governments, the private sector and scientific institutions to continue to drive innovation in this sector. With expanding support and adaptation of international best practices, methanisation has the potential to be one of the key technologies for sustainable development in global agriculture.

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STUDIES ON THE SUSTAINABLE IMPACT OF ARTIFICIAL INTELLIGENCE IN TECHNICAL AND AGRICULTURAL UNIVERSITY EDUCATION: BENEFITS CHALLENGE AND FUTURE DIRECTIONS,

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Abstract

This undertaken study analyzes how students and professors perceive the use of artificial intelligence (AI) in education, in technical and agricultural higher education. At the same time, there were examined the perceived benefits, existing challenges, and future directions for implementation. The research is based on the analysis of a dataset collected through online questionnaires, which provides a detailed perspective on how AI influences technical and agricultural educational processes. The results indicate that perceived AI is predominantly positive, being appreciated for its usefulness in personalizing learning and optimizing evaluation processes, especially in technical fields. Nonetheless, it was noted that educators in technical and agricultural higher education encounter considerable obstacles in adopting this technology owing to insufficient resources, the necessity for further training, and issues associated with its effective incorporation into technical and agricultural educational practices.
In this regard, we have developed a series of recommendations to address these contemporary challenges, including the development of sustainable training programs for teachers in technical and agricultural higher education. We proposed to stimulate investments in the technological infrastructure appropriate to the field under study, and last but not least, it is necessary to clearly define the ethical framework for the use of artificial intelligence in student education.

Key words*: AI in education, technical and agricultural higher education, university professors, students from technical and agricultural education*

INTRODUCTION

Artificial intelligence (AI) has a large utilization in many field like: "expert system for decision making management [14], natural language processing, neural networks, robotics, machine learning, fuzzy logic, computer vision" and has recently become increasingly present in the field of education, especially in technical and agricultural higher education, which offers significant opportunities for improving the learning process as well as academic efficiency [10].
However, there are also a number of obstacles in the implementation of AI that can pose major challenges for teachers and institutions, most of which are particularly related to access to resources, which is quite difficult and sometimes precarious, adaptation to new technologies, and the ethics of AI usage [4, 6, 7, 9].
In recent years, artificial intelligence (AI) has emerged as a prevalent sustainable instrument in education, particularly in technical higher education, as it provides innovative solutions that enhance learning personalization, automate administrative processes, and refine evaluation methods. The incorporation of this technology into the technical education system yields numerous advantages, yet also presents considerable challenges for educators and institutions, particularly regarding resource accessibility, adaptation to new technologies, and the ethical implications associated with AI utilization [3,10,17].

Review of the specialized literature

The introduction of artificial intelligence (AI) in higher education has become increasingly common, reflecting the growing concern of researchers about the subject. AI can be said to offer significant opportunities for personalizing learning, optimizing administrative processes, and improving academic performance.

In this section, there are analyzed the main studies regarding the use of AI in higher education, those research efforts that also include online applications, ethical considerations, and the impact of using this tool in the educational process.

Thus, following the review of the specialized literature, we observed that authors such as Schön, E.-M. et al. (2023) have addressed and analyzed artificial intelligence (AI) and stated that it has the potential to support creativity, generate new ideas, and contribute to the automation of various tasks that were often performed manually and required a high level of execution, fundamentally changing the way people work. This transformation can have a beneficial influence on both students and teachers, impacting the processes of teaching, learning, and assessment [16].

In the context of technological evolution, significant implications for higher education can be identified. On the one hand, as is to be expected, new challenges may arise, such as the unethical use of these tools by students, which can create increased difficulties for teachers in the evaluation process and uncertainties regarding the long-term impact of AI on education [12]. On the other hand, it is considered that AI offers valuable opportunities, such as the development of intelligent tutoring systems (ITS) and the stimulation of creativity in the educational process [12].

One of the major challenges of using ChatGPT in the academic environment [2] is represented by the inability of current control mechanisms, namely specialized plagiarism detection software, to accurately identify whether texts are written by humans or generated by AI (Gao et al., 2022). In this context, the need for a reevaluation of how teachers design and administer exams and other forms of academic assessment can be identified [5].

Thus, the need is felt to create a legislative framework as well as some ethical norms aimed at the responsible use of AI-based tools, both by students and by professors [2]. At the same time, technical changes are also targeted, which not only involve technical aspects but also require a cultural transformation through the adoption of a student-centered approach, focusing on the teacher, and promoting value-based learning [4, 16].

Considering the significant impact of these emerging technologies on higher education, there is a felt need for a broad debate as well as clear guidance on their effective and ethical integration into the educational process, so that teachers and students can utilize these tools [4, 5, 12, 16].

Ouyang et al. (2022) [13] conducted a systematic review of empirical research on the application of AI in online higher education between 2011 and 2020. The main conclusions of the study highlight the future importance through the increase of academic performance as well as the optimization of the educational process. It is recommended to personalize learning resources and to automate assessment and real-time feedback collection.

The authors assert that AI is a crucial instrument in digital learning environments, enhancing active and immediate student engagement for educational assistance, while also addressing challenges such as scalability, insufficient digital training for educators, and the ethical ramifications of algorithmic usage [13].

Sharma et al. (2024) performed a quantitative investigation of the implementation of AI in higher education institutions in India. Their research underscores the necessity for AI to perpetually grow in order to accommodate technology advancements and educational needs. The authors emphasize that national education policies are progressively endorsing the incorporation of AI into the curriculum to enhance student learning results and educators' instructional techniques. Simultaneously, it is emphasized that there exists uncertainty concerning the long-term effects of AI in education, indicating that examining prior advancements may offer insight into its revolutionary potential [18].

Khan et al. (2025) examine the function of AI in sustainable higher education, assessing its ethical ramifications and operational efficacy. Their research underscores various methods by which AI improves educational experiences, including the development of learning platforms that may be readily tailored to accommodate the requirements of the instructional process [8].

Despite the various apparent advantages, researchers express certain concerns, mainly pertaining to the ethics of AI use and the secrecy of the data employed or produced. The findings indicate that AI should serve as an enhancement or supplement to educational practices, rather than a total substitute .

Maphosa and Maphosa (2023) performed a bibliometric analysis that underpins a literature evaluation in the domain and a topic modeling study to investigate research on AI in higher education. This results reveal a significant surge in AI papers, with China, the United States, Russia, and the United Kingdom leading in research within this domain [11].

This study conducted by the authors illustrates the concern and growing significance of AI as a transformative instrument, perceived as a means to enrich students' learning experiences, optimize teachers' responsibilities, and expedite institutional operations [11].

In the framework of the global economy, artificial intelligence (AI) is crucial for fostering development and is progressively included into the national plans of major economies, including the USA, China, South Korea, and Japan [1]. Consequently, it may be asserted that poor nations encounter obstacles in the adoption of AI due to insufficient infrastructure, restricted access to technology, the absence of suitable policies, and a deficiency in data science expertise. The reviewed specialized literature indicates that the use of artificial intelligence for youth education has been identified as a generator of ethical challenges, with a special focus on the data collection and storage segment [19].

On the other hand, AI can contribute to the improvement of personalized learning by analyzing and anticipating the optimal study moments, thus adapting to the pace and needs of each student in technical and agricultural education. In this sense, artificial intelligence can contribute to optimizing the university educational process, facilitating a superior assimilation of specific concepts which can lead to academic performance [15].

Research on the influence of AI in higher education has predominantly occurred in industrialized nations, where the incorporation of this technology is regarded as a crucial element for socio-economic advancement, directly affecting enterprises and organizations.

Based on the reviewed literature, we can assert that artificial intelligence is crucial in revolutionizing higher education, impacting both students' learning experiences and educators' teaching methodologies.

Although a number of considerable benefits have been identified, the literature also highlights a series of challenges such as digital equity, teacher training, and the responsible integration of AI. Future research should focus on evaluating the long-term impact of AI, developing clear ethical frameworks, and strategies for improving digital literacy among teachers and students.

MATERIALS AND METHODS

This study investigates the opinions of students and instructors concerning the application of artificial intelligence (AI) in technical higher education, focusing on its advantages, problems, and future prospects. We choose the suitable research methodology to analyze the responses and to maintain a consistent study trajectory on the subject matter.

The survey was done online during the period 1 and June 30, 2024.

To examine the correlation between the application of AI in technical university education, we utilized a mixed research methodology, incorporating both qualitative and quantitative approaches.

The data collection for this study was conducted using an online questionnaire designed to ascertain the perceived advantages for both students and faculty in higher education, along with the problems they face in utilizing this tool. The questionnaire had open-ended questions aimed at examining the benefits and shortcomings of AI integration in education.

The questionnaire comprised open-ended questions:

1. In what ways might the incorporation of AI technology affect conventional pedagogical approaches over the long term? This inquiry seeks to examine the influence of artificial intelligence on conventional educational practices and the potential modifications in teaching methodologies.
2. What are the possible advantages of employing AI in educational environments? The advantages of AI in education are examined, including enhanced access to materials, personalized learning, and streamlined instructional processes.
3. Could you furnish examples of AI applications presently applicable in educational settings? This inquiry identifies AI tools now utilized in education, including virtual assistants, voice recognition software, and adaptive platforms.
4. In what ways might AI facilitate individualized learning experiences for students? They are examining how AI can customize instructional content to meet the specific needs of students.
5. What are the essential guidelines for ethical considerations regarding the use of artificial intelligence in education? (This question analyzes aspects such as data privacy protection, ensuring equitable access to educational resources, and the implementation of clear ethical principles in the use of AI in the educational process.)
6. How can AI contribute to improving assessment and grading methodologies? (The study explores how AI can optimize academic evaluation processes by reducing subjectivity, providing personalized feedback, and ensuring an objective and precise analysis of student performance.)
7. What obstacles may instructors encounter when integrating AI technology into their instructional methodologies? This inquiry identifies obstacles to AI adoption, including inadequate training and insufficient funding.
8. In what ways may AI-driven tools assist educators in lesson planning and curriculum design? The application of AI for the automation of administrative activities and the enhancement of the educational process is under investigation.
9. How might AI enhance accessibility and inclusivity in education? Examining the role of AI in enhancing educational access for children with special needs or from underprivileged backgrounds.
10. What is the students' perception of AI utilization in their educational experiences?

This research explores how students in technical and agronomic higher education understand the use of AI and how it influences their educational journey.

By using open-ended questions, the respondents to the questionnaire had the opportunity to express their opinions in detail and present various views on the subject under study. These responses play an important role in identifying evolving trends and how they view the future integration of AI in higher education.

At the same time, nuanced responses can be obtained to complement the quantitative analysis of the study. The diversity of opinions is explored based on professional experience and level of familiarity with AI.

Sample size:

The sample consists of 100 participants, of which: the majority of respondents, 60%, are students enrolled in undergraduate and postgraduate programs in technical higher education, while 40% are professors teaching in higher education institutions.

The study group was randomly selected and grouped in such a way as to be balanced and representative of the respondent cohorts.

RESULTS AND DISCUSSIONS

The paper focused on examining the perceptions of students and university professors regarding the use of artificial intelligence (AI) in education. The focus was on technical and agronomic higher education. The study analyzed both the identified advantages and the obstacles encountered in adopting this technology. Additionally, possible directions for the efficient integration of AI into the educational process were explored. The influence of AI on teaching methods was highlighted, including the adaptation of teaching strategies and the use of these innovative technological tools, and the way it affects communication, interaction, and the dynamics of the educational process between students and university professors was analyzed.

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Next, the literature review section explores current trends in research regarding the use of AI in technical higher education, its impact on the teaching process, and the ethical considerations associated with this technology.

In this regard, we conducted a bibliometric analysis of the specialized literature.

Introduction to the context

Artificial intelligence (AI) plays an increasingly important role in education, influencing both teaching methods and the learning process. The analysis of the relationships between the concepts associated with this field allows for the identification of the main research directions and how it can be effectively integrated into education. Thus, the bibliometric network of relationships between the analyzed terms in the field of AI applied in education helps highlight the main areas of interest. This offers a clear perspective on the connections between concepts and highlights the complexity of the field. Through this approach, one can better understand the impact of AI on education and identify current and future research trends.

Thus, the purpose of the analysis is to understand the structures and clusters in the bibliometric map, which is essential for identifying the main research directions and the challenges associated with the use of AI in education.

The visual representation of the relationships between terms in education and AI reveals three major thematic groups, each reflecting distinct perspectives and priorities. By analyzing the overall structure of the network and the clusters, we can discover new opportunities for the efficient integration of AI in education. Research on AI in education focuses on the relationships between educators' perceptions, integration in universities, and ethical aspects, themes that are reflected in the structure of the bibliometric network.

Thus, an advanced search of the Web of Science database was conducted to create the co-occurrence matrix of the keywords education, higher education, and AI in education. By using the specialized software VOSViewer, the following were generated.

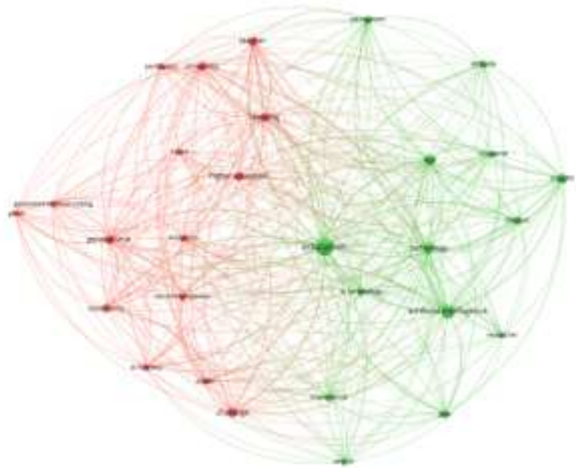

Fig.1. Co-occurrence matrix for key words
Source: author's processing using VOSViewer [20].

In the first phase, the minimum threshold for the occurrence of a term was selected. In this case, we set that threshold to 10, which means that only the terms that appear at least 10 times in the analyzed database will be taken into consideration. Thus, out of a total of 2,525 terms, only 69 met this criterion. This method is used to eliminate terms that appear rarely, focusing on the most significant ones.

In the next stage, specialized software was used to calculate a relevance score for each of the remaining 69 terms. This score allowed for the identification of the most significant terms for analysis, facilitating an objective selection based on statistical criteria. The selection process was based on a default value of 60% of the terms with the highest relevance scores. Thus. Out of a total of 69 terms, 41 were selected, considered the most representative for further analysis. This method ensured a structured approach and contributed to optimizing the process of extracting relevant information.

Thus, it was generated the co-occurrence matrix on clusters of interest.

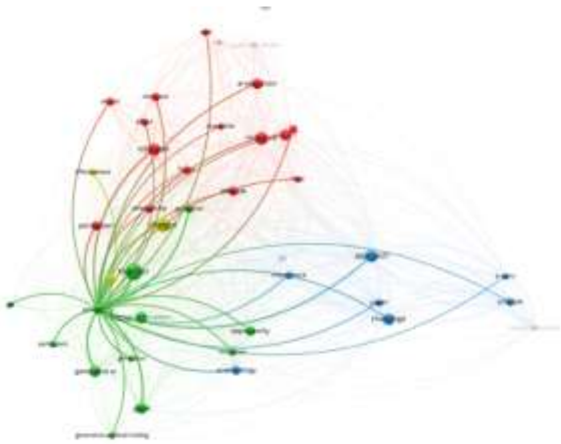

Fig. 2. Co-occurrence matrix of the cluster of interest
Source: author's processing using VOSViewer [20].

The bibliometric map is a visual representation of the relationships between concepts and research areas associated with AI in education. Three main groups of terms are observed, each represented by a distinct color:

• Red: Concepts related to research and educators.

• Green: Concepts related to higher education, teachers, and generative AI.

• Blue: Concepts related to challenges, ethics, and principles.

This segmentation indicates three major research directions on AI in education.

Cluster analysis

(A)The red cluster: Research and educators

Key terms: "research" (cercetare), "educator" (educator), "attitude" (atitudine), "perception" (percepție), "ai education" (educație AI), "effect" (efect), "factor" (factor)

This group focuses on how educators perceive and use AI in education. Teachers' attitudes, the effects of AI on teaching, and factors influencing AI adoption are analyzed. AI is viewed as a teaching tool, and researchers are investigating how it affects the effectiveness of learning.

We can observe that the term Research is connected with ChatGPT, indicating researchers' interest in using ChatGPT in education. The relationship between perception and educator suggests that there are studies investigating how teachers perceive AI and its impact on teaching.

(B) The green cluster: Higher education, generative AI, and teachers

Key terms: "teacher" (professor), "higher education" (educație superioară), "university" (universitate), "generative AI" (AI generativă), "GPT", "participant", "guideline" (ghid).

In this cluster, the emphasis is placed on the role of AI in universities and teacher education. Generative AI, including ChatGPT and GPT, is analyzed from the perspective of its benefits for higher education. Guidelines and recommendations are mentioned, suggesting the need for regulation of AI use in the academic environment.

Keywords Teacher and higher education are connected with generative AI, indicating that generative AI is a topic of interest in higher education. On the other hand, University and participant suggest that the studies include empirical research with professors and students.

(C)The Blue Cluster: Challenges, Principles, and Ethics

Key terms: "challenge" (provocare), "approach" (abordare), "principle" (principii), "ai ethic" (etică AI), "risk" (risc), "importance" (importanță), "paper" (lucrare).

It can be said differently that the interest of researchers analyzing the ethical challenges of using AI in education has increased.

Artificial intelligence (AI) in education has seen significant growth, generating debates regarding the principles of responsible use, advantages, and associated risks. Researchers are analyzing appropriate methods for the efficient integration of AI into the educational system. The relationship between principles and AI ethics reflects the concern for developing clear ethical guidelines regarding the use of artificial intelligence. At the same time, the challenges related to AI are closely connected with the proposed approaches, which suggests the efforts of the academic community to find effective solutions for the difficulties encountered in implementation. AI in education remains an active research

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field, structured around three main directions: teachers' perceptions, the integration of artificial intelligence in universities, and the ethical aspects associated with the use of this technology.

Generative AI, especially ChatGPT, is an important topic, indicating that these technologies are being analyzed for their impact on teaching and learning. Research highlights both the opportunities of AI in education and the associated challenges and risks.

The questionnaire was administered to students and professors at Iasi University of Life Sciences (IULS), participants in the DPPD, and consists of 10 questions, distributed in such a way as to provide information both about their opinions and about the concrete actions they undertake regarding the proposed theme. Specifically, 10 open-ended questions were formulated, which offered respondents—students and professors—the opportunity to freely express their opinions.

Next, 10 pie charts are presented, each illustrating the distribution of responses for a specific question, thus highlighting the trends and perspectives of the participants.

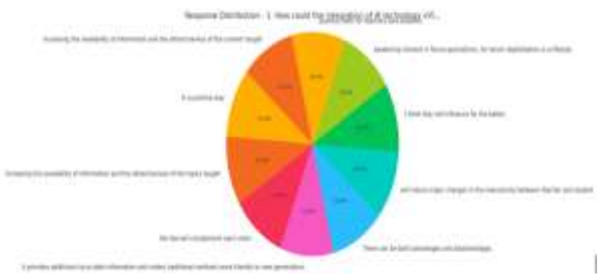

Fig. 3. Distribution of responses to question 1
Source: author's processing.

In question no. 1, the majority of the responses suggest that AI has a positive impact on education. Phrases such as "Adaptive learning" and "Improving the quality of teaching," which are frequently mentioned, indicate that AI is perceived as a tool for personalizing learning to the needs of the student/teacher. Some responses indicate the initial implementation difficulties, which in the long term generate benefits.

AI can become an essential tool in modernizing education, helping to personalize teaching materials and streamline the teaching process. However, teachers need training to use AI effectively, and the technological infrastructure must be adapted to the requirements of the new teaching methods.

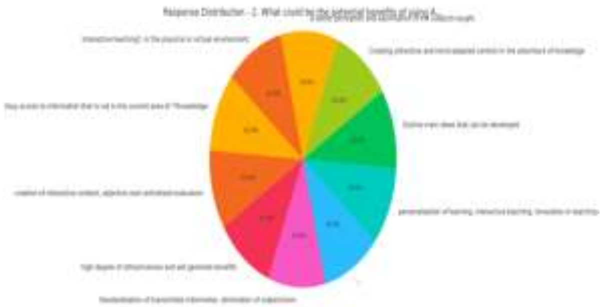

Fig. 4. Distribution of responses to question 2
Source: author's processing.

In question no. 2 from the responses given by students/professors, it can be observed that the most frequently mentioned advantages were: quick access to information, data processing, and increased accuracy in the teaching-learning process. In this case, AI is seen as a tool that can improve access to and distribution of educational materials, and it is also viewed as an additional aid for teachers.

The implementation of AI can significantly improve the educational process in technical education, providing access to diverse resources and facilitating data-driven learning. However, effective integration depends on the ability of teachers and higher education institutions to adapt these technologies to the real needs of students.

Fig. 5. Distribution of responses to question 3
Source: author's processing.

In question no. 3, the answers given by students/professors most frequently mentioned Grammarly, ChatGPT, Duolingo, and Kahoot. These applications are used for interactive learning, automatic correction, and

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language assistance. Machine translation and text analysis are also important aspects of using AI in education in general and in ethnic higher education in particular.

The development of AI tools specific to different technical academic disciplines is necessary to increase the impact of technology on the entire educational process.

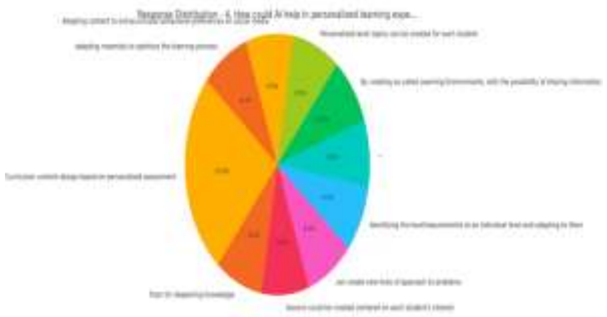

Fig. 6. Distribution of responses to question 4
Source: author's processing.

In question no. 4, "AI Tutors" and "Virtual Assistants" are frequently mentioned as tools used, suggesting that AI can provide instant feedback and personalized support for teaching/learning. Some responses indicate that AI could help in quickly selecting relevant information, which would streamline the learning process in technical higher education. Personalized learning is one of the greatest benefits of AI in education.

However, the use of AI must be parallel to traditional methods to avoid excessive dependence on technology and to maintain the student-teacher interaction in the educational process.

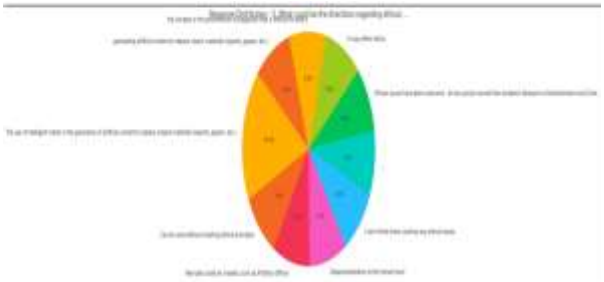

Fig. 7. Distribution of responses to question 5
Source: author's processing.

We can observe that in question no. 5, for the majority of respondents, the greatest concern is related to plagiarism and the unethical use of AI, but we can also see that some participants believe that AI can be used without violating ethical principles, as long as it is used appropriately.

At the same time, there are respondents who emphasize the necessity of having a clear ethical framework for the use of AI in education and that it should be integrated into a well-defined ethical framework, which would prevent inappropriate use and promote the responsible use of technology in education in general and in ethnic education in particular.

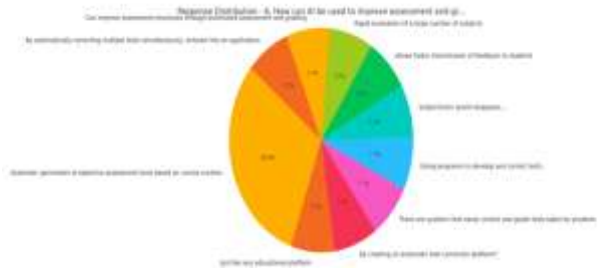

Fig. 8. Distribution of responses to question 6
Source: author's processing.

From analyzing the responses given by respondents to question no. 6, we can observe that the most frequent answers mention the automation of grading papers, thus eliminating subjectivity in grading.

Some even consider that AI can be used similarly to an educational platform, providing quick and objective assessments for the teaching-learning process. Thus, AI can be considered a valuable tool for automating assessment tasks, but final decisions regarding grades must be reviewed by teachers to ensure the accuracy and transparency of the evaluation.

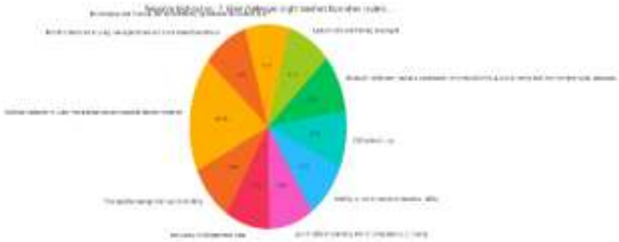

Fig. 9. Distribution of responses to question 7
Source: author's processing.

From the analysis of the responses received to question no. 7, it is observed that the most frequently mentioned difficulties are: lack of training for teachers, adoption of new technologies, and issues related to unreliable information sources. There are also responses suggesting that AI could diminish charisma and human interaction in the teaching/learning process in technical higher education. Therefore, the adoption of AI in education must be accompanied by training programs for teachers and a clear strategy for integrating new technologies into teaching.

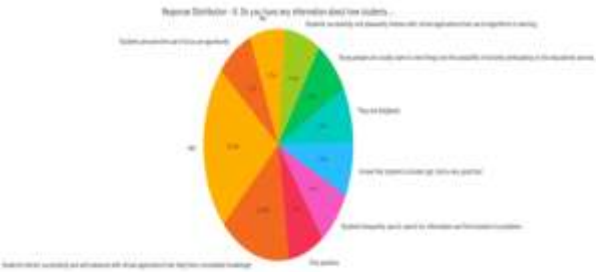

Fig.10. Distribution of responses to question 8
Source: author's processing.

In the graph above, we can observe that the majority of responses are positive, indicating that students consider AI a useful tool for quickly searching and organizing information. Some participants mentioned that students use AI very frequently for various academic activities specific to technical education. Among the respondents, students are more open to using AI compared to professors, which suggests that education needs to evolve to meet the new technological realities of today's society.

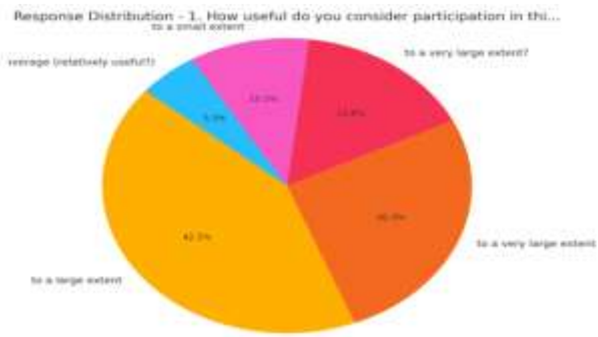

Fig. 11. Distribution of responses to question 9
Source: author's processing.

The majority of the responses to question no. 9 are very positive, indicating a high level of satisfaction. Participants: students and teachers consider that the workshop was extremely informative and relevant for educational practice in technical vocational education, being well received, but with the recommendation that future sessions should be more interactive and include more examples of applied AI usage.

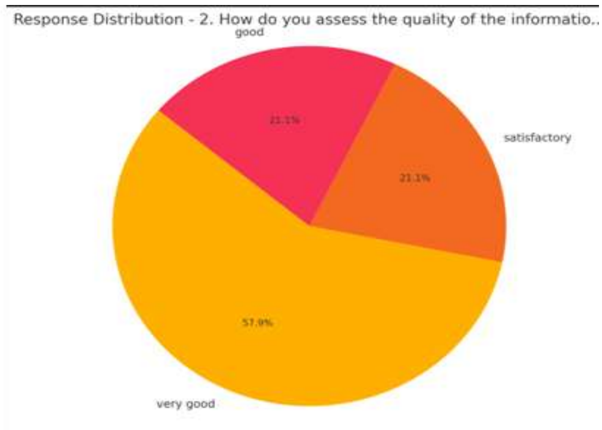

Fig. 12. Distribution of responses to question 10
Source: author's processing.

Most of the responses to question 10 indicate that the information received was very good or satisfactory. Some participants suggest that it would be useful to delve deeper into certain topics related to AI in education and for technical education.

AI is perceived as an extremely valuable tool for education in general and for technical higher education in particular, with the potential to personalize teaching and learning experiences and to automate assessment processes.

There are ethical concerns and challenges related to the implementation and training of teaching staff in technical education, but participants believe that the benefits outweigh the obstacles.

The workshop was highly appreciated, with recommendations for more frequent and applied sessions.

The limitations of the study

Since the sample size was relatively small, the representativeness and reliability of the results can be influenced by limiting the possibility of drawing generalizable conclusions about the target group studied: teachers and students.

Additionally, the interpretation of participants' open-ended responses may be subject to possible errors, either due to the ambiguity of the formulations or the subjectivity of their analysis. The limitation also arises from differences in expression and the use of vague terms or the multiple meanings of certain words, which can lead to difficulties in classifying and correctly understanding the responses.

CONCLUSIONS

The results of this study conducted during a workshop at Iasi University of Life Sciences (IULS) highlight the important role of artificial intelligence (AI) in transforming instructional-educational processes in technical higher education. Based on the data collected from students and professors and the analyzed literature, we can identify the main benefits, challenges, and future directions for integrating AI into the instructional-educational process.

In this regard, to maximize the benefits of using AI in education and to overcome the identified challenges, a clear and well-defined national strategy is necessary for the implementation of this technology in technical higher education.

We can recommend, following the conducted study, training sessions for teaching staff through the development of training programs on the effective use of AI in teaching, learning, and assessment. It is also important to invest in technological infrastructure for the modernization of university laboratories and the implementation of AI platforms dedicated to technical and agricultural education.

At the national and institutional level, it is essential to develop a clear ethical framework for the use of AI in education. This process requires the development of specific educational and regulatory policies aimed at ensuring transparency in the implementation of AI, ensuring equity in access to educational technologies, and protecting users' personal data. The creation of well-structured norms can help avoid unethical uses and increase trust in AI as a supportive tool in education. In this context, a gradual integration of artificial intelligence into the technical and agronomic university curriculum is recommended, with the objective of developing the digital competencies of students and professors, as well as the concrete application of AI technologies in the teaching-learning process. Such an approach would facilitate not only the theoretical understanding of this technology but also the development of the practical skills necessary for its efficient use in the future professional careers of students.

Artificial intelligence has a significantly positive impact on technical and agricultural university education, facilitating personalized learning, automating educational processes, and providing quick access to information. But care must be taken regarding how we adopt AI, namely to do so in a balanced and ethical manner, considering the need for teacher training, data privacy, and maintaining human interaction in education.

Therefore, by implementing appropriate strategies, AI can become an essential element in modernizing technical higher education, contributing to the preparation of students and teachers for the demands of the job market and the development of relevant digital skills for the future.

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DETECTION OF RICE WEEVIL LIFE STAGES IN RICE SEEDS USING RADIOGRAPHIC TECHNIQUES

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Abstract

Radiographic analysis is a nondestructive technique used to analyze the quality of seed lots and has shown efficiency and precision by reducing subjectivity and time in the performance of laboratory tests. The objective of this study was detect the developmental stages of S. oryzae (Coleoptera: Curculionidae) using X-rays. Healthy seeds of the rice cultivar CMG-1590 were infested with S. oryzae adults and evaluated by X-ray analysis according to the times estimated for the development of the stages weevil, namely, 5, 10, 20, 30 and 40 days after infestation. Additionally, analysis of the infested seeds were performed to evaluate the different life stages of the S. oryzae present. Statistical differences were observed regarding the levels of infestation detected between treatments. The egg, larva and adult stages of development were detected, except for the pupal stage, which was not possible to observe. Damaged seeds and empty seeds were also detected as a result of the feeding habit and life cycle of the insect. In conclusion, the X-ray analysis allowed us to verify the infestation of S. oryzae in rice seeds, as well as characterize the development cycle of the weevil and identify its life stages.

Key words**:** *seed infestation, sanitary quality, storage, X-rays*

INTRODUCTION

Rice is one of the most important commodities, is the third most common grain in the world, and is considered an energy and protein source with the ability to meet the daily caloric needs of millions of people worldwide [7], [15].

Productive success in rice fields involves the use of steps such as seed selection; sowing; the integrated management of pests, diseases and weeds implantation; harvest and post-harvest processing; harvesting and postharvest processing. The choice of rice seeds is very important because it is through them that the transfer of genetic advances of regional adaptability occurs, with the ability to provide better stand quality, plant vigor, initial development, plant uniformity in the field and increased productivity [17], [37]. Thus, rice seeds with high physical, physiological, genetic and health standards are considered essential inputs for the establishment and development of successful crops [12]. Among these attributes, sanitary quality is more relevant, as pests and diseases are usually spread by seeds [9], [25]. The examination of infested seeds is of paramount importance in the detection of storage insect pests, which can cause great economic losses in seed lots [9]. The beetles *Rhyzopertha dominica* (Fabricius, 1792) (Coleoptera: Bostrichidae), the weevils *Sitophilus oryzae* (Linnaeus, 1763) and *Sitophilus zeamais* (Montschulsky, 1885) (Coleoptera: Curculionidae) are considered primary and cross-infested pests and are capable of causing damage to seeds, both in the larval and adult stages. They can attack healthy seeds, pierce their external parts and consume their interiors to complete their life cycle [2], [29].

The detection and location of these pests in the early stages of development are difficult tasks; however, the use of methodologies that allow for the accurate and rapid identification of their presence is being increasingly studied [16]. Among the nondestructive techniques, the X-ray technique has been used in the evaluation of seed quality, determination of embryonic defects, morphological and morphometric evaluations, identification of broken seeds, and identification of seeds damaged by storage pests, bacterial and fungal infections [6], [33]. In the detection of stored seed pests, X-ray analysis has shown high repeatability and reproducibility in the determination of R. dominica infestation in wheat [20]. X-ray analysis has also been applied to analyze *Callosobruchus maculatus* (Fabricius, 1775) (Coleopetra: Bruchidae) on soybeans [8] and *S. zeamais* on maize seeds [14]. However, studies on the identification and verification of the developmental stages of this insect in stored rice seeds are still emerging [24], [35], [5]. Hence the need to research and develop new approaches that allow for the early and accurate detection of insect developmental stages, as well as the internal damage caused to rice seeds, offering a promising solution for assessing seed health, which may in the future contribute to the development of more efficient management and control strategies in storage.

Thus, the objective of the present study was to detect the developmental stages of *S. oryzae* (Coleoptera: Curculionidae) using X-rays

MATERIALS AND METHODS

This study was conducted at the Central Laboratory for Research on Seeds (CLRS) of the Department of Agriculture and the Laboratory of Ecotoxicology and Integrated Pest Management (LEMIP) of the Department of Entomology of the Federal University of Lavras (UFLA), in February and April 2022. Untreated rice seeds (CMG 1590 2020/2021 crop) developed by the Program for Genetic Improvement of Rice of the Highlands – "MelhorArroz da UFLA" in partnership with Empresa Brasileira de Pesquisa Agropecuaria rice and beans, and Empresa de Pesquisa Agropecuária de Minas Gerais were used. These seeds were infested with adult *S. oryzae* insects from the LEMIP laboratory.

To simulate infestation and ensure progression of *S. oryzae* developmental stages, five plastic containers with a capacity of 100 mL were used, each containing 40 g of rice seeds and 50 adult *S. oryzae* insects (aged 1-30 days). Seeds were collected at intervals of 5, 10, 20, 30, and 40 days after infestation, thus five treatments were defined based on the collection time after the initial infestation: T1 – seeds collected five days after infestation, corresponding to the egg stage; T2 – seeds collected to 10 days after infestation, corresponding to instars first and second of the larval stage; T3 – seeds to collected 20 days after infestation, corresponding to instars three and four of the larval stage; T4 – seeds collected 30 days after infestation, corresponding to the pupal stage; and T5 – seeds collected 40 days after infestation, corresponding to the presence of the pre-emergence adult stage in the rice seeds.

The containers were sealed with voile fabric to allow aeration, ensure survival, and prevent insect escape. The recipients were kept in climatic chambers at 25 ± 2°C and scotophase for 24 hours. The experimental design used was completely randomized, with five treatments and five replicates of 100 seeds of rice.

Sample collection and X-ray analysis

One hundred seeds were randomly removed from each container, constituting a replicate, for a total of 500 seeds evaluated for each treatment. For X-ray analysis, 100 seeds from each replicate were placed on acetate papers of 100 µm and fixed with double-sided transparent adhesive tape for fixation and subsequent individual identification.

Radiographic images were obtained using digital FAXITRON X-ray equipment, model MX-20, with a voltage adjustment of 30 kV and exposure for 19 seconds at a distance of 22.0 cm from the radiation source. Seeds with possible weevil presence at any developmental stage were set aside for further radiographic analysis, adjusting the focal length to 15 cm for clearer imaging while maintaining radiation intensity. Additionally, the radiographic images were used to determine the oviposition site in all infested rice seeds. Subsequently, the collected seeds were analyzed according to the methodology described in the Rules for Seed Analysis [4] to verify the presence or absence of each stage of development of the insect pest. For this purpose, the collected seeds were placed individually in plastic boxes and immersed in distilled water for a period of 24 hours. Afterwards, they were sectioned with a scalpel to evaluate the presence of eggs, larvae, pupae, adult insects or the exit holes of the insects.

Experimental design and statistical analysis

The infestation data were subjected to analysis of normality (Shapiro–Wilk; $p>0.05$) and homogeneity of variance (Bartlett; $p>0.05$). The F test of analysis of variance was performed, and the means were compared using Tukey's test ($p<0.05$). Data on the number of eggs, larvae, and adults and the detection of damaged and empty seeds were analyzed using the Kruskal–Wallis test, followed by the Bonferroni correction to determine differences between treatments ($p<0.05$). All analyses were performed with the Agricolae statistical package using R statistical software, version 4.1.1.

RESULTS AND DISCUSSIONS

Detection and characterization of rice weevil damage to rice seeds

Radiographic analyses of the rice seeds allowed for the detection and identification of the developmental stages of the weevil *S. oryzae* and the damage generated in the seeds (Figure 1). Radiographic images are characterized by white and black colors, where the color intensity is determined by the density and composition of the seed [20], [30]. Compared to the healthy seeds (Figure 1A), the infested seeds showed changes in internal tissues, especially in the endosperm, which is associated with the detection of the early stages of weevil development (Figure 1B, 1C and 1D) and with damaged and empty seeds (Figure 1E and 1F). Pupae were not detected by X-ray, and the absence of this stage was confirmed by traditional tests of infested seed analysis. X-ray analysis allowed the detection and identification of the infestation and developmental stages of *S. oryzae*, as well as the variations in the tissues that compose the seed, mainly due to the ability of the technique to detect hidden defects in the seeds [1]. The routine application of this technique in laboratories has shown high repeatability and reproducibility; however, its use still depends on the training of technicians to avoid misinterpretation of the images and on the acquisition of equipment, which has is expensive [14].

The oviposition hole detected in the X-ray test appeared as a dark circular or oval-shaped cavity located on the seed surface, with a small white spot (Figure 1B). Radiographic images of the oviposition site revealed 94.5% of the eggs in the endosperm and 5.6% in the perimeter of the rice seed embryo. Although the site of oviposition in the seed is not very clear, radiographic analyses conducted of wheat seeds infested with *S. oryzae* and found that the eggs are mostly present in the endosperm (69%) and in the perimeter of the embryo (11%) [32]. Through the observation of *Sitophilus* sp. in wheat [19] and maize [6] seeds via the X-ray technique, it was possible to distinguish oval-shaped and black sites that are related to the oviposition process. The female creates holes with her mandible, which is located at the distal end of her rostrum, and then secretes a gelatinous protective coating substance at the laying site [31], [10]. Internal detection in insect seeds at early stages of infestation tends to be confusing and difficult to interpret [8]. This is mainly due to the similarity between oviposition, larval instars and initial damage, which can be observed as small, darker gray spots. In addition, there are factors that make the distinction even more difficult, such as the density of the materials, the focal length [21] and the use or absence of contrasting agents, which can affect the quality of the image obtained [6], [14].

The shape and color of the larvae were detected, as they were oval and white and were present between the galleries and the seed tissues. These galleries or tunnels are formed as a function of the feeding habit of the larvae and were distinguished in the images as areas of darker color that contrasted with the endosperm of the seed (Figure 1C).

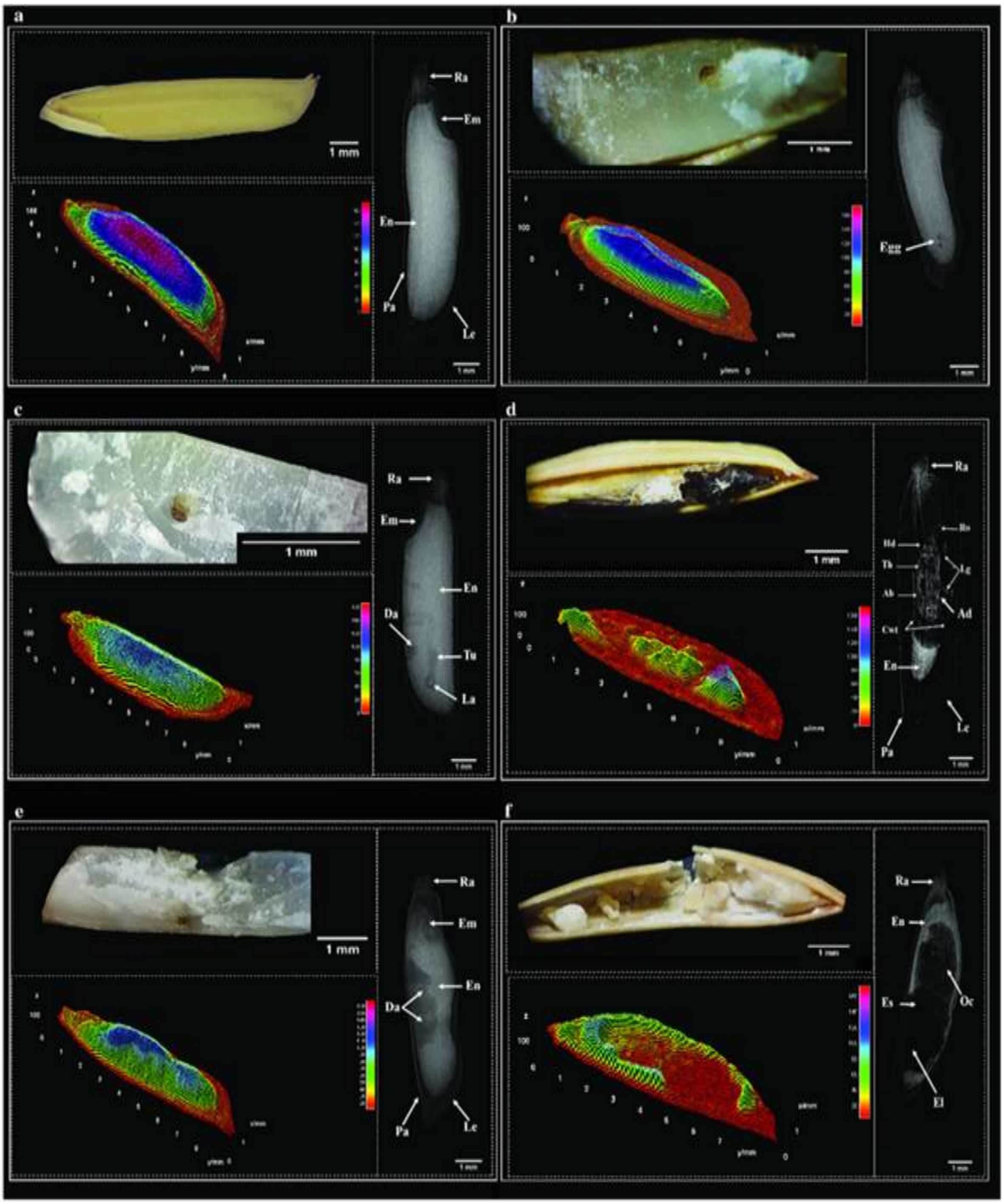

Fig 1. Detection of the developmental stages and characterization of *Sitophilus oryzae* damage on rice seeds by examining infested seeds and X-rays: A) healthy seed; B) egg; C) larva (La) and tunnel (Tu); D) Adult (Ad); E) Damage seed (Da); F) Empty seed (Es). Seed structure: embryo (Em), endosperm (En), caryopsis wrap tissue (Cwt), rachilla (Ra), lemma (Le), palea (Pa), oval cavity (Oc) and exit location (El). Adult parts inside the seed: abdomen (Ab), head (Hd), rostrum (Ro), thoracic segment (Th) and Leg (Lg).
Source: Authors' own illustration.

Approximately five days after oviposition, the larvae hatch, begin feeding on the endosperm and pass through four larval instars until they pupate [10], [3]. This characteristic makes identification easier in more advanced instars due to the size of the larval body [18]. Research shows that after 20 days of infestation with *Sitophilus granarius* (Linnaeus, 1758) (Coleoptera: Curculuonidae) in wheat seeds, galleries and voids, which tend to be darker in color, were the dominant features in X-ray images [13], [26]. This contrasts with the white colors of the tissues not affected by the larvae, [8], [14], [5]. In the last instar, a dark oval cavity forms [6], [19], where pupal formation occurs [18].

Radiographically, preemergent adults tend to be distinguished by the clear identification of certain anatomical structures that have already developed in the body of the insect, such as the abdomen, rostrum and legs of the insect. The adults were observed inside a cavity in the tissues of the caryopsis envelope, protected by the seed shell, which contrasted by presenting dark gray colors compared to the white portions of the endosperm not consumed during the larval stage (Figure 1D). When the adult emerges, it remains inside the seed, moving to find the thinnest place to consume and perforate the seed tissues (envelope of the caryopsis, palea or lemma) and thus creates at hole where it exits the seed [32], [11].

After the emergence of the adult, empty tunnels located in wheat [6], [19] and maize seeds [34] were observed in radiographic images, which presented lower density in the tissues than healthy grains or with than grains with larvae inside them [5].

The damage caused by the rice weevil is mainly the result of the feeding habit of this pest and is differentiated according to the amount of tissue affected in the seed, which begins in the external tissues of the seeds, such as the palea, lemma and caryopsis envelope, until reaching the endosperm. The damage was also distinguished by dark rounded spots that contrasted with the light tones of the endosperm and seed embryo, although in advanced damage, irregular spots of larger size were observed that affected a large part of the endosperm (Figure 1E).

The empty seeds are the final result of the developmental cycle of the rice weevil, with the emergence of the adult insect, since consumption of a large part of the endosperm occurred for its development, forming a cavity, usually oval, with attenuations that contrasted with residues of the endosperm and embryo, and with the healthy seeds. It was also possible to identify the weevil emergence site, which was characterized by rupture of the pericarp and the palea and lemma (Figure 1F).

Percent infestation and detection of weevil developmental stages

Data analysis using a box plot (Figure 2) indicated that the infestation had a normal distribution for the evaluated treatments, in addition to the absence of nonstandard data. The percentages of infestation detected by X-rays at 5, 10, 20, 30 and 40 days after infestation ranged from 0.0% to 2.0%, 2.0% to 4.0%, 1.0% to 4.0%, 1.0% to 4.0%, and 4.0% to 8.0%, respectively (Figure 2).

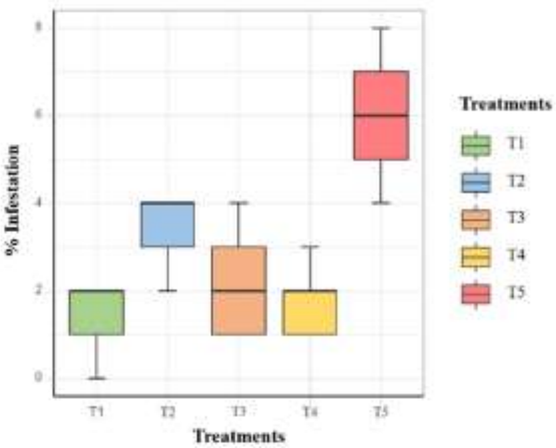

Fig 2. Box plot for the percentage of *Sitophilus oryzae* infestation detected by X-rays. The box plots show the median plus the upper and lower quartiles of the percentage of infestation for each treatment. The minimum and maximum values are indicated by the lower and upper limits, respectively. Treatments were evaluated at 5(T1), 10 (T2), 20 (T3), 30 (T4) and 40 (T5) days after infestation.
Source: Authors' determination.

The percentages of infestation detected showed significant differences ($p < 0.05$), where the T5 treatment presented the highest level of infestation (Figure 3), which may be related to the longer time needed to complete its biological cycle and ensure greater numbers of offspring.

The percentage of eggs identified and the percentage of damaged seeds showed no significant differences between the infestation times according to the Kruskal–Wallis test (p >0.05).

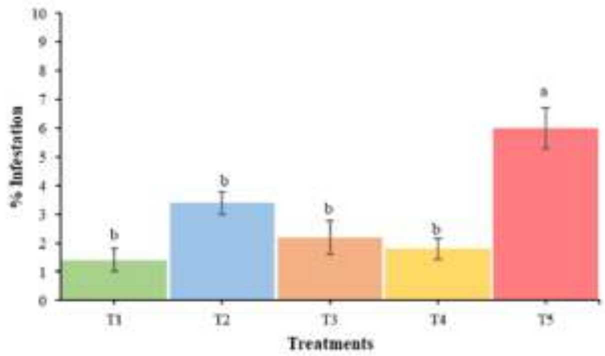

Fig 3. Percentages of infestation detected by the radiographic images at the sampling times. The different letters above the columns for each treatment indicate significant differences according to Tukey's test (p <0.05). The bars represent the standard error. Treatments evaluated at 5 (T1), 10 (T2), 20 (T3), 30 (T4) and 40 (T5) days after infestation of rice seeds by *Sitophilus oryzae.*
Source: Authors' determination.

The percentages of larvae, adults and empty seeds detected by X-ray images and confirmed by the infested seeds test were significantly greater in treatment T5, which corresponded to the longer exposure time to infestation with *S. oryzae* (Table 1).

The traditional analysis of infested seeds has been shown to be susceptible to human error, high subjectivity and slowness when evaluating large amounts of seeds and even more when they are smaller [36].

This justifies the importance of using more precise tools and techniques, such as X-ray analysis, for the detection of insect pests inside seeds. As insects are detected at more advanced stages of development, a greater amount of affected tissue is observed [26], [27], [5]. Thus, image analysis tools could assist in the detection and quantification of the effects of seed storage pests, and thus establish models that aid in the quality control of seed batches [34], [22].

This analytical technique has demonstrated potential in determining the percentage of infestation, as well as advances in the evaluation of the sanitary quality of seeds, aiming to safeguard the quality of seed lots.

Table 1. Differences in the mean percentage ± SE in the detection of developmental stages and the identification of damaged of *Sitophilus oryzae* in rice seeds.

Treatment	Developmental stages			Damage seeds	
	% egg	% Larva	% Adult*	% Damage	% Empty
T1	1.0±0.32a	0.0±0.0b	0.0±0.00b	0.4±0.25a	0.0±0.00b
T2	1.6±0.24a	0.4±0.25b	0.0±0.00b	1.4±0.60a	0.0±0.00b
T3	0.8±0.20a	0.0±0.0b	0.0±0.00b	1.4±0.60a	0.0±0.00b
T4	1.0±0.32a	0.4±0.25b	0.0±0.00b	0.4±0.25a	0.0±0.00b
T5	0.8±0.20a	2.0±0.54a	1.4±0.60a	0.8±0.20a	1.0±0.32a

Note: Means in the column followed by the same letter are not significantly different (p >0.05) according to the Kruskal–Wallis test. Treatments evaluated at 5 (T1), 10 (T2), 20 (T3), 30 (T4) and 40 (T5) days after seed infestation by the rice weevil. *Preemerged adult. SE: Standard error.
Source: Authors' determination.

This approach can also reduce the time required to obtain results, allowing the detection of insects in a few seconds or minutes [23], [28], in addition to being repeatable, reliable and easy to perform results, compared to traditional infested seed tests, in which it is necessary to soak the seeds for 24 hours before being segmented and to perform visual confirmation of the presence or absence of insect pests [4].

CONCLUSIONS

The use of X-ray analysis allows for the characterization and identification of *S. oryzae* at the egg, larval and adult stages in rice seeds. The damage caused by the larvae and adults of *S. oryzae* in rice seeds is characterized by the formation of tunnels and consumption of the endosperm and embryo. The empty rice seeds and endosperm traces observed via X-ray analysis are the result of the completion of the weevil development cycle, which culminates with the exit of the adult insect from the seed.

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STUDY ON THE EVALUATION AND CHARACTERIZATION OF THE POTENTIAL AND ACTIVITY OF RURAL TOURISM AND AGRITOURISM IN ALBA COUNTY, ROMANIA, IN THE PERIOD 2018-2023

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Abstract

The study aims to evaluate and characterize the tourism activity in Alba County as a whole, from the point of view of potential and resources, but the main direction targeted is focused especially on the rural tourism and agritourism activity practiced in principle in tourist and Agritourist guesthouses, but also in other types of structures that have not been exploited to their maximum potential, both at national and local level. In order to bring this aspect to attention, structures such as Inns, Tourist villas, Tourist chalets, Holiday villages, Tourist cottages were also taken into study, structures that we discovered during a preparatory study in France, as being widely used in the development and promotion of rural tourism in general. The research methodology was a classic one, but in which a series of new aspects were also addressed, which aimed at the need to diversify the types of structures used in rural tourism, leading to a diversification of the original and personalized tourist offer, both at the level of Alba County and at the national level. The conclusions highlighted the fact that at the county level, rural tourism activity, but especially agritourism activity in which farmers also practice a primary activity, through which they provide tourists with traditional local products with a very good taste, "the taste of grandparents", is well developed, but insufficiently promoted and exploited to its true potential.

Key words**:** *agritourism, tourist attractions, original tourist offer, tourist potential, rural space*

INTRODUCTION

The scope of agritourism is very wide, being a real, specifically human activity, in a process of continuous development. The main factor determining the continuous growth of the interest of citizens in agritourism is: "where does food come from and how is it produced" [17, 23]. Agritourism is an activity that includes a vast area of knowledge with the possibility of development in almost all rural areas of our country [3, 16, 37]. The economic importance of agritourism is crucial, in the context of income generated from plant and animal production. Most farmers obtain insufficient income to meet their own material needs [8, 10, 15].

Additional income from non-agricultural sources is imperative for the continuity, development and especially to avoid the abandonment of farms. Economic and social policies in European countries aim to maintain the population in rural areas and stop the exodus to cities [2, 9, 20]. Rural space plays an important role in the practice of rural tourism and agritourism and represents a complex concept, which arouses great interest from the scientific community and international organizations. In defining the area of interest and treating the main components, there are a multitude of approaches, using different criteria (statistical, administrative, functional, legislative, etc.) [1, 13, 22].

Therefore, rural space presents certain particularities from which the following stand out: pluriactivity (simultaneous development of agricultural and non-agricultural activities); attractiveness (landscape beauty, natural and cultural heritage unaltered by the passage of time, more humanized social environment, etc.) specificity (typical atmosphere of country life, local culture, traditional spirituality elements - traditions, customs, etc.) [28, 36]. The term rural derives from the Latin word "ruris", which means country, village, territory occupied, inhabited, arranged and worked by man. The characteristics of rural space vary greatly depending on the country or region. From a geographical, demographic and economic perspective, rural areas do not constitute a homogeneous whole, but they are not abstract spaces either. Major discrepancies arise when we compare rural areas in economically highly developed countries with those in countries under the former communist bloc or even less economically developed countries. The comparison does not make sense either in terms of the socio-economic characteristics of the population or when we refer to the coordinates of the geographical environment [33, 34].

The criteria applied in the hierarchy of localities and areas as rural or urban present major differences. For example, the criteria used in the classification of rural settlements at European level are differentiated in accordance with national specificities. Each country has a certain degree of autonomy in the administration of its own territory, distinct standards and levels that determine a different typology from one country to another. The level of development of rural settlements in the European space is measured by the existence of a modern rural territorial infrastructure – branched and modernized road network, new residential spaces, housing with a high degree of comfort, technical equipment of households, the infrastructure necessary for the production and use of energy from renewable sources, water and natural gas supply networks, sewage and thermal energy installations, etc. [35, 41].

Romania as an EU member state should align itself with this level of development and organization of rural space. The policy favoring urban administrative-territorial units during the communist period determined the maintenance of a significant gap between the village and the city. In recent decades, the Romanian countryside, from an economic, social and demographic point of view, has developed at a different pace, determining distinct forms of rural life. The Romanian village presents a pronounced heterogeneity, while some rural settlements have developed economically, many other communes seem not to have overcome the stage of underdevelopment inherited from communism. The low level of development of these localities is determined mainly by the precarious level of local infrastructure and the lack of attractiveness for investments [11, 30, 32].

From the studies and research carried out by most researchers in the field of agritourism and by us, research previously published in various journals in our country and abroad, it is very clear that agritourism can play an essential role in the development and emancipation of rural areas in our country and can ultimately lead to the reduction or total elimination of the glaring gap that has existed until now, between rural and urban areas in Romania [5, 36, 40].

MATERIALS AND METHODS

Starting from this goal aimed at developing rural areas in our country, the authors oriented the research method towards highlighting and quantifying the agritourism potential of Alba County, a county in which this activity has developed greatly in the last 30 years after the Revolution. The choice of this county was also due to the fact that the area is known to us, being also the birthplace of the authors. The area has been traversed by us over time, making contact with the local people and with all the resources available to this wonderful area.

Based on the studies carried out on the ground and the data from the various published monographs and articles, a thorough and detailed analysis of the rich natural and anthropogenic tourist resources available to the region was carried out and an attempt was made to create a clear and realistic image of the level of development of agritourism activity in this area. At the same time, based on data and indicators regarding tourism activity in general, data collected from the field and from the National Institute of Statistics (NIS), the level of development of this activity was analyzed, but especially the level of development of agritourism activity, this being the main objective of our research [6, 7, 18].

The agritourism potential of the studied area was emphasized because it was considered from the beginning that this activity is a viable, efficient, fast and safe solution to put into practice, especially in this area, which would lead to the emancipation and elimination of the economic, social and cultural gap between rural and urban areas in the county. In the research methodology, we focused on the tourist structures specific to rural tourism and agritourism activity, such as Tourist Pensions and Agritourist Pensions, but also on other structures that are widely used in European countries in practicing such an activity, such as: Inns, Tourist Villas, Tourist Cabins, Holiday Villages and Tourist Cottages.

We also presented the level of development of these forms of tourism, in such structures, because we tried to highlight the fact that, compared to countries in Europe or other countries around the world, the level of use and promotion of these structures in our country is much lower, although their potential may be relevant in increasing the total accommodation capacity in certain areas [24, 21, 19].

RESULTS AND DISCUSSIONS

Alba County is located in the central-western part of the country, in the historical province of Transylvania, with the capital in the municipality of Alba Iulia. It is part of the Centru development region and consists of 4 municipalities (Alba Iulia, Aiud, Blaj, Sebeș), 7 cities (Abrud, Baia de Arieș, Cugir, Câmpeni, Ocna Mureș, Teiuș, Zlatna), 67 communes and 656 villages. In terms of accessibility, this is easy, being ensured by a network of communication routes, roads, which ensure the connection between localities such as, A 1, A 10 and A 3, national roads DN 75, DN 14 B, DN 1, DN 74, DN 7, DN 67 C, 59 county roads (DJ) with a length of 1,086.262 km and 197 communal roads, with a total length of 1,130.290 km [12].

Also, a railway network has been developed that runs mainly in the lowland and plateau areas, crossing the county from one end to the other and ensuring the connection with the main railway nodes in Transylvania. In the area of the Apuseni Mountains and the Şureanu Mountains this is not present, access to the area can be achieved exclusively on road routes.

There are no airports or airfields located in Alba County, but it has easy connections with several international airports in neighbouring counties: Sibiu International Airport, Avram Iancu in Cluj, Transylvania Târgu Mureș and Oradea [12].

Analysis of the natural and anthropogenic tourism potential of Alba County

Relief. Predominantly mountainous, mountains occupy 52% of the surface, hilly and plateau areas 26%, and plain areas including river meadows 22%. The mountainous area is made up of the Apuseni Mountains, located in the north-west, comprising the Bihor Mountains (see Curcubăta 1,849 m) with the Găina massif (1,486 m), Muntele Mare, the Metaliferi Mountains, the Trascău Mountains and the Muncei Vintului. The Southern Carpathians in the south, represented by the Şureanului (Sebeş) Mountains with the Pătru Peak 2,130 m and partly the Cindrelului Mountains. The area of hills and plateaus is made up of the piedmont hills of Sebeș, those of Trascău and the Transylvanian Plateau, the area of depressions is made up of depressions located in the valleys of: Abrud, Cîmpeni, Lupșa, Mogoş, Ponor, Sălciua, Trascău, Almașului, Zlatna, Ampoi – Ampoița, and the corridor unit is made up of the Mureș corridor that separates the Apuseni Mountains from the Transylvanian Plateau and the Orăștie corridor that stretches between the Apuseni Mountains and the Southern Carpathians [12, 31].

Climste is temperate - continental with slight shades of excess in the lower areas but moderate and more humid in the mountainous area. Due to its position, Alba County is in an area where the influence of the western circulation is felt, over which the influences of the south - west and north - north - east circulation are also superimposed. It is found that during the year the highest temperature is recorded in July (20.6 degrees Celsius) on average, and the lowest in January (-2.7 degrees Celsius) on average, the multiannual temperature reaches about 9 degrees Celsius. The amounts of precipitation fallen during the year reach an annual average of 600 mm. When precipitation falls below 450 mm, the years are dry, but during the year rainy years have also been recorded, with high precipitation of 650 mm. Usually, in June the confluence of Atlantic air intensifies and torrential rains bring large amounts of water. In contrast, during spring and autumn, there is a low intensity and long duration of liquid precipitation. In winter, solid precipitation in the form of snow reaches an average thickness and persists for 60 days.

Hydrography. It belongs entirely to the Mureș River basin, a river that enters the county upstream of the confluence with the Arieș (270 m) and exits downstream of the confluence of the Băcăinți Valley (202 m). The most important tributaries are the Arieș, Aiudu, Geogiu, Galda and Ampoi on the right and the Târnava, Sebeș, Pian and Cugir on the left. The lakes constitute part of the water reserve cantoned in the natural lakes Iezerul Șureanu, Iezerașul Cârpa and Iezerul Ighiel but also in the anthropogenic ones in the surroundings of Roșia Montana or in those in the Sebeș Valley [12, 21].

Vegetation. Beech and coniferous forests still cover large parts of the Metalic Mountains, Trascău and Sebeș. In the region of gold mining (Roșia, Abrud, Zlatna, etc.) they have long been cut down. The same fate befell the oak forests on the plateau and in the Mureș plain. In the northern part of the county, the steppe has penetrated the forest domain. In Alba County there is only one natural park, namely the Apuseni Natural Park, which is characterized by a special beauty given by the karst landscape. The caves, sinkholes, ravines, dry valleys, gorges, waterfalls, karst plateaus and the spring, offer a unique landscape variety in which a rich fauna and flora develop. Natura 2000 sites cover 26.13% of the area of Alba County and were created for the protection of extremely valuable species and habitats, namely: - 178 species of flora and fauna of community interest (including: 14 species of flora, 13 species of fish, 4 species of amphibians, 2 species of reptiles, 103 species of birds, 15 species of mammals and 27 species of invertebrates); - 47 types of habitats of community interest [12, 38].

Flora and fauna. Among the most important flora species encountered are the spruce, fir, beech, mountain ash, birch, acacia, blueberry, juniper, raspberry, rosehip, etc., and among the fauna species encountered, there are: wolf, otter, bear, lynx, brown toad, yellow-bellied pond otter, newt, lizard, lizard, adder, viper, woodpeckers, jay, cuckoo, mountain grouse, raven, great horned owl, otter, Carpathian deer, lynx, brown bear, etc. Alba County is one of the counties that presents a great faunal and floristic diversity in Romania. Over 25% of the county's territory has the status of a protected natural area. At county level, there are 245 protected natural areas, of which: 83 natural reserves of national interest; 1 natural park; 25 Natura 2000 Sites (20 sites of community importance and 5 special avifaunistic protection areas); 10 nature reserves of county interest; 126 natural monuments of county interest. As can be seen from the above, the county has an extremely rich nature, which generates a very high and diversified natural tourist potential.

The mountainous relief is predominant and reaches heights greater than 2,000 meters, in the south of the county and over 1,800 meters in the northwest. The southern area of Alba County has experienced significant tourist development, the Șureanu Mountains with the existing ski area, have become a tourist destination for practicing winter sports, preferred by many tourists. Due to this and the fact that the county is crossed by the Transalpina high road, the flow of tourists has increased significantly, especially in the summer season [12, 25, 21].

Regarding the anthropic tourist potential, we can say that it has been significantly influenced by the historical evolution of this area, which has been extremely tested over time. Some of the most important events in Romanian history took place here, the best known being the Union in the year 1600 under Michael the Brave, the Union on December 1, 1918 and the Coronation of the Kings of Great Romania on October 15, 1922, in Alba Iulia. But the story of these places has been fascinating since prehistoric times, with numerous fortresses found on the territory of Alba County, such as those at Cugir, Cetatea de Baltă, Piatra Craivii and Căpâlna, the latter included on the UNESCO World Cultural Heritage List. Numerous silver and bronze objects have been preserved from the Dacians, true treasures, discovered at Lupu (Cergău commune), Saracsau (Șibot commune), Săliștea and Inuri, demonstrating a true mastery in metalworking [12, 21].

The colonization of Saxons in Transylvania began in the 11th century, with their first communities being established in Cricău and Ighiu, from which they inherited religious and civil buildings such as: the Roman Catholic Cathedral of Alba Iulia, the Aiud Fortress, the Evangelical Church of Sebeș, the Fortified Church of Câlnic, and this one included on the UNESCO World Cultural Heritage List. The beginning of pre-modernity coincides with the first major event in the history of the unification of the Romanians, namely the unification of Wallachia with Transylvania and Moldavia carried out by Michael the Brave in 1600, the capital of the new state being Alba Iulia.

The administrative role, as the capital of the Principality of Transylvania, was obtained after the abolition of Hungary, following the Battle of Mohacs (1526), as a result of which the Principality of Transylvania was established as an independent state formation and which was later called the Grand Principality of Transylvania.

True emancipation took place in the 18th century through the Transylvanian School in Blaj, whose precursor was the visionary Bishop Inocențiu Micu Klein. During this period, Blaj assumed a very important role in the national struggle; in 1848, one of the most important moments of the Revolution of 1848 took place on the Freedom Plain, where the National Program of the Romanian Revolution in Transylvania was drafted. One of the prominent leaders of the time was Avram Iancu, a symbol of Rumanians [12, 29, 21].

As is well known, the most important event that took place in the lands of Alba was the Union of December 1, 1918, when delegates gathered in Alba Iulia, in the current Union Hall, decided to unite Transylvania with Romania, this event also giving rise to the National Day of Romania. The event was immortalized by the young Samoilă Mârza from Galtiu, the only one who took photos on that historic day. Later, on October 15, 1922, it hosted the Coronation of Kings Ferdinand and Maria as Kings of Greater Romania.

From the studies carried out, it was found that the territory of Alba County includes 686 historical monuments listed in the List of Historical Monuments LMI 2015, of which monuments of national interest - category A - 187; UNESCO monuments - 3 - Câlnic Fortress, Dacian Fortress from Căpâlna and the Roșia Montana Site. The area also has a rich archaeological heritage: Dacian Fortress from Căpâlna; Dacian Fortress from Cetatea de Balta; Dacian Fortress from Craiva (Apoulon or Ranistorum); Ancient cities from Apulum: Colonia Aurelia Apulensis and Colonia Nova Apulensis; The XIII Legion's Camp Gemina from Alba Iulia [12, 26, 21]. Also, on the territory of the county there are ethnographic areas with specific architectural and identity features, including: Saxon Villages, Târnave Valley, Trascău Valley, Sebeș Valley, Golden Land, Arieș Valley, Trascău Peak, Moților Country, Stone Villages. A specificity of the county is the diversity of religious cults, the Orthodox, Catholic, Evangelical, Reformed and Jewish communities have built extensive architectural monuments that enrich the cultural heritage, these being made up of churches and monastery complexes, private property of religious cults - the Romanian Orthodox Archdiocese of Alba Iulia; the Roman Catholic Episcopate; the Roman Catholic Archdiocese; the Franciscan Church, etc. [12, 21, 39].

On its territory are also present the Saxon settlements with fortified churches in Transylvania, included in the UNESCO heritage since 1993, such as: Biertan, Calnic, Darjiu, Prejmer, Saschiz, Valea Viilor and Viscri. Also present are architectural ensembles with cultural heritage value such as: The birthplace of the poet Lucian Blaga, the interesting civil architecture reserves in Alba Iulia, Sebeș, Aiud, Blaj, Abrud as well as the rural sites in Câlnic, Rimetea and Roșia Montana, where we find street fronts and spatial organizations around central squares. A central place in an itinerary of fortresses is occupied by the Alba Carolina Fortress, the largest bastion fortress in Romania, in which it preserves the two symbols of ecclesiastical architecture: the Roman Catholic Cathedral of Saint Michael and the Orthodox Coronation Cathedral.

Famous crafts have developed throughout the territory of this county, such as: that of the Romanian church painters, names like Simion Silaghi, Simion Belgrădeanul, Savu, Simion and Toma have changed the face of religious art, through the murals of the wooden and brick Orthodox churches in Apuseni. Icon craftsmen, through the glass icons of the Poienari family from the village of Laz, famous throughout the world for the craft of painting on glass, according to the oldest canons. Wood crafts emerged and diversified over time, as the technical means for processing various wood essences were perfected, numerous villages in the hilly and mountainous areas specialized in wood processing, Tara Moților is the most famous area in terms of wood processing, through the making of conifer wood vessels. Some specialized in carpentry and wood carving for construction, especially shingles, others as traveling coopers, who made vessels from the clients' material [12, 29, 21]. In recognition of the value of the various iconic craftsmen, potters, furriers, folk craftsmen, rhapsodes, etc., people who capitalized on Romanian traditions and crafts and passed them on unaltered by modernity, 11 Romanians from the county received the title of "Living Human Treasure of Alba County". The first Romanian declared a "Living Human Treasure", in 2010, was the folk artist Maria Deac Poenaru, recognized as the last representative of the iconic painters from Laz. Following her: Eugen Gavrilă from Pianu (woodworking); Constantin Petra from Ceru Băcăinți (woodworking); Ana Neamțu from Cut (horitor, spirituality – singer – vocal music); Olivia Tima from Sălciua (weaver); Nicolae Muntean from Vinerea (icon painter); Nicolae Coroiu from Avram Iancu (instructor and folk craftsman – titre); Nicodim Gligor from Vidra (traditional woodworking); Mariana Gligor from Vidra (creator of folk costumes and performer of the tulnic); Maria Dulău from Biia (spirituality – singer – traditional vocal music); Florin Nicolae Poenari from Laz (icon artist/carpenter) [12, 29, 21].

Traditions and customs represent a valuable cultural heritage, due to the original architecture of the houses from Arieșeni, Gârda, Vidra, Avram Iancu, Albac, Mogoș, Ponor, Râmeț, Rimetea, Săsciori, Șugag, etc. The Moților Land is a center of folk art and customs, with the following localities being distinguished: Avram Iancu - traditional hearth of the tulnic used by women; Bucium - the richest and most interesting Romanian folk costume in this part of the country; Căpâlna - customs related to the existence of shepherds; Laz - folk art school: weaving, sewing, painting on glass; Săsciori - glazed and unglazed red ceramics; Șugag - folk art school: wood carving; Vidra - typical Moț settlement, with tulnicari and ciubăraș craftsmen. A good part of the customs and habits of the elders are still preserved today in localities in the county, these are closely linked to certain religious holidays and ancestral rituals, being true performances of music, dance, traditional costume, local cuisine, artistic skill, creativity and play. Among these, the most special artistic manifestations are: "Butea" from the Secașelor area, "Călușul" or "Călușorul", "Înmormântarea Fărșangului" or "Purtata Fetelor de la Căpâlna" and others. Folklore lovers will feel at ease at the annually organized celebrations, which have become traditions, in which soloists and folk craftsmen from all over the country take part [12, 29, 21].

As for the tourism activity in general and agritourism, this has continuously developed and diversified on the territory of Alba

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County, the most practiced forms of tourism are mountain tourism, rural tourism and agritourism, cultural tourism and that generated by the existence on the territory of the county of several elements included in the UNESCO world heritage. Rural tourism and agritourism have recorded a spectacular dynamic especially in recent decades, the number of tourist guesthouses in the rural area being almost 300 units, offering over 5,000 accommodation places. This form of tourism attracts especially foreign tourists interested in Romanian culture, customs and traditions, and local gastronomy, being a direct means of getting to know the authentic traditional civilization. Agritourism is one of the forms of tourism best represented in the Apuseni Mountains through the area of the upper Arieș (Albac, Garda de Sus, Arieșeni, Avram Iancu, Vidra) and through the commune of Rimetea in the Trascău Mountains [12, 29, 21].

In order to best highlight, revitalize and promote the county's tourism offer, during 2020 the Alba County Council created four cultural-tourist routes for which it received the certification of "regionally developed cultural-tourist routes" from the Ministry of Economy, Energy and Business Environment, as follows:

- The Apuseni Transcultural Route is located in the northwestern part of Alba County and follows the route of two county roads through the localities of Rimetea, Aiud, Râmeț, Mogoș, Bucium and Abrud.
- The Icon Road Route crosses the central area of Alba County through the localities of Alba Iulia, Teiuș, Stremț, Geoagiu de Sus and Valea Mânăstirii.
- The National Unity Route 1848-1918-1922 passes through the localities of Blaj, Sântimbru, Alba Iulia, Zlatna, Abrud, Câmpeni and Avram Iancu.
- The Via Auraea route targets the gold quadrilateral of the Ore Mountains, delimited in Alba County by the area of Zlatna and Roșia Montana with the adjacent areas of Almașul Mare, Bucium and Baia de Arieș, areas very rich in precious metal [12, 29, 21].

Table 1. Evolution of the number of tourist reception structures with tourist accommodation functions, by type of structure in Romania, Alba County

Types of structures of tourist reception	Total	Years						
		1990	2018	2019	2020	2021	2022	2023
TOTAL	Romania	3,213	8,453	8,402	8,610	11,736	12,201	12,697
	Alba	38	204	196	227	305	333	357
Inns	Romania	:	4	3	3	3	4	5
Tourist villas	Romania	1551	695	709	752	752	758	756
	Alba	:	12	10	29	23	22	20
Tourist chalets	Romania	226	231	222	226	222	220	223
	Alba	6	6	7	6	4	6	5
Holiday villages	Romania	:	10	9	8	8	8	10
Tourist cottages	Romania	:	73	82	92	112	127	155
	Alba	:	:	1	1	1	2	4
Tourist guesthouses	Romania	:	1,709	1,669	1,729	1,745	1,696	1,642
	Alba	:	29	30	27	29	30	28
Agritourist guesthouses	Romania	:	2,821	2,800	3,022	3,460	3,484	3,498
	Alba	:	119	113	126	131	132	139

Source: processing based on own data and from NIS [27].

Also, in order to be able to highlight and highlight the tourist activity in Alba County, several indicators were studied in the period 2019-2023 on the basis of which to characterize the tourist activity and to assess its quality level as accurately as possible. In our analysis, we focused in particular on the activity of tourist reception structures specific to rural tourism and agritourism activities, because the present study wanted to be one focused especially on these forms of tourism, which have developed, as we have shown above, at a faster pace, in recent decades, in this county [12, 29, 21].

A very important indicator regarding the evolution of tourism activity in general in the county under study is the dynamics of the number of tourist reception structures, presented in Table 1.

Table 2. Dynamics of tourist accommodation capacity expressed in existing places by type of tourist reception structures, Romania/Alba

Types of structures of tourist reception	Total	Years						
		1990	2018	2019	2020	2021	2022	2023
TOTAL	Romania	353,236	353,835	356,562	358,119	410,291	422,114	433,487
	Alba	3,419	5,278	5,218	5,688	7,273	7,798	7,864
Inns	Romania	:	101	80	80	80	90	120
Tourist villas	Romania	46,757	16,555	16,665	17,124	17,325	17,457	17,450
	Alba	:	346	296	517	467	450	396
Tourist chalets	Romania	12,430	6,384	6,216	6,331	6,356	6,256	6,067
	Alba	250	140	149	129	93	143	113
Holiday villages	Romania	:	493	477	375	375	456	688
Tourist cottages	Romania	:	2,782	2,503	2,662	3,122	3,518	4,012
	Alba	:	:	24	12	12	36	42
Tourist guesthouses	Romania	:	35,823	35,198	35,312	35,387	34,587	33,930
	Alba	:	608	651	599	641	652	655
Agritourist guesthouses	Romania	:	48,574	49,053	52,389	55,778	56,850	58,086
	Alba	:	2,157	2,140	2,383	2,459	2,505	2,596

Source: processing based on own data and from NIS [27].

Analyzing the data from Table 1, it can be seen that in the reference year 1990 the situation of tourist reception structures intended especially for rural tourism and agritourism activities was not very poor, because in this year there were no tourist reception structures in the county, with a specific rural tourism or agritourism activity. Subsequently, in the study years 2018 -2023, it is found that the rural tourism and agritourism activity has developed considerably, this being practiced in almost all types of structures analyzed, with such a specificity. A significant element in this analysis is the appearance after 1990 of tourism structures very representative of rural tourism activity, such as tourist and Agritourist guesthouses, the number of which has continuously increased, reaching 30 tourist guesthouses in 2022 and 139 Agritourist guesthouses in 2023, these being the maximum values reached in the analyzed period.

From Table 2, it can be seen that the dynamics of accommodation places at the total level of tourist reception structures in Alba County followed the same growth trend as that at the Romanian level, reaching the level of 2023, at the maximum value of 7,864 accommodation places, a year in which the value at the national level was also the highest at 433,487 accommodation places. Also, from this table it can be seen a difference between the evolution of the dynamics of accommodation places at the national level, compared to that at the Alba County level, in terms of the number of accommodation places in structures specific to rural tourism in general. Thus, the number of accommodation places in rural tourist guesthouses has continuously increased, albeit at a slow pace, reaching 655 in 2023, and that in Agritourist guesthouses 2,596 places. This fact demonstrates the maximum attention given by local authorities and local people to the more sustained development of this specific form of sustainable tourism, which lends itself very well to the specifics of the area.

Regarding this indicator listed in table 3, it can be seen that at the level of Alba County, the total accommodation capacity in operation has increased very significantly, being almost five times higher in 2023, reaching 2,503,909, compared to the reference year 2001, when it was only 505,096. Also from this table, it can be seen that for this indicator, the tourist reception structures specific to the rural area, tourist and Agritourist guesthouses, have achieved a significant increase, in terms of the number of accommodation places-days in tourist guesthouses, in which it increased 13.5 times compared to the reference year 2001, reaching 216,571 in 2023. Another gratifying thing is the fact that the number of accommodation places-days has also increased in Agritourist guesthouses, by over 34 times, compared to the same reference year 2001. This phenomenon manifests itself with the increase in accommodation capacity expressed in accommodation places, which has increased continuously, reaching the maximum value for these types of guesthouses in 2023. This evolution can only be explained by the increasing interest of guesthouse owners in increasing the quality of services offered to tourists, by increasing accommodation areas and adapting the number of tourists in the guesthouse, so that they can be given more attention, in accordance with the new guesthouse classification criteria.

Table 3. Tourist accommodation capacity in function by types of tourist reception structures in places - days, in Romania, Alba County

Types of structures of tourist reception	**Total**	**Years**						
		2001	2018	2019	2020	2021	2022	2023
TOTAL	Romania	51,882,465	89,075,891	88,789,656	64,040,595	87,217,823	93,007,230	98,293,110
	Alba	505,096	1,575,437	1,566,155	1,064,249	1,711,700	2,182,758	2,503,909
Inns	Romania	70,864	36,173	28,580	22,237	24,890	27,268	37,240
Tourist villas	Romania	2,488,256	3,738,166	3,753,539	2,780,569	3,485,815	3,590,100	3,588,609
	Alba	3,836	105,383	106,398	93,873	120,992	128,006	129,081
Tourist chalets	Romania	1,880,532	1,508,188	1,494,759	995,642	1,371,743	1,378,194	1,361,159
	Alba	20,636	38,679	43,679	23,971	31,237	27,618	45,341
Holiday villages	Romania	13,140	109,663	114,390	66,680	93,224	112,698	182,007
	Alba	:	:	:	:	:	3780	:
Tourist cottages	Romania	311,211	230,040	230,114	225,344	299,693	334,975	475,147
	Alba	:	:	2,952	:	6,876	11,280	13,590
Tourist guesthouses	Romania	1,026,975	10,644,927	10,454,735	7,290,415	8,784,339	8,804,999	8,862,371
	Alba	16,028	193,297	199,171	135,926	166,581	190,383	216,571
Agritourist guesthouses	Romania	1,105,724	12,498,050	12,615,982	9,195,563	12,228,257	13,269,082	13,973,610
	Alba	23,198	582,685	605,567	422,227	588,956	687,299	795,139

Source: processing based on own data and from NIS [27].

Table 4. Dynamics of tourist arrivals in tourist reception structures by type of structure and number of people in Romania, and Alba County

Types of structures of tourist reception	Total	Years						
		2001	2018	2019	2020	2021	2022	2023
TOTAL	Romania	4,874,777	12,905,131	13,374,943	6,398,642	10,205,322	12,588,333	13,910,956
	Alba	59,901	194,818	201,840	119,741	184,719	231,640	252,738
Inns	Romania	3,670	2,630	2,911	759	697	1,345	1,820
Tourist villas	Romania	174,956	440,497	463,600	267,338	382,473	420,838	437,492
	Alba	34	11,638	13,639	10,898	12,371	13,418	10,633
Tourist chalets	Romania	104,049	144,182	153,374	95,370	130,051	131,805	137,390
	Alba	554	1,997	2,219	1,314	1,195	1,417	1,195
Holiday villages	Romania	1,862	4,841	6,341	2,987	5,986	8,420	38,944
	Alba	:	:	:	:	:	70	:
Tourist cottages	Romania	18,358	16,350	20,556	20,086	27,673	31,348	48,795
	Alba	:	:	178	:	666	1,836	1,247
Tourist guesthouses	Romania	106,129	1,234,295	1,254,476	654,397	893,859	977,694	1,037,475
	Alba	3,209	33,486	34,700	19,320	25,648	31,572	35,329
Agritourist guesthouses	Romania	41,658	1,173,455	1,272,878	755,436	1,087,327	1,181,699	1,306,683
	Alba	1,151	50,901	57,334	42,408	54,561	55,475	65,937

Source: processing based on own data and from NIS [27].

The dynamics of tourist arrivals in the different types of tourist reception structures, as can be seen from Table 4, was characterized by a continuous increase from year to year, both at the level of our country and at the level of Alba County. At the national level, the data presented shows that it increased three times more than the reference year 2001, reaching 13,910,956 arrivals in 2023. At the level of Alba County, this increase was much more significant, because the value of the number of tourists arriving in

2023 is almost five times higher than that of the same reference year 2001, which was 252,738. This growth trend is much more significant in the case of tourist reception structures specialized in rural tourism and agritourism, thus, the number of tourists registered in 2001 in tourist guesthouses was approximately 11 times lower than that of those arriving in 2023. In the case of Agritourist guesthouses in Alba County, this was much more relevant, because the growth rate of the number of tourists arriving in these types of structures was over 60 times higher than that of the same reference year 2001, the value of this indicator being in 2023, 65,937.

Table 5. Dynamics of overnight stays of tourists in tourist reception structures by type of structures and number, in Romania, Alba County

Types of structures of tourist reception	Total	Years						
		2001	2018	2019	2020	2021	2022	2023
TOTAL	Romania	18,121,688	28,644,742	30,086,091	14,579,140	22,747,562	27,044,372	29,691,592
	Alba	95,706	364,474	370,750	219,746	336,089	429,477	464,850
Inns	Romania	6,142	4,027	3,622	1,415	1,651	2,288	2,432
Tourist villas	Romania	792,519	970,413	1,039,641	593,440	865,471	885,701	949,886
	Alba	89	24,502	26,029	20,186	26,495	26,912	20,613
Tourist chalets	Romania	211,024	253,086	266,010	161,230	214,004	218,605	240,108
	Alba	601	4,311	5,061	3,281	2,657	3,241	2,743
Holiday villages	Romania	4,863	13,981	16,318	7,225	14,432	19,847	71,657
	Alba	:	:	:	:	:	210	:
Tourist cottages	Romania	68,994	39,646	44,298	49,824	60,127	64,706	93,546
	Alba	:	:	699	:	1,484	4,219	2,827
Tourist guesthouses	Romania	187,533	2,229,463	2,324,217	1,201,697	1,605,766	1,754,388	1,837,049
	Alba	3,992	47,421	50,907	31,277	39,727	49,690	54,552
Agritourist guesthouses	Romania	88,349	2,255,286	2,518,605	1,515,305	2,089,781	2,265,633	2,529,052
	Alba	3,369	109,678	126,909	92,991	113,086	124,083	144,009

Source: processing based on own data and from NIS [27].

Following the data recorded in Table 5, it can be easily observed that this indicator followed approximately the same trend as that of the number of tourists arriving in the different types of structures, both at the national level and at the Alba County level. The increase in the number of overnight stays was due in the case of tourist guesthouses at the national level and at the Alba level, as a result of the increase in the average length of stay from 1.1 nights in 2001, to over 1.5, in 2023. On the other hand, in the case of Agritourist guesthouses, the average length of stay decreased from 2.9 nights in 2001, to 2.2 nights in 2023. The increase in this indicator overall, at the level of Agritourist guesthouses was largely due to the increase in accommodation capacities in recent years at the county level.

The net utilization index of the tourist accommodation capacity in operation, in percentage, is a very important indicator in assessing the quality of tourist services and management in the various tourist reception structures, both in Romania and in Alba County.

Table 6. Dynamics of the net utilization index of tourist accommodation capacity in operation in %, since August, by types of tourists reception structures, in Romania, Alba County

Types of structures of tourist reception	Total	Years					
		2018	**2019**	**2020**	**2021**	**2022**	**2023**
TOTAL	Romania	51.5	52.1	39.1	48.5	45.1	45.7
	Alba	37.6	43.3	41.4	37.4	34.1	35.1
Inns	Romania	21.4	11.9	7.8	3.7	6.4	8.4
Tourist villas	Romania	48.3	49.6	37.6	49	43	43.1
	Alba	37.5	46.7	43.6	46.1	34.1	31.8
Tourist chalets	Romania	32.5	29.7	29	27.4	29.2	28.8
	Alba	27.7	22.4	23.4	21.3	32.9	9.9
Holiday villages	Romania	40.2	31	15.7	36.7	34.8	62.2
Tourist cottages	Romania	28.1	36	39.2	35.8	28.2	30.2
	Alba	:	28.9	:	93.3	70.2	58.5
Tourist guesthouses	Romania	33.4	35	28.1	33.3	31.5	32.2
	Alba	39.3	41.2	41.6	42.3	40.3	40
Agritourist guesthouses	Romania	32.4	34.7	31.8	32.4	30.5	31.5
	Alba	36.1	39.9	44	37.3	35.2	37.9

Source: processing based on own data and from NIS [27].

As can be seen from Tables 6 and 7, it was taken into study the net utilization index of tourist accommodation capacity in operation, in order to have a greater relevance in terms of the seasonality aspect of tourism activity, both at the national level and at the Alba County level. From the data presented in the two tables, it is very clear that at the national level there is a significant difference of over 16-19%, between the occupancy index in August and the annual one, over the entire analysis period 2018-2023.

Table 7. Dynamics of the net utilization index of tourist accommodation capacity in operation in %, by years and types of tourist reception structures, in Romania

Types of structures of tourist reception	Total	Years					
		2018	2019	2020	2021	2022	2023
TOTAL	Romania	32.2	33.9	22.8	26.1	29.1	30.2
Inns	Romania	11.1	12.7	6.4	6.6	8.4	6.5
Tourist villas	Romania	26	27.7	21.3	24.8	24.7	26.5
Tourist chalets	Romania	16.8	17.8	16.2	15.6	15.9	17.6
Holiday villages	Romania	12.7	14.3	10.8	15.5	17.6	39.4
Tourist cottages	Romania	17.2	19.3	22.1	20.1	19.3	19.7
Tourist guesthouses	Romania	20.9	22.2	16.5	18.3	19.9	20.7
Agritourist guesthouses	Romania	18	20	16.5	17.1	17.1	18.1

Source: processing based on own data and from NIS [27].

Also, from these tables it can be seen that in the case of tourist reception structures specific to rural tourism and agritourism, the difference between the values recorded is smaller at national level, only 12%, but it is much higher at county level, approximately 18%, which denotes a higher degree of occupancy in August when it is considered that it is the month in which most people go on vacation. The higher value of the occupancy index in August indicates that tourist structures must focus on diversifying the tourist offer in general and especially the perception that there is more to do in the area, throughout the year, not only in summer or on vacation. Comparing the utilization index of tourist guesthouses in August in Alba with that at the national level, it is found that it is higher in Alba, by approximately 7%, over the entire 2018-2023 period, the same is found in the case of Agritourist guesthouses, but this difference is slightly smaller, only approximately 5%, with the exception of 2020, when it was approximately 13%, the year in which restrictions regarding the level of isolation due to the pandemic were maximum.

CONCLUSIONS

In terms of accessibility, Alba County is characterized by a high level of accessibility, since almost all roads and access roads have been modernized both through EU funds and local investments. As can be seen, special attention was paid to access roads to areas with specific reception structures, especially for rural tourism, which developed greatly especially in the analyzed period 2018-2023. The analysis of natural tourist resources shows very clearly that the researched area enjoys numerous, rich and varied tourist attractions, which consist of wonderful mountain, submountain and hilly landscapes, which is a very important asset, because the area largely satisfies the first of the four magical criteria, level I, based on which the quality of a future tourist destination is assessed.

Also from this analysis it is found that the county has a unique flora and fauna, made up of a wide range of valuable plant and animal species, which, as we have shown in other previously published works, favors the practice of tourism specialized in image hunting, a tourism that is beginning to be loved by more and more clients, to the detriment of tourism based on classic hunting and sport fishing [4, 5, 7, 14].

The anthropic tourist potential of Alba County is original and rich and includes 686 historical monuments listed in the LMI 2015 List of Historical Monuments, a rich archaeological heritage represented by the ancient fortresses and cities presented above. It also has ethnographic areas with architectural and identity specifics, including: Saxon Villages, Târnave Valley, Trascău Szekler, Sebeș Valley, Tara Aurului, Arieș Valley, Trascău Peak, Tara Moților, Stone Villages and a diversity of religious cults, Orthodox, Catholic, Evangelical, Reformed and Jewish communities that have built extensive architectural monuments that enrich the cultural heritage. A rich heritage that is used with great success in rural tourism and agritourism in the studied area is represented by iconic craftsmen, potters, furriers, folk craftsmen, rhapsodes, etc., people who have capitalized on Romanian traditions and crafts and passed them on unaltered by modernity, of which 11 of these special people from the county have received the title of "Living Human Treasure of Alba County". Also, traditions and customs represent a valuable cultural heritage used in the development and promotion of rural tourism in general, due to the original architecture of the houses from Arieșeni, Gârda, Vidra, Avram Iancu, Albac, Mogoș, Ponor, Râmeț, Rimetea, Săsciori, Șugag, etc. Tara Moților is a center of folk art and customs, but other localities in the county have also preserved a good part of their ancient customs and traditions, these are closely linked to certain religious holidays and ancestral rituals.

The conclusions regarding the characterization of tourism activity in general and rural tourism and agritourism activity, which is also the specific objective of this research, are very relevant, significant and gratifying, because during the more than 5 years of study it was found that the evolution of these indices is positive, their values recorded in the tables above having an increasing trend from year to year. This was mainly due to the local people who realized that this specific form of tourism, with its two components rural tourism practiced mainly in tourist guesthouses and to a lesser extent in other structures such as villas, chalets, houses, etc. and agritourism practiced in Agritourist guesthouses, can lead to the revitalization and repopulation of the wonderful but isolated areas, characteristic of the Apuseni Mountains and beyond. The accentuated, sustained and somewhat directed development was also due to the initiative in 2020 of the Alba County Council to create four cultural-tourist routes for which it received the certification of "regionally developed cultural-tourist routes" from the Ministry of Economy, Energy and Business Environment.

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CASE STUDY ON THE ANALYSIS OF THE POTENTIAL AND AGROTURISM ACTIVITY OF A GUESTHOUSE IN THE MUNICIPALITY OF TURCINEȘTI - GORJ, ROMANIA, IN THE PERIOD 2019-2024

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Abstract

The case study started from the premise of presenting a real and viable possibility of practicing a profitable and sustainable family economic activity, by implementing and developing a rural tourism or agrotourism activity in the area. The first part presents the rich natural tourist heritage of the area bordering Turcinești commune, which can constitute an essential advantage in the implementation and development of such activities specific to the authentic rural space of Gorj County, Romania. As can be seen from the results obtained, the activity of agrotourism and rural tourism can be viable solutions for reconversion and revitalization of the workforce and economic activities in the Gorj area, which has been particularly hard-pressed in recent decades, due to the closure of most economic activities. In addition to the exceptional natural tourist potential, the study demonstrated that the area also has a series of rich and valuable anthropic tourist attractions that can constitute a real magnet in attracting tourists. From the analysis of the situation of agritourism activity in the area, we came to the conclusion that it developed more strongly especially after 2000, primarily focusing on qualitative aspects, but also neglecting aspects regarding the promotion and popularization on a wider scale of the rich and original tourist offer that this area has.

Key words**:** *agritourism, family business, original tourist offer, professional retraining*

INTRODUCTION

From existing studies and specialized literature, it has been observed that tourism is described as a solution to many economic problems of a country or region, being also responsible for balancing the balance of payments, as a generator of capital investments in many fields of activity [1, 2]. Therefore, the tourism industry is particularly linked to the creation of new jobs, the generation of income for the host population and taxes and duties for the local or national budget, as well as regional development [5, 6]. The basis of the movement of tourists to a certain destination is the tourist potential of the area, evaluated by value, composition, capacity, its degree of attractiveness, these directly influencing the intensity and constancy of tourist flows [11, 15].

In order to be used by tourists, this potential must be arranged and equipped in such a way as to satisfy a wide range of needs and expectations [17, 30, 33]. Also, the competitiveness of tourism is closely linked to its sustainability, as the quality of tourist destinations depends largely on their natural and cultural environment and their integration into a local community [10, 14, 16]. The sustainability of tourism covers many aspects: the responsible use of natural resources, taking into account the impact of activities on the environment (waste generation, pressure on water, soil and biodiversity, etc.), the use of "clean" energies, the protection of heritage and the preservation of the natural and cultural integrity of destinations, the quality and permanence of jobs generated, the positive impact on the local economy or the quality of reception [9, 12, 19]. Responsible tourism is one of the most important catalysts for economic growth and can contribute to the sustainable development of the area of Rugi village and Turcinești commune from an economic, social and environmental protection point of view. Sustainable development is based on an important tourist potential, due to geographical areas with rich biodiversity (mountainous, depressional, hilly areas), protected natural areas, national parks, natural reserves and natural monuments, a large number of caves - over 2,000 representing about 1/6 of the speleological potential of Romania, the diversity of flora and fauna (some of them species unique to Romania) [20, 25].

In support of the development of responsible tourism in the area, this paper attempts to bring to the attention of local and central authorities that rural tourism, agrotourism and ecotourism are the most viable forms because they present a very competitive advantage mainly related to authenticity and originality, with the help of which a rich and diversified tourist offer can be created. These specific forms of tourism can be practiced especially in the area at the base of the mountain range in the north, being closely linked to detachment from the accelerated life of the present, by accessing the slow and relaxing time of the Romanian village of Gorje and by reconnecting with the healthy roots of humanity.

Practicing such tourism requires collaboration between authorities (which have legislative, economic, social instruments), economic agents (which initiate development projects and tourist services), important actors who campaign for environmental protection and the preservation of cultural heritage, local tourism service providers, tour operators and travel agencies and, last but not least, tourists.

The development of responsible and sustainable tourism satisfies the needs of the present customers of the host regions, at the same time as protecting and increasing the chances and opportunities for the future. It is seen as a way of managing all resources, so that economic, social and aesthetic needs are fully satisfied, maintaining cultural integrity, essential ecological dimensions, biological diversity and the life system [26, 28].

Also to develop the offer in the area, the authorities must support businesses in the agritourism field, by simplifying the regulatory acts necessary for the approval/authorization of agritourism guesthouses, with the aim of encouraging investments in agritourism, registering private accommodation units, as well as perpetuating culinary recipes, traditional products specific to the regions, by preparing and serving meals for tourists, from products from their own household, obtained by cultivating the land and raising domestic animals [31].

Capitalizing on crafts, at risk of extinction under the impact of technology, with the effect of increasing the prosperity of locals by: identifying (by specialized institutions) villages with high handicraft production, to ensure assistance for the development of crafts, selecting folk crafts, identifying the export market and support for the creation, promotion and marketing of traditional handicrafts; supporting the creation of centers for the production, exhibition and marketing of handicraft products, etc., in the main ethnographic areas; stimulating socio-cultural entrepreneurship, in order to preserve and transmit crafts and folk traditions; supporting regulations regarding the marketing of traditional, Romanian-specific handicrafts in tourist attractions [29, 31, 18].

Starting from these desiderata, which mainly aim to contribute to the well-being of local communities, by preserving and promoting cultural authenticity, this case study attempted to present a possibility of improving economic, social and environmental conditions by reconversion of the workforce in the Gorj area, where the aggressive exploitation of the natural environment (mining, ballast pits) took place, and orienting the workforce towards the tourist area and especially towards practicing forms of tourism specific to rural areas, such as agrotourism and rural tourism.

MATERIALS AND METHODS

The research method is a classic one and widely used in research in the field of rural tourism and agritourism. Within it, a case study was carried out in which, in order to identify the natural and anthropic tourist potential of the area, master's students from the specialization in Agrotourism Management and the Quality of Agri-Food Products [7, 8] were involved in a multidisciplinary research project with a complex study character. They went to the field to carry out the preliminary research stage which consisted primarily in observing and describing the real situation of the development and evolution of the tourist activity in the area, which has been affected recently, as well as the entire Gorj County, by the phenomenon of depopulation and economic regression, due to the almost complete closure of mining and energy industry activities. The data collected from the field were rigorously processed, obtaining a series of significant results and based on them, several conclusions and recommendations were formulated regarding the future development of rural tourism and agritourism in the area [7, 8].

RESULTS AND DISCUSSIONS

As part of the case study, we also made an inventory of the natural and anthropogenic tourist heritage of the area surrounding the Pensions under study, over a radius of over 30 km, a distance from which all tourist attractions must be taken into account in any major tourist study carried out. The area of interest for the pension is delimited to the north by the parallel of 45°58' north latitude, which passes near the town of Țântăreni. The eastern limit is near the towns of Alimpești and Polovragi, passing by the meridian of 23°39' east longitude. The western limit is represented by the Dobru peak in the Godeanu Mountains, located on the meridian of 22°6' east longitude. The 45° parallel crosses the territory through its southern part.

The study area is well equipped in terms of transport infrastructure, communication routes and accessibility to the Danube ports and the sub-mountain tourist area [13]:

- favorable, relatively central position of the Târgu Jiu municipality at the intersection of major traffic axes (Craiova – Deva and Râmnicul Vâlcea – Drobeta Turnu Severin);
- most cities are adjacent to a DN National Road (except Țicleni) and there is a good degree of coverage of the territory with road arteries (39.3 km - 100 km²), but not qualitatively;
- railway accessibility and density is good (34.4 km / 1,000 km²), the area is located near the Bucharest – Craiova highway;
- Sibiu International Airport is 95 km away, and Craiova International Airport is 120 km away.

Relief is formed by three large physical-geographical units that descend in steps from north to south. 1. The Southern Carpathians, a mountainous area represented by the southern slopes of the Parâng, Vâlcan and Godeanu Mountains; 2. The Getic Subcarpathian area - consisting of two rows of hilly peaks and two depressional gullies; 3. The Getic Plateau is made up of sedimentary deposits (sands, gravels, clays, marls) of materials eroded from the mountains, carried by rivers and deposited in the Getic Basin. These three landforms, arranged in steps from north to south, descend from an altitude of 2,519 m, the highest altitude, in the Parângu Mare Peak, to the lowest altitude of 100 m in the Jiu meadow, in the Picu locality, in the Ionești commune [13, 31, 34].

Climate. The climate is mainly temperate continental, with a wide variety of nuances, as a result of the geographical position, atmospheric circulation and the relief components present. The average annual temperature records different values from north to south: 0 degrees C on the peaks above 2,000 m and 10.1 degrees C in Târgu Jiu. Precipitation has an uneven distribution in the territory and decreases from north to south as follows: 1,200 mm/year at above 2,000 m, 865 mm/year in Novaci, 750 mm/year in Târgu Jiu, 585 mm/year in Țântăreni. The snow cover has an uneven distribution, in the high mountain area above 1,500 – 1,600 m it lasts 180-200 days (Parâng, Vâlcan, Godeanu). In the middle mountain area, the duration is only 140-150 days and decreases to 60-80 days/year in the plateau [13, 31, 34].

The flora and fauna consist of over 2000 plant species and include: the alpine meadows located at high altitudes; - the coniferous forests, between 1,400-1,700 m, the predominant species being spruce and fir; - the deciduous forests include: beech, hornbeam, hornbeam. The fauna is very varied and includes - the ibex on the alpine peaks, the bear, the wild boar, the wolf, the deer, the roe deer, the wild cat, the ferret in the deciduous forests, some Mediterranean species: the horned viper, the land turtle, numerous bird species 8 as well as a large aquatic fauna in the mountain rivers (trout, carp, etc.). The diversity of the fauna of the area is an important attraction especially for foreign tourists for whom there are offers that include hunting and fishing activities [13, 27, 31, 34].

The hydrography is represented by the rivers: Jiu, Gilort and their tributaries, the Olteț and Cerna Rivers. There are several important glacial lakes: Gâlcescu, Tăuri, Slăveiul, Mija, Pasărea and Godeanu. The lakes are few and are artificially created to mitigate floods (Ceauru) or to produce electricity (Motru, Cerna, Valea lui Ivan). The area is also rich in groundwater such as karst waters coming from the limestone mountain bar where the two springs at Runcu and Izvarna were also captured, with a flow rate of over 100 liters/second each. Groundwater at shallow depths of about 2–3 m is found in the subcarpathian depressions and in the river meadows in the plateau area used by the inhabitants through wells. Mineral waters appear at Săcelu in springs, used for baths [13, 31, 34].

From the point of view of human-made tourist resources, we highlight the fact that the Pension is located in the Turcinești commune, which is attested by the document of August 5, 1424, in which the village of Turcinești is mentioned for the first time. The second document attesting to the existence of the village of Turcinești dates back to October 28, 1428, issued in Bratislava. The village of Turcinești is later mentioned in the document of January 18, 1480, in which Basarab the Younger gives Ticuci and his brothers several villages and parts of villages, and another document is from April 3, 1635, given by Matei Basarab [13, 31, 34].

Among the very important human-made cultural-historical objectives, we mention: – The “Elvira Godeanu” Dramatic Theater in Târgu Jiu, the professional artistic ensemble “Doina Gorjului”, 203 libraries, of which 62 are public. Museums: Gorj County Museum "Alexandru Ștefulescu", Gorjești Folk Architecture Museum in Curtișoara, Lelești Village Museum, Arcani Village Museum, Tudor Vladimirescu Memorial House in Vladimir village, Ecaterina Teodoroiu Memorial House in Târgu Jiu, Padeș Proclamation Monument [13, 27, 31, 32, 34].

The list of historical monuments attractive from a tourist point of view is made up of a number of 511 objectives: 46 monuments and archaeological sites, 352 historical monuments, 4 urban ensembles, 24 public monuments and 28 memorial monuments. Among these, the "Path of Heroes" Monumental Ensemble, included in the UNESCO heritage, in the municipality of Târgu Jiu stands out. Other specific objectives of the area are the cults, some of which are still preserved today: the Cula de la Curtișoara, the Cula Crăsnaru, the Cula din Șiacu and the Casa-culă in Glogova. Also included in this list are historical monuments such as: the wooden church with porch "Sfântul Vasile" in the village of Pieptani, the wooden church "Sfântul Ioan Botezătorul" in Fărcășești, the wooden church "Sfântul Nicolae" in Negomir, the wooden church "Sfîntii Împarați" in Curtheana and the wooden church "Sfîntii Arhangheli" in Ceauru, one of the wooden churches of great architectural value and one of the oldest of this type preserved in Gorj county [3, 13, 21, 23, 31, 35].

Among the most visited religious sites, we mention the Gorj Monasteries, which attracted people who love culture and beauty through their architecture, the Tismana Monastery, which is the oldest monastic settlement in Wallachia. The Polovragi monastery complex is located at the foot of the Piatra Polovragilor Mountain near the Olteț Gorges and is 500 years old (1505). It was later painted during the reign of Constantin Brâncoveanu, who is considered its third founder. The Crasna Monastery was founded in 1636. The ensemble includes a church built in Byzantine style with fresco painting made in 1757. The Lainici Monastery, located in the Jiu Valley gorge, developed around a wooden church. It has original paintings that have been preserved since 1817. Other objectives included in the list of historical monuments are: the wooden church with a porch "Saint Basil" in the village of Pieptani, the wooden church "Saint John the Baptist" in Fărcășești, the wooden church "Saint Nicholas" in Negomir, the wooden church "Holy Emperors" in Curtheana and the wooden church "Holy Archangels" in Ceauuru, one of the wooden churches of great architectural value and one of the oldest of this type preserved in Gorj county [4, 13, 23, 31, 35].

The wooden architecture of the area has a great artistic value, unique and unparalleled in the world remains the "Brâncușian Open-Air Museum Complex from Târgu Jiu" [13, 23, 31, 32]. Also valuable from an artistic and architectural point of view are the houses and mansions built especially between the 16th and 19th centuries: Dimitrie Măldărăscu House, in the municipality of Târgu Jiu; Cartianu House, located in the village of Cartiu, Turcinești commune; Cornea Brăiloiu House, in the Vădeni neighborhood of the municipality of Târgu Jiu; Barbu Gănescu House, in the municipality of Târgu Jiu; Vasile Moangă House, in the municipality of Târgu Jiu; Moangă - Pleșoianu House, in the resort of Săcelu [13, 23, 31]. In order to highlight the capacity to use the rich natural and anthropogenic tourist heritage presented above, we show that the Casa Hortopan Guesthouse, located in one of the most picturesque areas of Gorj, 6 km from the city of Târgu Jiu, welcomes tourists with 4 double rooms and two twin rooms classified as 3-4 daisies, with a total of 12 accommodation places [3, 4, 24, 27].

The interior and exterior design stands out by combining modern and classic style, and the high-quality finishes satisfy the most demanding requirements. As for the rooms, they stand out by their generous size, private terrace and amenities such as air conditioning, smart TV, minibar [3, 4, 24]. Tourists have a fully equipped kitchen at their disposal where they can prepare their own food, or they can opt for dishes prepared at the restaurant, which are composed mostly of products obtained in their own household. It offers accommodation with free bikes, free private parking, a bar, various facilities, including a 24-hour front desk, a shared kitchen and free WiFi throughout the property, a garden and barbecue facilities [3, 4, 24, 27]. The guest house rooms are equipped with air conditioning, a desk, a flat-screen TV, bed linen, towels, a private bathroom and a balcony with garden views, each room is fitted with a terrace and includes a seating area.

Table 1. Dynamics of the number of tourists arrivals and the number of overnight stays

Years	Number of tourists	Overnight stays
2020	89	153
2021	97	162
2022	85	125
2023	127	232
2024	131	249

Source: processing based on data from the Agrotourism guesthouse and NIS [22].

From Table 1 it can be seen that the tourist activity at the guesthouse has revived much after 2020, which was also the year of maximum pandemic. This year was also considered the year in which the guesthouse began to operate at its full capacity. The number of tourists and overnight stays have continuously increased, along with the increasing experience of the staff and guesthouse administrators in the field of agritourism activity. After the staff began to learn new skills in this field, the quality of services has increased considerably, which also led to a considerable increase in the values of the two indicators listed in Table 1.

Table 2. Dynamics of the number of tourists arriving per day and the average length of stay

Years	Average number of tourists arriving per day	Average length of stay
2020	0.25	1.72
2021	0.27	1.67
2022	0.24	1.47
2023	0.36	1.83
2024	0.39	1.90

Source: processing based on data from the Agrotourism guesthouse and NIS [22].

The average number of tourists arriving per day and the average length of stay listed in Table 2 followed the same increasing trend as the two indicators presented previously, as there is a close interdependence between them. In 2022, a slight regression of these two indicators is observed, as the guesthouse tried to readapt to a new level of customer requirements, who came to the guesthouse especially to spend a quiet weekend stay, with children and family.

Table 3. Calculation of the total number of tourists days – arrivals at the Agrotourism guesthouse

Years	Number of tourists	Overnight stays	Total number – tourist days
2020	89	153	13,617
2021	97	162	15,714
2022	85	125	10,625
2023	127	232	29,464
2024	131	249	32,619

Source: processing based on data from the Agrotourism guesthouse and NIS [22].

Based on the number of tourists arriving and overnight stays, the total number of days spent by tourists at this guesthouse was calculated. From the data entered in this table, it can be seen that the year 2022 is the year with the lowest number of days, of only 10,625, but after this turning point year, the guesthouse began to recover and reach a considerably improved value, in the year 2024 of 32,619 days - tourists arriving.

Table 4. Determining the accommodation capacity in operation of the Agrotourism guesthouse

Years	Number of days of effective operation	Accommodation capacity in operation
2020	197	2,364
2021	169	2,028
2022	162	1,944
2023	219	2,628
2024	234	2,808

Source: processing based on data from the Agrotourism guesthouse and NIS [22].

As can be seen from Table 4, the owner of the guesthouse and the staff have continuously worked to increase the number of effective days of operation. The guesthouse, as previously presented, is located in the vicinity of the city of Târgu-Jiu, approximately 6 km from it, which means that the guesthouse is used at maximum capacity, especially on weekends. To compensate for this small disadvantage, the management team has continuously worked mainly to improve the quality of the services offered, but also to diversify and personalize the leisure offer, so that tourists perceive that they have more activities to do and visit, at the guesthouse and in the area.

Regarding the dynamics of the occupancy rate (lu) % and the occupancy rate (Do) %, it can be seen from Table 5 that the values of these indices had a progressive increase throughout the entire research period, reaching the maximum value in 2024, when it is found that the quality level of services offered to tourists is also the highest and also the management of tourist activities at the guesthouse has reached almost full maturity and performance.

Table 5. Dynamics Index of use of accommodation capacity in operation (Iu) % and Occupancy Degree (Do) %

Years	Index of use of accommodation capacity in operation (Iu) %	Occupancy Degree (Do) %
2020	21.99	32.89
2021	26.93	29.55
2022	22.46	26.98
2023	31.27	43.91
2024	33.16	48.76

Source: processing based on data from the Agrotourism guesthouse and NIS [22].

From the overall analysis of the tourism situation in the studied area, it was observed that the guesthouse contributed to the revitalization of the well-being of the local community, by preserving and promoting cultural authenticity, by retraining the workforce from natural areas where the aggressive exploitation of the natural environment took place (mining, ballast pits), by directing the workforce to the tourist area and creating a platform dedicated to farmers interested in entrepreneurship in sustainable tourism in the Carpathians, according to the Carpathian Convention. At the same time, through its own example, it draws the attention of local authorities that the quality of the tourist infrastructure depends on: the way of valorisation (reduced/high) of the tourist fund; the degree of satisfaction (complete/incomplete) of the tourist demand depending on the diversity of the tourist services offered; ensuring a tourist consumption (lower/higher).

Attracting tourists to the area and to the guesthouse was also achieved by using local stories about people and places, both in the interaction between tourists and the local population, and in promotional actions in the online environment, by broadcasting video materials on their own websites, videos or on social networks, but also in the offline environment, in brochures or tourist guides. Increasing the visibility of the presence in domestic and foreign trade fairs (within the Romanian stand) by permanently improving the degree of diversity and attractiveness of the stand, the quality of the offer and the disseminated information, the hospitality of the representatives and exhibitors at the stand, the cultural programs presented on such occasions. Popularization was also achieved by developing gastronomic and oenological tourism by: identifying tourist reception structures with food functions, which present specialties of traditional gastronomy, appealing to creativity and modernity; developing and promoting thematic gastronomic tours; valorisation and promotion of tangible and intangible heritage, wine and vine culture and the continued development and promotion of European, national and regional wine routes.

CONCLUSIONS

The paper presents a complete and well-documented study on a successful tourism activity carried out in Gorj County, which from an economic point of view is part of the category of disadvantaged areas in our country. From the study we conducted, we believe that the closure of mining activities and the minimization of pollution, due to the cessation of many activities in the energy field, is a beneficial thing, because the area has numerous natural and anthropogenic tourism resources, which can be quickly used in the implementation and development of successful family businesses, similar to those presented by us in the case study.

We also concluded that in order to practice such tourism, local people must collaborate with local and county authorities (which have legislative, economic, social instruments), economic agents (which initiate development projects and tourist services), important actors who campaign for environmental protection and the preservation of cultural heritage, local tourism service providers, tour operators and travel agencies and, last but not least, with tourists. Carrying out an activity in the field of rural tourism and agrotourism in this area does not require very large investments, the locals can make the free spaces they have available to tourists with a minimum of equipment and modernization, so as to achieve maximum efficiency and profitability with a low level of expenses.

At the same time, responsible and sustainable tourism must be practiced in the area that meets the needs of customers and the host population, but at the same time leads to the protection and increase of chances and opportunities for the future, as can be seen from the experience before the revolution and in the first decades after, when several irresponsible and harmful economic activities were practiced in the area, which led to the almost irreversible deterioration and degradation of the area and the surrounding environment. In our opinion, rural tourism and agrotourism are activities with a strong favorable impact on the area, and by practicing modern management oriented especially towards quality and sustainability like that of the guesthouse under study, all resources can be successfully managed, so that economic, social and aesthetic needs are fully satisfied, while at the same time maintaining cultural integrity, essential ecological dimensions, biological diversity and the traditional way of life.

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THE EFFECTS OF FINANCIAL INNOVATION IN THE AGRIBUSINESS LANDSCAPE: ASSESSING THE IMPACT OF BEHAVIORAL FACTORS ON THE ACCEPTABILITY OF E-FISCALIZATION

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Abstract

Through digitization and transparency of tax monitoring and reporting, e–fiscalization has gained global traction for its potential for innovation and efficiency. The research focuses on the specific dynamics of fiscal innovation in the agribusiness landscape in Albania, aiming to identify the behavioral typology of agribusiness operators and its impact on acceptance or resistance to e–fiscalization initiatives and relying on a holistic review of the research literature and the qualitative-quantitative method, through the analysis and findings from the database obtained via the survey of agri–operators. The study shows their behavioral patterns according to their perceptions of e-fiscalization. Perceived benefits, ease of use, attitude towards the e-fiscal system, and compliance are some of the main factors examined. The findings provide a useful road map for policymakers, tax authorities, entrepreneurs, and researchers in the field, guiding the development of new strategies that match the behavioral patterns of agricultural operators and encouraging good institutional practices that successfully integrate innovations into the agrarian landscape in similar cases.

Key words**:** *e–fiscalization, behavior, acceptability, agribusiness operators*

INTRODUCTION

In the era of the Fourth Industrial Revolution and the Internet of Things (IoT), rapid innovation has far-reaching economic, technological, instrumental, and socio-psychological implications. Its presence in the financial sectors and the perceived efficiency of public policy effects constitute an important and primary topic.

Taxes are used as a financial tool to enrich the state and local budgets. The legal regulations established by the state regarding taxes have a beneficial effect on economic activity. Taxes are of various types (direct and indirect taxes, contribution to social insurance, profit tax, income tax, taxes on properties (land, house, cars, car park, etc. [17, 15]. Tax collection has an important role in diminishing the budget deficit [11] or, in other words, increasing the budget revenues and assuring the legality of economic transactions and payments [4].

Among the challenging dynamics of integration and sectoral (or contextual) consequences specific to agriculture and the food chain, Albania has recently implemented innovative practices in several key areas, such as the economy, administrative services, and banking. Perhaps the most debated has been the modernization of fiscal policy through e-fiscalization [4]. While the effort to develop a transparent and efficient fiscal environment has progressed alongside reform development, technological costs and challenges have been accompanied by consequences and uncertainties impacting entrepreneurs' perceptions and behavior, particularly agricultural operators.

The behavior of agro-operators or individuals within the agribusiness landscape can play a decisive role in determining the success of e–

fiscalization as a public policy, also serving as a driver (or not) for future innovations. Moreover, agri–operators have faced interpretative–regulatory challenges for e–fiscalization requirements from tax authorities, including electronic invoicing, data retention, and reporting guidelines. Their readiness for adaptation and integration of the necessary technology has included the implementation of electronic systems at points of sale, invoicing software, and other digital tools to facilitate electronic transaction registration. Agri–operators now accurately perform data in electronic systems, reflecting the nature of transactions, ensuring their financial integrity, and contributing to preventing potential errors or mismatches.

Training programs and awareness campaigns have been essential in educating them about the benefits and new requirements of e-fiscalization, helping to minimize resistance to changes (and the status quo as a culture mainly, in agriculture), and ensuring a better understanding of technology use. Within the agribusiness landscape, trust in the security of electronic transactions and financial data has generally increased, providing previously unknown capabilities of agri-operators regarding cybersecurity and protection against unauthorized access to data and security risks. Furthermore, by avoiding outdated (or abusive, corrupt, etc.) practices of tax authorities or subjectivism (often justified) in the agricultural sector through new audit-inspection practices, cooperation has deepened, improving the business environment and trust.

However, agri–operators often expressed concerns about the costs of implementing the e-fiscalization system and sometimes uncertainties about understanding the long–term benefits of system modernization and reducing the possibilities for tax evasion. Moreover, the acceptability or recognition process of the value of these investments (economic, technological, social, epistemological, etc.) involves a shift from the traditional (or evasive) document-based processes to digitalization, thus an evolutionary scale not so simple. Their behavior toward openness and changes stemming from innovations impact technological acceptability, progress in the knowledge society, and the speed of transition in public services.

Literature review

To understand the e–fiscalization signs in Albania, it is important to examine the literature in the field of fiscal systems and their modernization progress. The Technology Acceptance Model (TAM) posits that ease of use and perceived usefulness are key determinants of technology acceptance [5]. In the context of agriculture, the importance of farmers' perceptions of the simplicity of technology and practical value in influencing their adoption decisions [22] [10]. Technological literacy plays a crucial role in technology acceptance [13]. Farmers with higher levels of digital literacy are more likely to embrace and adopt new agricultural technologies [23]. Perceived risks has been associated with technology adoption [3] [6]. Farmers' concerns about financial investments, system reliability, and potential disruptions to established practices can act as barriers to technology acceptance.

Social networks significantly influence technology acceptance [19]. The opinions of peers, family members, and community influencers play a vital role in shaping farmers' decisions to adopt new technologies [14] [20]. Government support is a critical factor influencing technology acceptance [13] [7] [16]. Agricultural policies and subsidies can positively impact farmers' willingness to adopt new technologies. Effective training programs and technology demonstrations facilitate technology acceptance [13]. The importance of practical experiences and educational resources in building farmers' confidence and encouraging technology adoption [18] [13].

Perceived ease of use is a key factor in technology adoption [5]. According to the Technology Acceptance Model (TAM), individuals are more likely to use technology if they perceive it as easy to use. This perspective is echoed on the extended TAM [22], which emphasizes the importance of perceived ease of use in shaping user behavior. Perceived usefulness or the belief that technology enhances job performance is closely related to user behavior [5]. The Theory of Reasoned Action posits that individuals are more likely to use new technology if they perceive it as useful for achieving their goals [8].

Psychological factors play a significant role in technology adoption behavior. Social Cognitive Theory suggests that individuals learn by observing others, implying that social influences can shape technology-use behavior [2]. The role of perceived attributes of innovation, including compatibility and relative advantage, influences individual behaviors toward technology adoption [13]. Individual differences such as personality traits and demographic factors influence technology adoption behavior. Factors such as openness to experience, computer self-efficacy, and age can impact individuals' attitudes and behaviors in adopting new technologies [21].

Contextual factors such as organizational and environmental influences are crucial in shaping technology behavior. The role of emotions in technology use behavior emphasizes how emotional responses to technology can influence usage decisions [1], [12]. User experience (UX) is a major determinant of technology use behavior. Positive experiences, ease of interaction, and overall satisfaction significantly contribute to individuals' continued technology use [9] [12].

Considering the gap in the literature, the study aims to examine the factors that determine the behavior of agri-operators towards fiscal innovations by analyzing their impact on the acceptability of the e-fiscalization reform in Albania.

MATERIALS AND METHODS

To cover the analysis, we used an advanced methodology employing interviews with representatives of the agribusiness sector.

The survey included 121 respondents from various regions in Albania, with the highest participation from Shkodra, Berat, and Tirana. Data was collected from March to July 2024 using Google Forms, following initial improvements after three case studies. The communication involved emails and reminder messages to legal representatives of agribusinesses. The mixed qualitative-quantitative method enabled a holistic approach to the impact of behavioral factors on the acceptability of e-fiscalization by agro-operators.

The variables explaining the behaviour of agri–operators towards the implementation of e–fiscalization are summarized in Table 1.

Table 1. Variables indicating the behavior of agricultural operators

Independent Variable			
Concept	**Variables**	**Symbol**	**Measurement by Likert scale**
Behavior of agri–operators	Awareness in Reporting	Behav_1	1 (Strongly Disagree) 2 (Disagree) 3 (Neutral) 4 (Agree) 5 (Strongly Agree)
	Higher payment readiness	Behav_2	
	Mandatory employment of an accountant	Behav_3	
	Price increase	Behav_4	

Source: Author's processing.

RESULTS AND DISCUSSIONS

The study analyzes the main characteristics of the sample, which includes 121 valid answers. Geographically, approximately 30.58% of respondents are agribusiness people in Shkodra, followed by Berat (19.01%) and Tirana (13.22%), with the remaining distributed across other cities in Albania.

The gender distribution is uneven, with 83.47% male and 16.53% female respondents. Regarding roles, 48 respondents were company owners, while 73 held various operational positions.

The average age of respondents is 44 years, with a standard deviation of 9.43 years.
The average work experience is 11 years, with a standard deviation of 7.09 years. Educational levels indicate that approximately 43% have higher education, 52% have secondary education, and only 5% have primary education.
The types of business activities include processors (11.57%), domestic and export traders (0.83%), collection points (4.96%), and agricultural producers (5.79%). Additionally, 50.41% are engaged in a combination of these activities.
The classification of economic units shows that 9.1% are large units, 10.7% are medium-sized, 14.9% are small, and 65.3% are micro–unit.
The sector distribution includes dairy (34.7%), meat (11.6%), and wine (6.6%), with the remaining in other sectors.
According to the survey results presented (Fig. 1), 37% of respondents agree that if they encountered a non–tax invoice, they would report it to the tax administration, and 24% strongly agree with this statement.

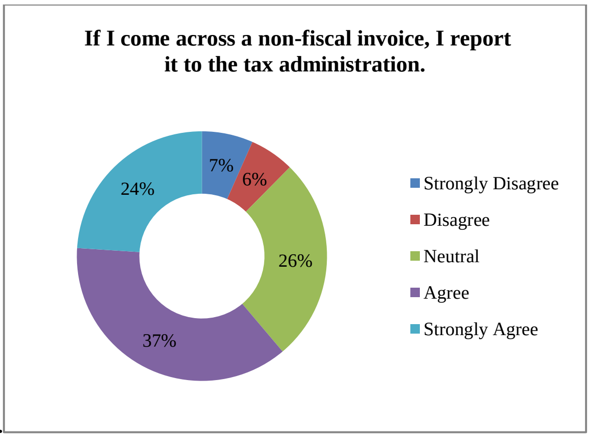

Fig. 1. Consent to report a non–tax invoice
Source: Authors' elaboration from questionnaire data.

According to Figure 2, 34% of respondents remained neutral regarding an increase in their willingness to pay tax obligations with the implementation of e–fiscalization, while only 30% agreed that their willingness to pay would increase.

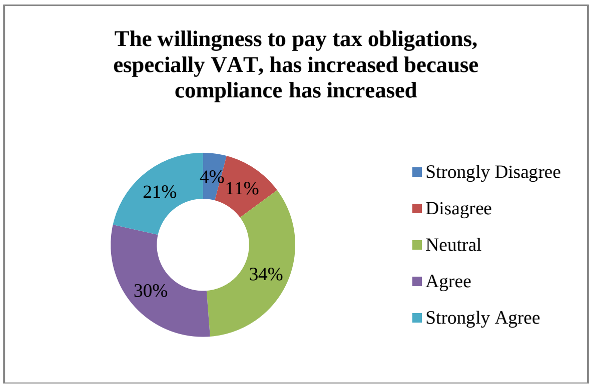

Fig. 2. Agreement on the readiness to pay tax obligations.
Source: Authors' elaboration from questionnaire data.

The majority of surveyed agribusinesses, nearly 62% (Fig. 3), had contracted an accountant to support the implementation and ongoing management of e–fiscalization.
In contrast, only 3% managed to implement e–fiscalization independently, thereby increasing their administrative costs.

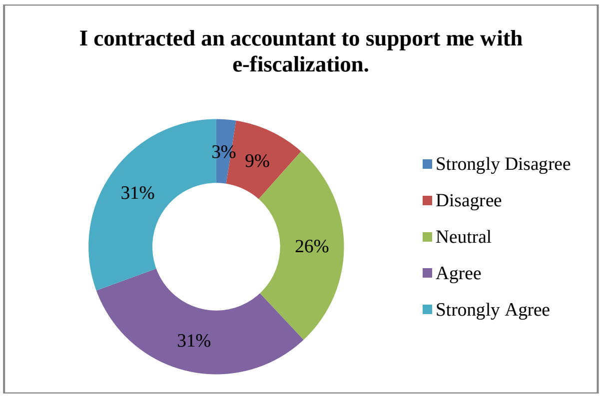

Fig. 3. The need to contract an accountant
Source: Authors' elaboration from questionnaire data.

From the data in Figure 4, it can be concluded that the majority of respondents view e-fiscalization as a factor contributing to the increase in agricultural product prices, with a significant portion strongly agreeing with this statement.
Only 3% of respondents disagree with this assertion.

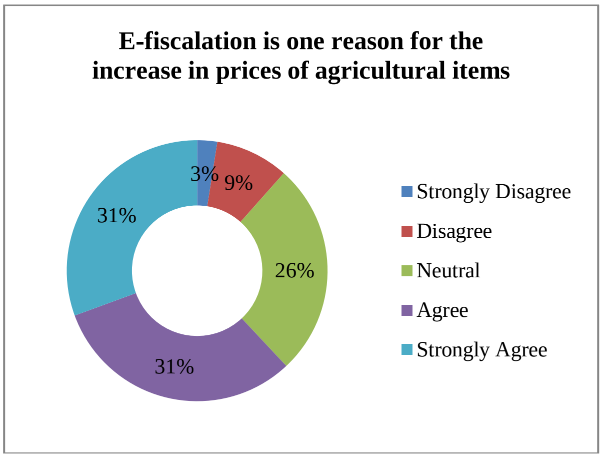

Fig. 4. The impact of e–fiscalization on the prices of agricultural items.
Source: Authors' elaboration from questionnaire data.

The answers to questions 1, 2, 3, 4, 5, and 6 are shown in Figures 5, 6, 7, 8, 9, and 10.

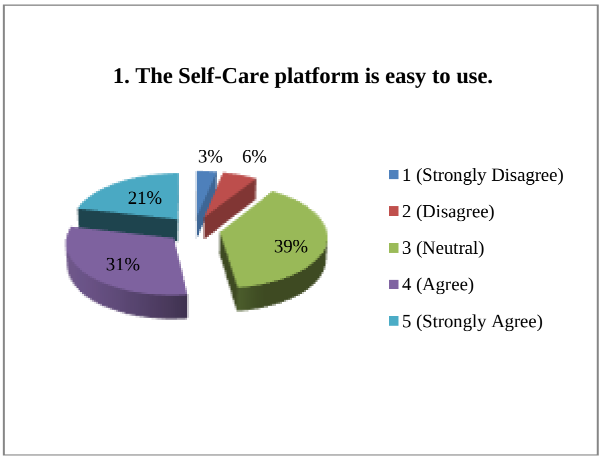

Fig. 5. Respondents answers regarding the acceptability of the self-care platform
Source: Authors' elaboration from questionnaire data.

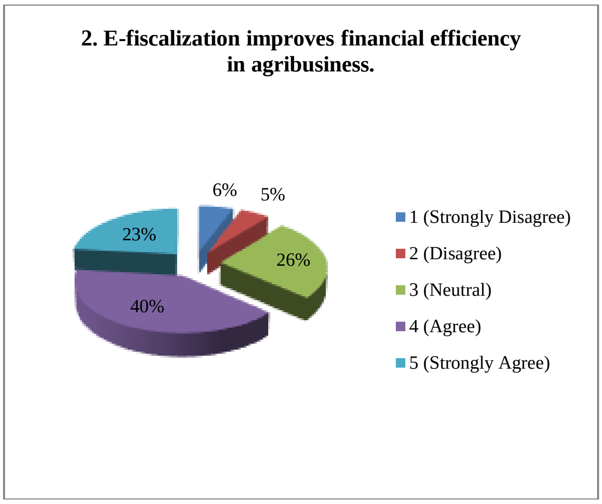

Fig. 6. Respondents answers to the question if E-fiscalization improves financial efficiency in agribusiness.
Source: Authors' elaboration from questionnaire data.

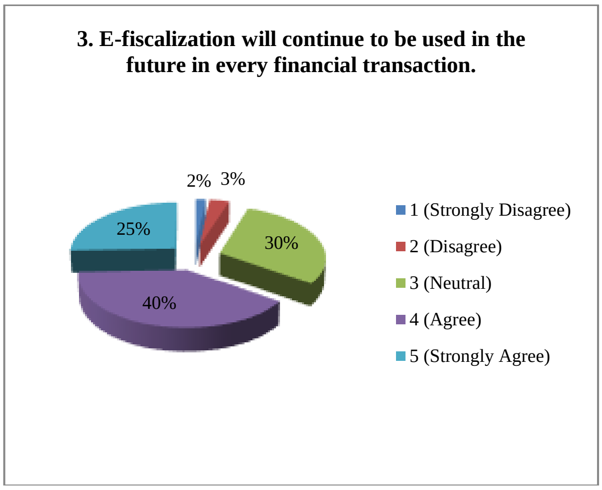

Fig. 7. Respondents answer if they agree or not as E-fiscalization to continue in the future.
Source: Authors' elaboration from questionnaire data.

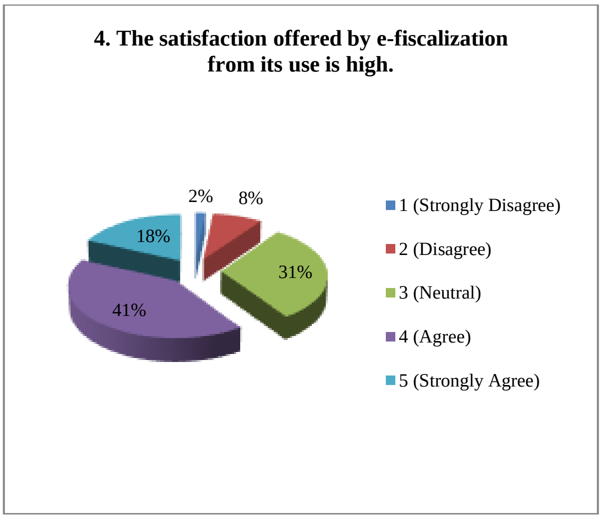

Fig. 8. Respondents answers on their satisfaction that E-fiscalization will be highly used.
Source: Authors' elaboration from questionnaire data.

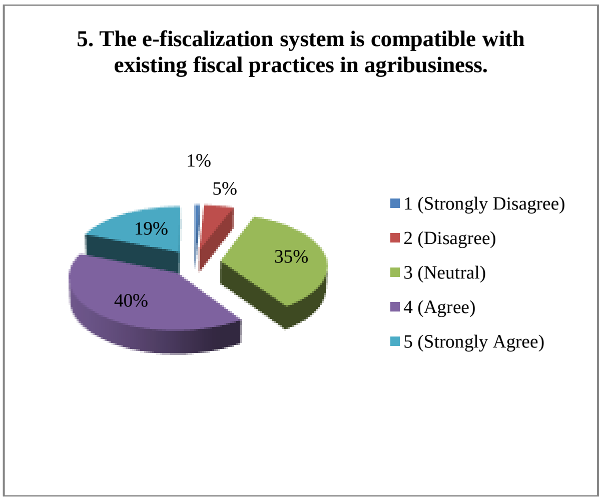

Fig. 9. Respondents' opinion if E-fiscalization is compatible with the existing fiscal practices.
Source: Authors' elaboration from questionnaire data.

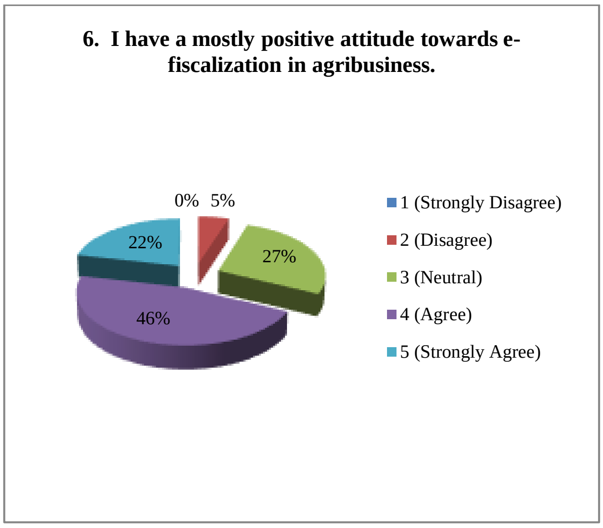

Fig. 10. Respondents answer the question if they have a positive attitude towards E-fiscalization.
Source: Authors' elaboration from questionnaire data.

Table 2 presents the acceptability of– fiscalization by agri–operators.
Referred to Accep_1, 3% strongly disagree, 6% disagree,
39% are neutral, 31% agree, and 21% strongly agree, indicating that most users find the Self-Care platform easy to use.

Accep_2 shows that 40% agree and 23% strongly agree that e-fiscalization improves financial efficiency, although 26% remain neutral.
Accep_3 shows that 40% agree and 25% strongly agree that e–fiscalization will continue to be used.
For Accep_4, 41% agree and 18% strongly agree about the satisfaction offered by e–fiscalization.
For Accep_5, 40% agree and 19% strongly agree that the system is compatible with existing practices.
For Accep_6, 46% agree and 22% strongly agree that they have a positive attitude towards e–fiscalization.
The overall average behavior (Behav_AVG) is 3.65, which suggests an average positive tendency of users' behavior towards e–fiscalization.
The averages of the various behaviors are similar, indicating a consistency in the perception and behavior of users towards e–fiscalization.

Table 2. Means and standard deviations of the variables

X	MEAN	STD	Y	MEAN	STD
Behav_1	3.66	1.11	Accep_1	3.73	1.24
Behav_2	3.54	1.07	Accep_2	3.47	1.54
Behav_3	3.79	1.06	Accep_3	4.20	0.83
Behav_4	3.6	1.11	Accep_4	3.33	1.19
Behav_AVG	**3.65**	**1.09**	Accep_5	3.73	1.18
			Accep_6	3.80	0.98
			Accep_AVG	**3.71**	**1.16**

Source: Authors' elaboration from questionnaire data.

The standard deviations of the behaviors are relatively narrow (around 1.07 to 1.11), which indicates a moderate distribution of responses. This implies that most users have similar responses to behavioral questions.
The overall acceptability average (Accep_AVG) is 3.71, showing a positive trend of acceptability of e–fiscalization. Accep_3 (E–fiscalization will continue to be used in the future in every financial transaction) has the highest average (4.20), which suggests that users are particularly inclined to use e–fiscalation in the future.

The standard deviations of acceptability range more (from 0.83 to 1.54), indicating that there is more variation in users' perceptions of e–fiscal acceptability compared to behaviors. Accep_2 (E–fiscalization improves financial efficiency in agribusiness) has the highest standard deviation (1.54), indicating a wider distribution of users' perceptions of this aspect of acceptability.
The results show a strong and positive relationship between user behavior and e–fiscal acceptability.
High means and relatively narrow standard deviations for behaviors indicate a

consistency of positive perceptions towards e–fiscalization.

On the other hand, acceptability means are also positive, but with more variation, suggesting that there are some aspects of acceptability that are perceived differently by users.

The regression analysis is presented in Table 3.

Table 3. Regression statistics

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.97
R Square	0.95
Adjusted R Square	0.94
Standard Error	0.86
Observations	121

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1,677	1,677	2,290	0.00
Residual	120	87.86	0.73		
Total	121	1,765			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
X -Behav_AVG	0.996	0.02	47.86	0.00	0.96	1.04	0.96	1.04

Source: Authors' elaboration from questionnaire data.

Fig. 11. Regression chart.
Source: Authors' elaboration from questionnaire data.

Figure 11 shows the behavioral variable in the acceptability of e–fiscalization and gives a clear picture of the influence of user behavior on the acceptability of this technology. The table shows a very strong correlation between the behavioral variable and the acceptability of e–fiscalation as Multiple R: 0.97. Thus, 95% of the variation in the acceptability of e-fiscalization can be explained by the behavior of users. The test F=0.00 shows that the model is significant as a whole. This shows that the result is statistically significant ($p < 0.05$). The regression result shows that user behavior has a very significant and positive impact on the acceptability of e–fiscalization. The model explains a large part of the variation in the data and is statistically highly significant.

CONCLUSIONS

E–fiscalization has significantly contributed to the improvement of transparency and fiscal efficiency in the agricultural sector in Albania. This digital innovation and the accompanying process have enabled more accurate monitoring and reporting of taxes, reducing bad practices and reducing opportunities for fiscal evasion. The behavior of agri–operators has directly influenced the acceptance of e–fiscalization. Operators who have a high level of awareness and are willing to adopt new technologies have shown greater acceptance of the new system. The study shows that the majority of agri–operators agree or strongly agree on the importance and ease of use of e–fiscalization. The implementation of e–fiscalization has brought an increase in administrative costs for agri–operators, including the need to contract accountants. Also, there is a general perception that e–fiscalization has influenced the increase in prices of agricultural items.

Social–psychological factors, such as the perception of ease of use and usefulness of the system, are important in the acceptability of e-fiscalization. There is a general consistency in the behaviors and perceptions of agri–operators towards e–fiscalization. High means and relatively narrow standard deviations indicate that most users have similar and positive responses to questions related to behavior and acceptability. It is important to continue training and awareness programs for agro-operators. These programs should focus on the benefits of e–fiscalization, ease of use of the system and ways that reduce administrative costs. The government should continue to provide support, including subsidies and financial facilities to agri–operators that implement e–fiscalization. This would help speed up the positive perception of future innovations as well. A strong cyber security framework should be implemented to protect sensitive financial transactions and data. Agri–operators should be educated about the importance of security measures and protection against security threats. By following recommendations, Albania can increase the effectiveness and acceptability of e–fiscalization in the agribusiness landscape, ensuring a fairer and more efficient fiscal system.

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ORDINAL LOGISTIC MODEL FOR THE ENGAGEMENT OF SMALL-SCALE ABACA FARMERS WITH PHILIPPINE FIBER INDUSTRY DEVELOPMENT AUTHORITY (PhilFIDA)

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Abstract

This paper aimed to investigate the small-scale abaca farmers' engagement level towards the Philippine Fiber Industry Development Authority (PhilFIDA) in Eastern Visayas, Philippines, and capture its significant predictors. Primary data was gathered from a cross-sectional survey of 263 abaca farmers using random sampling. The survey is in the form of face-to-face interviews to gather useful information with the aid of a developed semi-structured questionnaire. The data were analyzed using descriptive statistics and ordinal regression analysis. Results depicted that, on average, abaca farmers have no engagement (M=1.44; SD=0.85; M_d=1) with PhilFIDA. This implies that small-scale farmers are not collaborating with PhilFIDA in terms of their extension delivery system and project implementations for the development of the abaca fiber industry. The ordinal regression model revealed that being an owner (p-value=0.072) and the number of years in farming (p-value=0.088) are both significant predictors of farmers' level of engagement towards PhilFIDA. This means that a farmer who owns the land and has more experience is more likely to collaborate with PhilFIDA's agricultural projects and development programs. Moreover, the regression model showed that PhilFIDA's visit (p-value<0.001) and interaction with the Local Government Unit (LGU) (p-value<0.001) can increase the farmers' engagement towards PhilFIDA. This implies that communication and campaign to the PhilFIDA's development program can increase the abaca farmers' participation. Hence, the PhilFIDA and LGU must work together to reach out to small-scale farmers, especially in remote areas.

Key words: *Abaca farmers, Philippine Fiber Industry Development Authority, engagement level, ordered regression*

INTRODUCTION

One of the important agricultural resources in the Philippines is abaca (*Musa textilis Née*), considering its usefulness and economic measure which helps the gross domestic product (GDP) and national income in the country [8], [13]. In addition, abaca fiber can be transformed into a useful product in different forms which become a major contributor to the Philippine economy and a key player in the abaca trade globally through export activities [9], [10]. In Eastern Visayas, Philippines, abaca fiber is one of the leading sources of income, especially for the small-scale farmers in the region, and is considered the largest supplier [13] [14]. In that case, the Philippine government has focused on improving and widening the abaca fiber production in the different areas of the country through programs and organizations that support farmers in regard to agricultural information and inputs. Implementing agricultural programs is a way to enhance farmers' income and productivity, address food security in the country, promote sustainable economic growth, and alleviate poverty, among others [18], [19].

One of the organizations that is promoted by the Philippine government is the *Philippine Fiber Industry Development Authority* (PhilFIDA) which aims to advance the development and growth of the abaca fiber industry in the country by doing research and development [8]. Additionally, PhilFIDA also aims to support abaca production by introducing some innovative agricultural technologies, providing training and seminars to farmers, and implementing standards in trade regulation. With that, it is stated in [19] that PhilFIDA staff and extension agents must be trained and be educated to function well in their required tasks and obtain the development in the abaca production in the country. However, several issues impede the effective delivery of extension services of PhilFIDA in the country. In [17], it is depicted that not all of the abaca farmers are being supported by PhilFIDA due to some constraints which resulted in the existence of challenges in the production process in the Philippines. In fact, in [4], it is mentioned that there are a lot of problems in the abaca industry and there is only a small interaction between small-scale farmers and PhilFIDA. Among other problems, it includes inadequate human resources development programs, limited funding support for inputs, poor initiatives of agencies and institutions on agricultural development, and even a lack of social media as a means of providing extension services. Hence, to enhance government programs and agencies like PhilFIDA, it is necessary to investigate the perception of abaca farmers which gathers information to formulate useful arguments for improving the existing policies.

Apparently, the study about the abaca farmers' perception of the government agencies involving the fiber industry is scarce. In fact, there is no paper in the literature that deals with regression analysis in modeling the perception of abaca farmers towards the PhilFIDA functions. Henceforth, this research paper is realized. The general objective of this study is to describe the level of perception of abaca farmers towards the PhilFIDA functions and support and develop a statistical model that determines its predictors. Specifically, this paper sought the following research objectives: (1) to characterize the abaca farmers' profile (socio-demographic and economic); (2) to measure the level of abaca farmers' perception towards their interaction with PhilFIDA; (3) to develop a statistical model that determines the significant predictors of abaca farmers' perception towards PhilFIDA. The significance of this paper is to provide insights and suggestions that are useful in improving PhilFIDA's implementation of programs and projects. Additionally, the results of this research paper may stipulate how to improve the engagement of abaca farmers and PhilFIDA that leads to productivity and sustainability. Moreover, the findings of this study may be used as baseline information for many agricultural economists focusing on the abaca industry and contribute new knowledge in fiber stakeholders' literature.

MATERIALS AND METHODS

The Research Design

This research paper applied a quantitative survey in collecting data which is cross-sectional. In analyzing the information, the study employed some descriptive metrics and inferential statistics in analyzing multivariate correlation. Hence, this paper utilized a complex correlational research design to achieve the objectives, particularly in exploring causal relationships between dependent variables and independent variables using regression analysis.

The Participants and Sampling Method

Region VIII also known as Eastern Visayas is a place in the Philippines that has a wide area devoted to abaca production and is considered as largest supplier in the country [8]. Due to some problems in the production process, farmers' income, and agricultural support, the researchers decided to investigate the farmers' relationship to PhilFIDA as an organization that is responsible for enhancing their farm activities. Thus, the population of interest is the abaca farmers in the whole region of Eastern Visayas. In that case, the list of registered abaca farmers was asked in the Municipal Agriculture Office (MAO) in each town of Eastern Visayas. After securing the list of all abaca farmers with their farm area in hectares, a farmer with more than 2 hectares was excluded since the study only considered small-scale farmers. Due to constraints of time and researchers' resources, a simple random sampling technique was employed to ensure no bias in choosing a respondent, that is, every farmer has an equal chance of being selected as a participant in the survey. A Slovin's formula with a researcher's reasonable margin of error was used to determine the sample size needed. Hence, the study employed 263 small-scale abaca farmers as participants in the research survey.

The Research Instrument, Data Collection, and Ethics

In this study, the researchers have developed a structured questionnaire which was founded on the agricultural studies in the literature [6], [19]. The questionnaire has two sections such as (i) the profile of abaca farmers and (ii) the level of farmers' perception towards their engagement with PhilFIDA. In the first section, the abaca farmers were asked on the following profile: (1) age (number of years), (2) sex (male or female), (3) marital status (married or not married), (4) educational attainment (number of years), (5) other income aside from abaca farming (yes or no), (6) size of abaca farm (number of hectares), (7) tenurial status (owner or not owner), (8) farming experience (number of years), (9) visited by PhilFIDA? (yes or no), (10) abaca yield (kilogram per hectare), (11) distance from home to abaca farm (number of kilometers), and farmers' level of interaction (4-point rating scale: 1-No interaction, 2-Weak interaction, 3-Moderate interaction, 4-Strong interaction) to abaca stakeholders such as (12) State Universities and Colleges (SUCs) and (13) Local Government Unit (LGU).

As for the second section, the farmers were asked to rate their level of engagement with the abaca stakeholder PhilFIDA using a 4-point rating scale such as 1-No engagement, 2-Weak engagement, 3-Moderate engagement, 4-Strong engagement. In that case, Table 1 presents the possible perception scores and their verbal interpretation.

Table 1. Level of engagement perception scores.

Possible perception scores	Verbal description
1.00-1.75	No engagement
1.76-2.50	Weak engagement
2.51-3.25	Moderate engagement
3.26-4.00	Strong engagement

Source: [8].

To ensure that this research study is aligned with an ethical procedure, the researchers have secured consent letters from the higher authorities especially the officials of MAO in each town of Eastern Visayas. The content of the letter is to inform them of the purpose, procedures, and benefits of the research study.

Another letter was secured for the participants (abaca farmers) of the survey which informed them that their participation is safe and voluntary.

Additionally, anonymity and confidentiality were also guaranteed to the abaca farmers and no potential harm or sensitive words existed in the gathering of information.

Empirical Model and Data Analysis

To ensure statistically sound results, the data collected from abaca farmers has been subjected to clearing which involves the removal of missing data and outlier responses. After which, coding, which is converting from qualitative to quantitative was applied before encoding to Microsoft Excel. Additionally, necessary formatting was done for the data in Microsoft Excel so that it would be aligned for statistical calculations in STATA version 14.0 software.

In summarizing and giving a description of the data, descriptive measures were calculated and presented in a statistical table such as mean (M) average, median (M_d) average, standard deviation (SD), minimum and maximum values, and percentages (%). In addition, a bar graph was constructed to give a clear picture of comparing categorical responses.

To capture the statistical predictors of abaca farmers' perception of their engagement towards PhilFIDA, regression analysis was employed.

Now, since the farmers' perception as dependent variable is ordinal data, in particular, the ordered regression model was considered as an appropriate statistical method.

Hence, the empirical statistical model is presented as follows:

$$\begin{aligned} PPhilFIDA_j = b_0 &+ b_1 FAge_j + b_2 Male_j + b_3 Married_j \\ &+ b_4 Educ_j + b_5 OSincome_j + b_6 FarmS_j \\ &+ b_7 Owner_j + b_8 YFarming_j \\ &+ b_9 Yield_j + b_{10} Visit_j + b_{11} HomeDist_j \\ &+ b_{12} SUCs_j + b_{13} LGU_j \\ &+ \varepsilon_j \quad \ldots\ldots\ldots \ (1) \end{aligned}$$

where $PPhilFIDA_j$ is the ordinal dependent variable (0-No engagement, 1-Weak engagement, 2-Moderate engagement, 3-Strong engagement.), j is the j^th respondents where j$\in \{1, 2, \ldots, 349\}$, b_i represents to the parameters in the regression model (1) where i $\in \{0, 1, 2, \ldots, 13\}$, $FAge_j$ is the age of a farmer (in years), $Male_j$ refers to a indicator variable that captures a male farmer (dummy: 0-female, 1-male), $Married_j$ refers to a indicator variable that captures a farmer who is officially married (dummy: 0-non married, 1-married), $Educ_j$is the farmers' number of years in schooling, $OSincome_j$ refers to a indicator variable that captures a farmer who has other income (0-None, 1-With other income aside from abaca farming), $FarmS_j$ is the farmer's abaca farm area (in hectares), $Owner_j$ refers to a indicator variable that captures a farmer who owned their abaca farm (dummy: 0-non owner, 1-owner), $YFarming$ is the number of years in abaca farming, $Yield_j$ refers to the abaca yield (kilogram per hectare), $Visit_j$ refers to a indicator variable that captures a farmer that is visited by PhilFIDA personel (dummy: 0-not visited, 1-visited), $HomeDist_j$ is the number of kilometers from farmer's home to their abaca farm, $SUCs_j$ is the farmer's perception to their interaction to the SUCs (1-4 scoring), LGU_j is the farmer's perception to their interaction to the LGU (1-4 scoring), and $\varepsilon_j$is the remaining error term in the model (1). A variance inflation factor (VIF) was calculated to capture multicollinearity problems in the model and necessary corrections must be made if it exists [2]. All statistical inference results were subjected to hypothesis testing at standard alpha level or significance level (1% or 5%).

RESULTS AND DISCUSSIONS

Profile of Small-Scale Abaca Farmers

Table 2 presents the descriptive statistics computation for the socio-demographic and farm profile of small-scale abaca farmers. The youngest farmer is 24 years old and the oldest is 90 years old with an average age of 52.01 (SD=12.16). This mean age result is parallel to the findings in [8] and [18] that most of the farmers in the Philippines are around 50 years old. Most (72%) of the abaca farmers are male and there are only 28% of them are female. It is mentioned in [16] that farming is a masculine job in which male farmers are more productive and appropriate in their activities. About 79% of the abaca farmers are married and only 21% of them are non-married (single, widow, or widower, among others).

It is worth noting that most of the farmers are close to late middle age (M=52.01), hence, it is more likely that they are married and this is consistent with the findings of an existing study in [7]. The farmers' number of years spent in education is close to 7.6 (SD=3.36), which indicates that most of them are high school level and not able to finish a college degree. In [7], it is stated that what they have learned from their schooling is enough in their daily activities in farming which means that they don't need higher thinking skills to achieve in abaca production activities. Most (89%) of the farmers have other income aside from abaca farming and only 11% of them have no other income. Other income is necessary for their daily expenses particularly since abaca farming is not on a monthly basis for financial gain and this finding is consistent in [8]. The average abaca farm size of the small-scale farmers is close to 1 ha (SD=0.59 ha), and the smallest is 0.02 ha while the largest is 2 ha. About 86% of the farmers owned their abaca farm and only 14% of them did not own (e.g. tenant).

Approximately, the abaca farmers' average number of years in farming is close to 20.32 (SD=14.76) where the minimum is 1 year and the maximum is 70 years. In addition, the average yield of abaca farming is close to 307.68 kg/ha (SD=924.23 kg/ha) where the minimum is 5 kg/ha and the maximum is 2,000 kg/ha. About 48% of the small-scale farmers are visited by PhilFIDA to aid them in their farm activities and 52% of them have not visited so far. On average, the farmers' distance from home to their abaca farm is close to 6.85 km (SD=17.65 km) where the nearest is 0.05 km and the farthest is 250 km. Based on the perception score of abaca farmers, their interaction with SUCs (M=1.02;

SD=0.14) and LGU (M=1.17; SD=0.56) is weak. This implies that abaca farmers are not collaborating with other stakeholders in their farm activities and these results are consistent with the findings in [4], [19].

Table 2. Descriptive statistics for the profile of abaca farmers (n=263).

Independent variables	Descriptive statistics			
	Mean	*SD*	*Minimum*	*Maximum*
Age (in years)	52.01	12.16	24	90
Male (dummy variable)	0.72	0.47	0	1
Married (dummy variable)	0.79	0.40	0	1
Education (in years)	7.60	3.36	0	16
Other income (dummy variable)	0.89	0.32	0	1
Size of abaca farm (hectare)	1.00	0.59	0.02	2
Owner (dummy variable)	0.86	.39	0	1
Years in abaca farming	20.32	14.76	1	70
Yield per hectare (kilogram)	307.68	924.23	5	2,000
Visited by PhilFIDA personnel (dummy variable)	0.48	0.50	0	1
Distance of farm from home (kilometers)	6.85	17.65	0.05	250
SUCs rating (1-4 scaling)	1.02	0.14	1	2
LGU rating (1-4 scaling)	1.17	0.56	1	4

Source: Authors' own computation (2025).

Abaca Farmers' Level of Engagement towards PhilFIDA

Figure 1 shows the level of engagement of abaca farmers toward the PhilFIDA. It is revealed that most (73.88%) of the farmers have no engagement in PhilFIDA projects and agricultural activities. In [15], it is found that farmers with no involvement with agricultural extension services have lower productivity and profitability as opposed to farmers with engagement. About 13.06% of the farmers have a weak engagement towards PhilFIDA, 7.84% with moderate engagement and only 5.22% have a strong engagement. It is worth noting that a farmer that is influenced by extension services has a positive effect on their farming activities since they will adopt innovative technologies and can increase their agricultural knowledge and techniques [1], [3], [11].

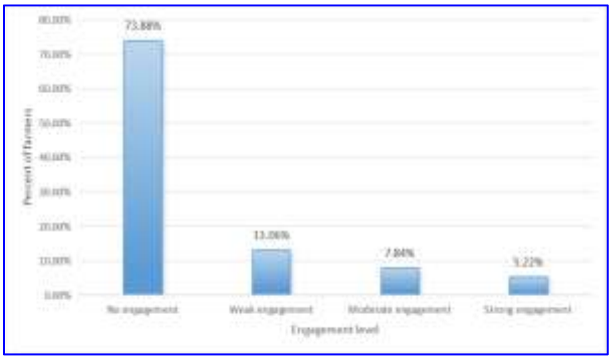

Fig. 1. Farmers' engagement level with PhilFIDA.
Source: Authors' construction (2025).

Table 3 depicted that the abaca farmers' engagement perception score is close to 1.44 (SD=0.85) and the median is 1 which can be interpreted that they have no engagement towards PhilFIDA on average. This implies that the PhilFIDA project management program must be advertised and needs additional personnel to reach small-scale farmers in remote areas. In [4], it is mentioned that PhilFIDA must increase its resources to support abaca farmers and conduct training and seminars to educate farmers on how to adopt new technologies and improve decision-making in farm production activities. In [5], it is depicted that PhilFIDA's responsibility is to promote the development and growth of the fiber industry in the country, hence, the government must support widening its implementation and reach out to more small-scale farmers, especially the remote areas in the Philippines.

Table 3. Perception score for farmers' engagement with PhilFIDA.

	Mean	*SD*	*Median*	*Interpretation**
Farmers' engagement with PhilFIDA	1.44	0.85	1.00	No engagement

Note: * - See Table 1 for details.
Source: Authors' own computation (2025).

Ordinal Regression Analysis

Table 4 presents the derived ordinal regression model with farmers' level of engagement as the dependent variable. The regression model (X^2=107.23) is highly significant at a 1% level with the number of observations of 263 (small-scale abaca farmers). The coefficient of determination is approximately 0.245 (Pseudo R^2) and the log-likelihood of the ordinal regression is -165.567 which indicates that the model has a better fit and it implies that there are some significant factors that affect the abaca farmers' level of engagement towards PhilFIDA. It is revealed that age (*p*-value=0.577), sex (*p*-value=0.287), marital status (*p*-value=0.559), educational attainment (*p*-value=0.146), other income (*p*-value=0.862), size of abaca farm (*p*-value=0.489), yield (kilogram) per hectare (*p*-value=0.287), distance from home to abaca farm (*p*-value=0.736), and farmers' rating towards their interaction to SUCs (*p*-value=0.124) are not significant predictors to the farmers' level of engagement towards PhilFIDA. This implies that the said variables do not influence their interaction with the PhilFIDA program activities and project implementations.

One of the significant predictors of farmers' level of engagement towards PhilFIDA is the tenurial status, in particular, a farmer is an owner (*p*-value=0.072) of an abaca farm is more likely to engage with the PhilFIDA development activities and production support and this is statistically evident at 10% level. This goes to infer that a farmer being an owner of an abaca farm is more confident to seek help from PhilFIDA and coordinate with them about the production process and activities. Moreover, on the side of PhilFIDA, they can easily reach out to the farmers who own the farm since the owner is more capable of deciding about the projects and technologies offered to them. In [17], it is mentioned that they reach the small-scale abaca farmers to improve their productivity and farming techniques through extension delivery systems. The years in farming (*p*-value=0.088) is a significant factor that influences the abaca farmers' level of engagement towards PhilFIDA. This means that a farmer with higher experience tends to be interacting with PhilFIDA in regard to their project implementations and extension services which implies that farmers are willing to be helped in their production process.

Table 4. Ordinal regression model for farmers' engagement with PhilFIDA.

Independent variables	Ordered logistic model (Dependent variable: Farmers' engagement)		
	Coefficient	***Standard Error***	***p-value***
Age (in years)	-0.0088^{ns}	0.0157	0.577
Male (dummy variable)	0.3878^{ns}	0.3644	0.287
Married (dummy variable)	-0.2476^{ns}	0.4238	0.559
Education (dummy variable)	0.0729^{ns}	0.0502	0.146
Other income (dummy variable)	-0.0864^{ns}	0.4971	0.862
Size of abaca farm (hectare)	0.2303^{ns}	0.3331	0.489
Owner (dummy variable)	0.8142*	0.4519	0.072
Years in abaca farming	0.0221*	0.0129	0.088
Yield per hectare (kilogram)	-0.0002^{ns}	0.0008	0.794
Visited by PhilFIDA personnel (dummy variable)	1.7098**	0.3771	<0.001
Distance of farm from home (kilometers)	-0.0070^{ns}	0.0208	0.736
SUCs rating (1-4 scaling)	1.2829^{ns}	0.8330	0.124
LGU rating (1-4 scaling)	1.8938**	0.3326	<0.001
Number of observation	263		
Chi-square (X^2) computed	107.23		
p-value (two-tailed test)	<0.001		
Pseudo R^2	0.245		
Log-likelihood	-165.567		

Note: **p<0.01; *p<0.1; ns - not significant.
Source: Authors' own computation (2025).

In [3], it is mentioned that farmers are more likely to apply agricultural technologies if they have more experience and knowledge in the farming system. In addition, farmers with enough years of experience have the ability to understand the advantages of interacting with the project implementation and innovative technologies brought by PhilFIDA. In addition, Table 4 revealed that the number of visits (*p*-value<0.001) by PhilFIDA personnel is a highly significant factor at a 1% level that affects the farmers' engagement level to the project implementations and extension support. This implies that a farmer being visited is more likely to engage the extension services, production support, and education and training provided by PhilFIDA as opposed to not being reached out. In [3] and [12], it is portrayed that if a farmer is educated and trained, they are more likely to adopt new techniques and innovative technologies as opposed to non-trained farmers. In fact, it is stated in [4] that PhilFIDA must strengthen its ability to communicate and collaborate with abaca farmers as main producers to improve its production process and attain sustainability. Furthermore, the ordinal regression model depicted that the abaca farmers' level of interaction with LGU (p-value<0.001) has influenced the level of engagement with PhilFIDA at a 1% level of significance. This implies that interacting with LGU programs and activities helps to connect to the growth and development brought by PhilFIDA. In [4], [8], and [19], it is depicted that LGU and PhilFIDA are working together to provide provisions in abaca farming to farmers for the development of the fiber industry in the country. Moreover, in [19], it is mentioned that LGU is the frontline of the extension delivery system and PhilFIDA is responsible for helping the abaca farmers improve their farming activities.

CONCLUSIONS

This research study aims to develop a statistical model that captures the significant factors affecting the small-scale abaca farmers' level of engagement towards PhilFIDA. Results revealed that the small-scale abaca farmers are considered as no engagement (on average) in the PhilFIDA project and program implementations in improving the fiber industry. In conclusion, PhilFIDA has not rigorously reached out to the small-scale farmers in the remote areas in Eastern Visayas, Philippines. Based on the regression model, an owner and more experienced abaca farmer is the one who collaborates with PhilFIDA in improving their production process in which they apply new agricultural techniques and technologies. Moreover, farmers who are visited by PhilFIDA and interact with LGU are the ones who engage PhilFIDA's projects and programs for the growth and development of the fiber industry. In that case, pro-active communication and a campaign for the abaca rehabilitation program should be initiated by PhilFIDA in the quest to increase the production of small-scale farmers and improve the harvest of quality fibers in Eastern Visayas. This activity should be a continuous process and it should also be dynamic enough to face changing conditions in the communities. Moreover, LGU personnel can provide extension support through the establishment of abaca demofarms and train their agricultural technicians on abaca production with the aid of PhilFIDA. The need for a more collaborative undertaking especially on studies related to varietal improvement, development of protocols for effective disease management, and mass production of quality planting materials, among others can be pursued. This can be done by developing a program proposal participated by SUCs and other stakeholders anchored on the innovation systems approach. SUCs as the powerhouse of innovation and technologies can assist the PhilFIDA in framing this innovative strategy. In future research, one may include the economics of happiness of abaca farmers in the statistical model to strengthen the current findings.

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THE IMPACT OF NATURAL GAS CONSUMPTION ON ENERGY SUSTAINABILITY AND THE SUSTAINABLE DEVELOPMENT OF THE AGRICULTURAL SECTOR

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Abstract

The analysis of natural gas consumption and its impact on energy sustainability and the sustainable development of the agricultural sector is an important topic, given the energy transition and challenges related to the security of resource supply. Natural gas is essential for energy production, industry and agriculture, and changes in its consumption directly influence production costs. This study aims to investigate the relationship between variations in gas consumption and sustainable agricultural growth, as well as to detect patterns in natural gas consumption within the European Union and analyze their effects on sustainability. The research's methodology is based on statistical analysis of data on natural gas consumption at the European level using a number of pertinent indicators, including the rates of domestic consumption growth and decline, the final consumption of energy generated from natural gas, the non-energy use of natural gas, and the availability of natural gas in European nations. The data was processed using comparative and correlative analytical tools to determine the effect of gas use on economic sustainability, which directly affects agriculture. The findings show that natural gas use has significantly decreased since 2019, accentuated in 2022, which generated increases in prices and energy costs for all categories of consumers, including agricultural farms. Also, the reduction in the amount of natural gas used in energy transformation processes indicates a decrease in dependence on energy generated from fossil fuels, but also the need for substantial investments to adopt viable alternatives, including in the case of agriculture. On the other hand, the decrease in non-energy consumption of natural gas has a direct impact on production, which has led to price increases, including agricultural inputs, and to economic pressures on businesses with limited financial resources, including agricultural farms. The study underlines the need for support policies, aimed at facilitating adaptation to the new energy conditions and ensuring a balanced transition towards sustainable and energy efficient production systems.

Key words: *natural gas, energy sustainability, sustainable development, transition*

INTRODUCTION

Since natural gas is inexpensive, efficient, and has a lower environmental impact than other fossil fuels like coal and oil, it is one of the most popular energy sources and plays a significant position in the global energy mix. Because they burn cleaner and emit less carbon dioxide, they are referred to as a "transition fuel" in the process of lowering greenhouse gas emissions.
[8, 12].

In order to generate power, supply industrial infrastructure, and meet domestic energy needs, the energy sector employs natural gas. Because it can offset the unpredictability of renewable energy sources like solar and wind, natural gas also plays a crucial role in maintaining the stability of the energy system, emphasizing the significance of striking a balance between present energy demands and long-term sustainability and emission reduction targets [1, 10]. This transition is essential to ensure sustainable economic development in a constantly changing global context [4, 9, 14].

Economically, natural gas is a more cost-effective and efficient alternative to other fossil energy sources, making it attractive to developing countries looking to expand their energy access. At the same time, international trade in natural gas, including pipelines and liquefied natural gas, has become an essential component of the global economy, facilitating trade and reducing the dependence of some states on local resources [7, 15].

Changes in the amount of natural gas used in energy transformation processes indicate a reduction in gas dependence for the production of electricity and heat, which has led to a reconfiguration of the energy mix of European states.

Analyzing the rise and fall rates of natural gas consumption in Europe is motivated by the need to comprehend how these trends affect energy sustainability and the sustainable growth of the agricultural sector, given that agriculture is an energy-intensive industry. Energy efficiency regulations and the shift to renewable energy sources are intimately linked to domestic natural gas use, which also reflects the overall dynamics of the energy market [3, 11]. This relationship is essential to agriculture, as natural gas is used both as an energy source for farms and as a raw material in the production of inputs.

Thus, changes in the domestic consumption of natural gas influence the costs of agricultural production and the ability of farmers to maintain productivity at an optimal level [2, 16].

Analysis of the final consumption of energy produced by natural gas is relevant for agriculture because this indicator provides insight into how gases are used to generate electricity and heat. These forms of energy are used in agricultural processes, from irrigation and heating greenhouses, to transporting and processing agricultural products. With the use of natural gas for energy production declining, agriculture needs to find other ways to meet its energy needs without sacrificing crop yields.

The non-energy use of natural gas is another essential aspect, having direct implications on the availability of chemical fertilizers. The declines in natural gas use in this category show the challenges the agricultural sector can face, including increases in production costs and reductions in the amount of fertilizers available on the market. This phenomenon can affect both food security and the long-term sustainability of agricultural production.

The analysis of the amount of natural gas used in energy transformation processes is important for evaluating the degree of efficiency in the use of this fuel in agricultural production. A shift toward alternative energy sources like biogas, solar, or wind energy could be indicated by the decline in usage in this sector [13]. In agriculture, this translates into the need to adapt to new market conditions and increase investments in sustainable energy infrastructure.

The total amount of natural gas available in Europe influences their accessibility for agriculture, and fluctuations in this indicator can have implications on the energy security of farms. A reduction in gas availability may lead to higher prices and the need for support policies for farmers to offset the economic impact of higher energy input prices.

Analyzing indicators related to natural gas consumption allows a better understanding of the interdependence between energy policies and the sustainability of agricultural production [5, 17]. This highlights the need for an integrated strategy that includes energy efficiency measures, diversification of energy sources and policies to support farmers in the transition to a more sustainable agricultural model.

In this context, this study researched the relationship between variations in gas consumption and sustainable agricultural growth, the patterns in natural gas consumption within the European Union and their effects on sustainability.

MATERIALS AND METHODS

The research is based on a quantitative and comparative analysis of the dynamics of natural gas consumption in Europe.

In order to identify the relevant trends and the effects they can have on agriculture, the methodology used combines the statistical analysis of the data available on Eurostat, with the correlative interpretation of the calculated indicators.

In the first stage, we selected the relevant indicators for this analysis, which included:

The growth/decrease rates of domestic natural gas consumption in Europe, used to identify general trends in natural gas use at national and regional level;

The rates of increase and decrease in the ultimate energy consumption generated by natural gas give an indication of how natural gas affects the generation of heat and electricity, as well as in agriculture;

The growth/decrease rates of final consumption – non-energy use of natural gas, relevant for the analysis of the impact on essential agricultural inputs;

Understanding the efficiency of converting natural gas into usable energy and the possibility of switching to renewable sources requires knowing the *rates at which the amount of natural gas used in energy transformation processes is increasing or decreasing*;

The growth/decrease rates of the total amount of natural gas available in Europe reflecting changes in gas supply and their impact on the energy market, including agriculture.

The research methodology was based on the collection and analysis of data from official sources (Eurostat).

The indicators were calculated using statistical analysis methods, comparing annual values and evaluating trends for the period 2014-2023.

To validate the results, a comparative analysis was carried out between European countries, highlighting the differences in adaptation and the alternative strategies adopted according to the energy specifics of each country.

This methodological approach allows a detailed understanding of how the consumption of natural gas influences energy sustainability and agriculture, being the basis for the formulation of recommendations regarding the transition to renewable sources and the optimization of resource consumption in the agricultural sector.

RESULTS AND DISCUSSIONS

Analyzing natural gas use and its effects on agricultural and energy sustainability becomes crucial for EU member states in light of the energy transition and global economic challenges. With a significant impact on industry, agriculture, and the generation of thermal and electrical energy, natural gas is a vital part of the European energy mix.

Studying the growth and decline rates of natural gas consumption allows for a detailed assessment of long-term trends, providing essential data for the formulation of effective strategies to adapt to changes in the energy market. This research contributes to the identification of optimal solutions for ensuring a balanced energy transition, minimizing the economic impact on agriculture and promoting sustainable development at European level.

Using the gross calorific value (GCV, or gross calorific value) and terajoules (TJ), an analysis of the internal consumption of natural gas for the years 2014–2023 reveals variations in natural gas consumption in Europe, influenced by the energy crisis, price increases and the transition to alternative sources. In 2022-2023, most countries recorded significant decreases (EU -12.9%, Euro Zone -12.11%, Finland -47.81%, Lithuania -31.7%), due to the reduction of imports from Russia, the energy saving process and the increase in the share of renewable energy. Countries such as Germany (-12.72% in 2022) and France (-9.58%) were less affected due to diversified imports important adjustments, and Finland and Norway, had increases in 2023 (+14.48% and +14.36%). The extreme fluctuations of some countries like Albania +78.27% in 2019, -28.46% in 2020, Greece +30.36% in 2016, -19.18% in 2022 are due to the impact of infrastructure development, but also economic adjustments.

Ukraine and Moldova have seen steady declines due to economic difficulties as a result of the war. In order to stabilize the energy market, strategic measures are needed, such as the diversification of supply sources through LNG and hydrogen, the efficiency of industrial and household consumption, massive investments in renewable energy and the reduction of dependence on fossil gases, i.e. solutions that will contribute to Europe's energy security in the current geopolitical context (Table 1).

Table 1. Growth/decrease rates of domestic natural gas consumption in European countries (TJ)

Country	2014/ 2015	2016/ 2015	2017/ 2016	2018/ 2017	2019/ 2018	2020/ 2019	2021/ 2020	2022/ 2021	2023/ 2022
GEO (Labels)									
European Union - 27 countries (from 2020)	4.45	5.86	5.65	-1.83	3.20	-2.42	4.07	-12.90	-7.31
Euro area – 20 countries (from 2023)	4.81	5.94	5.78	-2.19	3.88	-3.43	3.89	-12.11	-7.91
Albania	10.22	27.77	7.05	-13.68	78.27	-28.46	7.43	-13.85	3.79
Austria	6.82	4.84	7.37	-5.32	4.43	-4.67	5.63	-10.88	-14.45
Belgium	10.32	2.01	2.20	3.21	1.35	-0.56	0.46	-15.00	-5.70
Bosnia and Herzegovina	16.86	4.09	8.15	-0.34	-5.56	-8.78	20.51	-2.53	-9.81
Bulgaria	9.83	3.54	2.82	-5.43	-6.52	3.00	12.95	-18.15	-6.58
Croatia	3.09	4.26	14.87	-8.06	4.96	4.96	-3.80	-12.20	7.31
Czechia	4.86	8.23	2.63	-5.30	4.97	1.66	7.16	-18.66	-13.11
Denmark	2.35	2.61	-2.77	-0.98	-2.97	-10.94	-2.32	-18.10	-1.28
Estonia	-10.35	9.68	-5.21	2.34	-7.74	-7.99	13.83	-25.07	-12.32
Finland	-10.86	-7.90	-6.05	12.38	-2.07	-0.74	0.69	-47.81	14.48
France	7.51	9.30	0.57	-4.24	2.03	-6.83	6.50	-9.58	-11.19
Georgia	10.16	-5.99	5.33	-0.47	13.30	0.36	3.66	19.70	0.14
Germany	2.81	7.94	7.12	-2.37	2.81	-1.35	4.16	-12.72	-4.19
Greece	7.75	30.36	20.46	-2.06	9.04	9.78	10.55	-19.18	-9.78
Hungary	7.28	7.18	6.46	-3.14	2.31	3.54	6.05	-14.69	-10.90
Ireland	0.72	12.97	1.55	4.06	1.62	0.13	-4.30	2.12	-7.14
Italy	9.06	5.02	5.99	-3.28	2.44	-4.30	7.19	-10.03	-10.19
Latvia	1.55	1.36	-10.81	17.73	-5.62	-17.50	5.93	-28.24	-0.83
Liechtenstein	**	**	**	**	**	-3.59	11.54	-15.99	-7.40
Lithuania	0.14	-10.93	4.34	-7.58	4.99	5.76	-4.84	-31.70	-2.33
Luxembourg	-8.68	-7.73	-2.15	-1.41	-0.21	-8.88	7.63	-21.41	-6.26
Malta	**	**	**	21.18	4.53	3.93	0.27	1.15	4.45
Moldova	-3.98	2.66	-0.12	8.83	-7.60	1.91	14.33	-28.75	-18.51
Montenegro									
Netherlands	-1.69	4.92	3.75	-1.32	4.37	-1.74	-4.04	-22.12	-5.04
North Macedonia	0.73	57.23	28.61	-7.77	16.90	14.47	26.96	-32.63	26.51
Norway	8.23	-10.14	-10.56	10.62	-9.61	-8.80	10.38	-20.35	14.36
Poland	2.77	6.23	5.54	4.40	0.64	5.42	6.57	-17.45	4.75
Portugal	16.63	6.71	25.27	-7.26	5.20	-1.87	-4.42	-3.12	-20.70
Romania	-4.62	1.19	6.51	2.42	-6.81	4.53	2.70	-16.05	-6.12
Serbia	8.79	8.06	11.94	0.69	-6.50	-0.19	20.36	-3.31	-2.65
Slovakia	2.84	0.41	6.20	-1.44	0.22	0.05	11.32	-16.68	-4.80
Slovenia	6.12	6.13	4.76	-1.89	1.50	-0.01	5.39	-11.82	-3.53
Spain	3.91	2.01	9.25	-0.56	14.09	-9.61	5.33	-3.66	-10.94
Sweden	-8.87	13.08	12.39	8.81	-5.80	32.92	-17.15	-36.38	13.40
Türkiye	-2.04	-2.85	15.60	-7.27	-9.69	7.21	23.68	-14.56	-1.34
Ukraine	-22.02	-1.85	-4.09	4.48	-8.85	1.97	-2.65	**	**
United Kingdom	3.35	11.82	-2.50	1.26	-1.75	**	**	**	**

Source: own processing [6].

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Table 2 analyzes the final energy consumption, i.e. the actual use of natural gas by consumers (industry, residential sector, transport, etc.). Final energy consumption in European countries has been influenced by economic factors, global crises and energy policies.

Table 2. Growth/decrease rates of final energy consumption produced by natural gas in European countries (TJ)

Country	2014/ 2015	2016/ 2015	2017/ 2016	2018/ 2017	2019/ 2018	2020/ 2019	2021/ 2020	2022/ 2021	2023/ 2022
European Union – 27 countries (from 2020)	3.66	4.05	0.78	-0.06	-1.30	-2.45	10.14	-14.15	-6.68
Euro area – 20 countries (from 2023)	3.84	4.08	0.43	0.14	-1.34	-3.03	9.97	-14.16	-6.60
Albania	-6.39	20.82	15.88	-1.71	-0.4	1.83	19.36	-18.76	9.78
Austria	6.05	3.26	-0.78	-0.84	-3.31	-4.37	7.65	-19.12	-8.15
Belgium	7.24	4.11	1.58	0.7	-0.6	-4.14	11.83	-18.08	-2.39
Bosnia and Herzegovina	0.22	-1.33	8.82	-9.62	8.29	-14.05	6.96	-6.28	-9.03
Bulgaria	10.26	0.07	4.01	-3.77	-11.91	1.34	13.31	-15.65	-8.43
Croatia	4.16	5.46	4.93	-0.5	1.73	0.5	5.73	-9.89	-3.08
Czechia	4.52	5.17	4.65	-6.57	0.41	-0.56	6.66	-14.28	-10.81
Denmark	3.94	1.54	4.47	-1.65	-1.63	-0.02	5.76	-19.05	-1.1
Estonia	-0.63	13.49	-6.63	7.39	-2.63	1.07	6.23	-32.35	-9.79
Finland	0.46	3.2	7.42	-3.69	-3.15	-5.37	11.29	-9.34	-8.04
France	2.61	4.9	-2.66	-1.25	-2.49	-6.25	8.99	-14.51	-8.43
Georgia	1.75	6.42	2.56	13.39	-3.4	3.97	21.22	-25.49	-18.85
Germany	3.95	6.32	0.68	0.81	-1.56	-0.57	9.77	-13	-6.52
Greece	16.09	8.12	-19.18	-4.14	10.47	22.46	7.23	0.42	-9.14
Hungary	4.81	5.12	-1.51	-0.02	-0.01	-9.46	7.65	-21.24	-4.04
Ireland	6	4.44	1.53	7.74	0.57	-0.7	-0.6	-7.13	-8.04
Italy	6.73	0.77	2.06	-0.86	-1.74	-3.74	15.02	-13.7	-6.66
Liechtenstein	7.52	-18.98	6.98	-5.63	2.21	-0.87	-2.68	-16.01	-18.88
Lithuania	-3.1	1.49	2.1	5.02	-6.06	-0.21	8.88	-15.37	-6.66
Luxembourg	-0.59	6.23	3.37	4.76	-2.15	-0.22	11.18	-9.59	-2.28
Malta	5.82	4.66	3.06	-2.44	-1.59	3.8	6.93	-14.61	-13.12
Moldova	18.63	3.08	9.68	-0.65	-5.46	-10.57	25.96	-1.16	-11.61
Montenegro	3.59	2.81	-1.95	4.4	-0.9	**	**	**	**
Poland	4.15	3.66	1.23	-2.74	2.72	-1.97	5.47	-11.71	-11.39
Portugal	1.7	8.67	-0.61	0.73	0.55	-1.13	17.03	-10.34	-2.47
Romania	4.33	1.29	6.44	3.19	0.66	-6.74	10.59	-9.38	-3.02
Serbia	7.16	0.15	8.9	-0.96	8.96	3.85	12.74	13.75	-0.34
Slovakia	7.7	7.25	1.99	-2.09	-0.98	-2.15	6.49	-9.99	-5.78
Slovenia	-3.05	-1.8	6.08	3.22	-2.25	3.92	12.04	-17.88	-7.04
Spain	-4.6	3.41	1.3	4.33	1.61	-3.53	6.16	-14.78	-2.85
Sweden	-8.15	-2.22	10.27	-5.43	12.94	-0.94	9.76	-19.77	-11.01
Türkiye	63.21	-10.05	24.56	-40.96	-12.2	-0.02	0	-8.94	92.16
Ukraine	10.1	6.27	19.31	10.04	-11.82	-7.58	29.09	3.76	-6.09

Source: own processing [6].

In the period 2014-2019, a moderate increase in final energy consumption is observed, with annual rates between 3% and 4% in the EU-27 and the Eurozone, driven by economic growth and industrial development. The COVID-19 pandemic of 2020 caused financial hardships and a decrease in transportation and industry, which in turn led to a drop in consumption (-2.45% in the EU-27 and -3.03% in the Eurozone). Due to the recovery of economic activity and the demand for energy, the return in 2021 was +10.14% in the EU-27 and +9.97% in the Eurozone. Rising energy prices, the energy crisis caused by the conflict in Ukraine, and EU-mandated energy efficiency standards all played a part in the reduction in consumption in 2022.(-14.15% in the EU-27 and -14.16% in the Eurozone). Consumption declined by -6.68% in the EU-27 in 2023, confirming the trend of energy demand adjustment. The countries with the largest fluctuations were Estonia (-32.35% in 2022), affected by the decline in industrial activity, and Türkiye (+92.16% in 2023), where the increase in consumption was due to changes in energy supply Germany, France and Italy recorded moderate decreases, as a result of their ability to manage the energy crisis more effectively.

Table 3. Growth/decrease rates of final consumption - non-energy uses of natural gas in European countries (TJ)

Country	2014/ 2015	2016/ 2015	2017/ 2016	2018/ 2017	2019/ 2018	2020/ 2019	2021/ 2020	2022/ 2021
European Union - 27 countries (from 2020)	-4.26	10.49	-2.32	7.93	-3.06	-1.36	-4.39	-1.61
Euro area – 20 countries (from 2023)	-1.78	9.70	-0.52	9.14	-6.76	-0.15	-6.90	0.90
Austria	-13.72	17.87	-11.16	4.71	-6.05	6.98	0.51	-1.68
Belgium	14.63	15.52	-0.94	14.43	12.42	-11.39	-0.39	2.08
Bosnia and Herzegovina	6.07	12.38	-10.5	0.58	-5.11	-12.65	-17.12	8.28
Bulgaria	23.59	-3.47	-25.21	-27.81	-0.98	7.62	6.56	-7.59
Croatia	-1.02	7.93	-13.5	-6.64	-4.62	-33.13	-36.22	114.06
Czechia	1.48	-11.51	0.44	-11.12	-2.09	-13.56	-15.37	-14.7
Finland	34.48	12.52	17.11	31.77	7.05	4.63	12	-7.82
France	5.34	0.1	-5.1	-5.01	-10.53	2.14	-8.62	-2.37
Germany	-6.16	-1.56	16.47	14.66	-17.01	1.3	-15.93	1.67
Greece	-0.1	177.85	19.29	231.44	-12.36	-18.81	-28.85	453.5
Italy	12.39	0.45	-6.02	-5.59	1.61	1.61	3.26	-16.81
Liechtenstein	7.66	256.91	1.25	261.36	10.62	-4.43	5.72	4.1
Luxembourg	7.82	18.4	-13.84	2.02	-5.54	-12.8	-17.63	-1.1
Malta	-10.22	14.31	-12.49	0.04	10.75	-2.53	7.95	41.09
Montenegro	-3	-3	-3	-5.91	**	**	**	**
Poland	-3.61	-2.86	-16.46	-18.85	-4.64	-2.75	-7.26	4.26
Portugal	2.83	3.37	-8.26	-5.17	9.66	-4.6	4.61	-20.04
Serbia	5.17	12.47	10.95	24.79	0.31	-8.66	-8.38	-3.83
Slovakia	12.5	-0.89	5.17	4.24	-6	9.81	3.22	-16.66
Slovenia	-59.47	24.35	7.57	33.77	18.18	-12.69	3.18	-20.38
Spain	-10.02	-1.79	6.09	4.19	-4.61	34.58	28.38	6.02
Sweden	-10.29	11.31	18.6	32.01	-7.47	182.5	161.39	-12.98
Ukraine	38	2.48	-34.05	-32.42	10.87	-29.09	-21.38	**

Source: own processing [6]

In the long term, these fluctuations in energy consumption will have effects on the European economy, industry and energy policies. The decreases in natural gas consumption are due to investments in renewable sources and energy efficiency measures to reduce dependence on gas imports. High energy costs and imposed austerity measures can have a social impact, changing consumer behavior, even generating economic tensions. These changes are the result of the transition to more efficient energy consumption, but also of the major challenges that the European economy was facing.

The data on the rates of increase/decrease in final consumption for the non-energy use of natural gas, i.e. their use for purposes that do not involve the direct production of energy, are missing for some European countries, due to their non-publication (Table 3).

However, it emphasizes how natural gas use has varied over the examined period, impacted by world events, energy policy, and economic considerations. In the EU-27, consumption increased by 10.49% in 2016 and 7.93% in 2018. Starting with 2019, the decreases were 3.06%, 1.36%, 4.39% and 1.61%. The Eurozone had a similar evolution, with increases in 2016 (+9.70%) and 2018 (+9.14%), and decreases in 2019 (-6.76%) and 2020 (-0.15%). This dynamic reflects the impact of the energy transition, the pandemic and the instability of the gas market. Some countries recorded high growth, such as Belgium (+15.52% in 2016), Finland (+31.77% in 2018) and Slovenia (+33.77% in 2018), driven by increased industrial demand. In 2021, some states saw a recovery in consumption, with high values in Sweden (+161.39%) and Croatia (+114.06%), due to the post-pandemic economic recovery.

In contrast, Germany recorded decreases (-17.01% in 2019, -15.93% in 2021), along with the Czech Republic (-15.37% in 2021), Poland (-7.26% in 2021) and Italy (-16.81% in 2021), driven by reduced industrial activity and stricter energy efficiency measures.

There are also extreme cases, such as Greece, where consumption increased exponentially (+177.85% in 2016, +231.44% in 2018, +453.50% in 2021) or Liechtenstein (+256.91% in 2016, +261.36% in 2018) as a result of the development of the gas infrastructure (Table 4).

In the long run, these fluctuations have significant economic and political implications. The European Union has stepped up its efforts to reduce dependence on fossil fuels, which explains the steady declines in many states. The evolution of gas consumption indicates a general trend of energy efficiency and transition to renewable sources, but in certain regions natural gas remains an essential strategic resource. However, it should be highlighted that these decreases in consumption directly influenced all industrial production sectors, including those related to agricultural inputs that turned into higher costs that influenced the entire production and marketing chain.

Economic variables, energy policy, and world events all influence the evolution of natural gas usage in Europe's energy transition processes.. At the level of the European Union (EU-27), consumption increased between 2014 and 2017 (+8.15% in 2015, +13.48% in 2016, +10.31% in 2017). Starting with 2018 and until 2023 this consumption started to decrease after (-5.66% in 2018) and (-11.07% in 2023). In the Eurozone, the trends were similar, with a sharp increase between 2015 and 2017 (+7.95%, +14.10%, +11.08%) and a gradual decrease from 2018 (-6.83%) to 2023 (-12.96%).

These declines are correlated with the energy transition towards renewable sources, energy efficiency policies and reducing dependence on fossil fuels. Certain countries registered increases: France (+45.47% in 2015, +45.31% in 2016), Romania (+30.49% in 2015, +36.94% in 2017) and Spain (+42.12% in 2018), as a result of the intensification of the use of natural gas for the production of electricity, but also the increase in industrial demand.

Germany, one of the largest gas consumers in Europe, recorded an increase of 23.56% in 2016 and 5.19% in 2017), followed by decreases of 5.53% in 2019, 11.95% in 2022, as a result of the transition to energy alternatives.

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Table 4. Growth/decrease rates of the amount of natural gas used in energy transformation processes (TJ)

Country	2014/ 2015	2016/ 2015	2017/ 2016	2018/ 2017	2019/ 2018	2020/ 2019	2021/ 2020	2022/ 2021	2023/ 2022
Euro area – 20 countries (from 2023)	7.95	14.10	11.08	-6.83	13.16	-2.65	-2.89	-3.19	-12.96
European Union - 27 countries (from 2020)	8.15	13.48	10.31	-5.66	11.73	-1.90	-2.17	-5.15	-11.07
Albania	3.39	0.20	5.53	0.69	1.13	5.62	23.21	1.19	3.37
Austria	-12.13	11.36	7.58	-3.14	18.65	0.53	-20.55	-14.77	-3.15
Belgium	13.22	-1.01	-0.34	5.21	2.50	5.65	-16.87	-0.77	-19.95
Bosnia and Herzegovina	12.42	7.00	4.05	-0.13	-5.61	-5.58	8.22	-6.57	-3.99
Bulgaria	3.70	8.13	2.88	-4.41	2.26	1.38	16.29	-18.63	-5.59
Croatia	6.43	16.51	39.21	-17.79	4.10	19.63	-6.25	8.63	11.16
Czechia	8.05	25.14	-3.22	-0.53	21.63	10.60	10.16	-31.75	-11.01
Denmark	-1.88	10.49	-13.77	0.04	-9.91	-29.79	5.99	-36.95	13.26
Estonia	-20.70	-8.27	10.86	-11.91	-15.93	-23.40	22.91	-1.54	-17.16
Finland	4.05	-4.84	1.87	-3.02	23.36	13.34	14.92	-33.20	3.35
France	45.47	45.31	11.58	-20.80	24.42	-8.50	-3.54	19.51	-23.56
Georgia	13.72	-19.60	1.63	-5.41	38.07	-9.22	-19.39	51.85	1.35
Germany	0.89	23.56	5.19	-5.53	6.56	4.87	1.93	-11.95	1.03
Greece	2.79	69.59	27.71	-5.58	11.97	5.98	16.69	-15.41	-15.96
Hungary	-37.10	-52.86	-7.13	-12.95	-2.11	-3.23	7.09	-23.18	-26.54
Ireland	-4.23	23.43	3.04	1.32	2.54	1.75	-9.02	9.90	-6.56
Italy	14.20	11.66	10.99	-7.32	8.78	-4.77	-1.02	-4.06	-15.40
Liechtenstein	4.67	37.22	-56.22	37.99	-26.51	-66.97	220.60	-45.22	40.04
Lithuania	5.04	1.52	-16.38	24.32	-6.04	-24.82	4.41	-36.27	2.65
Luxembourg	-13.18	-26.48	-20.22	-10.43	-15.84	54.05	-1.27	-50.98	-1.00
Malta	11.60	9.09	11.55	-4.82	9.23	3.89	3.94	-9.73	-13.43
Moldova	-7.65	1.12	-2.85	5.92	-9.75	0.77	5.76	-34.88	-17.51
Netherlands	**	**	**	26.22	4.52	4.10	-0.15	1.59	4.45
North Macedonia	3.68	72.04	32.28	-9.38	21.12	17.43	28.47	-35.18	29.71
Norway	-1.03	1.02	-2.73	3.04	-8.59	-24.73	-57.78	75.43	15.47
Poland	25.19	9.67	24.12	-10.90	5.50	-9.24	6.57	-7.73	-24.71
Portugal	16.06	9.80	13.30	18.12	8.71	11.09	-3.30	-23.83	34.04
Romania	30.49	12.26	36.94	-13.67	8.47	-0.09	-11.77	0.29	-32.37
Serbia	-13.87	-10.01	17.51	-17.31	-32.35	18.76	50.18	-30.73	-7.11
Slovakia	-2.14	2.45	21.24	-1.21	13.85	9.56	1.14	-15.76	13.57
Slovenia	10.73	-0.21	8.44	2.14	-15.95	4.61	-1.70	-6.70	0.50
Spain	18.67	-2.11	22.79	-9.57	42.12	-16.43	2.77	24.28	-24.43
Sweden	-10.54	-6.51	-12.10	19.83	-9.60	0.95	-3.18	-65.49	43.64
Türkiye	-15.94	-2.23	-5.41	10.37	-6.11	11.06	**	**	**
United Kingdom	-0.81	35.67	-4.18	-3.63	-1.50	**	**	**	**

Source: own processing [6].

The general trends indicate an increase in the consumption of natural gas until 2017, followed by a period of stagnation and decrease starting in 2018, against the background of the energy transition and the increase in the use of renewable sources. Starting from 2020, a decrease is observed in many European states, due to the instability of the gas market. In the long term, this evolution indicates a decreasing dependence

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on natural gas in energy production, but with variations depending on the adopted energy strategy.

Table 5. Growth/decrease rates of the total amount of natural gas available in European countries (TJ)

County	2014/ 2015	2016/ 2015	2017/ 2016	2018/ 2017	2019/ 2018	2020/ 2019	2021/ 2020	2022/ 2021	2023/ 2022
European Union - 27 countries (from 2020)	0.54	-3.01	8.31	6.85	1.37	-3.58	-8.01	-35.70	17.33
Euro area – 20 countries (from 2023)	1.77	-3.70	6.22	12.59	-0.10	-2.13	-9.36	-41.39	17.45
Albania	-9.92	53.81	0.00	0.00	105.05	-32.06	8.81	-14.69	-12.38
Austria	-29.36	-6.87	4.80	18.14	0.25	-14.26	13.76	-22.54	-2.49
Belgium	12.07	-7.07	15.31	55.76	30.11	-5.23	-22.64	-35.44	30.84
Bulgaria	83.99	-27.07	10.22	40.38	-2.42	-1.63	9.83	-61.91	7.56
Croatia	-2.77	-10.95	9.41	3.67	3.66	-3.35	-2.68	-10.71	22.88
Czechia	0.30	-16.00	19.75	-7.91	11.96	-15.82	-1.28	15.28	-0.04
Denmark	4.60	-8.92	3.81	-7.82	-5.84	-32.01	13.03	-1.46	-10.16
Estonia	-18.40	421.28	-82.86	253.32	-14.01	-35.56	127.75	-85.26	-37.43
Finland	-20.35	-29.06	-7.10	8.41	13.65	-12.38	-17.93	-75.51	163.90
France	4.10	-9.64	-1.94	20.14	5.80	-5.26	-1.45	-31.59	-2.24
Germany	5.41	-10.49	9.32	13.29	-5.92	21.48	-21.43	-46.85	8.36
Greece	-14.22	17.83	360.15	31.55	20.25	133.32	-13.09	-81.67	189.47
Hungary	-14.13	59.12	23.14	-4.91	1.54	2.76	2.23	-10.17	-1.22
Italy	-6.00	5.14	20.26	11.74	-3.17	-4.88	-20.87	-22.19	4.98
Latvia	-17.72	-25.63	-13.38	18.24	9.63	-13.51	6.82	-28.83	55.69
Lithuania	430.15	-15.05	-29.88	0.70	261.16	35.98	-43.50	-45.96	-34.00
Moldova	**	**	**	-66.67	0.00	200.00	163.33	-68.99	161.22
Netherlands	-1.27	-12.29	1.96	10.20	-3.63	-1.95	-9.41	-42.33	-1.69
Norway	3.37	-1.60	2.27	-6.05	1.09	-3.31	-6.12	-5.01	-2.27
Poland	4.43	-12.06	36.44	-14.72	20.80	3.07	-8.38	-24.01	28.58
Portugal	-9.76	-30.66	20.75	-10.21	-0.30	-7.99	4.22	-33.86	32.87
Romania	-25.09	30.89	-18.68	-9.35	-13.97	-31.58	-19.38	9.43	20.85
Serbia	14.25	-13.70	12.15	-2.77	6.65	7.84	6.18	-10.25	-19.95
Slovakia	-32.92	24.82	-10.20	3.15	-7.90	-23.26	-7.02	12.12	-4.35
Slovenia	0.00	-83.69	62.05	3.95	7.82	-17.49	-23.08	11.43	-35.89
Spain	16.59	9.08	1.05	5.86	-5.13	-16.81	11.54	-51.62	45.37
Sweden	-78.29	45.64	204.23	82.75	-16.69	-4.66	195.76	-22.58	50.20
Türkiye	37.28	-0.53	15.09	-15.77	14.82	-15.25	16.01	-21.46	-2.96
Ukraine	-5.13	-1.66	7.82	-1.30	-25.08	-0.88	**	**	**
United Kingdom	11.41	-1.45	0.48	1.57	6.09	**	**	**	**

Source: own processing [6]

Although the data on the total quantities of natural gas available in the countries of Europe have not been published for quite a large number of countries, it can be seen that at the EU-27 level there was an increase of 8.31% in 2016 and 6.85% in 2017 (Table 5). Although in the following period there were stagnations and sharper decreases in 2022 a severe contraction was observed (-35.70%). The Eurozone followed a similar pattern, but some countries experienced extreme fluctuations (Estonia, Lithuania or Greece). Countries such as Germany and France faced the strong effects of the energy crisis, while Sweden had high volatility in gas consumption. Volatility in this sector remains high, reflecting a difficult transition to more sustainable energy sources and a reconfiguration of the gas market in Europe.

CONCLUSIONS

Natural gas is utilized in the framework of energy sustainability to produce heat and power, and it is crucial for the effectiveness of agricultural and industrial systems.

Reducing natural gas consumption in energy production processes has led to a decrease in greenhouse gas emissions, but has also imposed significant challenges for industries dependent on this fuel, including agriculture.

This study provides essential information for policy makers, energy companies and investors, helping to identify trends in gas consumption and anticipate future developments.

In the context of the energy transition, data shows that many states have begun to reduce dependence on natural gas, accelerating investments in renewables and energy efficiency.

As Europe accelerates its energy transition, the agricultural sector must adapt to new market conditions by investing in more efficient technologies and diversifying energy sources. Support policies for farmers and energy efficiency measures will play a key role in ensuring sustainable agricultural production, while reducing dependence on natural gas and contributing to carbon reduction targets.

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STUDY ON THE PERCEPTION OF ROMANIAN CONSUMERS REGARDING FOOD WASTE

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Abstract

In accordance with the objectives of the European Union, Romania, along with the other member states, must take measures to reduce food waste in the coming period. This phenomenon represents a major problem for our country, which involves consumer education, prevention campaigns and legislative measures. In this context, within the project "Research on agro-food waste, its causes and ways to prevent it in Romanian households", ReWaFA, a study was carried out that investigates the perception of Romanian consumers on food waste, their behavior and prevention measures. The data was collected through an online questionnaire, through Google Forms, distributed between January 29 and March 5, 2024 to 260 respondents. The analysis was performed using SPSS, applying the relative frequency method for data interpretation. The results showed that young people, between 18 and 24 years old, from urban areas, with higher education, have information about food waste and its implications, but do not always have the necessary levers to manage the food surplus. Because many continue to throw away food, especially cooked food and bakery products, respondents proposed as solutions to combat food waste: the distribution of informative materials, partnerships with schools for early education and the holding of events on this theme.

Key words: *consumer perception, food waste, food purchasing habits, waste reduction measures*

INTRODUCTION

Food waste is a widespread issue worldwide, posing a significant challenge for everyone involved in the agri-food sector [10]. Nearly 40% of all food produced goes uneaten [5, 12] due to factors such as storage and transportation conditions [5]. Additionally, approximately one-third of global food production is either lost or discarded throughout the supply chain. This phenomenon generates major environmental, social and economic effects [10], contributing to increased greenhouse gas emissions and considerable financial losses [12].

Simultaneously, it should not be forgotten that food waste, together with the high consumption of meat and dairy products, currently exerts a significant influence on food systems [17].

In recent years, reducing food waste losses and quantities has been perceived as an effective strategy for lowering production costs and increasing food quality [11]. At the same time, bibliometric studies on this topic have highlighted the importance of continuing to maintain interdisciplinary and international collaboration in order to effectively manage the complexity of food waste challenges [16].

In Romania, food waste results from a combination of factors, including consumer habits, business strategies, supply chain inefficiencies, and strict quality standards. Issues such as incorrect labeling, misunderstandings regarding expiration dates, poor storage conditions, oversized portions, and frequently changing menus further exacerbate the problem [13].

To address this challenge, several initiatives have already been introduced, beginning with

Law no. 217/2016, subsequently amended by Law no. 49/2024. Thus, the donation of surplus food was legislated by simplifying donation contracts and clarifying the types of economic operators that can redistribute food. According to the same law, donated food is exempt from VAT if it is redistributed at least 10 days before the expiration of the validity period [6]. A key development in 2024 was the requirement for all businesses within the agri-food sector to adopt strategies aimed at reducing food waste [14].

Additionally, the Ministry of Agriculture and Rural Development (MADR), in partnership with the Ministry of Education, launched awareness and education campaigns to inform students about the environmental, social, and economic consequences of food waste [6, 9].

At the same time, international projects carried out by the Food and Agriculture Organisation of the United Nations (FAO) will be translated and implemented in schools to educate young people [8].

Based on online data from Barilla Center for Food & Nutrition platform, Romania achieved a Food Sustainability Index score of 64.40 [2, 3]. This score represents the average performance across three key categories: sustainable agriculture (68.00), food loss and waste (67.70), and nutritional challenges (57.40). It reflects an average level of sustainability. The best result was obtained by France, 76.10.

The article is based on the study undertaken to examine the perception of Romanian consumers on food waste, analyzing both attitudes and level of awareness, as well as specific behaviors related to the purchase, consumption and management of food. The research also investigated the prevention measures that consumers are willing to implement to reduce food waste, highlighting the factors that influence these decisions, such as education, access to information and daily habits.

MATERIALS AND METHODS

The authors conducted an analysis of the literature to understand the context and factors influencing food waste. The bibliographic study included scientific articles, government reports and statistical data, providing a broad perspective on trends at national and international level. This step allowed the correlation of the results obtained by the questionnaire with the conclusions of other researches, contributing to the validation of the data.

Study Design

Within the Project "Research on agro-food waste, its causes and ways to prevent it in Romanian households", ReWaFA, the project team was also interested in finding out what is the consumers' perception of food waste. For this purpose, an online questionnaire was compiled, through Google forms, with voluntary self-administration, which included 24 items, predominantly closed items, with the following exceptions: Question(Q) 4, Q9, Q10, Q11, Q20, Q22 and Q24.

The questions and answers were grouped into the following categories:

Q1-Q6 - general information about respondents (gender, age category, area, county, studies and monthly income),

Q7, Q8 - knowledge of the topic of the questionnaire,

Q9-Q13 - shopping cart,

Q14, Q15 - food preparation,

Q16-Q19 - information on wasted food,

Q20-Q24 - measures to reduce food waste.

The questionnaire was distributed electronically to potential respondents, between 29.01.2024 and 05.03.2024, by e-mail (without collecting e-mail addresses) and on WhatsApp, to subjects from the academic and entrepreneurial environment, both in urban and rural areas. The participants were informed about the objective of the study and the data protection measures according to the GDPR regulations.

A total of 260 responses were received and the collected data were analysed using the SPSS (Statistical Package for Social Sciences), using the relative frequency of the examined indicators, as a processing method.

Study Participants

Figures 1-3 graphically represent data related to the questionnaire respondents, which were extracted from the “General information about respondents” category, Q1-Q6:

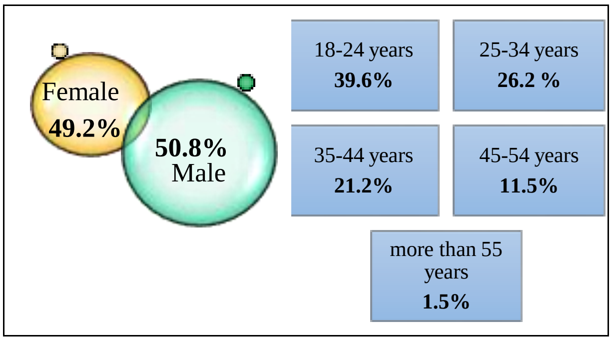

Fig. 1. Gender of respondents and age category (%)
Source: own processing of questionnaire information.

As can be seen from Figure 1, men and women answered the questionnaire in approximately equal proportions (Q1), and the age category in which most of the respondents were included was "18-24 years old", 39.6%. At the opposite pole was the "over 55 years" category, with only 1.5% (Q2).

60.4% of the respondents came from urban areas and the rest from rural areas (Q3), and the counties of residence (Q4) are shown in Figure 2. Most of the people interviewed were from Calarasi County and Bucharest – 57 responses each. It should be noted that out of the 260 answers received, to the question regarding the county of residence, 259 answers were correct, i.e. they clearly specified the county, and 1 answer was incomplete.

Fig. 2. Area (%) and counties to which the respondents belong
Source: own processing of questionnaire information.

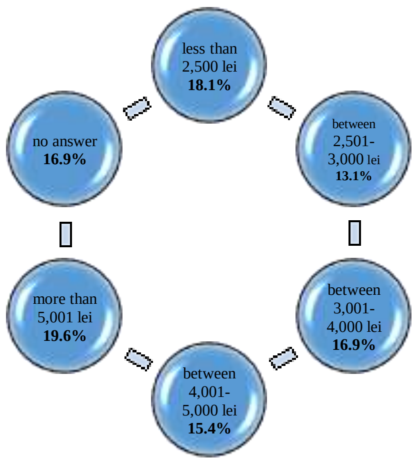

Fig. 3. Categories of respondents' monthly income (%)
Source: own processing of questionnaire information.

The answers received in terms of income (Q5) were relatively balanced for all six options, but two stood out: "more than 5,001 lei/month" – 19.6% and the opposite, "less than 2,500 lei/month" – 18.1%, Figure 3.

The respondents' studies (Q6) framed into the "bachelor's level" category - for 90.8% of them, the remaining 9.2% ticking the "higher education - master's level" category.

It is known that gender, age, residence, level of education and income significantly influence various aspects of the social and economic life of individuals, affecting access to education, employment opportunities, determining income and social status, access to resources and opportunities and, finally, quality of life. Therefore, using the answers received from the questionnaire, the authors set out to track how these factors leave their mark on food waste.

RESULTS AND DISCUSSIONS

In the European Union, it is estimated that 59 million tons of food waste are produced, i.e. around 131 kg/person. Households are responsible for the majority of this waste, accounting for 53% of the total [7]. Estimates suggest that Romania ranks ninth among the countries with the highest levels of food waste [1]. Although awareness campaigns have taken place, in Romania these initiatives remain limited compared to those in other European countries [4].

Therefore, the questions in the *category "knowledge of the topic of the questionnaire"* highlighted the fact that even among our respondents the term food waste (Q7) is known in proportion of 96.5%, and 43.1% of them are "very interested" in avoiding this phenomenon, respectively "quite interested" – 49.2%, the rest being not at all interested (3.1%) or indifferent (4.6%) – Q8.

"Shopping cart" category

Answers to the question "Do you usually get your food through..." (Q9), a multiple-choice question, shows a predominant trend towards the option "Do you or another member of the family cook?". This choice reflects a common eating behavior in many societies, especially in environments where the culture of cooking at home is well rooted, either for economic reasons or out of a desire to control the quality and health of food. Cooking at home is associated with achieving healthier meals, prepared according to the taste and needs of each family, and is often viewed as a social or traditional activity within the family. The "Order food" and "Go to a restaurant" options mentioned quite often, seem to be occasional or complementary choices and suggest that some respondents adopt a more flexible lifestyle, alternating between different ways of obtaining food depending on context, schedule or preferences. There are also some responses that refer to "Other" options, such as self-producing food by raising animals or obtaining products from trusted local sources, aspects that show an orientation towards sustainability and self-sufficiency, especially in rural communities.

Answers to the question "Where do you usually shop for groceries?" (Q10) showed a predominant preference for supermarkets and hypermarkets, stores that offer a balance between price, accessibility and diversity. However, a significant part of the respondents also indicated a preference for "market" and "specialized stores". This suggests an appreciation for fresh, local or artisanal products, which offer confidence in quality and freshness. There is also a trend towards purchases "from local producers or farmers' associations", which denotes an increased interest in local, organic, or less processed products. This behavior can be influenced by concerns about sustainability, supporting the local economy, or the desire to consume food with a low environmental impact. The multiple options, frequently mentioned by some respondents, indicate the diversity of sources of supply, which suggests that people are not limited to a single purchasing channel. This can be caused by factors such as seasonal product availability, convenience, or specificity of certain products. The "online" option, although less frequently mentioned, reflects a growing trend, especially in the context of the evolution of e-commerce and the COVID-19 pandemic, which has forced a rapid adaptation to remote shopping.

Answers to the question "Approximately, how much do you spend monthly on purchased food products?" (Q11) varies significantly, with values ranging from 50-100 lei to 4,000 lei. This fact indicates a monthly budget between 1,000 and 2,000 lei for food products, which is a typical average for a medium-sized family in urban areas. Higher or lower expenses depend on factors such as income, lifestyle, number of household members, and geographic area.

Although the majority of respondents (38.5%) largely check supplies before sourcing and 19.2% check every time, there is still a significant percentage (16.2%) who do not attach any importance to this aspect, and 26.2% attach less importance–Q12. This trend could indicate either a lack of time for organization or more spontaneous shopping habits.

Regarding the expiration date of products (Q13), the majority of respondents (40.4%) check it frequently or almost always (32.3%), which reflects a careful and cautious consumer behavior. However, there is a percentage of 11.2% that does not pay any or not enough attention (16.2%) to this aspect, which can lead to food safety problems or the purchase of products that need to be consumed urgently. Educating consumers on the importance of checking the expiration date could improve this behavior.

"Food preparation" category

Within the sample on which the questionnaire was applied, most responses (48.5%) showed that respondents prepare food 2-3 times a week at home, and 35.4% daily. Other answer options were "once a week" – 6.2%, "rare" – 5%, "at special events" – 0.4%, while 4.6% "don't cook" – Q14.

Answers to the question "What do you do when you cook too much food?" (Q15), indicated that the majority of respondents adopt sustainable methods for managing surplus food, either by cooking as much as necessary (31.9%), or by sharing food with close people – colleagues, friends, family (7.3%) or third parties (7.3%), or by preserving surplus food (25%) or even giving it to pets (21.2%). However, there is a percentage that throws away food (7.3%), which highlights the need for awareness of food waste.

"Information about wasted food" category

Although the majority of respondents try to reduce food waste (44.2% rarely throw away food and 13.5% never), 42.3% throw away food either occasionally or often (Q16).

This highlights the need for more effective strategies, such as shopping planning, proper food storage and reuse of food scraps - Figure 4.

The majority of respondents (77.31%) stated that they are mindful of the amount of food discarded each week. However, 22.4% reported disposing of more than 1 kg of food per week (Q17), likely due to factors such as over-purchasing, poor meal planning, or inadequate food storage (Figure 5).

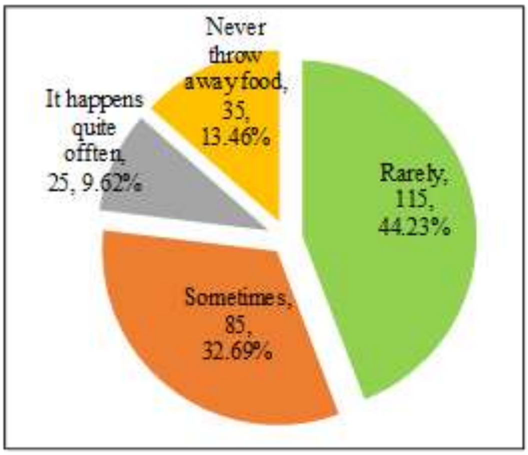

Fig. 4. Frequency of throwing food in the trash (number of respondents, %)
Source: own processing of questionnaire information.

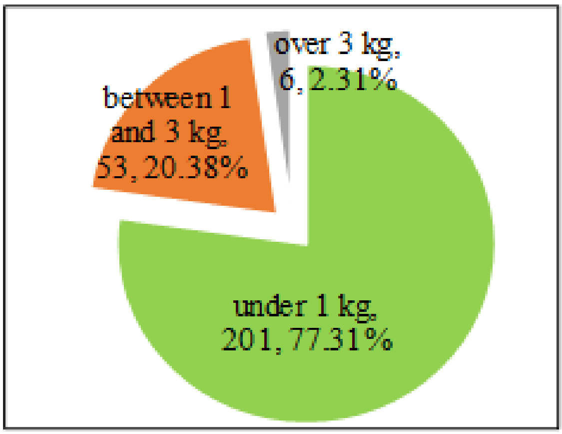

Fig. 5. The weekly volume of discarded food (number of respondents, %)
Source: own processing of questionnaire information.

Figure 6 shows that cooked foods (41.2%) and bakery products (25%) are the most wasted, highlighting the need for better meal and portion planning. Among the products least discarded by respondents were fruits (6.5%), although it is known that these are perishable and Expired groceries and canned goods (flour, rice etc.) – 4.2% (Q18).

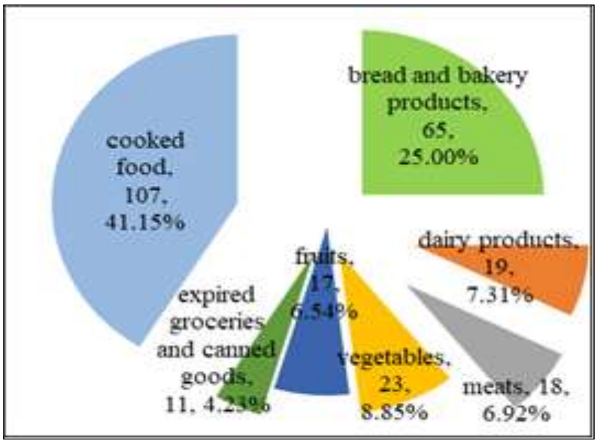

Fig. 6. The most often discarded food category (number of respondents, %)
Source: own processing of questionnaire information.

In the opinion of the respondents in the analyzed sample, the main cause of food waste is the variation of household consumption (36.2%), followed by excess purchases (16.5%) and lack of shopping planning (15.8%). A significant percentage of people (22.3%) are not aware of exactly why they throw away food (Q19), suggesting the need for information campaigns on meal planning, appropriate food storage and limiting spontaneous purchases (Figure 7).

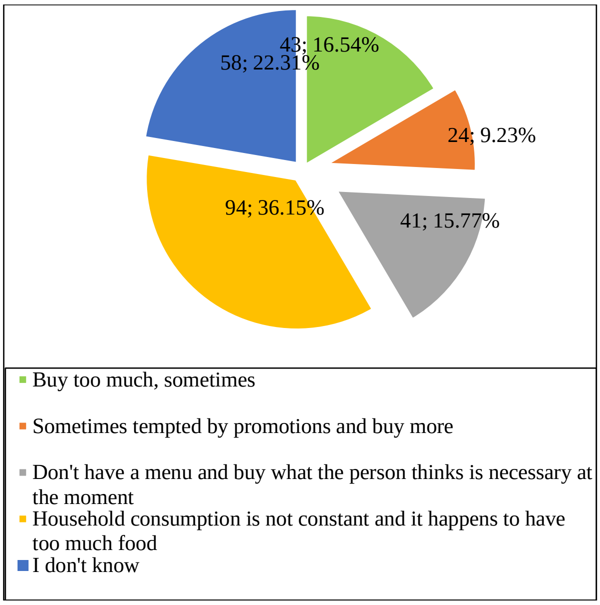

Fig. 7. The causes behind food waste (number of respondents, %)
Source: own processing of questionnaire information.

"Measures to reduce food waste" category

To the open question "What do you think would make you throw away less food?" (Q20), the majority of respondents (around 70%) believe that more information about organising food and reducing waste would help them throw away less food. A percentage of 10% believe that a higher sanitation tax would be an influencing factor. The rest of the respondents offered other solutions, such as responsible buying, economic crises or the existence of systems to redistribute the surplus.

The most effective solution to reduce food waste (Q21) is "Shopping planning", as appreciated by 44.2% of respondents. Other important percentages, 23.5% - highlighted the importance of efficient use of food, either by cooking all purchased ingredients or by reusing food scraps in other preparations, and 18.1% the importance of "Food storage and organization". The other 2 answer options had a low impact. (Figure 8).

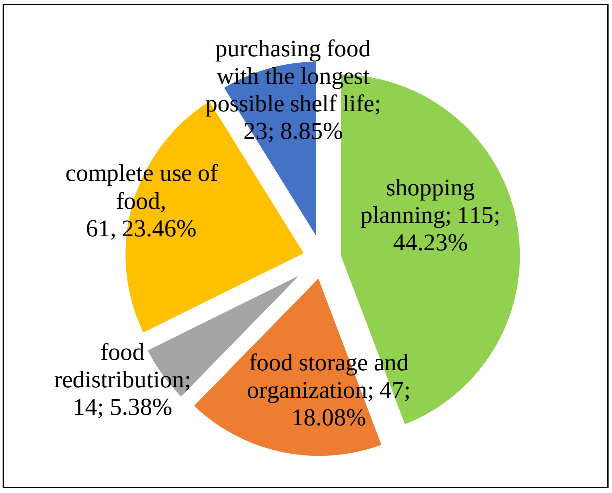

Fig. 8. Measures to reduce food waste (number of respondents, %)
Source: own processing of questionnaire information.

To the open question "At national and/or local public authority level, I believe that the most important concrete measure to reduce food waste and loss is..." (Q22), respondents rated "Distribution of information (guides, leaflets)" as the most effective measure, receiving 67 responses, followed closely by "Collaboration with schools" (64 responses). Local events are considered a fairly effective method, but less popular the first 2 and this variant received 52 responses. Other respondents proposed other solutions, such as the creation of "Food Collection Centers", "Food Banks", "Local collections and social canteens for food redistribution", "System for taking over surplus food for those in need".

The authors of the article also wanted to know how online posts affect consumer behavior (Q23): 45.8% of respondents considered that influencers have an important role in reducing food waste, which may be motivated by the dominant age categories of the sample on which the questionnaire was applied, between 18-24 and 25-34 years old. This finding can be explained by the growing influence of social networks on the behavior of young consumers, who are more receptive to the messages sent by influencers. Previous studies show that people in the 18-24 and 25-34 age groups are active users of digital platforms and are more likely to adapt their consumption habits according to trends promoted online. Also, educational content and awareness campaigns carried out by influencers on reducing food waste can have a significant impact on their purchasing decisions and sustainable behavior. However, 27.3% do not consider the intervention of influencers useful, and 26.9% "do not know".

At the same time, the majority of respondents (over 50%) considered that influencers do not affect their decisions at all, while about 25% appreciated that influencers can have a positive impact, especially by promoting responsible behaviors. However, 15% considered that influencers have a negative impact, promoting consumption and products of questionable quality, 5% said they are influenced according to the credibility and transparency of the influencer and 5% admitted that although they are not personally influenced, influencers have a strong impact on young people (Q24).

The analysis of the results of the questionnaire, correlated with data from similar studies [15], confirmed certain consumption trends: the preference for purchasing food from hypermarkets, the habit of cooking frequently at home, shopping planning and checking stocks before supply. Meanwhile, most respondents believe that adopting a national policy and implementing educational projects are essential for preventing and reducing food waste.

Despite being a major issue in Romania, food waste remains insufficiently documented, emphasizing the need for extensive national-level research [15].

As a member of the European Union, Romania is also required to align with EU targets, which aim to cut food loss and waste by 30% per capita by 2025 and by 50% per capita by 2030 [14, 15].

Promoting responsible food consumption, raising awareness through prevention campaigns, and enforcing legislative measures can play a crucial role in reducing food waste across the country.

CONCLUSIONS

The results of the study showed that young people from urban areas (age category 18 - 24 years), with higher education, are aware of the problem of food waste and interested in reducing it. However, consumption habits and management of food surplus are not always effective. A significant portion of respondents continue to throw away food, mainly from the "cooked foods" and "bakery products" categories, which indicates the need for meal and portion planning.

The answers also revealed that most respondents prepare their food at home and prefer to stock up on supermarkets and hypermarkets. However, there is also considerable interest in the market and local producers. This suggests a diversity of consumer preferences and habits, influenced by factors such as accessibility, product quality and sustainability.

To minimize food waste, respondents identified the most effective strategies as careful meal planning, maximizing the use of purchased food, and better organizing household supplies. On a national scale, the proposed solutions include the creation of information guides, collaboration with schools for education in this field and the organization of local events. Although the influence of social media is a controversial issue, an opportunity has been identified to develop awareness campaigns through opinion leaders relevant to young audiences.

In addition, in order to combat food waste, an integrated approach involving consumers, public authorities and the private sector is essential in Romania. It must aim at: educating and informing consumers on meal planning, proper food storage, avoiding excessive purchases; supporting short supply chains; promoting local products to reduce food waste.

By adopting such measures, Romania can make significant progress towards a more responsible and sustainable food consumption.

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THE TOBACCO MARKET IN ROMANIA: DECLINE OF CULTIVATION, RISE OF PROCESSING

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Abstract

The paper analyses Romania's tobacco market, focusing on both agricultural production and processing industries. The research is based on open-access sources from major international databases, reports from national and international organizations, and specialized articles from online media. Statistical data were collected from national and European sources.The findings indicate a decline in domestic raw tobacco production, driven by decreasing internal consumption and competition from low-cost, high-quality imports. Romania's tobacco processing industry is dominated by subsidiaries of multinational corporations, which play a major role in the sector's development. The domestic tobacco processing market is moderately concentrated, with a few dominant players holding significant market share. If the current concentration trend continues, the market could evolve into a highly concentrated oligopoly, potentially limiting competition.The growing demand for heated tobacco products in international markets presents an opportunity for Romanian-based processors, reinforcing the country's role as a regional hub for tobacco production and exports.

***Key words*:** tobacco, market, processing industry, competition, Romania

INTRODUCTION

In Romania, tobacco production has a long-standing tradition, but in recent years, it has recorded a significant decline due to new legislative regulations, decreased domestic demand, and increased imports in the context of fierce international competition. The import of tobacco and processed products, offered at lower prices and higher quality, has reduced the presence of locally produced goods on the domestic market.

Tobacco is a plant belonging to the *Solanaceae* family, *Nicotiana* genus, originating from the Americas, where it was used in religious rituals by the Mayan civilization. Of the over 70 varieties of tobacco, the most widely cultivated worldwide is *Nicotiana tabacum* [8].

The history of tobacco cultivation spans over 8,000 years, as indigenous American populations used the plant for religious and therapeutic purposes [16].

Tobacco was introduced to Europe at the end of the 15th century by Christopher Columbus after the discovery of the New World. Initially, it was cultivated for ornamental purposes and used for medicinal applications. Tobacco smoking was later introduced at the French royal court by the French ambassador to Portugal, Jean Nicot, from whom the plant's scientific name derives. It was recommended for medicinal use and for maskingodors. The first cigarettes were manufactured in 1843, and in 1881, the first technological production line was developed in the United States, with a production rate of 200 units per minute. By 1910, Europe had over 20,000 registered cigarette brands. Today, the global market is dominated by major American manufacturers, who account for about 20% of global tobacco production, totalling over a trillion cigarettes annually [20].

In the Romanian principalities, historical evidence suggests that tobacco was introduced by the Ottomans in Transylvania and Wallachia, and by Cossack warriors in Moldova during the 16th-17th centuries. From the beginning, it was regarded as a practice contrary to Christian morality and good customs, often referred to as "the devil's weed." Despite initial prohibitions and restrictions, the pleasure of smoking and nicotine addiction contributed to the spread of tobacco consumption, making it a common practice among the population [22].

According to the Food and Agriculture Organization (FAO), global raw tobacco production reached approximately 6 million tons in 2022. The world's leading producers are China (2.19 million tons), followed by India (772,000 tons) and Brazil (667,000 tons). Indonesia (225,000 tons), a country with a high smoking prevalence, is also a significant producer, alongside the United States (about 203,000 tons) and Zimbabwe (167,000 tons) [6].

The leading global company in the tobacco industry in 2022 was British American Tobacco, with net sales exceeding $34 billion. The second-largest company was Philip Morris International, with sales surpassing $31.8 billion.

In 2023, the United States produced less than half a million pounds of tobacco, valued at over $1 billion. The total harvested area covered approximately 187,600 acres, with North Carolina being the leading tobacco-producing state since 2020 [15].

Health and Economic Impact of Tobacco Consumption

Smoking has a severe negative impact on health and consumer incomes, with the tobacco epidemic being considered one of the leading causes of death, disease, and poverty worldwide.The first scientific study documenting a link between cigarette consumption and lung cancer, along with other diseases caused by active and passive smoking, was conducted in the United States in 1964. This research led to the introduction of new legislative regulations governing the production and marketing of tobacco products, as well as public awareness campaigns on the harmful effects of smoking.

The "Cigarette Labelling and Advertising Act", issued by the U.S. Congress in 1965, required that each cigarette pack must include a warning about the risks associated with smoking.The 2005 WHO Framework Convention on Tobacco Control established regulations related to protection against exposure to tobacco smoke, labelling, advertising restrictions, accountability, illicit trade, product standards, and taxation [21].

Tobacco consumption, despite being a legal product, leads to the death of more than half of its users [11].

Currently, tobacco addiction affects approximately 1.3 billion consumers worldwide, with 80% of them living in low-income regions. Smoking is responsible for approximately 8 million deaths annually, of which 1.3 million are non-smokers exposed to second-hand smoke.

Moreover, World Health Organization (WHO) officials warn that tobacco cultivation poses a serious threat to food security. Farmers growing tobacco are exposed to chemical hazards due to the extensive use of fertilizers and pesticides, as well as chronic lung conditions and nicotine poisoning caused by tobacco smoke inhalation.

WHO has called on governments to stop subsidizing tobacco cultivation and instead support farmers in transitioning to more sustainable crops that contribute to improving food security [23].

Efforts to Reduce Tobacco Production in the European Union

The European Union has made continuous efforts to reduce domestic tobacco production. In 1991, tobacco production in the EU reached approximately 400,000 tons, but by 2018, it had declined to 140,000 tons. The cultivated area also shrunk significantly, from 66,000 hectares, with 26,000 specialized farmers, across 12 European countries.

The main tobacco producers in the EU are Italy, Spain, Poland, Greece, Croatia, France, Hungary, and Bulgaria, collectively accounting for 99% of the EU's tobacco output. Due to declining domestic demand, there has been a continuous reduction in cultivated areas.Agricultural yield varies between 1 and 3 tons per hectare, with most production coming from Virginia tobacco (71%), followed by Burley (16%) and Oriental varieties (7%).

The European Union accounts for less than 2% of global raw tobacco production. In 2018, the EU imported 420,000 tons of tobacco, resulting in a trade deficit of 360,000 tons [5].

Economic Analysis of Tobacco Production in Turkey and Ukraine

A study on tobacco production in Turkey conducted by Yildirim (2022) evaluates the cost structure and profitability of tobacco farming in the Uşak province [24] .

The findings highlight the importance of family labour and farmer organizations in improving production conditions [24].

Similarly, Ivanov (2023) analyses the technological characteristics and economic efficiency of tobacco seed cultivation in Ukraine. The study assesses the new tobacco seed varieties developed by Ukrainian research institutions and emphasizes the critical role of specialized research centers in seed production [9].

Tobacco Trade in Romania

Several studies have examined Romania's tobacco trade. Toma si Vlad (2014) provides an analysis of Romania's tobacco imports and exports between 2002 and 2011, as part of a broader agricultural trade evaluation [17].

A study by Chiurciu, Zaharia & Soare (2019) evaluates the key indicators of the EU tobacco market, including cultivated areas, total production, per capita consumption, and tobacco product prices in leading tobacco-growing countries. According to their research, in 2017, the largest tobacco producers in the EU were Italy, Poland, Spain, and Greece, while Bulgaria had the highest number of registered tobacco farmers in 2014 [2].

Harm Reduction Strategies in Tobacco Consumption

Building on the idea that the primary health risk associated with smoking is the combustion process rather than nicotine, several countries have incorporated alternative nicotine products into their anti-smoking policies.

These alternatives includeNicotine patches and chewing gum; Snus (a smokeless tobacco product used in Sweden); Electronic cigarettes; Heat-not-burn tobacco devices.

These products are particularly targeted at smokers who struggle to quit using traditional methods [21].

Smoking Trends in the European Union

According to Eurostat data, cited by Spotmedia (2024) [13], approximately 20% of EU citizens smoke daily, with men having a higher prevalence than women.The highest smoking rates in the EU are recorded in:Bulgaria (28.2%),Turkey (27.3%), and Greece (27.2%).

Meanwhile, Sweden has the lowest smoking rate in Europe (9.3%), attributed to educational programs and strict anti-smoking measures, such as:"The 2005 smoking ban in bars and restaurants"; and "The 2019 extension of the ban to terraces and public spaces".

In Romania, 19.8% of the population smokes daily. The proportion of male smokers is three times higher than that of female smokers (30.6% vs. 7.5%). Most daily smokers have maintained this habit for over a decade [13].

Targeted Marketing of Tobacco Products to Young People and Women

Research conducted by the National Institute of Public Health (INSP) indicates that:Young people have the highest increase in smoking prevalence; Women of all age groups are strategic targets for the tobacco industry.

The presence of smoking among minors (under 15 years old) is an alarming national trend, often associated with:Lack of physical activity,Unhealthy diets.

To address this, awareness campaigns should focus on educating at-risk groups, particularly in schools and high-risk communities [11].

Taxation Policies and Economic Implications of Tobacco Consumption

The increase in tobacco consumption has led to the implementation of taxes on production, processing, and trade, generating substantial revenue for public authorities, even in the present day.

Recently, a new approach to tobacco taxation has emerged, emphasizing its positive impact on consumer health. Fiscal measures have significantly contributed to reducing alcohol and tobacco consumption and have been proposed as a strategy to curb the intake of junk food as well [14].

Experts estimate that increasing excise duties on cigarettes in Romania to 65% of the retail price (currently between 56-60%) could: Reduce the number of smokers by over 400,000 people; Generate additional state revenue exceeding €250 million per year.

Moreover, introducing annual tax adjustments on cigarettes would make these products less accessible as incomes rise, while equalizing tax rates across all tobacco products would discourage the consumption of alternative tobacco items.

A portion of the additional tax revenue could also be allocated to smoking prevention and cessation programs, alongside stricter measures to combat tax evasion and eliminate duty-free tobacco sales [14].

Evaluating the Effectiveness of Tobacco Taxation as a Control Strategy

A study conducted by Chaloupka et al. (2011) [1] assessed the impact of higher tobacco taxes on smoking reduction and public health benefits. By analyzing over 100 specialized studies, the researchers found that:

- Significant tax increases effectively lower tobacco consumption.
- The greatest impact is observed among young and low-income populations.
- The health benefits are amplified when a portion of the tax revenue is reinvested in tobacco control programs.

Their findings underscore the importance of integrating fiscal policies with public health education initiatives to maximize the effectiveness of tobacco taxation [1].

MATERIALS AND METHODS

For documentation, open-access publications available on Clarivate, Google Scholar, and ResearchGate were used, along with reports from international organizations (World Health Organization - WHO, Food and Agriculture Organization - FAO), regional institutions (European Commission), and national bodies (National Institute of Public Health).

Additionally, the research incorporated articles from specialized journals available in online media. The study was conducted using data provided by Eurostat, the National Institute of Statistics, and the Ministry of Agriculture and Rural Development.

A large part of the data identification, language verification in English, and partial systematization of information was assisted by an AI model (ChatGPT), which was used for organizing information efficiently and synthesizing literature sources.

However, the processed information was critically verified and interpreted by the authors themselves, ensuring its scientific accuracy and relevance. The final validation of results was conducted through a comparative analysis with relevant specialized studies.

RESULTS AND DISCUSSIONS

Areas Cultivated and Raw Tobacco Production in Romania

The evolution of the areas allocated for tobacco cultivation in Romania during the period 1990-2023 is presented in Figure 1.

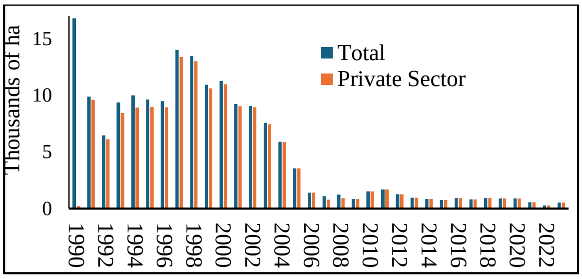

Fig. 1. Area cultivated with tobacco in Romania, 1990–2023

Source: Authors' design using the data from [12].

In 1990, approximately 16,800 hectares of land were cultivated with tobacco in Romania, with production covering most of domestic consumption and allowing for some exports. The privatization of agricultural land led to a 50% reduction in cultivated areas by 1991.

After a slight decline in 1992, there was a temporary increase, reaching a peak of approximately 14,000 hectares in 1997.

However, after 1997, tobacco cultivation underwent a drastic decline, and following Romania’s accession to the European Union, the cultivated area dropped significantly, remaining below 2,000 hectares.

The lowest historical level was recorded in 2022, with only 278 hectares cultivated, representing about 1.65% of the area cultivated in 1990 [12].

To support farmers who still cultivate tobacco, various financial aid programs have been implemented, including Basic support for sustainability; Assistance for young farmers; Aid for traditional households; Transitional support measures.

However, these efforts have not succeeded in revitalizing the sector [10].

If this trend continues, Romania will remain dependent on tobacco imports in the future. Any potential revival of production would likely be driven by agricultural subsidies or increased demand from domestic processors.

The total raw tobacco production in Romania has declined in parallel with the reduction of agricultural land (Figure 2).

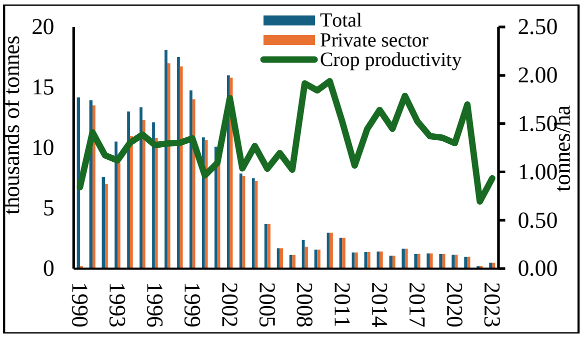

Fig. 2. Tobacco production in Romania
Source: Authors' design using the data from [12].

During the analysed period, a rising trend in Romania's total tobacco production can be observed, reaching a peak of approximately 18,000 tons in 1998. This increase was correlated with the continuation of transitional agricultural support policies after 1990.

In the following years, however, production declined significantly, falling below 5,000 tons per year. This trend can be attributed to:Market liberalization measures,Reduction of tobacco subsidies,Competition from foreign producers, who introduced low-cost, high-quality tobacco exports to the domestic market.

After Romania's accession to the EU in 2007, tobacco production became marginal, remaining below 2,000 tons per year.

The average productivity of tobacco crops in Romania is around 1.6 tons per hectare, placing it at the lower end of the European average (1–3 tons/ha). The leading tobacco producers in the EU—Italy, Spain, and Greece—have significantly higher productivity levels, nearing the upper limit of this range [7].

In Romania, 10 agricultural producers/associations are registered under NACE Code 115 – Tobacco Cultivation, but only 6 of them report a non-zero turnover.

The total turnover of the sector amounts to €2.6 million, with a total profit of €45,898, employing 64 workers [18].

The economic data for each active operator is presented in Table 1.

These figures were sourced from the TopFirme.com database.

Table. 1. Tobacco producers in Romania

Company	Turnover*	Employees	Profit*
Seeds Procesing S.R.L.	1.700	57	25
Adria Leaf S.R.L.	830	3	15
Grupul de Producători Tutun Luduș S.R.L.	78.5	0	0.8
Galaxy Agri Production S.A.	22	4	0
Grup de Producători Tutun Mădăraș S.R.L.	12	0	0
Nicovasi SRL	6		5

*Thousands of Euros.
Source: Own calculation based on data from [18].

In the tobacco processing sector (NACE Code 1200 – Manufacture of Tobacco Products), a total of 14 economic operators are registered in the TopFirme.com database.This sector reports:A cumulative turnover of €690.6 million,A total profit of €39.1 million, Employment for 2,972 workers [19].

Table. 2 Tobacco processing companies in Romania

Company	Turnover*	Employees	Profit*/
JT International Manufacturing SA	328,900	57	13,900
Philip Morris Romania SRL	210,900	1,256	21,500
British-American Tobacco Romania Investment SRL	137,200	953	3,000
China Tobacco International Europe Company SRL	15,500	4	0
Rom-Ital S.R.L.	1,400	0	98
Galaxy Tobacco SA	621.7		621

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Gold Steam Garden SRL	212.6		39
Mozana Business S.R.L.	187.7		16
LuscanSpeditionS.R.L.	507.9		9.5

*Thousands of Euros
Source: Own calculation based on data from [19].

An analysis of market concentration in the NACE Code 1200 – Manufacture of Tobacco Products sector, based on turnover figures, indicates a Herfindahl-Hirschman Index (HHI) of 1813.

The top three companies—JT International Manufacturing SA, Philip Morris Romania SRL, and British-American Tobacco Romania Investment SRL—hold approximately 65.6% of the market, suggesting a moderate to high level of concentration [19].

The market is not highly fragmented, yet it is not dominated by a highly concentrated monopoly either. Additionally, smaller economic operators are present in the sector, contributing to market competition.The regulatory framework within the EU market, where imports are easily facilitated, further limits monopolization potential.

Romania's International Tobacco Trade

Romania's international tobacco trade transactions are presented in Figure 3.

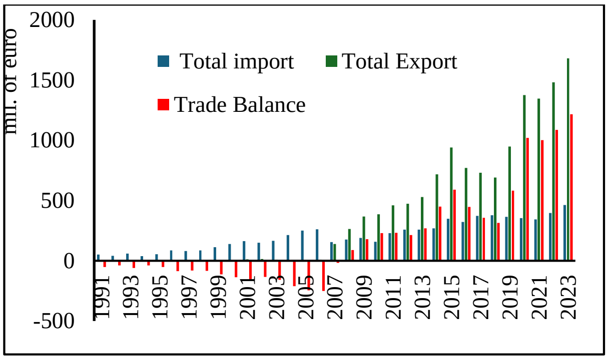

Fig. 3. Romania's International Trade with Tobacco
Source: Authors' design using the data from [12].

Between 1991 and 2000, Romania's international tobacco trade was relatively limited, with both imports and exports remaining below €100 million per year.

Starting in 2001, imports began to rise gradually, surpassing exports. From 1990 to 2006, Romania's trade balance was negative, indicating a high dependence on imports for domestic consumption.

After Romania joined the EU in 2007, a rapid increase in exports was observed, exceeding imports and leading to a trade surplus starting in 2007. Between 2007 and 2023, exports continued to grow significantly, surpassing imports, particularly after 2015.

In 2023, exports of raw and processed tobacco exceeded €1.8 billion, while imports remained below €1 billion.

It can be concluded that Romania has become an important hub for tobacco processing. The presence of major foreign investments from international tobacco companies has stimulated exports.

Due to the declining domestic consumption, primarily caused by high taxation, there has been a continuous decrease in internal demand, with most domestic production shifting toward exports.

More than half of Romania's international tobacco transactions involve EU member states (Figure 4).

The data suggests that the EU is Romania's main trade partner in the tobacco industry, with a substantial volume of exports, particularly after 2010.Romania's accession to the European single market has reinforced its position as a net exporter, turning its trade balance positive.

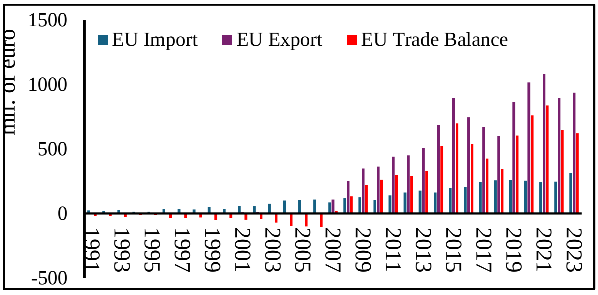

Fig. 4. Romania's Trade with EU in tobacco
Source: Authors' design using the data from [12].

The increase in tobacco exports to the EU has contributed significantly to Romania's overall trade surplus, as shown in the previous chart. However, Romanian exports are not limited to the European market, indicating that the country's tobacco industry has access to important external markets.In 2023, the tobacco sector contributed approximately €1.2 billion to Romania's positive trade balance. Total domestic tobacco exports reached over €1.68 billion, marking an increase of more than €200 million compared to 2022.

British-American Tobacco Romania Investment SRL (BAT), recognized as one of the largest companies in the local market, has invested approximately €500 million in its processing facility in Ploiești, which is the second-largest BAT factory in Europe. Over 70% of BAT's production in Romania is designated for export [18].

The shift towards heated tobacco products has become a key strategic direction for multinational tobacco companies operating in Romania (Table 3). Approximately 90% of the production from Philip Morris' factory in Otopeni—which has received over €600 million in investments—is exported to 54 countries across five continents [25].

Table 3. Romanian export of tobacco (mill. of euro)

Year	Cigarette	Heated Tobacco	Total exports
2017	660	32	692
2018	660	50	710
2019	650	150	800
2020	640	350	990
2021	635	600	1,235
2022	627	830	1,457
2023	666	1,007	1,673

Source: Own calculation based on data from [25] and [12].

From a total value of €692 million in 2017, Romania's tobacco and tobacco product exports have nearly doubled by 2022, reaching €1.457 billion.This growth was primarily driven by the rapid expansion of heated tobacco exports, which surpassed cigarette exports by approximately 30% [3].

The increase in 2023 exports was also primarily fuelled by the expansion of the heated tobacco segment, which exceeded cigarette exports by approximately 51%.

The upward trend continued, with:Heated tobacco exports increasing by 21.33%; Cigarette exports registering a more modest growth of 6.22%.

This evolution reflects a structural shift in the market, with a growing preference for alternatives to traditional cigarettes.

Consumers in the target markets for Romanian tobacco products are increasingly favouring heated tobacco, a trend that strengthens Romanian-based manufacturers in the global competition.

CONCLUSIONS

Romania's tobacco sector has undergone significant transformations over the past decades, characterized by a drastic decline in domestic cultivation, a shift towards processing and exports, and the dominance of foreign capital in the industry.

Decline in Domestic Tobacco Cultivation

The post-revolutionary period saw a substantial reduction in cultivated areas and raw tobacco production, mainly due to strong competition from imported raw materials, which offered lower prices and superior quality.

Despite financial support measures for farmers, these efforts have not succeeded in revitalizing the domestic tobacco cultivation sector.

Romania as a Regional Hub for Tobacco Processing

Romania has transitioned from being a major tobacco cultivator to a key regional processing centre, driven by large foreign investments in the sector.

Most tobacco processing companies operate with imported raw materials from both EU and non-EU countries, producing high-value-added finished products for export.

The country has established itself as a strong player in the international tobacco trade, with a trade surplus in the tobacco sector, mainly due to the rising demand for heated tobacco products.

Market Concentration and Competitive Challenges

The Romanian tobacco market is moderately to highly concentrated, with the top three multinational companies controlling approximately 65.6% of the sector.

While competition exists, the dominance of foreign capital raises concerns about pricing power, potentially limiting market entry opportunities for new players.

The EU regulatory framework, which facilitates import trade, helps prevent full monopolization, yet major corporations continue to shape market dynamics.

Future Perspectives

If the current trends continue, Romania will remain heavily dependent on tobacco imports, with domestic production playing an increasingly marginal role.

Any potential revival of local production would require substantial agricultural subsidies or a rise in demand from domestic processors.

The shift towards heated tobacco products presents a growth opportunity, as consumers in international markets are increasingly adopting alternatives to traditional cigarettes.

Given the high taxation on tobacco, domestic consumption is expected to continue declining, while exports will remain the primary driver of industry growth.

Final Consideration

Romania has successfully positioned itself as a key exporter of processed tobacco products, yet challenges remain in balancing domestic production, market competitiveness, and regulatory influences. The future trajectory of the sector will depend on global market trends, EU regulations, and investment in product innovation.

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ASSESSING THE IMPACT OF CLIMATE CHANGE ON MOLDOVA'S AGRICULTURAL SECTOR: QUANTIFYING DROUGHT AND TEMPERATURE EFFECTS ON SELECTED CROPS YIELD

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Abstract

Drought, hail, floods and heavy rains are and will represent the biggest problems that the agricultural sector will have to face due to climate change. Moldova is experiencing significant climatic variability, affecting agricultural productivity. Main agricultural crops are vulnerable to climate change. In this research, the vulnerability of main agricultural crops as wheat, maize and sunflower will be assessed to changes in factors as precipitation (drought), temperature fluctuations, and sown area. A polynomial regression model was applied. The dataset for 2007–2023 included annual yield, average temperature, precipitation level, and sown area for selected crops in the Republic of Moldova. To assess the impact of drought on the yield of particular crops, various scenarios with decreased precipitation level (20, 40 and 60%) were applied. Combined effects of drought, temperature and area was applied to simulate changes in yield for selected crops. The polynomial regression model was used to forecast the corresponding yields of wheat, maize, and sunflower after adjusting for precipitation, temperature, and area for each scenario. A heatmap was used to visualize the predicted yields of selected crops across different combinations of drought levels and temperature changes. - The results show that while temperature and precipitation effects differ by crop type, sown area is a major positive determinant of crop yields. Higher temperatures and drought conditions worsen yield declines, especially for wheat and maize, but under certain circumstances, cooler temperatures and mild drought might increase sunflower yields.

Key words: *agricultural crops, climate change, maize, sunflower, wheat.*

INTRODUCTION

Moldova's agricultural sector is important to economic development due to its contribution to GDP and providing employment to one third of population. Nevertheless, due to climate change it becomes more and more vulnerable to the effects of frequent droughts, temperature variability and changes in precipitation level. Obviously, these negative climate change effects impact agricultural productivity and yield, imposing challenges to food security and wellbeing of people living in rural areas [3, 9].

Different research results shows that extreme weather has a negative impact on crops productivity, particularly for crops as winter wheat or corn [10, 11]. According to studies, depending on drought severity, crops yield can be affected by a reduction of 10 to 50 percent [1]. These can be caused by an increase of temperature by 2 to 5 degree Celsius, imposing more challenges for farmers and requiring adapted mitigation efforts. Combined effects of heat stress and water scarcity will impact significantly on crop yields for similar regions as Moldova [8].

Different modelling techniques are used to assess the climate change impact on agricultural crops. Usually, factors as precipitation level, temperature variations and CO_2 concentration are used to forecast different yield scenarios in various models. Crop yields are particularly sensitive to drought and other climate changes. Lower precipitation levels will negatively impact yield, under severe drought conditions, thus is important to include drought simulations into models to assess crops vulnerability [7].

Studies suggest that extreme droughts can decrease yields in crops as maize and sunflower by 40 percent, accentuating the vulnerability of some crops to water stress [10].

Different studies suggest that addressing climate change issues require specific adapted mitigation measures [7, 8]. These solutions must be adapted and tailored for specific zones problems. To ensure productivity growth and stable food security, innovations in technology as precision agriculture and process-based crops modelling might be used. Grigoras et al [5] suggests the use of different practices to improve soil moisture retention and boost crop resilience as reduced tillage and crop residue retention. This measure could be also adapted for Moldova's agricultural sector as a measure to increase sustainability in conditions of climate vulnerability.

The aim of this paper is to assess the yield vulnerability of main agricultural crops as wheat, maize and sunflower to climate changes factors.

MATERIALS AND METHODS

Moldova, like many other countries, is experiencing significant climatic variability, affecting agricultural productivity. Main agricultural crops are vulnerable to climate change. In this study the vulnerability of main agricultural crops as wheat, maize and sunflower will be assessed to changes in factors as precipitation (drought), temperature fluctuations, and sown area.

Different studies suggest that statistical and machine learning models to forecast yield under various climate change factors can be used [2, 4, 6, 7, 13]. Some machine learning methods focus on explaining nonlinear relationships between yield and temperature, precipitations [2]. Other studies applied fuzzy logic and regression models for crop yield predictions, by determining the direct combined effects of temperature and precipitation level on yield outcomes [4]. Among regression-based models, polynomial regression is considered efficient for modelling nonlinear relationships between yield and temperature, precipitation, area, based on historical trends to forecast yield outcome [6].

A polynomial regression model was applied to capture nonlinear relationships between yield and the independent variables (precipitation, temperature, and area). The model also included interaction terms (temperature × precipitation) to account for combined effects of these variables.

$$Yield=\beta0+\beta1\cdot Area+\beta2\cdot Temperature+\beta3\cdot Precipitation+\beta4\cdot(Temperature^2)+\beta5\cdot(Precipitation^2)+\beta6\cdot(Temperature\times Precipitation)+\epsilon$$

where:

Yield is the dependent variable in the model, while area, temperature and precipitation level are the independent variables.

Temperature² shows the nonlinear effect of temperature on yield, accounting for scenarios where temperature variations beyond an optimal range may negatively affect crop yield.

Precipitation² shows the nonlinear effect of precipitation, considering cases where excessive precipitation level could affect crop yield.

Temperature × Precipitation - represents the combined effect of temperature and precipitation on yield. This allows the model to assess whether the impact of one variable depends on the level of the other (e.g., high temperatures may exacerbate or mitigate the effects of precipitation).

$\beta0$, $\beta1$, $\beta2$, $\beta3$, $\beta4$, $\beta5$, $\beta6$ – coefficients.

ϵ - represents the random error in the model, capturing variability in yield not explained by the independent variables.

The model was fitted using historical data, minimizing the residual sum of squares between observed and predicted yields.

The dataset for 2007–2023 included annual yield, average temperature, total precipitation, and sown area for selected crops in the Republic of Moldova.

To assess the impacts of drought on wheat yield, we focus on various scenarios where precipitation decreases significantly and assessing occurred changes in yield for wheat, maize and sunflower crops. Thus, a decrease in precipitation by 20%, 40%, 60% compared to the average is examined. Based on this, yield under these reduced precipitation levels while keeping temperature and area constant at their average values is forecasted and the change in yield for each level of precipitation reduction is quantified.

To evaluate the combined effects of drought, temperature, and area, yield was simulated under various scenarios representing changes in these variables. First scenario involves drought simulation, which supposes that precipitation level was reduced by 20, 40 and 60 percent from average, for mild, moderate and severe drought case.

Second scenario implies temperature adjustment, by -1°C, 0°C, and +1°C to simulate cooler, stable, and warmer possible climate variations.

Last scenario applies changes in sown area between +10 and -10 percent variation to examine its impact on yield.

For each scenario, precipitation, temperature, and area values were adjusted, and the polynomial regression model to predict the corresponding wheat yield was used.

Interaction terms, such as temperature and precipitation, were included to capture how the combined effects of these variables influence yield. In certain cases, higher temperatures may stimulate yield loss during drought conditions.

A heatmap to visualize the predicted yields across different combinations of drought levels and temperature changes was used. The x-axis of the heatmap represents different drought levels, quantified as percentage reductions in precipitation from the historical average. The y-axis shows temperature changes in degrees Celsius (°C). The cell values represent the predicted crops yield for each scenario.

RESULTS AND DISCUSSIONS

In the Republic of Moldova in recent years, agriculture, especially crop production, has been affected by climate change, often by droughts (once every 3-10 years). According to the State Hydrometeorological Service, the 2007 drought was one of the most severe in the history, affecting over 80 percent of the area, with losses of over 1 billion US dollars. In the same time, the drought in 2020 caused a 27.1 percent drop in global agricultural output and the loss of about 20 percent of jobs.

Crop production is exposed to natural risks, such as: natural disasters, frequent temperature fluctuations, pest attack, irregular rainfall and humidity, erosion, etc., which in turn affect the productivity of agricultural products and influence the farmers economic activity. Climate change can affect agricultural production and have a significant impact on the country's economy. Climate instability is one of the main causes of unstable harvests and poses a risk to the development of plant technology, the most vulnerable sector in agriculture. With the significant decrease in harvests, the low efficiency of their cultivation imposes questions regarding food security stability.

The dynamics of the sown areas in Moldova reflect the adaptive responses of the agricultural sector to both market and climatic challenges. Climate changes, as frequent droughts and temperature fluctuations, has significantly influenced agricultural output, causing farmers to reallocate land to more resilient or profitable crops. These changes are not only a reaction to climate change but also reflect broader economic and technological developments in the agricultural sector.

Figure 1 illustrates these changes through of the sown areas fluctuations for the main agricultural crops in the period 2007-2023, providing a more precise description of the evolution of the crop production sector in Moldova.

Analysing the dynamics of the areas sown with main crops, there is an increase in the sown area of the following agricultural crops in 2023 compared to 2007, namely: cereals and grain legumes total by 15 thousand hectares or 1.5%, total wheat by 57 thousand hectares or 18%, corn for grains by 20 thousand hectares or by 4.2%, sunflower by 158 thousand hectares or by 67.5% (Fig.1).

The areas sown with sugar beet decreased by 67.6% in 2023 compared to 2007, tobacco by 93.3%, soybeans by 50.9%, potatoes by 34.2%. Analysing the total areas sown with crops, we observe an increase of 174.3 thousand hectares in 2023 compared to 2007.

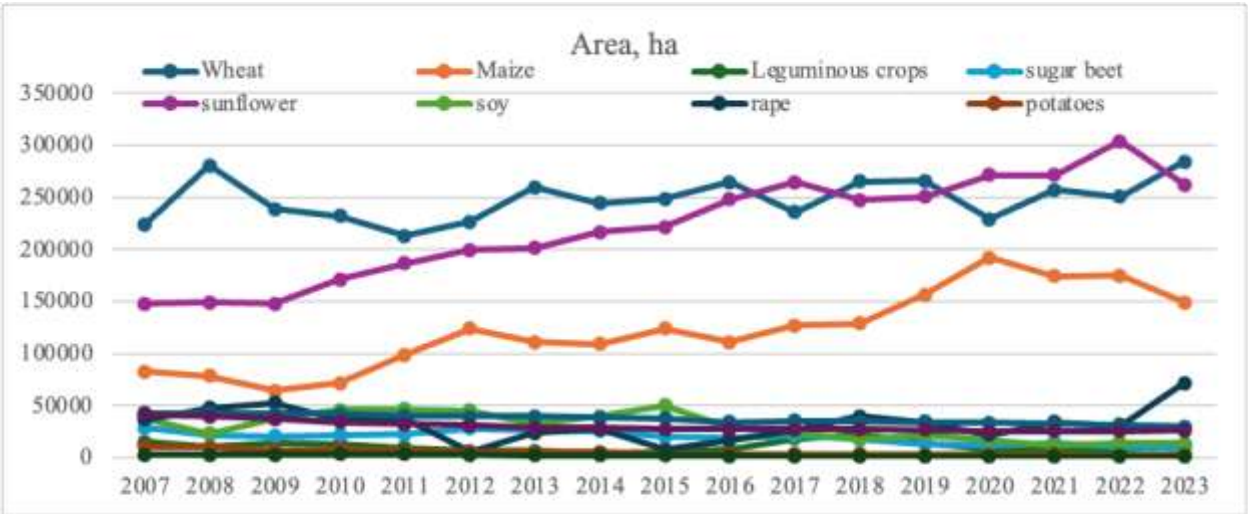

Fig. 1. Area dynamics of main sown crops in Moldova
Source: own design based on the data from National Bureau of Statistics [12].

The drought of 2007 had a considerable impact on global agricultural output, being classified as the most catastrophic in history, affecting over 80% of the territory of the Republic of Moldova. If in 2007 the global agricultural output amounted to 12,825 million MDL, in 2021 the size of this indicator increased 3.2 times, amounting to 41,017 million MDL.

The share of crop production in total global agricultural output increased by 11.6% in 2023 compared to 2007. Climate change had a considerable impact on yield of main agricultural crops (Fig. 2)

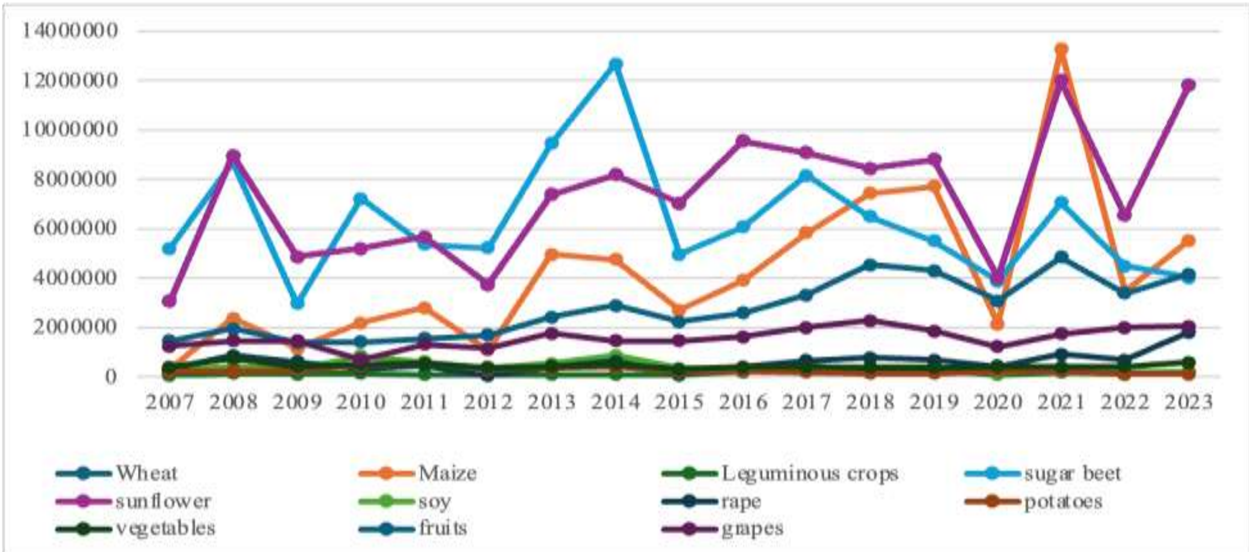

Fig. 2. Yield dynamics of main sown crops
Source: own design based on the data from National Bureau of Statistics [12].

The dynamics of the production of the main agricultural products is constantly changing, we notice that such crops as: cereals and grain legumes, including wheat, corn for grains and sunflower have registered a considerable increase from 2007 to 2023 (Fig. 2). A record harvest was obtained in 2021 for wheat 1565 thousand tons, 1158 thousand tons more than in 2007, corn grains 2793 thousand tons, 2430 thousand tons more than in 2007, sunflower 960 thousand tons, 804 thousand tons more than in 2007 and fruits, nuts and berries registering 876 thousand tons in 2021, 599 thousand tons more than in 2007. Analysing the total global agricultural output in 2023, the total harvest amounted to 9,136 thousand tons, 5,356 thousand tons or 241.6% more than 2007. Over the years, sugar beet harvest decreased by 184 thousand tons in 2023 compared to 2007, in tobacco by 3.7 thousand tons. However, the year 2021 is considered as the best harvest year within the last 30 years for Moldova.

Climate change had impacted significantly crop yields in Moldova. To assess the impact of climate change factors as temperature and precipitation level on crops yield a regression was performed. Thus, yield was considered as determinant factor, while sown area, average temperature and precipitation level were main factors on influence (Table 1).

Table 1. The influence of different factors on yield for selected crops

Y	R	R squared	Factors of influence	Beta coefficient
wheat				
Wheat Yield	0.83	0.66	Area	113.06
			Temperature	-1,567
			Precipitations	-10,967.79
maize				
Maize Yield	0.85	0.73	Area	1,061.551
			Temperature	−61,617,030.63
			Precipitations	196,311.63
sunflower				
Sunflower Yield	0.75	0.56	Area	907,430.7
			Temperature	-1,756,753
			Precipitations	−382,065.2

Source: own calculations.

The analysis of different factors as sown area, annual average temperature and precipitation level on wheat yield shows a regression result of 0.83 for wheat, indicating a moderate-to-strong relationship (Table 1). The results of R squared is 0.66, which indicates that approximately 66.17% of the variation in wheat yield is explained by the applied model. Among the influencing factors, the sown area has a positive effect on wheat yield, as an increase in the sown area leads to a corresponding rise in yield. However, temperature and precipitation levels do not appear to have a significant impact on wheat yield. Specifically, temperature does not show a statistically significant effect on yield outcomes. However, the negative coefficient suggests that higher temperatures might slightly reduce yield. Precipitation does not have a statistically significant impact on wheat yield.

For maize crops, about 73% of the variance in maize yield is explained by the polynomial regression model (Table 1). There is a positive contribution of sown area to maize yield, thus for every one-unit increase in the area sown, maize yield increases by approximately 1,061.55 units, assuming other variables remain constant. Similarly, a large positive effect is observed in relation to precipitation level, for every mm more of precipitation, maize yield increases by 196,311.63 units, assuming other variables remain constant. Regarding temperature, there is negative coefficient, thus for every one-degree Celsius increase in average temperature, maize yield decreases by approximately 61.6 million units, holding other factors constant.

In case of sunflower there is 56.1% of the variability explained by the model, while 43.9% of the variability is due to other factors not included. As the standardized sunflower sown area increases by one unit, sunflower yield is expected to increase by approximately 907,430 units, holding other variables constant.

This indicates a strong positive relationship between sown area and yield, as expected in agricultural production.

However, when temperature and precipitation increases by one standard deviation, sunflower yield decreases by about 1,756,753 and 382,065 units**,** considering all other factors constant.

This suggests that higher temperatures and excess precipitation level within the observed range negatively impact sunflower yield (Table 1).

As drought levels increase (moving from left to right), wheat yield declines significantly. At a constant temperature (zero degree Celsius), the yield drops from 5,507,416 q at 20% drought to -2,955,453 q at 60% drought (Fig. 3).

At smaller temperatures, yields are generally higher across all drought levels. This suggests that cooler conditions mitigate some of the negative impacts of reduced precipitation.

At warmer temperatures, yields are lower compared to no temperature change (0°C), highlighting the negative effects of heat on wheat under drought.

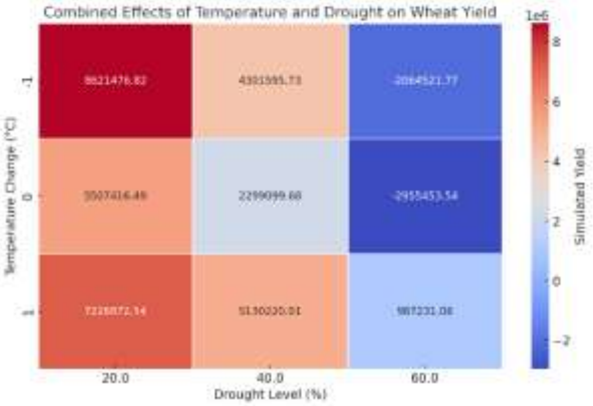

Fig. 3. Heatmap illustration of combined effects of temperature and drought on wheat yield
Source: Own calculations and processing.

The most severe yield reductions occur when high drought levels are combined with warmer temperatures.
At 60% drought and +1°C, the yield drops to 987,231 q, compared to 2,299,099 q at 0°C for the same drought level.
The combination of higher drought and warmer temperatures has a multiplicative negative effect, as seen in the severe yield reductions under these conditions.
As drought levels increase from 20% to 60% (left to right on the horizontal axis), maize yield declines significantly.
This decline is particularly pronounced under warmer temperature conditions (+1).
At lower temperatures (−1∘), yields are consistently higher across all drought levels, demonstrating the mitigating effect of cooler conditions on the adverse impacts of reduced precipitation (Fig.4).
At cooler temperatures, maize yields are the highest, even under severe drought conditions (60%).
This demonstrates the capacity of cooler climates to alleviate water stress and reduce heat-related impacts on maize growth.
At stable temperatures, yields decline more gradually with increasing drought levels, showing that reduced precipitation becomes a significant limiting factor in the absence of heat stabilizing effects (Fig. 4).

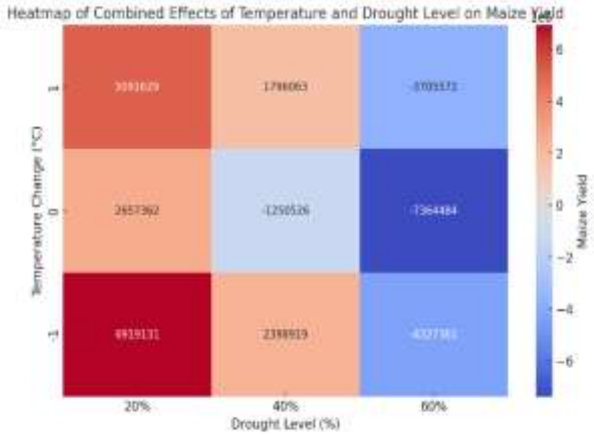

Fig. 4. Heatmap illustration of combined effects of temperature and drought on maize yield
Source: Own calculations and processing.

At warmer temperatures, the negative effects of drought are amplified. Severe drought conditions (60%) lead to negative yield reductions, demonstrating the compounded stress of high temperatures and low precipitation level.
At 20% drought, yields remain relatively stable across temperature changes, with the highest yields occurring under cooler conditions. At 40% drought, yields begin to decline more noticeably. Under warmer temperatures, maize yields drop to 1,796,063 q compared to 2,398,919 q under cooler conditions. At 60% drought, maize yields are lowest across all temperature scenarios. The combination of severe drought and warmer temperatures results in yields decreasing to -3,705,572 q, demonstrating the mixed effects of heat and low precipitation level.
The heatmap shows that sunflower yields are highly sensitive to increasing drought levels and temperature changes. Warmer temperatures tend to amplify the impact of drought, while cooler temperatures mitigate some of the yield losses caused by reduced precipitation (Fig. 5).
For sunflower, in case of mild drought (20%), yields remain relatively stable under all temperature conditions. At cooler temperatures, yields reach 6,837,873, while at warmer temperatures, yields increase to 8,293,529.

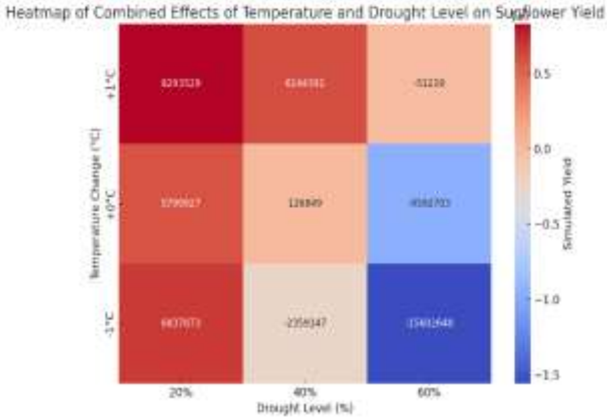

Fig. 5. Heatmap illustration of combined effects of temperature and drought on sunflower yield
Source: Own calculations and processing.

This suggests that sunflower growth may benefit slightly from mild drought under warmer conditions. In case of moderate drought sunflower yields start to show significant declines, especially at cooler temperatures where yields drop to -2,359,147. Under constant temperature, yields remain positive at 126,849, and under warmer conditions, yields improve to 6,144,391, indicating that higher temperatures may partially compensate for moderate drought stress.
Severe drought of has the most devastating effect on sunflower yields. At cooler temperatures, yields fall considerably, showing the catastrophic impact of extreme water scarcity.
Under stable and warmer (+1) conditions, yields are slightly less negative, reaching, suggesting that warmer temperatures mitigate losses to some extent but cannot offset the severe impact of drought.

CONCLUSIONS

The analysis of wheat, maize, and sunflower yields reveals varying impacts of sown area, temperature, and precipitation. For wheat, the regression model explains 66.17% of yield variation, with sown area exerting a strong positive influence, while temperature and precipitation show minimal and statistically insignificant effects. Maize yield variation is 73% explained by the model, with sown area and precipitation contributing positively, while temperature has a significant negative impact. For sunflower, 56.1% of yield variability is attributed to the model, with sown area positively influencing yield, whereas temperature and precipitation increases negatively affect yield. Overall, sown area consistently exhibits a significant positive impact across all crops, while temperature and precipitation effects vary depending on the crop.
The research results the significant impact of drought and temperature on crop yields, emphasizing the varying sensitivities of wheat, maize, and sunflower to these stressors. Wheat yields decline markedly with increasing drought severity, particularly under warmer temperatures, where the combination of high drought and heat has a multiplicative negative effect. Cooler temperatures mitigate some of the drought impacts but cannot fully offset severe water scarcity. For maize, yields similarly decline with increasing drought, with cooler temperatures alleviating water stress and heat amplifying drought-related losses. Severe drought coupled with higher temperatures results in the steepest yield reductions. Sunflower yields are highly sensitive to both drought and temperature changes, with moderate drought showing mixed effects where warmer conditions partially mitigate yield losses. However, severe drought causes catastrophic yield declines across all temperature scenarios, though warmer conditions slightly reduce the severity of these losses. Overall, the results suggests the importance of cooler temperature regimes in moderating drought impacts and the compounded stress caused by the combination of high temperatures and severe drought.

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STUDY ON THE QUALITY OF THE PRACTICAL TRAINING IN VOCATIONAL AND TECHNICAL EDUCATION HELD AT THE LEVEL OF ILFOV COUNTY, ROMANIA, IN THE SCHOOL YEAR 2023 – 2024

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Abstract

The primary objective of career and technical education (CTE) is to enhance the school's contribution to the rapid and efficient transition to a competitive economy based on innovation, knowledge, and inclusivity. In addition to these aspects, we must consider the challenges posed by the swift phenomenon of demographic ageing and external migration flows, leading to the conclusion that CTE will increasingly need to address the immediate needs of employers in Romania. Career and technical education, through its objectives, aligns with the dual role of education: economic and social. Therefore, CTE cannot be narrowly focused on fulfilling the immediate requirements of a specific job; rather, it must ensure the preparation for a successful career that facilitates socio-professional integration. Under these conditions, CTE must be viewed as a stage in the lifelong learning process, which is immediately followed by workplace learning to adapt to its specific demands. In this context, the study aimed to present a study case regarding the quality of the practical training in vocational and technical education experienced at the level of Ilfov County, Romania, in the school year 2023 – 2024. The questionnaire method was applied to a sample of 679 enrolled scholars in high schools with a technological profile in Ilfov County, Romania. Statistical analysis and processing and Likert scale quantified the scholars' responses for identifying solutions to improve practical training courses, to evaluate the system applied, and employment intention after completing the studies and their career path.

Key words**:** *practical training, vocational and technological education, traineeship*

INTRODUCTION

High school education ensures the continuation of studies in compulsory education (9th and 10th grades) and in higher education (11th and 12th grades), developing, deepening, and customizing previous learning skills (knowledge, skills, and attitudes) formats. High school education includes the following streams and profiles:

a) the theoretical branch, with humanistic and real profiles;

b) the technological chain, with technical profiles, services, natural resources, and environmental protection;

c) the vocational sector, with military, theological, sports, artistic, and pedagogical profiles.

The duration of studies in high school education, the full-time form of education, is 4 years, following the framework plans approved by the Ministry of Education. For some forms of full-time and part-time education, the duration of studies is extended by one year. High school studies are completed with the National Baccalaureate Exam and Certification Exam for graduates of the technological and vocational streams. High school graduates without a Baccalaureate Diploma can continue their studies in post-secondary education and can subsequently obtain the 5th qualification level. Graduates with a Baccalaureate degree can continue their studies in post-secondary education to obtain a level 5 qualification or in higher education in any qualification 6, 7, and 8 according to the EQF European Qualifications Framework [7], [8], [9], [16].

On the other hand, vocational education has the following forms of organization:

- professional education, with a duration of 3 years, organized after the completion of the

8th grade, as part of the upper secondary education, starting from the 2014/2015 school year, based on a framework contract concluded between the educational unit and the economic operators involved in professional training of students;

- dual education with a duration of 3 years, organized after the completion of the 8th grade, as part of higher secondary education, starting with the 2017/2018 school year, based on a partnership contract concluded between one or more economic operators or between an association/a consortium of economic operators, the educational unit and the administrative-territorial unit within the radius of which the school unit is located. A practical training contract concluded between the educational unit - the economic agent, and the student;
- practical training programmes with a duration of 720 hours, organized after the completion of the 10th grade of high school, a form of organization currently specific to "Second chance" type programs.

In professional education, subjects for compulsory education and specialized training modules for obtaining a professional qualification are covered. The studies are completed with a certification exam. Graduates who pass the professional qualification certification exam acquire a level 3 qualification certificate of the National Qualifications Framework (skilled worker) and the descriptive supplement of the certificate, according to Europass [6].

The literature in the field emphasizes the need of vocational training and technological education in order to empower the youth to become more employable [2, 3, 5, 12].

In this context, the purpose of the research is to analyse the quality of the practical training in vocational and technical education experienced at the level of Ilfov County, Romania, in the school year 2023 – 2024.

This research is a continuation of the previous studies [2, 3].

MATERIALS AND METHODS

The development of CTE is a priority of the Ilfov County School Inspectorate, also defined by the strategic target of the Institutional Development Plan - TS3: The development of professional and technical education and the correlation of the educational offer with the requirements of the labour market, with a view to a good socio-professional insertion of the graduates.

This priority was based on two directions:

- ✓ developing the skills of CTE students for a good socio-professional insertion on the local and European labour market;
- ✓ the geospatial characteristics of Ilfov county that favour the development of CTE, as a result of the interest shown by students for the much more theoretical education in Bucharest.

The Erasmus+ VET (Vocational Education and Training) mobility projects implemented over the past years in educational institutions across Ilfov County have contributed to the development of CTE. These mobility programs have taken place both individually (at *Cezar Nicolau* Brănești Technological High School and *Nicolae Bălcescu* Voluntari Technological High School) and within a consortium, which included the aforementioned high schools along with the Forest College *Theodor Pietraru* Brănești, *Barbu Știrbey* Buftea Technological High School, *Dumitru Dumitrescu* Buftea Technological High School, and *Pamfil Șeicaru* Ciorogârla Technological High School. So, 5 of the 7 technological high schools in Ilfov were represented in mobilities/traineeships for students in Europe, with obvious positive effects regarding the socio-professional adaptation of the graduates.

Dual education is on the rise, becoming a suitable alternative for students who are unable to adapt to the demands of high school education. Currently, students are enrolled in this form of education in the "Pamfil Șeicaru" Technological High School units, Ciorogârla – with the following professional qualifications: auto mechanic, CNC machine operator, inorganic chemical industry operator and distributor receptionist; "Cezar Nicolau" Technological High School, Brănești - with the following professional qualifications: Baker-pastry-preparer of flour products and Meat and fish products preparer; "Barbu

Știrbey" Technological High School, Buftea - with the following professional qualifications: Distributor receptionist and Salesman and "Mihail Kogălniceanu" Theoretical High School - with the following professional qualification: Hotel worker [15].

Practical training courses are specific to career and technical education and involve the combination of direct, real experience and simulated experience, in imaginative work situations, representing a form of participative learning that maximizes the retention rate of information for the student. After completing the practical training courses, the students acquire skills and skills necessary for integration into the labour market, as the practical training hours provide an opportunity to apply the theoretical knowledge acquired in school [10], [14].

The information that was the basis of this study was collected using the questionnaire method. This is a method or technique often used in descriptive research. Through the questionnaire, the selected group of people (called the sample) fills in the requested data and expresses their opinions, regarding the conditions for carrying out the practical activities, the way in which the organizational aspects were fulfilled, the skills acquired by participating in the traineeships, such as and suggestions regarding assessment methods [1], [13].

The data was collected between September and November 2024, the questionnaires being conducted in digital format. The questionnaire was made up of 11 Likert scale items, which express both agreement/disagreement with some statements describing the school environment, as well as the intensity of agreement/disagreement.

Întrebările au fost construite pornind de la analizarea conceptului-cheie al evaluării reprezentat în acest caz de caracteristicile stagiilor de pregătire practică, mijloacele și modalitățile de implementare și desfășurare a acestora, dar și instrumentele de evaluare utilizate. Apart from the 11 questions obtained in this way, we formulated four open questions aimed at identifying solutions to improve practical training courses, four items about a series of respondents' data (gender, age, class, the specialization they study) and four dichotomous and semi-open questions, independent variables according to which the analysis of the answers was carried out [4], [11].

RESULTS AND DISCUSSIONS

The applied questionnaire is structured in four sections which are made up of questions related to general characteristics of the educational environment from which the respondents come, questions related to theoretical notions and their applicability in practical training courses, the way of carrying out the practical courses, the evaluation system applied, up to questions referring to the employment intention after completing the studies and their career path.

A. In the first section of the questionnaire, dichotomous and semi-open questions (1-4) were applied to which the students filled in information regarding:

1. their age category: 48% of the respondents belong to the 14-16-year-old category, 51% to the 17-19-year-old category and 1% to the 20-26-year-old category)

2. the level at which they are assigned (9th grade, 10th grade, 11th grade,12th grade)

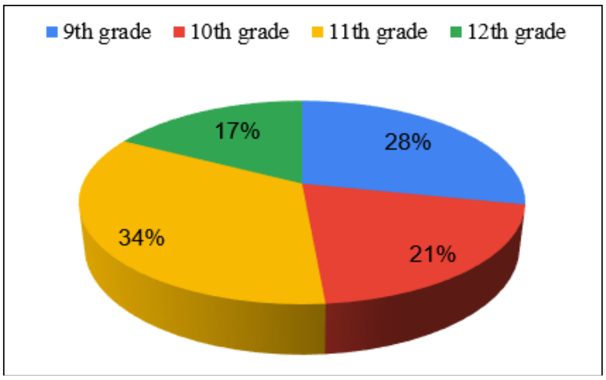

Fig. 1. Distribution of respondents according to the class in which they are enrolled
Source: Own contribution.

3. the area of origin: 27% of the respondents come from the rural area, respectively 73% from the urban area

4. the specialization in which they are enrolled: Tourism and food; Trade; Economics; Environmental Protection; Agriculture; Forestry; Mechanics; Electronics and automation; Health; Manufacture of wooden products; Aesthetics and hygiene of the human body; Textile and leather industry; Construction and public works.

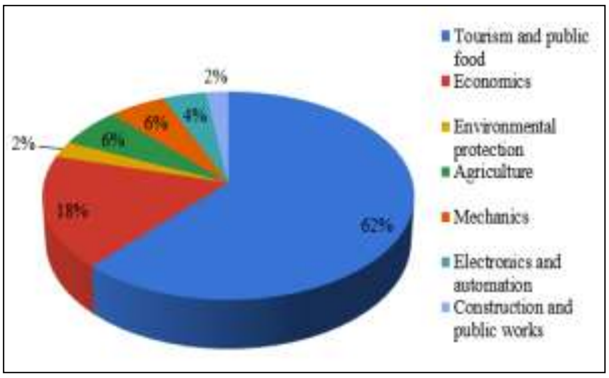

Fig. 2. Distribution of respondents according to the specialization in which they are enrolled
Source: Own contribution.

Table 1. Respondent distribution based on enrolled specialization

Educational unit	Profile	No. of valid answers
Theoretical High School "Mihail Kogălniceanu", Snagov, Ilfov	Tourism and public food	178
Technical High School "Vintilă Brătianu", Dragomirești-Vale, Ilfov	Economics	11
	Environmental protection	17
	Agriculture	21
Technical High School "Nicoale Bălcescu", Voluntari, Ilfov	Tourism and public food	17
	Economics	16
Technical High School "Barbu Știrbey", Buftea, Ilfov	Tourism and public food	98
	Economics	62
Technical High School "Pamfil Șeicaru", Ciorogârla, Ilfov	Tourism and public food	21
	Economics	14
	Mechanics	18
	Electronics and automation	13
Technical High School "Doamna Chiajna", Roșu, Chiajna, Ilfov	Tourism and public food	57
	Electronics and automation	16
Technical High School "Cezar Nicolau", Brănești, Ilfov	Tourism and public food	48
	Economics	16
	Mechanics	20
	Construction, installations, and public works	15
	Agriculture	21
Total respondents		**679**

Source: Own contribution.

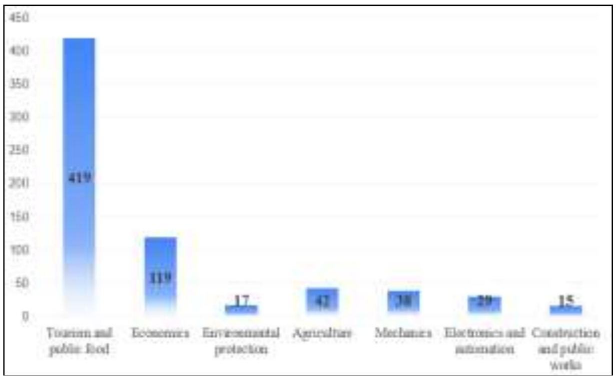

Fig. 3. Distribution of the respondents based on the enrolled specialization
Source: Own contribution.

B. The second section of the questionnaire presents respondents with a series of ranked-response questions. Through these questions, respondents are required to prioritize the answer options in order of the importance they assign to each. Research has shown that this type of question effectively captures the beliefs, expectations, attitudes, and values of the surveyed individuals.

To analyze the quality of the traineeships, several variables were identified, each based on a series of items from the administered questionnaire. Through the questionnaire, respondents were asked to express their level of satisfaction using a scale with the following response options: (1) – totally unsatisfactory, (2) – unsatisfactory, (3) – average, (4) – good, and (5) – very good. Each response option on this scale was assigned a corresponding value (the figures in parentheses); this coding corresponds to the logic according to which a higher agreement for the item in question expresses an agreement or a closeness to the general characteristic sought.

In the following section, we have analysed each variable based on the students' answers to the questions and, accordingly, the averages obtained.

5. The conditions for carrying out the practice activity:

a) working conditions (space, atmosphere, etc.)

b) to what extent the equipment provided by the economic operator was appropriate for carrying out the activities within the practical training

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c) evaluate the level of guidance provided by the tutor appointed by the host company
d) evaluate the level of intercollegiate collaboration during practical activities

To assess the level of satisfaction regarding the conditions under which activities were conducted, a variable was developed, described by four items related to the internal factors of the economic operator. The variable referring to activity conditions was structured based on four specific items: working conditions, the equipment provided, the guidance offered by the tutor, and intercollegiate collaboration. Figure 4 illustrates that this variable registers the highest average satisfaction level concerning the alignment between the equipment provided and the assigned work tasks. This finding underscores the importance of conducting traineeships within economic operators that actively involve students in all stages of the technological workflow and integrate them into the working environment.

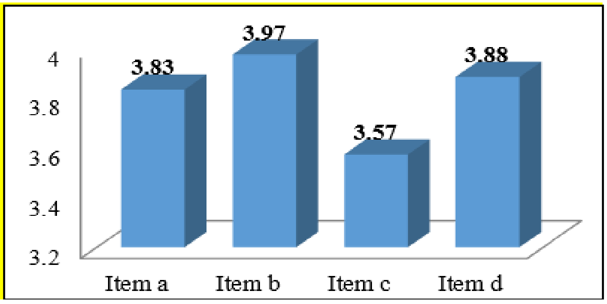

Fig. 4. The conditions for carrying out practical training activities
Source: Own contribution.

6. The way in which the organizational aspects were fulfilled:
a. practice period and daily schedule
b. the partners' activity corresponded to the students' expectations
c. the activity of the partners did not create problems in the running of the program

The organization of the traineeships led to the development of another variable, described by three items that reflect the level of student engagement in the activities of the host economic agents, as well as their satisfaction regarding the duration of the traineeship. The data obtained from the questionnaire indicate that the traineeships were not negatively affected by the activity of the economic operators, with this item receiving the highest level of satisfaction. However, analyzing this variable also reveals a lower level of satisfaction concerning the duration of the traineeship and the students' daily schedule.

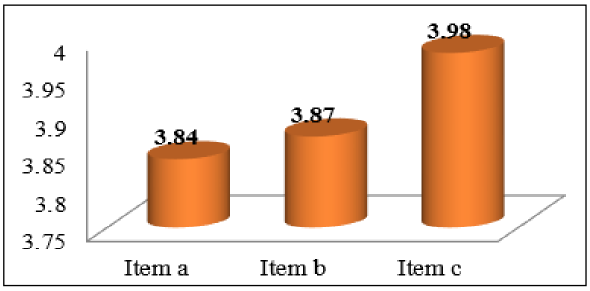

Fig. 5. The fulfilment of organizational aspects
Source: Own contribution.

7. The economic operators fulfilled the students' expectations related to:
a. availability
b. cooperation
c. stimulating active participation in practice
d. flexibility/diversity of the proposed program
e. creating an appropriate environment
f. communicability
g. proper logistics

Starting from the indicators of availability, cooperation, stimulation, flexibility of the program, environment, communication and logistics, the variable satisfaction of students' expectations regarding collaboration with economic operators was constructed. In its case, we observe from the data analysed in Figure 8 that the maximum satisfaction of the students was recorded by the environment corresponding to the instructional-educational process, and the minimum level of satisfaction was represented by the flexibility/diversity of the program.

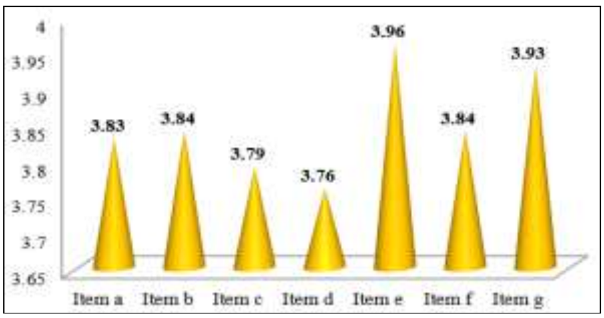

Fig. 6. Students' satisfaction with business operators' performance
Source: Own contribution.

8. To what extent does the students' traineeship contribute to:

a. the development of practical skills
b. developing teamwork skills
c. practical application of the acquired theoretical knowledge
d. increasing the degree of responsibility towards the assigned tasks
e. entering the labour market as a graduate

From the perspective of the five items developed based on the enhancement of practical and teamwork skills, the applicability of theoretical knowledge, and the empowerment of practitioners for their integration into the labour market, the variable "contribution to the development of students' work skills and capacities" was constructed.

The data presented in Figure 7 indicate that a significant number of respondents believe that traineeships play a crucial role in fostering students' sense of responsibility toward their assigned tasks.

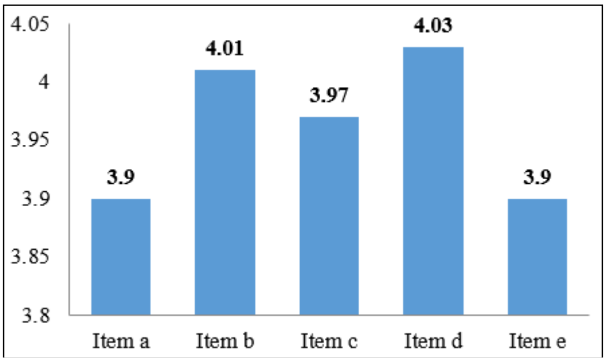

Fig. 7. Contribution of traineeships to the development of skills and work capacities
Source: Own contribution.

9. To what extent do you think it is necessary for students' pre-practice training to include:

a. a career counselling and guidance module
b. basic elements of organizational communication, teamwork
c. specialized training in the field of activity of the company/institution
d. information about the organizational and decision-making structure of a company/institution
e. concepts related to organizational culture and corporate social responsibility

The importance of prior theoretical preparation before engaging in practical training constitutes a variable structured into five items, assessing respondents' satisfaction with career counseling and guidance, elements of organizational communication, training in the economic operator’s field of activity, the provision of information regarding its organizational and decision-making structure, as well as concepts related to organizational culture. The data presented in Figure 8 indicate that a significant number of respondents support theoretical preparation concerning the organizational and decision-making structure of a company or institution.

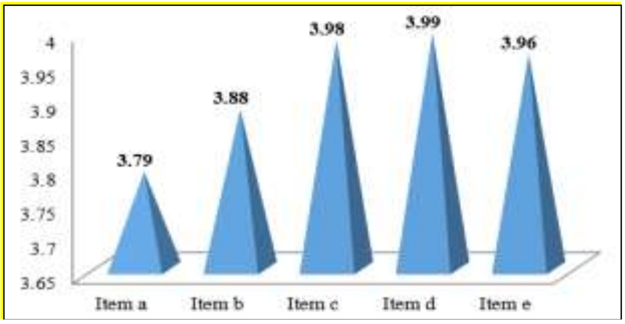

Fig. 8. The importance of theoretical preparation before traineeships
Source: Own contribution.

10. To what extent do you consider the following ways of evaluating the traineeship to be appropriate?

a. assessment along the way by the practice tutor appointed by the company/institution
b. evaluation at the end, based on the tutor's characterization
c. the combined evaluation, both during and at the end of the traineeship by characterizing the tutor and noting the practical activities, the project or other documentation made in the company/institution
d. conducting evaluations on an online platform

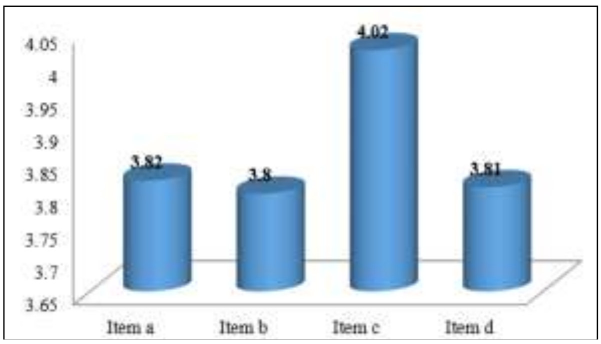

Fig. 9. Methods of evaluating traineeship periods
Source: Own contribution.

In order to ensure the implementation of a quality instructional-educational process, the level of knowledge, skills and skills acquired by the students must be periodically checked. Another variable influencing the quality of the traineeships is the evaluation process. To assess the level of satisfaction with the methods and tools used for evaluation, four items were developed.

Interpreting the results obtained from the administered questionnaire, it is evident that the majority of respondents support a combined evaluation method—both during and at the end of the traineeship—as it provides a clearer insight into the trainee's level of preparation.

11. Do you rate the effectiveness of the following forms of communication between the practice manager and the students?

a. Daily, through a student group coordinator

b. Telephone communication with all students, at their initiative

c. Daily participation in meetings held at the company headquarters

d. Constant communication through an online platform

Communication is a significant component influencing the teaching-learning-evaluation process. One key variable that attracted respondents' attention was the communication between students and the teacher responsible for coordinating the traineeships. This variable was developed based on four items that specify the communication methods deemed effective in facilitating the smooth conduct of practical training programs.

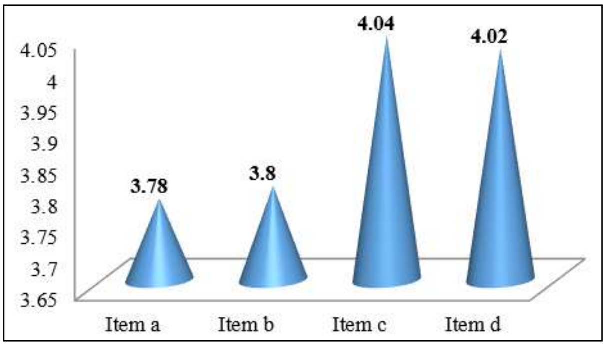

Fig. 10. Communication between the teaching staff responsible for traineeships and students
Source: Own contribution.

Figure 10 illustrates that the majority of respondents favour both traditional and modern communication methods. They consider daily meetings at the premises of the partner economic operator to be the most effective way of ensuring communication between teachers and students. At the same time, they also support modern communication methods available through online platforms.

12. To what extent do you consider the following activities of the practice coordinator to be important?

a. implementation of the student evaluation process along the way and at the end

b. permanent communication with students and tutors

c. permanent monitoring of the traineeships to achieve the objectives of the programme

d. substantiation of internal reports intended for the management of the educational unit

Another variable analyzed through this questionnaire is the role of the teacher in coordinating the traineeships. This variable is based on four items: the teacher's involvement in the evaluation process, continuous communication with students and tutors, ongoing monitoring of the traineeships, and the development of reports on the conducted traineeships. According to the data presented in Figure 11, the majority of respondents believe that the coordinating teacher has two primary roles: maintaining continuous communication with students and traineeship's tutors and monitoring the traineeship activities to ensure that the established objectives are achieved.

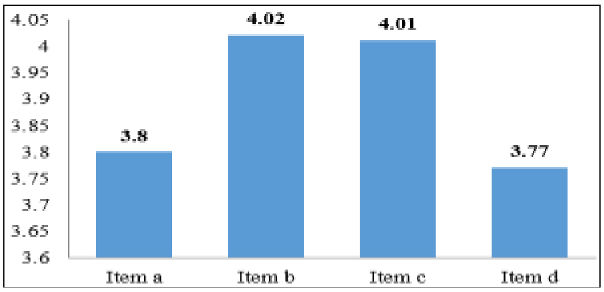

Fig. 11. Importance of the activity of the educational coordinator of the traineeships
Source: Own contribution.

13. The relevance of the traineeship for training as a specialist:

a. the degree of inclusion of the activity carried out in the recommended theme

b. to what extent the objectives/tasks were clearly outlined and their achievement was followed

c. the degree of use of the knowledge acquired in the theoretical training

d. to what extent are you satisfied with the acquired practical skills

A variable assessing the impact of the traineeships on students' professional development consists of four items that focus respondents' attention on the following aspects: the relevance of activities concerning the study program, the clarity of assigned tasks and the monitoring of their completion, the applicability of theoretical knowledge, and the practical skills acquired. According to the data presented in Figure 12, it is noteworthy that the majority of respondents placed particular emphasis on the clarity with which objectives and work tasks were defined, as well as on the establishment of clear goals for their achievement.

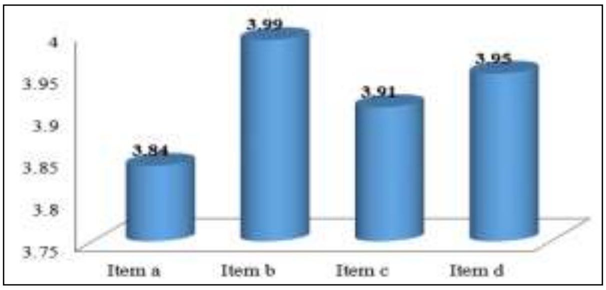

Fig. 12. The relevance of traineeships in the professional training of students
Source: Own contribution.

14. What do you think are the main attributes that student traineeships should fulfil?

a. the proper arrangement and equipment of the spaces intended for the practical traineeships

b. ensuring permanent monitoring and feedback throughout the traineeship

c. suitability of the contents of the practice program to the requirements of the labour market

d. the access of students, teaching staff and practice partners to digital tools to facilitate the planning, running and monitoring of activities/traineeships, communication between all parties involved, involvement in the organization of activities

The practical training courses have a significant value, representing an instructive educational process that facilitates the assimilation of skills, abilities and skills that cannot be achieved based on theoretical notions. Regarding the usefulness of traineeships, the respondents expressed their opinion on the main attributes that they should fulfil. For this, four items were built that are based on the conditions for carrying out such activities, monitoring and permanent feedback, the correlation of contents with the requirements of the labour market, and the access of all those involved to digital tools to optimize the activity of these practical training schemes.

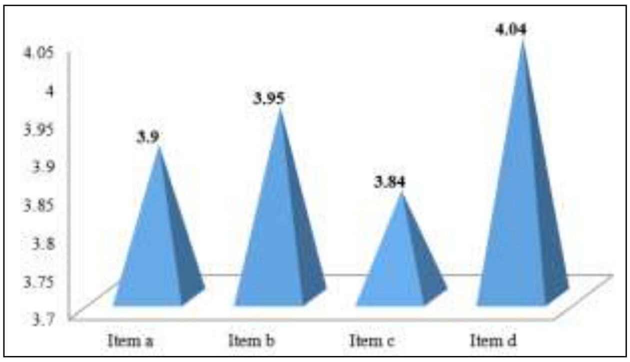

Fig. 13. Main attributes that traineeships should fulfil
Source: Own contribution.

Figure 13 shows that the majority of respondents consider it opportune for those involved to have access to digital tools to help optimize traineeships by facilitating the planning, running and monitoring of activities.

15. What do you consider to be the main benefits for the students participating in the traineeships carried out within some economic operators?

a. the possibility of familiarization with a work environment

b. acquiring knowledge specific to the field of training

c. training of practical skills specific to the field of activity

d. the opportunity to learn/acquire skills directly from tutors/specialized staff working in the field of activity
e. the opportunity to meet potential future employers
f. training in communication skills, teamwork, flexibility

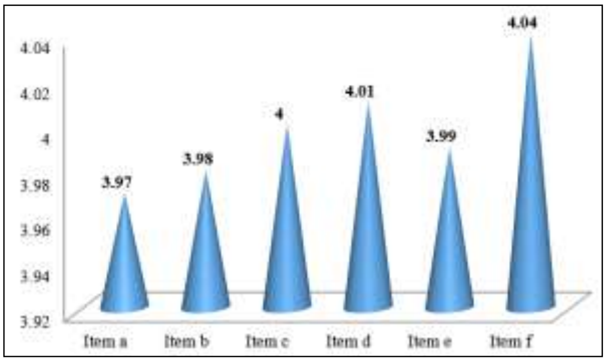

Fig. 14. Benefits that the traineeships offer to students
Source: Own contribution.

The questionnaire respondents expressed their views on the benefits of participating in the traineeships by ranking six items related to workplace familiarization, acquisition of specific knowledge, development of specialized competencies, the opportunity to learn from specialists and connect with potential employers, as well as the enhancement of communication skills, teamwork, and flexibility. Analyzing the data presented in Figure 16, it is evident that a significant number of respondents place great importance on the development of communication skills, teamwork, and flexibility.

C. The third section of the applied questionnaire is made up of a set of dichotomous and semi-open questions (from 16 to 19) through which the respondents express their opinion regarding the alternation of hours of theoretical training and practical training, the optimal size of the professional practice, employment intention in the studied field, as well as job offers received, to which the students responded by choosing one of the options available

16. In your opinion, do you think there should be more hours of practical or theoretical training in the acquired specialization?

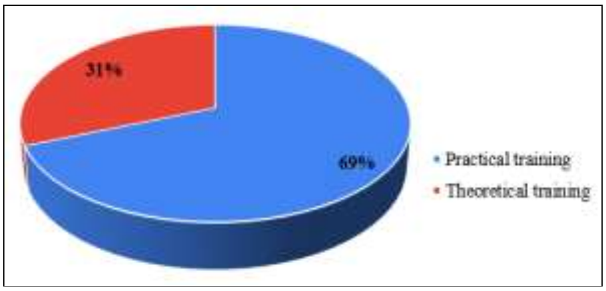

Fig. 15. Respondents' opinions on practical and theoretical training
Source: Own contribution

17. What period do you think is optimal to carry out a traineeship?

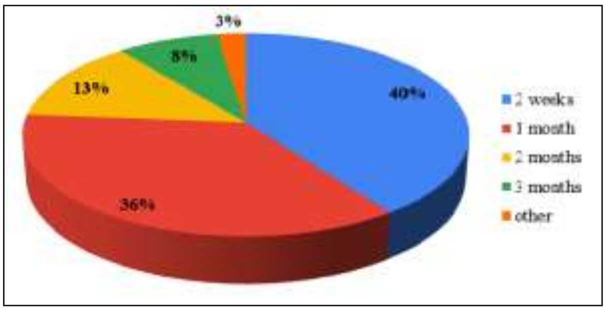

Fig. 16. Respondents' opinions regarding the duration of traineeships
Source: Own contribution.

18. After completing the study program do you intend to work in the field you are studying?

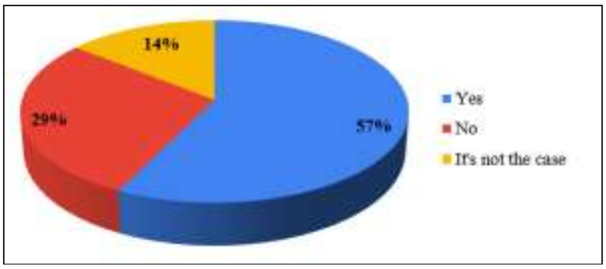

Fig. 17. Respondents' opinions regarding the intention to work in the field they are studying
Source: Own contribution.

19. Have you received job offers from practice partners?

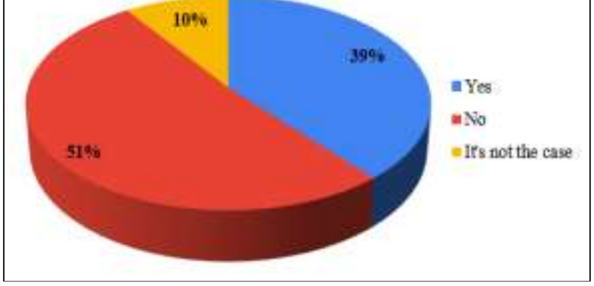

Fig. 18. Respondents' opinions regarding job offers
Source: Own contribution.

D. The fourth section of the questionnaire is made up of open questions (from 20 to 23) to which the students can answer using their own words, being used in the exploratory stage of the inquiry, in which the aim is rather to identify and describe the full range of situations, behaviours, attitudes, etc., than establishing their frequency (the answers to these questions being impossible, or very difficult, to codify).

20. List 5 positive aspects of the traineeship, in descending order of their importance.

The answers that prevailed to this question referred to the development of communication capabilities with clients, Formation of skills and abilities specific to the specialization they are studying, strengthening of inter-human relationships, Development of team spirit, the opportunity to interact with specialists and potential employers, increasing work skills by practising them in practice, getting familiar with the work environment.

21. How do you think the process of carrying out the traineeships can be improved?

To this question, the student respondents offered some suggestions regarding the improvement of the traineeship process: diversifying partnerships with economic agents, empowering students and staff in the practice units, improving communication between students - teaching staff - practice tutors, and increasing material incentives.

22. What contents would you like to be included in the practical training courses?

Questioned about the contents they would like to be introduced in the study programs, the students suggested that in the activities they carry out at the practical operators, they should be involved in administrative and economic activities, as well as in all stages of the technological flow for the realization of finished products.

23. What other ways of evaluating the traineeship (except for the options mentioned in point 10) do you think would be effective?

Concerning the evaluation methods of the practical training courses, the respondents propose to apply the collegial evaluation as well, observing the degree of involvement of the colleagues in carrying out the work tasks, corroborated with the evaluation carried out by the practical tutor and the coordinating teaching staff.

CONCLUSIONS

The analysis regarding the quality of traineeships in vocational and technical education was carried out based on the answers given by 679 students enrolled in high schools with a technological profile in Ilfov County to the Questionnaire for evaluating the implementation of traineeships for students in the 2023 school year - 2024. The empirical data were collected between September and November 2024. The questionnaires were distributed to the students in the format electronically.

The analysis highlighted the skills and professional competencies that the students want to develop during the practical training hours. The highest averages were obtained for: increasing the degree of responsibility towards assigned tasks (4.03); developing teamwork skills (4.01); training of communication skills, teamwork, and flexibility (4.04); training of practical skills specific to the field of activity (4.00); the acquisition of knowledge specific to the field of training (3.98) and the practical application of the acquired theoretical knowledge (3.97).

The analysis also sought to identify the respondents' expectations regarding traineeship evaluation activities. According to the averages, the main expectations of the students refer to the combined assessment, both during and at the end of the programme, by characterizing the tutor and marking the practical activities, the project or other documentation made in the company/institution (4.02).

The first and probably the most important recommendation refers to the relationship of the tutors (employees of the host economic agents who have direct duties and activities to guide the student trainees) with the students. The analysis highlighted the fact that the majority of students consider the relationship with the tutor and the guidance received from him/her to be essential for the smooth running of the practical training courses, and as such, during the practical training hours, the tutors should act as mentors for the young trainees. The high expectations of the students from the tutors can be turned into key points or success factors of the traineeships only with the agreement, dedication and interest of the latter.

Concerning the competencies/skills that the respondents want to develop as a result of their traineeships, we recommend that tutors focus on competencies/skills that tend to be transversal and avoid or limit as much as possible competences/skills with too specific character (although here it is up to the tutors, in collaboration with each practitioner, to distinguish between specific and transversal skills/competences according to the individual development needs of the students). Tutors should also emphasize those activities and tasks that can ensure personal development (acquiring new knowledge, discovering new skills/competencies or strengthening existing ones) and increase the employability of graduates.

The analysis also highlighted that a considerable percentage of respondents are not motivated to maintain contact with host economic agents, which can be seen as a problematic issue. The purpose of traineeships should extend beyond merely fulfilling the period allocated by the school year calendar in host organizations; instead, these programmes and weekly practical training hours should establish a connection between students and host economic agents—a connection that can later prove beneficial (directly or indirectly) for integrating graduates into the labour market.

Future graduates can—and, more importantly, should—view traineeships as an opportunity to engage with the professional world, organizations, and industry experts while laying the foundations for informal networks that can aid in securing employment after graduation.

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THE PERCEPTION OF SCHOOL DROPOUT IN PRE-UNIVERSITY EDUCATION. CASE STUDY: "MIHAIL KOGĂLNICEANU" THEORETICAL HIGH SCHOOL, SNAGOV, ILFOV COUNTY, ROMANIA

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Abstract

School dropout is a longstanding issue in many countries, with a profound impact on the lives of adolescents and society as a whole. Shifting from intervention to prevention is a more effective and efficient approach to addressing this problem. In this context, the study aims to explore the factors that lead to school failure, which often result in the negative consequence of school dropout. This topic was selected because school failure is an enduring educational challenge that continues to grow daily. Furthermore, every teacher inevitably encounters this phenomenon in their professional life, which is why we believe that all educators should be actively involved in investigating the causes of school failure and be familiar with a set of preventive measures aimed at combating or preventing school dropout. This research was conducted to identify the socio-cultural and family factors that, along with other individual and school-related determinants, contribute to the school dropout issue among students at "Mihail Kogălniceanu" Theoretical High School. A survey based on a structured questionnaire was used to collect the respondents' answers for identifying the number of students who dropout the school, the factors which determine them to do this, why they do not attend the school and how to reduce the absenteeism rate. The results proved that the main causes of school dropout are: family problems, the negative influence of the so called "friends", lack of school motivation, traditions of some minorities, lack of perspective after leaving the school, emotional and behavioural problems. To diminish this phenomenon special measures should be taken by improving education system especially in the rural areas.

Key words: *education, school dropout, case study*

INTRODUCTION

The issue of school dropout is complex, extending beyond the educational sphere to cultural, economic, political, and social dimensions that shape a society's core choices. It is characterised by the extreme devaluation of formal education and the erosion of learning motivation, signalling a mutual failure of adaptation—both the student's inability to meet school requirements and the school's inability to accommodate the student's individual learning needs.

School dropout constitutes a definitive act of disengagement, where students cease attending school and exit the educational system—regardless of the level reached—before obtaining a qualification, completing professional training, or finishing their study cycle [2]. The effect of dropping out of school has serious consequences because the young person who has neither a professional qualification indispensable for his socio-economic integration nor the moral and civic training necessary to exercise the role of a citizen of a community practically fails to adapt properly to social life. By lacking such qualifications, school dropouts are more likely to become the unemployed of the future, posing medium- and long-term challenges for society while also facing significant personal losses [3].

Specialised research highlights the fact that the student/young person on the verge of dropping out is unable to adapt and function adequately in the class group, has below-average school results, does not set educational and professional goals, and shows hostility towards adults and school authority representatives. As a rule, they usually come from families experiencing existential stress and do not participate in any activities organised by the school, whether formal or non-formal. In most cases, children/young people in this situation move away from school, looking for satisfaction in other environments, generally in dangerous ones for them (groups of young people who have no occupation). In conditions where the family no longer has time, resources or sufficient authority to help their child, he is exposed to marginalisation or social isolation [9].

From the perspective of economic costs, an insufficiently educated person is more expensive for society than a well-educated one because he has weak schooling and, as a consequence, a reduced ability to integrate into the labour market. In this case, the state supports the individual through various means of assistance (unemployment aid, heating aid, aid for disadvantaged people), etc.

Considering all these aspects, we believe that school counselling can be used to raise students' awareness of the benefits provided by acquiring the highest possible level of training in the field in which they will work.

Among the causes of school dropout frequently found among young people it can be mentioned some determinants such as poverty, unemployment, lack of information, low level of education of the parents, inadequate social protection measures, high costs for clothes, shoes and supplies, lack of housing conditions necessary for studying (many of the poor families live in houses without electricity and/or overcrowded), poor health, disorganisation of the family, lack of help for education from parents and the lack of control over children's activities in their free time [12].

The following cannot be neglected: the wrong mentality of some students, parents or social categories regarding the role played by the school in the education of children; the existence of poor school results, the limited educational offer from schools regarding the organisation of alternative and attractive forms of training, the lack of effective collaboration on the line of eliminating/reducing school dropout between various stakeholders in education, including educational institutions, Local Councils, County Councils, Prefectures, and NGOs, the lack of a legislative framework that allows the establishment of educational classes primary to another form of education than day education, withdrawing the child from school to be sent to work or to take care of younger siblings/cousins [2].

When the students' parents decide to work in a foreign country, situations may arise in which the children, left alone at home, drop out of school. Practically, the departure of an entire family abroad causes children to withdraw from school.

As in the rural areas, where school dropout reflects a critical situation, it is important to research the causes which determine this phenomenon [13, 5, 10, 8] and try to find solutions to diminish its intensity and stop its extend [14, 6, 7].

In this context, the paper goal is to present a study case of school dropout in a high school situated in Snagov Commune, Ilfov County, Romania.

MATERIALS AND METHODS

In order to carry out the proposed methodological approach, we determined that the general objective of the investigation is to analyse the situation of school dropouts in the "Mihail Kogălniceanu" Theoretical High School in Snagov commune, Ilfov County.

From the general objective, we derived the following specific objectives:

1. Identification of the number of students who dropped out of school in the 2023-2024 school year;
2. Highlighting the perception of school counsellors/mediators regarding the risk of school dropout;
3. Highlighting the reasons why some children do not attend school now;
4. Identifying the measures that could contribute to reducing the rate of absenteeism/abandonment;
5. Finding out how children who do not attend school spend their time.

Concept operationalisation:

✓ The role of the school in the life of the student/teacher;
✓ Causes of school dropout;
✓ Determination of the student's living environment;
✓ Determining the degree of satisfaction with the educational act;
✓ Determining the level of involvement of the student in the educational act;
✓ Educational attitudes and roles.

Research hypotheses:

1. A precarious socio-affective family climate is an important factor in the occurrence of school dropout;
2. The way in which the parents value the school is a determining factor in terms of the school results obtained by the child;
3. The busy school schedule negatively influences the student's attitude towards school;
4. The teacher's profile influences the intensity of course attendance;

Working hypothesis: School dropout is the result of socio-economic and educational factors.

To collect the data needed for the study, two questionnaires were designed and applied.

The first questionnaire was built from ten questions and addressed to teaching staff.

<u>Questionnaire regarding the perception of school dropout - for teaching staff.</u>

The first questionnaire was composed of ten questions and was addressed to teaching staff. The first five questions collected data on the respondents' gender, background, age group, years of experience in education, and qualification level. The following five questions primarily focused on the phenomenon of school dropout, its current relevance, the factors that may lead to students abandoning their studies, and the measures to prevent school dropout.

The second applied questionnaire was built from 25 questions and addressed to high school students.

<u>Questionnaire for assessing the risk of school dropout - for students.</u>

The first set of questions (from 1 to 3) was structured in such a way as to gather information about the gender of the respondents and the background they come from.

The second set of questions (from 4 to 7) measured the degree of satisfaction of the respondents regarding the results obtained and the environment in which school activities are carried out. They had four answer options:

a. Very satisfied;
b. Satisfied;
c. Dissatisfied;
d. Very dissatisfied.

The third set of questions (ranging from 8 to 25) gathered information on students' interpersonal relationships, their collaboration with peers and teachers, their level of interest in studying, and the challenges posed by dropout and absenteeism. Respondents provided brief answers to these questions:

a. Yes;
b. Not.

RESULTS AND DISCUSSIONS

1. Description of the group of study participants

"Mihail Kogălniceanu" Theoretical High School is a reference educational institution in Ilfov education. The institution has implemented and continues to carry out projects aimed at enhancing the development of knowledge in the field of professional training, with a particular focus on anticipating the skills and qualifications required by the labour market, as well as exploring new methods of training and evaluating this training.

In this research, a total of 110 students from the 9th, 10th, 11th, and 12th grades, out of 517 enrolled in day high school education, along with 53 teaching staff members, were surveyed.

We can assess that the chosen sample provides satisfactory representativeness, even though not all students from the institution were included in the research.

2. *Description of work tools*

Rigorously carried out sociological investigations can bring to light important aspects of social reality, allowing decision-makers and institutions to adopt suitable ameliorative strategie s for the identified problems. The present study aims to highlight the situation of school dropouts and the risk of dropping out at the level of the "Mihail Kogălniceanu" Theoretical High School. We aim to highlight the reasons why some of the students did not attend school, the activities/concerns of those who do not attend school, and the ameliorative measures proposed by school counsellors/mediators that could contribute to reducing the rate of this phenomenon [11].

To probe the profile of this phenomenon in pre-university education in the target group, we used the questionnaire method. This is a method or technique often used in descriptive research. Through the questionnaire, the selected group of people (called the sample) filled in the requested data and expressed their opinions regarding school dropout.

The conclusions of the investigation are based on the laws of standard mathematical statistics, which are based on the calculation of the frequencies with which different answer variants of each question appear and on the verification of the formulated hypothesis.

3. *The questionnaire*

The questionnaire is a technique and, at the same time, an investigative tool that consists of a set of written questions, ordered logically and psychologically, which, through the administration of the investigation operators, determines answers from the investigated to be recorded in writing [4].

In our research, an indirect survey using the questionnaire was employed, considering the advantages of this tool for gathering opinions. These include providing subjects with sufficient time to reflect before responding, eliminating the potential influence of the survey operator, and reducing errors in recording and interpreting the data, among other benefits.

In the compilation of the questionnaires, we had in mind the realisation of factual questions, as well as opinion questions that usually probe the inner universe of the individual, more specifically, the opinions of individuals and the subjective evaluations regarding the studied topic.

We built closed questions, starting from the premise that they ensure greater rigour and solid validity of the research instrument, but also open questions with short answers. In formulating the closed questions, the criterion of completeness was considered, i.e. the possibility offered to each respondent to find the answer variant satisfactory for himself, from those proposed, the necessity of framing the answer variants in distinct categories and the possibility of providing univocal answers.

The formulated questions are introductory, passing and with a moderate degree of abstraction. In making them up, I tried not to make them too demanding or boring. Through the form and content of the formulated questions and the language used, we wanted these investigation tools to be easy to understand and complete.

4. Organization of research

The theoretical basis of the research was carried out in December 2020 (theoretical considerations, construction of objectives and working hypothesis, creation of questionnaire models and their application).

The actual development of the research was achieved by collecting the data in the same time interval and then proceeding to the registration, processing and interpretation of the data.

5. Verification and validation of questionnaires

When checking the questionnaires, I mainly looked at three aspects: their completeness, accuracy and uniformity. Completeness refers to the fact that each question must receive an answer, and in the case of non-answers, their cause must be analysed. In the case of the present research, we only faced this problem to a small extent because some of the questions were closed.

As a rule, closed questions make completing and analysing the questionnaire easier. However, open-ended questions offer the advantage of providing a wide range of alternative responses, allowing researchers to gain a comprehensive understanding of the phenomenon under study.

The data were collected based on two questionnaires:

1. A questionnaire for teachers and managers;
2. A questionnaire for students.

To supplement the data obtained through the questionnaire, the school documents were used.

The analysis of the results was based on frequency distributions. The study focused on the following indicators, which can be found in the formulation of the questions for the questionnaire:

- ✓ The role of the school in the life of the student/teacher;
- ✓ Causes of school dropout;
- ✓ Determination of the student's living environment;
- ✓ Determining the degree of satisfaction with the educational act;
- ✓ Determining the level of involvement of the student in the educational act;
- ✓ Educational attitudes and roles.

This had a double purpose:

a. A quantitative purpose: obtaining information related to the structure of the class, the ethnic composition, the social status and the various risks to which the students of the class could be exposed - risk of dropping out of school, risk of family abandonment, risk of institutionalisation, risk of emotional abuse, risk of physical abuse, risk of social non-integration.

b. A qualitative aim: checking the degree of knowledge of the leaders of their own class.

6. Frequency tables - data interpretation

Questionnaire regarding the perception of school dropout - for teaching staff -

When asked about the actuality of the school dropout phenomenon, the teaching staff appreciated that at the level of Romania, the school dropout phenomenon is no longer so topical.

Analysing the responses of the subjects, we find that 45% (24 options) consider that, to a small extent, school dropout is still a current phenomenon, a challenge for the education system in Romania; 28% (15 options) believe that, to a large extent, the school dropout phenomenon is still current; 17% (9 options) consider that to a very large extent, the school dropout phenomenon is still current; and 10% (5 options) believe that the school dropout phenomenon is no longer current.

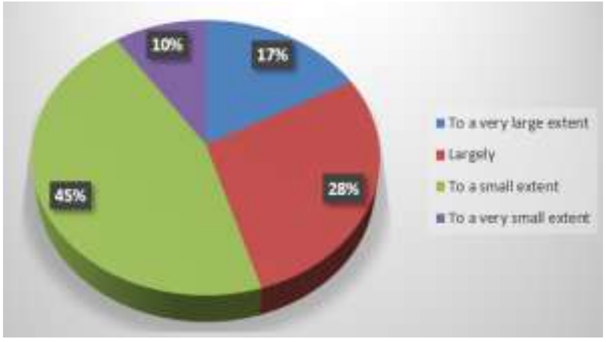

Fig. 1. The actuality of the school dropout phenomenon
Source: Own contribution.

To the question, "To remedy this phenomenon, it is necessary to know the causes that can lead to leaving the educational path. Mention a factor of school dropout noted in the unit of which you are a part", 58% (31 options) of the teachers believe that a main factor of school dropout is "lack of student motivation and adaptation difficulties"; 28% (15 options) believe that the "precarious material and financial situation of the family" is a factor in school dropout; 8% (4 options) claim that "lack of family involvement" is a factor in school dropout, and 6% (3 options) consider that "students' need for leisure" is a factor in school dropout.

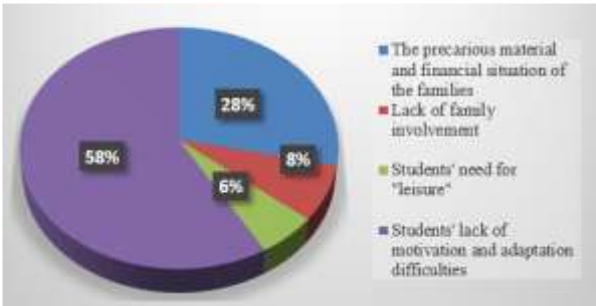

Fig. 2. Factors influencing school dropout
Source: Own contribution.

To the question regarding the influence of repetition on school dropout, 51% (27 options) of the respondents believe that repetition influences school dropout to a small extent, 28% (15 options) consider that school dropout is influenced to a large extent by repetition, 11% (6 options) consider that school dropout is influenced by repetition to an insignificant extent, and 10% (5 options) believe that school dropout is influenced to a very large extent by repetition.

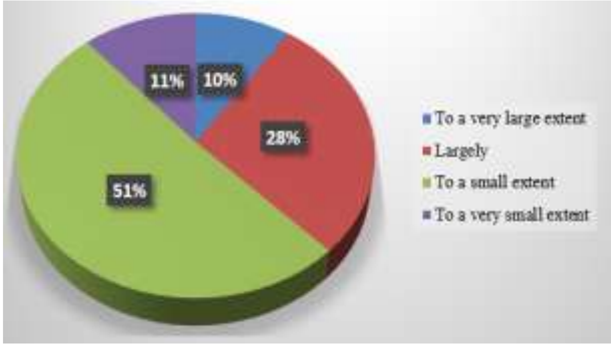

Fig 3. The influence of repetition on school dropout
Source: Own contribution.

To the question regarding the necessity of opening the school to the community, 70% (37 options) of the respondents believe that it is a very great necessity for the school to be open to the community through offers and services, 24% (13 options) consider it a great necessity, while 6% (3 options) maintain that the openness to the community is a small necessity.

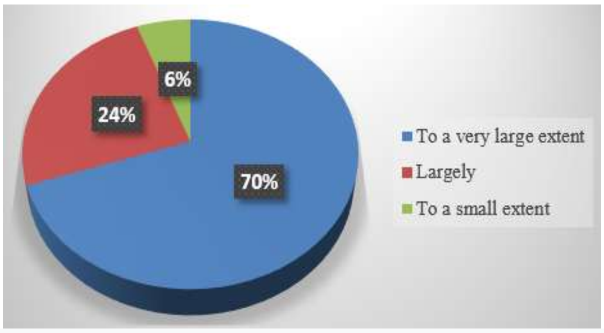

Fig. 4. The need to open the school to the community
Source: Own contribution.

To the question regarding the measures to prevent school dropout, 45% (24 options) consider that a good measure to prevent school dropout is to condition the allowance 36% (19 options) consider that special training activities for children from groups with a high risk of school dropout are an appropriate measure, 11% (6 options) consider that a good measure is to sanction parents who do not take care of ensuring the right to education, while 8% (4 options) believe that providing financial and material support to poor families would be a suitable measure to reduce school dropout.

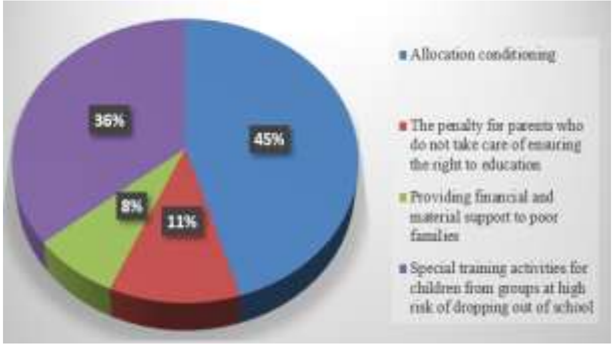

Fig. 5. Measures to prevent school dropout
Source: Own contribution.

CONCLUSIONS

School dropout is today a phenomenon encountered in all education systems. For teachers, the reasons for dropping out of school are primarily related to the children's family problems, the influence exerted by the so-called "group of friends" on them, the lack of school motivation, and the fact that they are made to work rather than learn. The information presented in this study is not new to the education system, but it emphasises the need for prompt and effective remedial measures to be implemented to reduce the school dropout rate. In the absence of these measures, the phenomenon of abandonment could increase, and this will have, as I stated at the beginning of the paper, negative consequences on society in the medium and long term. The implementation of modern technologies cannot be done with an unskilled or insufficiently skilled workforce.

It is strictly up to the school to take measures for students to participate in more attractive school activities, for students to care about their grades and for the accumulation of a large number of absences. The problems related to commuting, those related to the specific traditions of some minorities, or those related to the lack of perspective offered by the school due to its inadequacy with the labour market are not to be neglected either. At the same time, we made a special mention of the emotional and behavioural problems faced by some students. However, in these situations, solutions can certainly be found by the institutions responsible for these areas.

If, at present, children are staying at home or going out instead of attending school, some appropriate legislative measures must be taken to rectify the situation.

The improvement of the dropout phenomenon undoubtedly depends on the measures that the school will adopt. Considering the class of students as a social group characterised by a complex system of interpersonal relations, the educator can make it an attractive environment. The quality of the climate and the cohesion of the group can make students stay away from school. Through learning methods and techniques designed to promote learning motivation, both at the microsocial and individual level, teachers can stimulate students to develop empathic skills and the feeling of belonging to a group.

To some extent, it depends on the teachers as well as the students who, for reasons that are within their control or not, do not drop out of school. If these students are encouraged to come to school, they are positively appreciated for this, and they arrive in time to have better and better results in education in conditions where the other members of the group have already reached the set performances, the results obtained will certainly be positive. For the student who has been absent from school for a while, the return is beneficial not only from the perspective of his academic progress but also from the perspective of the fact that the interaction with the other students in the class creates a favourable atmosphere of acceptance and sympathy, which ultimately leads to an increase in self-esteem and an anxiety reduction.

The family and the school are the main agents of socialisation for the child, and therefore, together, they can act to prevent and reduce absenteeism/abandonment and the integration of children who have faced such problems at some point.

Dropping out of school has major implications on the personal development of the individual and short-, medium- and long-term consequences on the development of human resources and the development of communities in general. Surely, as society develops day by day, the evolution/involution of this phenomenon will be highlighted, as well as other ameliorative solutions that can be adopted for the benefit of our students.

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ASSESSMENT OF RESTAURANTS AND OTHER FOOD SERVICE SECTOR: TRENDS AND ANALYSIS IN ROMANIA

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Abstract

The document focuses on the transformation and dynamics of the restaurant and food service market in Romania ranging from 2015 to 2022 with a special attention to the 2023 financial information. The research is based upon on particular information obtained from the National Statistics Institute and certain other financial related data bases in order to single out and address the major trends occurring in the sector. Analysis focuses on the economic variations, shifts in the consumption patterns of people, as well as the consequential effects on revenue and operational expenditures in the food service business. Furthermore, the analysis presents with national and regional dimensions of the sector development, the spatial imbalances, and the main determinants of the growth and the viability of the companies in this industry. The obtained results give important insights into the functioning of the restaurant and food service market place and explain in details the general state of the industry in the mentioned economic situation.

Key words**:** *restaurants sector, other food service activities, trends, financial assessment*

INTRODUCTION

In the past ten years, the restaurant industry has had a significant impact on society and the environment, especially in countries with a developed tourism sector or with a food culture integrated with social and tourist activities [9]. However, the entire food services sector comes with numerous challenges from year to year due to food waste [13] [14], the competitive environment [1], labor shortages [3], the quality of management practices [15] etc. Specialized literature has addressed these challenges by focusing on: identifying market changes, service quality in the food sector, economic efficiency of restaurants, service marketing, food safety and health, etc. [5].

Despite all the challenges in the field, in Romania, the entire hospitality industry has had a favorable evolution, with increases in turnover and the number of tourists even in the context of reduced investments in the sector [2]. Moreover, studies in the field analyze the food service sector in general in close correlation with the tourism sector, aiming to highlight: the connection with the tourism infrastructure [4] [6]; the place in the service sector [8]; the evolution of the workforce [11] [16]; the competitive environment [7]; financial aspects [10] etc.

MATERIALS AND METHODS

The research method adopted for this paper focused on some indicators specific to the restaurant and catering sector in Romania. These were selected to highlight how the sector has evolved from 2015 to 2022 and to underline its size at the county level in 2023. The difference in years between the selected ones is given by the fact that the National Institute of Statistics is currently providing, for the year 2022, while the website topfirme.ro is supplying financial data for the latest annual reporting year, respectively 2023. We consider that the statistical data allows us to outline the evolution of the sector in the last ten years, according to the dimensions of: size - number of firms; social dimension - number of employees; economic indicators - financial parameters. On the other hand, the financial data provided by the Topfirme.ro website gives us an image of the sector at county level both in terms of size (number of active companies), social aspect (number of employees), and economic by evaluating turnover and profit. The results are presented structurally and dynamically, through graphic and tabular representation.

RESULTS AND DISCUSSIONS

The evolution of the sector between 2015 and 2022

This section presents the evolution of the growth of public catering units since 2015 in different categories of restaurants of the CAEN code class 56. There is an increase in catering event units with home delivery, customers being more interested in ordering ready-made dishes, and a decrease of 11.9% in service activities in units in the last 7 years.

Table 1 studies the changes that occurred in the food service sector with reference to the number of enterprises and the average number of employees over the years 2015 to 2022, focusing on the three main sectors of restaurants and mobile food services (CAEN 561), event catering and other food services (CAEN 562), and beverage serving activities (CAEN 563). It illustrates the growth and decline of certain sub-sectors during these seven years.

Our analysis indicates the following: a growth in restaurants and event catering; a decline in beverage serving activities; a growth in employment.

The total number of enterprises grew by 15.6% from 20,075 in 2015 to 23,197 in 2022. Sub-sectored, restaurants and mobile food services recorded the largest growth, with a 39.8% increase in the number of enterprises. These trend changes suggest a buoyant market for eating-in and take-out establishments, probably influenced by changing consumer patterns and the rise of food delivery services. Likewise, event catering and other food services experienced 61.3% growth, thus indicating a recovery in catering establishments as a result of the re-establishment of social and corporate events post-pandemic.

On the contrary, the beverage serving sector (563) experienced a downward trend, with the number of enterprises becoming 87.1% of the 2015 figure. Changes in social customs, economic constraints, or more stringent regulations on alcohol consumption could be responsible for this decline.

The total number of employees grew by 16.3%, being in line with the growth of enterprises. The sectors of restaurant activities and event catering experienced growth in employment, whereas the employment levels in beverage service activities are noted to have declined by 16.3% in tandem with the decline in the numbers of businesses.

Table 1. Data for CAEN class 56 Restaurants and other food service activities (2015-2022)

	2015	2022	2022/ 2015 (%, +/-)
Number of enterprises			
Total	20,075	23,197	115.6
561 Restaurants and mobile food service activities	9,340	13,059	139.8
%	46.5	56.3	9.8
562 Event catering and other food service activities	1,066	1,719	161.3
%	5.3	7.4	2.1
563 Beverage serving activities	9,669	8,419	87.1
%	48.2	36.3	-11.9
Average number of employees			
Total	**118,177**	**137,482**	**116.3**
561 Restaurants and mobile food service activities	78,005	101,046	129.5
%	66.0	73.5	7.5
562 Event catering and other food service activities	9,032	10,777	119.3
%	7.6	7.8	0.2
563 Beverage serving activities	27,335	22,878	83.7
%	23.1	16.6	-6.5

Source: Own calculation on the basis of data from Tempo on line data base 2015-2022, NIS [12].

Table 2 provides an overview of the main financial indicators for the CAEN 561 restaurant industry in Romania, with all indicators expressed in constant 2022 prices over the 2015-2023 period. Data show significant increases in all the major financial indicators in the restaurant industry, demonstrating strong sectoral expansion albeit under challenging economic conditions.

Regarding revenue and profitability growth we observed that from 2015 to 2023 turnover increased from RON 8,343.5 million to RON 20,877.2 million (with 150.2%). Similarly, production for the period grew by 158.0%, reflecting higher activity levels in the sector. The contribution to the economy, as measured by gross value added at factor cost, raised threefold. Of importance is the growth in gross operating surplus by 448.7% and gross profit by 540.3%, marking a substantial turn for profitability.

Personnel costs rose close to 250.4 %, while wages and salaries seemed to increase even faster at 299.1 %. These numbers suggest significant increases in wages, possibly because of labor shortages, inflationary pressures, or minimum wage adjustments initiated by policies. Though the costs of labor appeared to have an effect on profits, it seems that the growth in revenue has compensated much more for these increased costs.

Net investments increased by 202.4% while tangible goods gross investments rose by 235.3%, indicating that infrastructure has continued to grow. Meanwhile, export turnover increased by 281.3%, indicating a greater perspective toward foreign markets, though its contribution to overall revenue is minuscule.

Table 2. Main indicators for CAEN 561 Restaurants (real values, constant prices 2022, million RON)

	2015	2023	2022/ 2015 (%)
Personnel costs	1,586.7	3,972.5	250.4
Wages and salaries	1,294.2	3,871.7	299.1
Turnover	8,343.5	20,877.2	250.2
Exercise production	8,182.7	21,111.4	258.0
Gross value added at factors cost	2,243.2	6,918.4	308.4
Gross operating surplus	656.5	2,945.8	448.7
Gross result of exercise	607.6	3,282.7	540.3
Direct exports	6.1	17.1	281.3
Net investments	456.5	923.8	202.4
Gross investments for tangible goods	648.4	1,525.8	235.3

Source: Own calculation on the basis of data from Tempo on line data base 2015-2022, NIS [12].

The sector dimension in 2023

At the country level, for 42 geographical areas with Bucharest as its capital, the following data can be found: Bihor County, a frequently accessed tourist area, has 604 economic units and 2630 employees; Brașov, a mountain town with 1 economic unit larger than Bihor but with 4122 employees in restaurants and services and a declared profit of 27.7 million euros. The most economic units are found in Bucharest with 2474 and 27902 employees, registering a profit of 208.3 million euros.

In 2nd place is the county of Constanta on the shores of the Black Sea with 1241 restaurants and a profit of 50.3 million euros. Due to seasonal work in public catering, the county of Constanta reports 5967 fewer employees than Brasov. Despite the mere 442 public catering units in Iasi County, 3720 registered employees generate a profit of 24 million euros. The lowest number of public catering units is in Covasna County, with around 109 locations. Bucharest and Cluj remain the top locations with a profit of 208.3% and 155.2%.

Like we may see, the data highlights significant regional disparities in the distribution of economic agents, turnover, employment, and profit in the restaurant sector. Bucharest leads in all indicators, reinforcing its position as Romania's primary economic hub. Cluj and Constanța follow, reflecting their strong tourism and business environments. The contrast with smaller counties like Covasna and Giurgiu, where both the number of establishments and profit margins are lower, indicates differing levels of economic activity and local demand.

Counties with strong tourism sectors—such as Brașov, Constanța, and Suceava—show robust figures in employment and profitability. The seasonal nature of hospitality jobs in Constanța, which has a high number of restaurants but fewer employees than Brașov, indicates reliance on temporary workers.

While Bucharest and Cluj report the highest profits (208.3% and 155.2%), some counties show higher profit-to-employee ratios. For instance, Suceava (2.6%), Constanța (2.72%), and Valcea (2.48%) demonstrate strong efficiency, likely due to a mix of tourism-related activity and lower operational costs.

The presence of many economic agents in Cluj, Timiș, and Iași suggests a growing business-friendly climate in these regions, driven by urban expansion, student populations, and increased disposable income.

Table 3. Main indicators for CAEN 561 Restaurants at county level

	Number of economic agents	% county	Turnover	% county	Number of employees	% county	Profit	% county
Alba	298	0.68	47.2	0.5	1,127	1.7	7.6	1.16
Arad	402	0.67	68.8	0.65	1,574	1.85	9	1.05
Arges	438	0.65	87.2	0.41	1934	1.44	12.4	1
Bacau	341	0.73	65	0.5	1,611	1.81	7.3	0.43
Bihor	604	0.68	103.4	0.8	2,630	2.21	17.4	1.58
Bistrita-Nasaud	249	0.72	45.2	1.01	991	2.1	7.3	1.71
Botosani	155	0.52	38.9	1.26	822	2.84	7.4	2.86
Brasov	605	0.73	222.9	1.26	4,122	2.81	27.7	1.9
Braila	180	0.69	35.2	1.13	926	2.72	4	1.4
Bucuresti	2,474	0.51	1,800	0.87	27,902	2.59	208.3	0.39
Buzau	210	0.58	47.1	0.75	1,155	2.16	6.5	1.37
Caras-Severin	216	0.84	28.2	1.53	744	2.73	3.1	2.03
Calarasi	145	0.61	28.2	0.87	527	2.14	4.9	2.17
Cluj	906	0.64	276.5	1.06	5,569	2.68	155.2	0.13
Constanta	1,241	1.34	308.7	1.64	5967	4.74	50.3	2.72
Covasna	109	0.57	20.6	0.84	503	1.88	1.6	0.76
Dambovita	255	0.58	71.6	1.26	1,658	3.22	7	1.34
Dolj	443	0.67	91	0.78	2,135	2.33	15.5	1.6
Galati	321	0.65	72.1	0.9	1,860	2.53	8.1	1.34
Giurgiu	119	0.49	16.5	0.59	414	1.63	2.4	0.9
Gorj	216	0.79	46.7	1.27	969	2.13	6.1	1.23
Harghita	205	0.65	43.5	1.03	1,269	2.62	4.6	1.16
Hunedoara	354	0.85	52	1.4	1,456	2.86	5.9	1.71
Ialomita	131	0.67	20.4	0.71	503	2.08	2.7	1.33
Iasi	442	0.51	188.8	1.77	3,720	3.21	24	1.8
Ilfov	709	0.7	202.4	0.49	3,605	1.82	25.4	0.73
Maramures	337	0.55	67.9	1	1,691	2.18	7.7	1.34
Mehedinti	113	0.54	22.5	1.96	576	3.34	4	2.99
Mures	448	0.74	92.9	0.77	2,205	2.35	16	1.84
Neamt	244	0.65	54.3	1.2	1,446	2.95	7.1	1.59
Olt	201	0.66	25.4	0.47	599	1.37	5.6	1.47
Prahova	531	0.67	117.7	0.62	2,488	1.64	15.3	0.9
Satu Mare	223	0.69	35.3	0.54	893	1.61	4.4	0.88
Salaj	151	0.54	23.9	0.78	578	2.05	3.8	1.03
Sibiu	406	0.69	100	0.79	2135	1.98	14	0.85
Suceava	446	0.82	193.4	2.55	3,919	5.09	19.7	2.6
Teleorman	127	0.39	26.9	1.17	699	2.7	2.6	1.25
Timis	753	0.66	213.5	0.89	3,896	2.08	29.4	1.45
Tulcea	127	0.59	25.6	0.92	627	2.49	3.8	1.65
Vaslui	116	0.51	29.1	1.15	781	2.01	3.9	1.84
Valcea	316	1.01	66.1	1.49	1,665	3.32	10.4	2.48
Vrancea	208	0.76	30.9	0.98	764	1.99	3.9	1.31

Source: Own calculation on the basis of data from topfirme.ro [17].

CONCLUSIONS

Public food services play a significant role in the economic and social development of the country. Analyzing the statistical data from the last 7 years of registered public catering companies, we find an increase in the number of consumer customers in different sectors, a higher percentage allocated to catering units and a very large number of employees in Bucharest and due to the large population.

Overall, the data suggest movement in the food services industry, with restaurants and catering food service keeping the flag high while non-conventional beverage service operations find it increasingly difficult to survive. Also, the figures show that the restaurant industry has enjoyed great success, with higher revenue generating growth, investment, and profitability. The rise in labor costs remains a challenge, however.

The restaurant industry in Romania reflects a concentration of activity in urban and tourist-heavy counties, with regional variations in profitability, workforce dynamics, and business density shaping the sector's evolution.

However, this analysis of the restaurant sector presents a number of regional disparities regarding the entities' distribution of business, size of workforce, and levels of profitability.

Bucharest is the paramount economic pole, with 2,474 restaurants and 27,902 employees, values that far exceed the number in other regions. It also reports the highest profitability, namely 208.3 million euros, highlighting the capital's strong consumer demand, higher purchasing power, and business density.

Also, tourism is one of the most important determinants of the restaurant industry. Both internal and international tourism determines the high level of employment and profitability in Brașov, Constanța, and Suceava. Brașov is a mountain resort and has 605 restaurants with 4,122 employees, while Constanța ranks second in the number of restaurants (1,241) but has fewer employees (5,967) because of seasonal features of employment.

While Cluj and Iași counties are behind Bucharest in terms of the number of companies, their profitability remain very high, at 155.2 million euros and 24 million euros, respectively. That means good business conditions in a big city favour further development. Covasna County has the smallest number of public catering units—109 businesses—expressing weak local demand.

Investment and business expansion

The counties with developing urban centres, such as Cluj, Timiș, and Iași, offer an excellent environment for restaurant businesses, favoured by a combination of economic growth, student populations, and business investments.

Data underlines the role of urbanisation, tourism, and economic development in the restaurant industry. Whereas Bucharest, Cluj, and Constanța remain among the best-performing locations, smaller counties seem to struggle to attract and maintain restaurant businesses. More investment, adapting to seasonal demand, and innovation in food services are likely to drive further development within the sector.

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AGRICULTURAL TRADE AND TRANSFORMATIONS: THE IMPACT OF MOLDOVA – EU TRADE AGREEMENT ON COMPETITIVENESS

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Abstract

In June 2014, the Republic of Moldova signed the Association Agreement with the European Union, a key element of which was the creation of a Deep and Comprehensive Free Trade Area (DCFTA). Thus, from September 2014 an important part of Moldovan agricultural products started to benefit from this agreement and full liberalization for both sides was presumed to be achieved by July 2016. Over last decade the trade value between the signing parties has doubled, while Moldova's exports of agricultural and agri-food products to the EU have tripled. This alleviates concerns regarding the Moldovan agricultural sector's ability to maintain competitiveness under conditions of eliminated protectionist barriers. This research aims to present export dynamics on the EU market of the main Moldovan agricultural products at the same time revealing the impact of the DCFTA on the competitiveness of these products applying the Net Export Index methodology. Secondary data on trade dynamics of various agricultural commodities was sourced from the UN Comtrade Database. Research results outline the reasons why certain products (e.g cereals, grapes, stone fruits) performed better on the European market, while others had a longer journey in reaching their success.

Key words: *agricultural products, DCFTA, export, free trade, Net Export Index*

INTRODUCTION

The year 2024 marked a decade since the Republic of Moldova and the European Union engaged in a free trade agreement. This milestone offers a suitable occasion to evaluate the economic transformations that have taken place, particularly in Moldova’s agri-food trade sector. Prior to this agreement, Moldova maintained a highly open economy, with foreign trade constituting 96.31% of GDP in 2012. However, trade patterns were heavily influenced by historical dependencies, particularly with the Commonwealth of Independent States (CIS), notably Russia, a reliance that had proven economically and politically risky, as exemplified by the 2006 Russian embargo on Moldovan wines and fruits.

The global landscape of agri-food trade has undergone substantial transformations over the past decade. Various studies have documented these changes in specific regional contexts, highlights how structural adjustments, policy reforms, and external demand dynamics influence trade patterns [2, 4, 7, 8, 9, 10]. Similar findings emerge from studies on the efficiency of European Union agri-food trade, which reveal significant variations in competitiveness and export market penetration across member states [9].

One important aspect of agri-food trade competitiveness is the ability to leverage comparative advantages in specific product categories. Some research highlights that market dynamics are significantly influenced by product differentiation, value chain efficiencies, and regulatory frameworks [8]. Moldova’s experience with certain agricultural products exports aligns with these findings, as the country has emerged as a competitive exporter in niche markets. Similarly, trade patterns in non-traditional agricultural commodities, such as silk in the European Union, demonstrate the importance of market adaptation strategies in maintaining trade competitiveness[10].

Given these broader regional and global trends, this study aims to analyse Moldova’s agricultural export competitiveness under the

Deep and Comprehensive Free Trade Area (DCFTA). While current research has extensively examined the macroeconomic and sectoral implications of DCFTA, our study seeks to complement this understanding by focusing on specific high-export-value agricultural commodities. Different research employs a range of trade performance indicators, including export-import dynamics, competitiveness indices, and price trends, to assess whether Moldovan agricultural products have successfully integrated into the European market or have faced significant trade barriers [2, 3, 4, 11].

This paper evaluates the impact of the DCFTA on Moldova's agricultural exports, assessing trade dynamics, competitiveness, and key factors influencing market integration.

By integrating insights from broader literature on European and global agri-food trade competitiveness, this study provides a more comprehensive contextualization of Moldova’s trade experience. It also highlights key lessons learned that may be relevant for policymakers and industry stakeholders aiming to enhance Moldova’s position in the international agri-food trade landscape.

MATERIALS AND METHODS

The study was based on the analysis of statistical data series on the international trade of the Republic of Moldova with agricultural products that had significant shares in the country's exports during the period 2011-2023. This series include data starting from 2011, thus capturing the last years preceding the conclusion of the DCFTA agreement allowing to have a more solid basis for comparison for subsequent developments, knowing that the agricultural output in Moldova can vary significantly from year to year depending on climatic conditions.

To ensure that the trend analysis captures data on relevant products and that the research does not omit any commodities that have undergone major developments, the first stage of the study focused on determining the top of the most exported products in 2013 (prior to the conclusion of the agreement) but also the most recent year (2023) for which there are available valid statistical data. Admitting that the hostilities in Ukraine could have influenced the agricultural products market at European level, this topic is also presented for the year 2021, which preceded this intervention.

The second stage of the study includes the analysis of the performances for each commodity separately for the entire period 2011-2023 (on a biannual basis) considering a comprehensive list of indicators: export volume, trade balance, price trends, export growth rate compared to the baseline (year 2013 being considered as 100%), share of exports to the EU compared to total exports, and the evolution competitiveness level of the respective product on the EU market.

Since the EU is also a customs union, we admit that a significant part of trade within EU member countries may not be captured by international statistics. Therefore, the Net Export Index was considered as the most relevant indicator to determine competitiveness level as it is calculated based on trade figures between the Republic of Moldova and the EU in which case the records are more accurate due to necessity to fill-up customs declarations [13].

The Net Export Index (NEI) is calculated according to the formula below [5]:

$$NEI(ij) = \frac{X(ij)-M(ij).}{X(ij)+M(ij)} \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

where:

j denotes the evaluated commodity;

i designates the country (in our case Moldova);

X are the exports of the respective commodity from Moldova to EU and

M are the imports of the same commodity from EU to Moldova.

The Net Export Index can vary between -1 and 1, and a higher positive value pointing to a higher competitivity of the product.

The main source of statistical data was the UN Comtrade Database [12] and National Bureau of Statistics [6].

RESULTS AND DISCUSSIONS

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Analysing the structure of the agricultural sector in Moldova since 2012, it was noticed that throughout the entire period, crop production has dominated compared to animal production, the discrepancy between them only increasing over the years (about 60% to 40% in 2012 and 70% to 30% in 2023). During this period, crop production enjoyed a growth of 65% (1,659 million USD in 2023, vs. 989 million USD in 2012), while the increase in animal production was much more modest, only 8% (670 million USD vs. 622 million USD) (BNS, 2024) [6]. The same trend is also followed by exports. So, animal products remained at low export levels, while crop products enjoyed a positive trend.

Analysing exports from structural point of view, we can primarily observe that those products that were best exported until the conclusion of the free trade agreement (see year 2013) would continue to dominate the top in recent years (2021 and 2023).

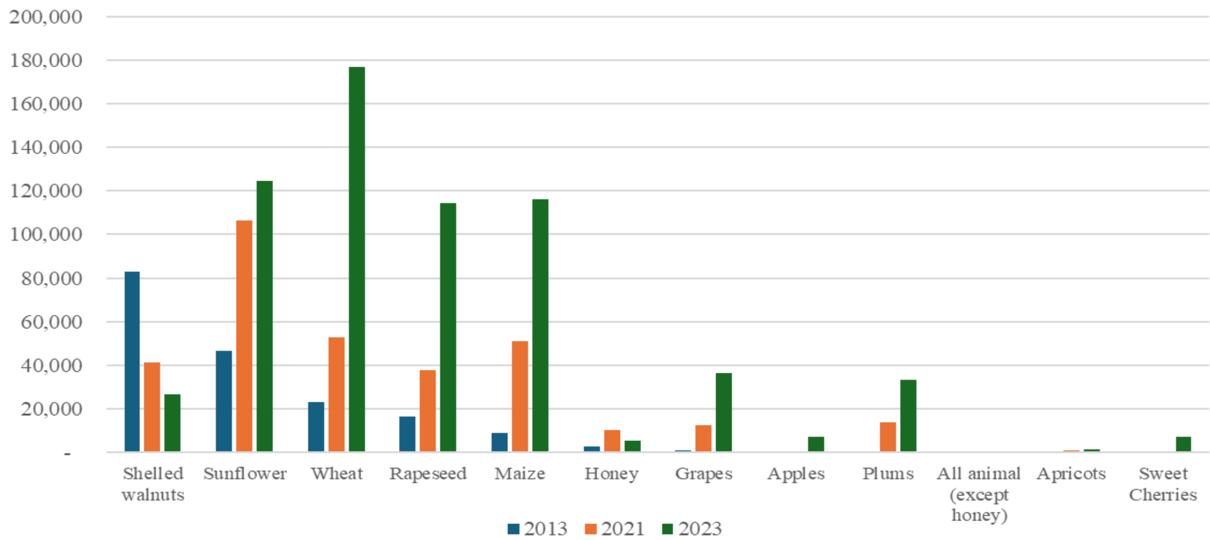

Fig. 1.Top of the most exported Moldovan agricultural products in the EU (million USD)
Source: elaborated by authors based on UN Comtrade Database, 2024 [12].

Most of the products that entered this top or enjoyed an increase in export to the EU, with the sole exception of shelled nuts, which will be analysed in more detail below.

Also, we can notice a dramatic increase of exports to EU for wheat, rapeseed and to a lesser extend of maize, grapes plums and sweet cherries in 2023 compared to 2021 the main cause for this being traced back to the war started by the Russian Federation in Ukraine.

Moldova had a remarkable increase of wheat exports to the EU in 2023 compared to the previous periods (Figure 1).

However, this is due mostly to interventionist measures, rather than economic ones.

On 1st of March 2022 the Moldovan Government imposed a ban on wheat exports to guarantee enough domestic supply for this strategic product in context of the Russian invasion of Ukraine that just had started. As result the country's storage capacities went full up to their maximum of about 720thousand tons [1].

Next year, being pressed by the local growers, this ban was lifted, exports soared and in 2023 the wheat became the most exported agricultural product from Moldova to the EU market.

At the same time, having a Net Export Index close to 1, wheat can be considered as one of the most competitive Moldovan products on the EU market (Table 1).

Generally, sunflower seeds are the most exported agricultural product from the Republic of Moldova, however they had considerable decrease in 2023. The main reason for this rooted in abnormally increased exports of the product from Ukraine in 2022 (30 times more compared to 2021). Considering that this trend continued in 2023, EU being the main destination of these exports, the market became oversaturated and as consequence prices went down in 2023, what affected the exports from Moldova (Table 2).

Table 1. Dynamics of the main indicators of trade with the EU for Moldovan wheat compared to total country's exports of the product

Year	Export, th. USD	Export, tons	Average export price, USD/kg	Import, th. USD	Import, tons	Average import price, USD/kg	Trade balance, th. USD	Net Export Index	Export increase rate	EU export share in total	Total export, th. USD
2011	9,302	36,383	*0.26*	30	104	*0.29*	9,271	**0.99**	40%	54%	17,362
2013	23,107	101,092	*0.23*	223	347	*0.64*	22,884	**0.98**	100%	35%	65,879
2015	23,345	136,564	*0.17*	517	838	*0.62*	22,829	**0.96**	101%	44%	52,491
2017	75,863	483,168	*0.16*	599	1,032	*0.58*	75,264	**0.98**	328%	72%	105,238
2019	43,515	249,366	*0.17*	304	454	*0.67*	43,210	**0.99**	188%	45%	97,645
2021	52,946	214,537	*0.25*	579	604	*0.96*	52,368	**0.98**	229%	25%	207,713
2023	176,769	850,747	*0.21*	496	417	*1.19*	176,273	**0.99**	765%	79%	223,764

Source: Authors' research, based on UN Comtrade Database, 2024 [12].

Still, there is a certainly positive trend for Moldova considering that the export value in 2023 was almost tree times higher compared to 2013 (the year that preceded the start of the implementation of DCFTA). Unfortunately, the country remains dependent on imported seeding, that is purchased largely from the EU. This is reflected in the table above showing the average import prices per kg, as well as in the NEI value, once both the product to be processed into oil and the one traded as seeding material were analysed together (as UN Comtrade Database displays these statistics under the same code) [12].

Table 2. Dynamics of the main indicators of trade with the EU for Moldovan sunflower seeds compared to total country's exports of the product

Year	Export, th. USD	Export, tons	Average export price, USD/kg	Import, th. USD	Import, tons	Average import price, USD/kg	Trade balance, th. USD	Net Export Index	Export increase rate	EU export share in total	Total export, th. USD
2011	66,037	120,101	*0.55*	3,138	384	*8.17*	62,899	**0.91**	142%	53%	123,720
2013	46,431	94,014	*0.49*	6,658	552	*12.06*	39,773	**0.75**	100%	34%	136,153
2015	121,994	318,395	*0.38*	5,797	463	*12.51*	116,198	**0.91**	263%	85%	143,692
2017	137,699	366,798	*0.38*	18,150	1,508	*12.03*	119,549	**0.77**	297%	70%	197,817
2019	111,146	290,477	*0.38*	19,733	3,054	*6.46*	91,414	**0.70**	239%	52%	213,988
2021	106,576	164,570	*0.65*	18,238	1,519	*12.00*	88,338	**0.71**	230%	54%	196,816
2023	124,379	256,499	*0.48*	30,529	2,175	*14.04*	93,850	**0.61**	268%	90%	138,739

Source: Authors' research, based on UN Comtrade Database, 2024 [12].

Maize (corn) is another product where Moldova succeeded very well on the European market, if to consider 12 times increase of exports in 2023 comparing to 2013. However, it looks like the country must boost investments in irrigation solutions for this crop, as well as work on elaboration on seedling material that can perform better in condition of shortage of precipitation. As Moldova experienced a severe drought in 2020 the output was very low in that year and these affected the export volume, and the NEI went to the lowest figure (0.23) for the analysed period (Table 3).

This drought was one of the most severe in the past two decades, causing a significant drop in agricultural production by almost 30%. Besides maize, the drought also affected crops like wheat and rapeseeds. It is worth noting that Moldovan rapeseed is among the products with the highest competitive index (NEI was 0.92 in 2023) for the EU, which is practically the only export destination (Table 4).

Table 3. Dynamics of the main indicators of trade with the EU for Moldovan maize compared to total country's exports of the product

Year	Export, th. USD	Export, tons	Average export price, USD/kg	Import, th. USD	Import, tons	Average import price, USD/kg	Trade balance, th. USD	Net Export Index	Export increase rate	EU export share in total	Total export, th. USD
2011	23,790	86,309	*0.28*	1,663	492	*3.38*	22,127	**0.87**	263%	61%	38,817
2013	9,043	42,064	*0.21*	5,071	1,143	*4.44*	3,972	**0.28**	100%	32%	28,080
2015	31,119	206,584	*0.15*	7,115	1,564	*4.55*	24,004	**0.63**	344%	71%	43,904
2017	25,021	154,917	*0.16*	9,626	2,169	*4.44*	15,395	**0.44**	277%	47%	53,655
2019	49,939	313,387	*0.16*	14,104	3,272	*4.31*	35,835	**0.56**	552%	40%	125,150
2021	50,983	204,909	*0.25*	15,746	3,213	*4.90*	35,238	**0.53**	564%	40%	127,207
2023	116,321	505,946	*0.23*	18,242	2,952	*6.18*	98,079	**0.73**	1,286%	81%	144,089

Source: Authors' research, based on UN Comtrade Database, 2024 [12].

Table 4. Dynamics of the main indicators of trade with the EU for Moldovan rapeseed compared to total country's exports of the product

Year	Export, th. USD	Export, tons	Average export price, USD/kg	Import, th. USD	Import, tons	Average import price, USD/kg	Trade balance, th. USD	Net Export Index	Export increase rate	EU export share in total	Total export, th. USD
2011	27,747	44,191	*0.63*	1,955	141	*13.87*	25,792	**0.87**	169%	85%	32,544
2013	16,432	35,007	*0.47*	1,308	90	*14.48*	15,124	**0.85**	100%	79%	20,704
2015	5,411	13,044	*0.41*	897	81	*11.05*	4,514	**0.72**	33%	72%	7,517
2017	29,534	76,554	*0.39*	2,661	176	*15.10*	26,873	**0.83**	180%	90%	32,840
2019	31,661	78,135	*0.41*	3,317	211	*15.69*	28,344	**0.81**	193%	94%	33,779
2021	37,935	62,575	*0.61*	2,598	180	*14.46*	35,337	**0.87**	231%	75%	50,802
2023	114,363	263,752	*0.43*	5,044	262	*19.29*	109,319	**0.92**	696%	98%	116,565

Source: Authors' research, based on UN Comtrade Database, 2024 [12].

The transition to hyper-intensive production technologies, huge investments in post-harvest and storage equipment have created the necessary infrastructure in the country to be able to supply fresh apples throughout the entire year. If 15-20 years ago it was common to have apple imports from Poland or other EU countries during winter or spring, currently the Republic of Moldova is more than self-sufficient in this regard and the country became a net exporter.

The embargo imposed by the Russian Federation in 2014 towards imports from Moldova, Ukraine and EU had a dramatic impact on Moldovan exports in the next periods. However, considering that the ban stayed for the rest of the competitors, while certain Moldovan exporters were granted access to the Russian market, where prices on condition of deficit went considerably up, Moldovan apple sector registered a boom starting from 2018. On the other hand, this situation did also a bad service for the sector, as apples became the fruit with the least diversified markets, 95% to 99% of all exports being made to Russia. As result, the full scale war in the region had a shocking effect on exports, halving them, as transportation to traditional clients became extremely expensive. Exports to the EU rose to 11% of the total in 2023, but the situation in the sector remains critical, especially considering that apples have always been the main export fruit for the Republic of Moldova (Table 5).

By opposite, going through similar kind of transformations with the regards of production technologies and postharvest infrastructure, grapes enjoyed for a much better market diversification. As a result, the war in Ukraine had a minor impact on the sector, and the EU taking over 55% of all exports in 2023 could replace some of the lost markets, especially given a compensating effect of the increase in the average price per kg (Table 6).

Table 5. Dynamics of the main indicators of trade with the EU for Moldovan apples compared to total country's exports of the product

Year	Export, th. USD	Export, tons	Average export price, USD/kg	Import, th. USD	Import, tons	Average import price, USD/kg	Trade balance, th. USD	Net Export Index	Export increase rate	EU export share in total	Total export, th. USD
2011	541	2,968	*0.18*	1,995	2,101	*0.95*	- 1,454	**- 0.57**	114%	1%	57,768
2013	474	3,312	*0.14*	706	732	*0.96*	- 231	**- 0.20**	100%	1%	47,557
2015	248	746	*0.33*	381	935	*0.41*	- 133	**- 0.21**	52%	1%	17,965
2017	2,064	6,330	*0.33*	365	631	*0.58*	1,699	**0.70**	435%	4%	46,122
2019	784	4,536	*0.17*	604	1,107	*0.55*	181	**0.13**	165%	1%	53,775
2021	382	1,004	*0.38*	617	1,065	*0.58*	- 235	**- 0.23**	81%	0%	87,616
2023	6,963	12,712	*0.55*	160	237	*0.67*	6,803	**0.96**	1,468%	11%	62,601

Source: Authors' research, based on UN Comtrade Database, 2024 [12].

Table 6. Dynamics of the main indicators of trade with the EU for Moldovan grapes compared to total country's exports of the product

Year	Export, th. USD	Export, tons	Average export price, USD/kg	Import, th. USD	Import, tons	Average import price, USD/kg	Trade balance, th. USD	Net Export Index	Export increase rate	EU export share in total	Total export, th. USD
2011	971	2,099	*0.46*	189	123	*1.53*	783	**0.67**	115%	6%	17,554
2013	846	1,786	*0.47*	98	55	*1.78*	748	**0.79**	100%	5%	17,017
2015	5,766	9,810	*0.59*	29	27	*1.11*	5,737	**0.99**	681%	34%	16,779
2017	15,355	19,951	*0.77*	71	41	*1.72*	15,284	**0.99**	1,814%	40%	38,626
2019	12,616	20,339	*0.62*	69	31	*2.26*	12,546	**0.99**	1,491%	43%	29,665
2021	12,646	16,670	*0.76*	158	58	*2.71*	12,488	**0.98**	1,494%	35%	36,078
2023	36,221	32,730	*1.11*	294	92	*3.21*	35,928	**0.98**	4,280%	55%	66,275

Source: Authors' research, based on UN Comtrade Database, 2024 [12].

Fresh plums represent another successful example of market penetration. For plums export figures to EU were rather modest before DCFTA (Table 7). Despite this low starting point, plums became the most exported fruit in 2023 (in quantitative terms) and currently Moldova isconsidered as one of the main sources of fresh plum imports from outside the EU.

Considering favourable growing conditions in Moldova and the fact that comparing to other fruits stone fruits are more labour intensive, especially during the harvesting period, many market players consider these products as being the new stars (according to BCG matrix) of Moldovan agriculture.

Sweet cherries and apricot exports almost inexistent 5 years ago, started to boom reaching respectively to over USD 7.2 millions and USD 1.2 millions in 2023.

Currently about a half of these fruits are exported to EU and in the next years they expect that the share of Moldovan cherries and apricots on the European market will be as significant as the one of plums.

Stone fruits certainly need special attention, once the growing export figures are also complemented by a sizeable positive price trend.

On the other hand, the walnut sector, however, seems to be facing an opposite trend, with exports declining after peaking in 2014. The main cause of this decrease residue in increasing labour costs in the country, which has influenced the business model. Traditionally, besides its considerable own production, Moldova imported walnuts in shell and after shelling re-exported the already processed product, which explains why the NEI for walnuts in shell was being negative, while the NEI for shelled walnuts was strongly positive. Currently, this type of business is losing popularity along with the diminishing labour cost advantage. This effect is also multiplied by the decreasing trend in the average price for both shelled and in shell walnuts (Tables 8 and 9).

Table 7. Dynamics of the main indicators of trade with the EU for Moldovan plums compared to total country's exports of the product

Year	Export, th. USD	Export, tons	Average export price, USD/kg	Import, th. USD	Import, tons	Average import price, USD/kg	Trade balance, th. USD	Net Export Index	Export increase rate	EU export share in total	Total export, th. USD
2011	-	-	-	400	484	*0.83*	- 400	**- 1.00**	0%	0%	5,116
2013	134	399	*0.34*	86	98	*0.88*	48	**0.22**	100%	2%	7,906
2015	2,025	6,004	*0.34*	2	1	*2.68*	2,023	**1.00**	1,512%	39%	5,182
2017	9,122	19,264	*0.47*	18	6	*2.84*	9,104	**1.00**	6,811%	52%	17,436
2019	6,097	17,588	*0.35*	141	147	*0.96*	5,956	**0.95**	4,552%	40%	15,218
2021	14,033	25,806	*0.54*	12	5	*2.22*	14,021	**1.00**	10,477%	61%	23,030
2023	33,108	55,574	*0.60*	220	146	*1.50*	32,888	**0.99**	24,720%	81%	40,805

Source: Authors' research, based on UN Comtrade Database, 2024 [12].

Table 8. Dynamics of the main indicators of trade with the EU for Moldovan shelled walnuts compared to total country's exports of the product

Year	Export, th. USD	Export, tons	Average export price, USD/kg	Import, th. USD	Import, tons	Average import price, USD/kg	Trade balance, th. USD	Net Export Index	Export increase rate	EU export share in total	Total export, th. USD
2011	54,518	6,788	*8.03*	0	0	*24.40*	54,517	**1.00**	66%	79%	68,824
2013	83,045	10,064	*8.25*	86	20	*4.27*	82,959	**1.00**	100%	87%	95,596
2015	81,815	10,985	*7.45*	0	0	*19.25*	81,815	**1.00**	99%	83%	98,777
2017	84,379	11,762	*7.17*	0	0	*10.07*	84,379	**1.00**	102%	88%	95,914
2019	73,876	13,222	*5.59*	2	0	*7.56*	73,874	**1.00**	89%	85%	86,606
2021	41,194	6,924	*5.95*	8	1	*9.85*	41,186	**1.00**	50%	83%	49,853
2023	26,642	5,506	*4.84*	235	78	*3.01*	26,407	**0.98**	32%	75%	35,667

Source: Authors' research, based on UN Comtrade Database, 2024 [12].

Table 9. Dynamics of the main indicators of trade with the EU for Moldovan in shell walnuts compared to total country's exports of the product

Year	Export, th. USD	Export, tons	Average export price, USD/kg	Import, th. USD	Import, tons	Average import price, USD/kg	Trade balance, th. USD	Net Export Index	Export increase rate	EU export share in total	Total export, th. USD
2011	1,421	573	*2.48*	3,831	2,186	*1.75*	- 2,410	**- 0.46**	141%	71%	2,011
2013	1,004	415	*2.42*	4,543	2,277	*1.99*	- 3,539	**- 0.64**	100%	54%	1,863
2015	169	92	*1.83*	6,621	2,610	*2.54*	- 6,452	**- 0.95**	17%	10%	1,659
2017	648	314	*2.06*	7,106	2,900	*2.45*	- 6,457	**- 0.83**	65%	31%	2,083
2019	445	324	*1.37*	6,641	2,873	*2.31*	- 6,196	**- 0.87**	44%	14%	3,179
2021	191	120	*1.60*	4,465	2,093	*2.13*	- 4,275	**- 0.92**	19%	19%	984
2023	726	585	*1.24*	2,671	1,520	*1.76*	- 1,945	**- 0.57**	72%	19%	3,859

Source: Authors' research, based on UN Comtrade Database, 2024 [12].

Honey is the only product of animal origin where Moldova stood competitive not only on the EU market, but in general. Unfortunately, beekeeping is still very much dependant on factors that are less possible to be controlled internally, such as weather conditions and global market prices. However, despite fluctuations, the evolution of NEI shows that honey remains competitive on the EU market and the export figures show the positive effect of DCFTA as exports after this were continuously higher than before signing of this agreement (Table 10).

Table 10. Dynamics of the main indicators of trade with the EU for Moldovan honey compared to total country's exports of the product

Year	Export, th. USD	Export, tons	Average export price, USD/kg	Import, th. USD	Import, tons	Average import price, USD/kg	Trade balance, th. USD	Net Export Index	Export increase rate	EU export share in total	Total export, th. USD
2011	606	181	*3.35*	6	1	*10.66*	601	**0.98**	22%	49%	1
2013	2,811	872	*3.22*	5	0	*10.83*	2,807	**1.00**	100%	86%	3
2015	8,587	2,592	*3.31*	9	1	*6.94*	8,577	**1.00**	305%	90%	10
2017	13,477	4,800	*2.81*	4	1	*5.65*	13,473	**1.00**	479%	96%	14
2019	11,235	3,766	*2.98*	17	2	*7.88*	11,218	**1.00**	400%	97%	12
2021	10,336	2,729	*3.79*	33	4	*7.82*	10,303	**0.99**	368%	78%	13
2023	5,486	1,585	*3.46*	47	14	*3.42*	5,438	**0.98**	195%	91%	6

Source: Authors' research, based on UN Comtrade Database, 2024 [12].

Unfortunately, the rest of the animal sector of the country struggles to find its niche on the global market. Even cumulated, the exports to EU of the products of animal origin, except honey, are far below the figures for any other crops considered in this research.Primarily this is due to strict EU sanitary and phytosanitary standards that Moldova found it challenging to meet consistently. Still,there are signs the things can improve. For instance, due to sufficient progress in the area, Moldovan poultry meat gained access to the EU market starting from 2024.

CONCLUSIONS

During its existence as an independent state, the Republic of Moldova has always faced various risks characteristic of small economies. Most often, these were determined by the dependence on a limited number of markets, both for exports of products from the country, especially agrifood products, and for imports, in this case energy resources. The dependence on a limited number of markets also had an amplifying effect on political risks and circumstances as embargoes and war in the region represented serious challenges for the country.

Since a small economy like Moldova cannot resist globalization trends, the only realistic solution for the country is to integrate into a larger economy like the EU. The first step in this direction was the signing of the DCFTA agreement. The analysis carried out in this study reveals that this was the right decision, even though there was a risk that some of Moldovan agricultural products would not be able to cope with competition in a liberalised trade. The figures show that the products that were most exported until the conclusion of the agreement remained in the top exports to the EU in 2023, and the level of competitiveness calculated based on the NEI was not affected in any way. It is remarkable that, apart from shelled walnuts, the analysed agricultural products registered significant increase in value of exports to the EU, some product categories registering notablesuccesses (cereals, fruits). It is important that exports of value-added products such as fruits and table grapes are increasing.

Stone fruits have all the prerequisites to become the new cash cow for the Moldovan agricultural sector. However, this sector needs investments, especially in post-harvest infrastructure (hydrocooling, sorting, packaging lines), but also at the area of international marketing, because with exception of plums the country still has to confirm as genuine supplier at the European level. At the same time, since this category of products is extremely perishable, they require as little handling as possible. Thus, Moldovan producers must be able to offer packaging solutions for the final product that meet the requirements of the most diverse segments of export markets, without need for any further manipulation.

Market diversification is another extremely important aspect to be considered by Moldovan exporters. Unfortunately, the hard lesson offered to winemakers in the mid-2000s was not convincing enough for those involved in the apple business. Being excessively dependent on the Russian market, apples exporters from Moldova had to learn from their own mistake in 2022 once the export routes to Russia became almost inaccessible because of the war in Ukraine.

To maintain and increase it's competitivity the country must develop its own potential to produce high quality certified seedling materials. This might be an opportunity for the main field crops, as well as for orchards considering that Moldova imports seedling materials for multiannual plantations valued to about USD4 mil annually and is still very much dependent on western breeding companies, which unfortunately do not always consider the specifics of climatic conditions in the country.

The animal sector necessitates substantial attention to enhance its competitiveness. The sector is too small yet, and there is no economy of scale that could make the products more competitive. Honey is the sole product successful on the EU market, however the apicultural sector also requires better conditions for its sustainable development, particularly concerning the establishment of adequate nectar sources to support bees during drought years. In this context, reforestation efforts across the country would be highly beneficial.

Low labour costs based not on the high productivity of this factor, but on low wages cannot provide a sustainable competitiveness. An eloquent example in this regard is the decline of the business based on the import of walnuts in shell to benefit from the cheap labour in the country that was used for shelling, with the purpose of re-exporting of the already processed product. The only way to keep labour costs low still ensuring decent wages, is to increase labour productivity. A solution with a noticeable impact in this regard would be investments in equipment that would have a multiplication effect for the labour factor.

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THE EVOLUTION OF ORGANIC FARMING IN ROMANIA (2012-2023): TRENDS, CHALLENGES AND OPPORTUNITIES

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Abstract

This study analyses the evolution of certified organic operators and the agricultural area dedicated to organic farming in Romania during the period 2012-2023. The methodology used included the collection and processing of official statistical data, the application of quantitative analysis methods and the calculation of relevant statistical indicators. The evolution of organic farming was examined through the lens of economic, political, and climatic factors, while also considering the impact of the Common Agricultural Policy (CAP) regulations and the financial support provided to farmers for land conversion. The analysis of organic agriculture in Romania from 2012 to 2023 reveals a notable increase in organically farmed areas, despite variations in the number of certified operators. The total area dedicated to organic farming grew by 140.7%, indicating a rising interest among farmers, bolstered by European subsidies, national policies, and a growing consumer demand for organic products.However, challenges such as certification costs, administrative burdens, and market volatility remain obstacles to further growth.The statistical analysis shows that certain categories of organic crops, such as legumes, industrial crops, and green harvested plants, experienced remarkable growth, driven by economic incentives and sustainability benefits. Meanwhile, other crops, like tuber plants, have shown fluctuating trends due to economic and climatic factors. Permanent crops, including orchards, vineyards, and pastures, have steadily increased, demonstrating long-term stability in organic farming.The SWOT analysis reveals that organic farming in Romania has strong potential for future development, benefiting from favorable policies and an expanding market. However, the sector requires continued support through investments in research, innovation, and infrastructure, as well as stronger incentives for small and medium-sized farmers to transition to organic practices.

Key words: *organic farming, certified operators, cultivated areas, CAP,financial support, organic products*

INTRODUCTION

Organic agriculture plays a crucial role in promoting sustainable development, a concept that refers to meeting the needs of the present without compromising the ability of future generations to meet their own needs [3]. Organic agriculture directly contributes to sustainability goals by implementing practices that protect the environment, promote biodiversity, conserve natural resources, and support the rural economy. This aligns with global demands to reduce the negative impact of agriculture on the planet, along with other areas that aim to encourage a sustainable and responsible lifestyle.

Organic farming is defined as the use of methods that comply with established regulations to protect the environment, human health and animals. These methods include the use of local resources, the reduction of greenhouse gas emissions, the protection of biodiversity and the avoidance of synthetic chemicals [10]. Organic farming is directly linked to sustainable development because it encourages the efficient management of natural resources and the protection of biodiversity, providing solutions to the challenges of climate change and environmental degradation.

A key feature of organic farming is its focus on environmental protection. Practices like crop rotation, the use of organic fertilizers, and natural pest control contribute to reducing pollution in soil, air, and water. Furthermore, organic farming enhances carbon sequestration in the soil, which aids in lowering greenhouse gas emissions [20]. According to a study conducted by the FAO in 2017, organic farming can significantly contribute to combating climate change by absorbing carbon and reducing emissions from agriculture [10].

Although organic farming brings many environmental and health benefits, there are also challenges, such as higher production costs, limited access to technology and information for organic farmers, and stringent certification requirements [15]. In addition, its widespread integration requires continued support from authorities to address these challenges.

In 2017, about 70 million ha represented the surface cultivated in organic system, of which Oceania covered 36 million ha, followed by Europe with 15 million ha [23].

Organic products are in increasing demand on the European market, as they are perceived as healthier by consumers [15]. Farmers who adopt these practices thus have access to larger markets and better prices for their products.

However, the outlook is optimistic, as more and more consumers are willing to pay a higher price for organic products, and policies such as the European Commission's "Farm to Fork Strategy" (2020) emphasize the development of organic and sustainable agriculture in Europe [7, 9, 6].

In the EU, organic farming is better and better developed and in Romania is just at its beginning, accounting for just 3% of he cultivated area. A part of cereals, vegetables, wine, honey, dairy products are carried out in organic farming system, representing a chance for Romania’s export on the EU market [19].

In Romania, there is a weak literature on organic farming. Several published articles discuss the cultivated area under organic farming, the number of operators, organic products, and labeling [1, 4]. Financial support plays a crucial role for farmers transitioning to or focused on organic farming.[11].

In this context, this study examines the trends in certified organic operators and the agricultural land allocated to organic farming in Romania between 2012 and 2023.

MATERIALSAND METHODS

The data for this study were sourced from official records, including annual organic farming reports from the Ministry of Agriculture and Rural Development (MADR) and databases on agricultural structure and cultivated areas from the National Institute of Statistics, Eurostat data on organic agricultural area at European level, as well as the European Union Regulations on organic farming to identify the influence of regulations on the dynamics of organic operators and cultivated areas.To interpret the collected data, the following statistical methods were used:

• The evolution of the number of certified operators and organic agricultural areas was analyzed through time series, using annual growth rates and variation ratios.

• *The growth index* (%) was calculated using the formula:

$$I_t = \frac{X_t}{X_{t-1}} \times 100 \quad (1)$$

where:
I_t= growth index for year t,
X_t = indicator value in year t,
X_{t-1} = indicator value in the previous year.

• *The coefficient of variation* was used to evaluate the fluctuations in the number of certified operators and cultivated areas, according to the formula:

$$CV=\sigma/\mu \quad (2)$$

where:
σ = standard deviation,
μ= arithmetic mean of the data series.

A CV below 0.2 indicates low variability, and a CV above 0.5 indicates high variability.

• *The compound annual growth rate* (CAGR) was used to analyze the growth trend of organically cultivated areas.

CAGR is an important tool in long-term data analysis, as it allows comparing increases (or decreases) from different periods, taking into account market or data volatility. Thus, it is useful for:

1. Evaluating investment performance – in cases where we want to understand how a

certain investment or economic sector has evolved (e.g. organic farming).
2. Long-term growth estimates – based on past trends, the future development of a sector or market can be forecasted.
3. Comparisons between sectors – such as comparing organic and conventional agricultural sectors, or between different regions.

$$CAGR = \left(\frac{V_f}{V_i}\right)^{\frac{1}{n}} - 1 \quad (3)$$

where:
V_f= the final value of the indicator,
V_i = theinitialvalue of the indicator,
n = thenumber of yearsunderreview.

•*SWOT analysis* is a method used to evaluate the Strengths, Weaknesses, Opportunities and Threats of a sector, organization or strategy. In the study on the evolution of organic agriculture in Romania, SWOT analysis was used to identify the internal and external factors influencing the development of this sector.

RESULTS AND DISCUSSIONS

Certified organic operators are natural or legal persons who undertake to apply specific rules for the production, processing or marketing of agricultural and food products, respecting the regulations of European and national legislation on organic farming. These operators
may be farmers, processors or traders who apply agricultural techniques that protect the environment, conserve biodiversity and natural resources, and use sustainable production methods that prohibit or limit the use of synthetic chemicals and artificial fertilizers [5].
The number of certified operators in organic farming decreased by 9.54% in 2023 compared to 2012 (Table 1).
There is a significant decrease until 2017 (Fig. 1), this decrease may be the result of a complex of economic, political and social factors, including high certification costs, lack of consistent support from the authorities, low demand for organic products and administrative difficulties. However, the number of operators started to increase again starting from 2018 (Fig. 1), which could suggest a return of interest in organic farming. This fluctuation can be attributed to various factors, such as shifts in national and international organic farming regulations, economic incentives, and market demands [20].

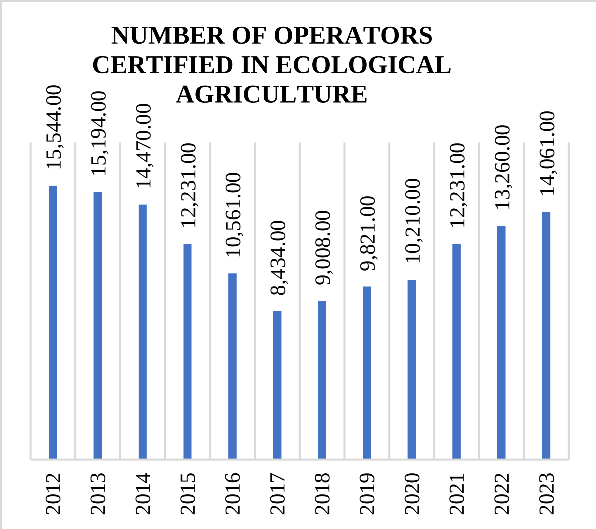

Fig. 1. The trend in the number of organically certified operators in Romania from 2012 to 2023.
Source: Reports on organic farming of the Ministry of Agriculture and Rural Development [12, 13].

The coefficient of variation is 0.195, indicating moderate variability in the number of operators over the period. This suggests that while fluctuations occurred, the changes were not extreme (Table 1). The agricultural area dedicated to organic farming has increased significantly, from 288,261 ha in 2012 to 693,998 ha in 2023 (Fig. 2), which represents an increase of 140.7% in 2023 compared to 2012 (Table 1). One of the main reasons why the organically cultivated area has increased in Romania is the financial support provided by the European Union through the Common Agricultural Policy (CAP). Subsidies for organic farming have served as a significant incentive for Romanian farmers to transition from conventional to organic land. Through the CAP, Romania has received substantial funding that has supported both the conversion of farms to organic farming and the ongoing maintenance of these practices [9].

Table 1.Statistical parameters of ecological agriculture in Romania

	Standard deviation	Mean	Coefficient of variation	Annual growth rate (%)	2023/2012 (%)
Number of operators certified in ecological agriculture	2,352.45	12,085.42	0.195	-0.9074	90.46
Total area in ecological agriculture(ha), of which:	157,138.28	393,060.13	0.400	8.314928	240.75
-Whole grain (ha)	29,255.12	117,133.80	0.250	4.591039	163.85
-Dry legumes and proteins for the production of grains (ha)	2,470.50	4,939.21	0.500	10.9533	313.72
-Tuberculiferous and totally rooted plants (ha)	252.68	625.63	0.404	-0.84937	91.04
-Industrial crops (ha)	25,262.93	76,697.50	0.329	8.529277	246.05
-Green harvested plants(ha)	28,257.08	37,512.61	0.753	21.16078	826.01
-Other crops on arable land(ha)	128.53	155.21	0.828	26.69983	1350.63
-Permanent crops: orchards, vines, shrubs, nuts (ha)	5,620.64	15,887.72	0.354	9.909551	282.74
-Permanent crops: pastures and meadows(ha)	74,851.16	139,280.71	0.537	9.400026	268.65

Sources: own calculation based on data provided by the Ministry of Agriculture and Rural Development [13].

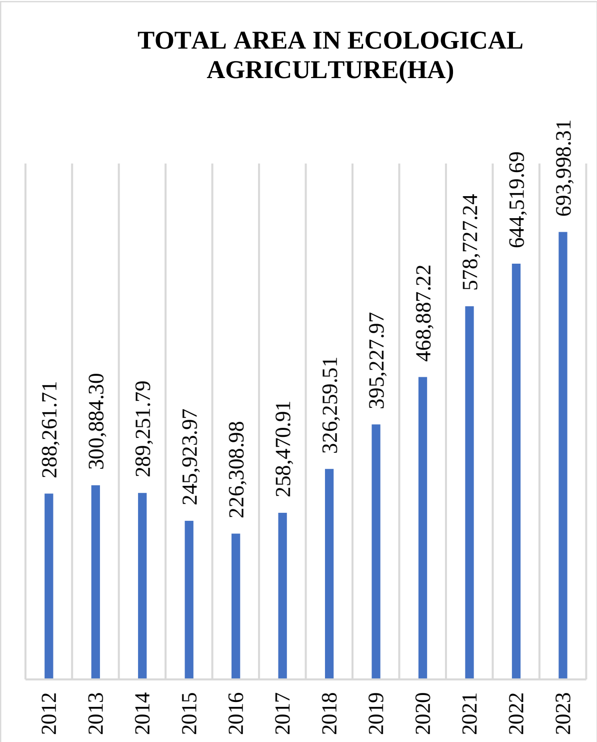

Fig 2. The trend in the total area of organic agriculture in Romania from 2012 to 2023.
Source: Databases on agricultural structure and cultivated area from the National Institute of Statistics [15].

The Romanian government has also encouraged the integration of organic farming into its national policies, providing additional financial support for its implementation. According to studies, Romania has a great potential in the market for organic products in the European Union, and more and more consumers prefer these products due to their health and environmental benefits [21]. Farmers have begun to realize the long-term benefits of organic farming, such as improved soil quality, reduced costs of chemical inputs, and increased biodiversity. Also, in some cases, organic farming can be more resilient to climate change, being less dependent on chemicals for pest and disease control [14]. Farmers who have adopted these practices have observed improvements in the quality and diversity of their harvest, which has contributed to greater economic stability. The Romanian government has introduced policies to support farmers who choose to practice organic farming. These policies have included tax incentives, tax exemptions for organic operators, and support for research and development in the field of organic farming. Thus, farmers were motivated to adopt organic practices, benefiting from favorable economic and legislative conditions [18].The coefficient of variation of 0.400 indicates a moderate variability of the area from one year to another.

The area cultivated with organic cereals increased from 105,149 ha in 2012 to 172,283 ha in 2023 (Fig. 3). Cereals remain an important part of organic agriculture. The increase in the area by 63.8% in 2023 compared to 2012 (Table 1) may reflect the constant demand for organic cereals. The

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coefficient of variation with the value of 0.250 shows a smaller variation compared to other crops.

Analyzing the area cultivated with legumes, an increase of 211.7% is observed in 2023 compared to 2012 (Table 1). These crops had a remarkable expansion until 2018, but fluctuations were observed thereafter. The increase in the area under legumes can be attributed to several factors, such as: The significant subsidies provided by the European Union for legume crops, particularly through the Common Agricultural Policy (CAP). Legumes receive direct financial support through payment schemes for protein crops, which are considered beneficial for agriculture due to their ability to fix nitrogen in the soil, thus reducing the need for chemical fertilizers [8].

Legumes are an important component of organic farming and crop rotation systems due to their ability to enrich the soil with nitrogen, which reduces the dependence on chemical fertilizers. In this sense, legumes are an attractive option for farmers adopting organic practices or who want to improve soil quality. Legumes also help to diversify production and reduce the risks associated with monocultures [16].

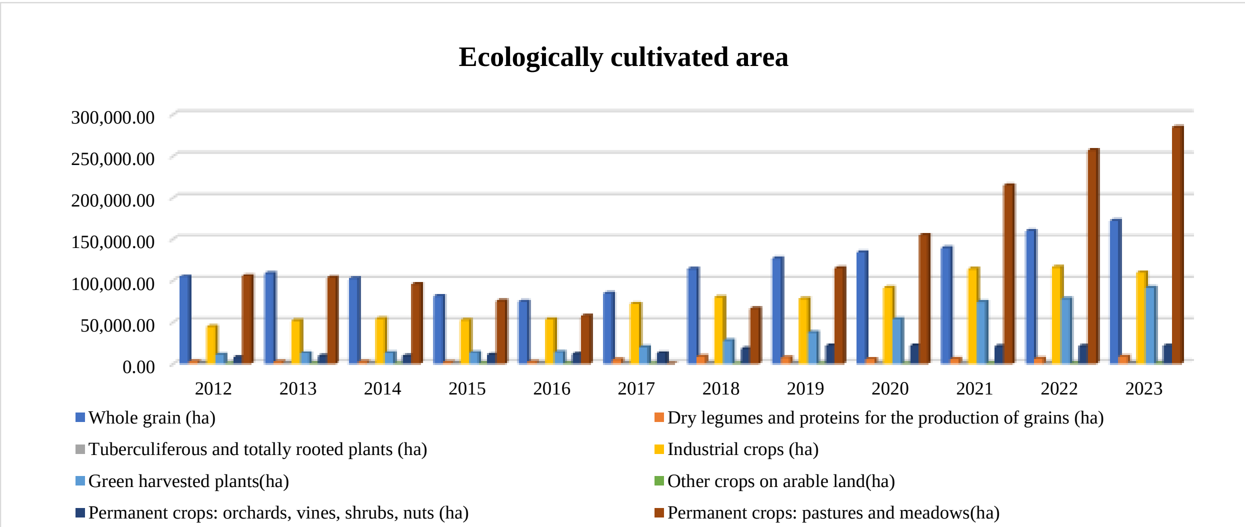

Fig. 3 .Ecologically cultivated area in Romania in the period 2012-2023
Sources: Databases on agricultural structure and cultivated areas of the National Institute of Statistics [15].

Demand for legumes has also increased due to the growing awareness of consumers about their nutritional benefits. Legumes are a key source of vegetable protein and are becoming more popular as the demand for plant-based foods and vegan or vegetarian diets rises. These crops are especially popular in international markets, particularly within the European Union, where there is a constant demand for vegetable protein products, and Romania has begun to take advantage of these economic opportunities [21].

The fluctuations in the area under legumes were caused by a combination of climatic, economic and political factors, including extreme weather conditions, changes in demand on international markets, changes in subsidy policies, production cost issues and lack of adequate investment in agricultural infrastructure. These variables led farmers to adjust the area under legumes according to economic and environmental circumstances.

The area under tuber crops fluctuated significantly during the period under review. These crops include species such as potatoes, carrots, sugar beets, parsnips, radishes and other root or tuber vegetables, which are important for both human consumption and the food industry.

The causes leading to these fluctuations are multiple and influenced by a series of economic, climatological and political factors. Climate change and extreme weather conditions have had a significant impact on the production of tuber and root crops, such as potatoes, carrots, beets and parsnips. Severe droughts as well as floods in some regions have negatively affected yields and led farmers to reduce the area cultivated with these organic crops. The higher production costs for organic crops, compared to conventional ones, can represent a barrier for farmers wishing to grow tuber and root crops organically.

Although farmers benefit from subsidies for organic farming, these crops require more manual labor and natural inputs, such as organic fertilizers, which can lead to increased production costs. In times of economic crisis or financial instability, farmers may be more reluctant to invest in such crops, which can lead to fluctuations in the cultivated area [17].

The area dedicated to industrial crops increased significantly by 2023, reaching 110,200 ha (Fig. 3).

The increase in the area cultivated with organic industrial plants in Romania has been influenced by a number of economic, political and market factors. Industrial plants, such as sunflower, rapeseed, soybean and hemp, play an important role in organic farming due to their lower requirements for chemical inputs, being more adaptable to environmental conditions and having a lower ecological impact compared to other crops. The CAP includes direct payments and payments for ecological practices and environmental protection, thus stimulating sustainable agriculture and favoring the cultivation of organic industrial plants [6].

Another important reason for the increase in the area cultivated with organic industrial plants is the increasing demand for biofuels and renewable energy. Organic vegetable oils are used for the production of biodiesel, and this demand has been continuously expanding in the period 2012-2023, due to policies to reduce carbon emissions and the need to transition to cleaner energy sources. Industrial crops like rapeseed and sunflower are key sources of oil for biofuels, and their organic cultivation has become a priority within the framework of the European energy strategy [6]. Romania has received European funds for research and innovation in agriculture, including funding for the development of more resilient and productive varieties of organic industrial crops. This research has contributed to improving the yield of organic industrial plants, thus reducing the risks associated with production and making their cultivation more attractive for farmers. In addition, the promotion of more efficient organic crop management practices has been supported through training and education programs for farmers [12].

The coefficient of variation of 0.329 (Table 1) suggests moderate volatility in the area allocated to them.

There was a significant increase in the area dedicated to green harvested plants, from 11,082 ha in 2012 to 91,545 ha in 2023, which represents an increase of 726% (Table 1). The area cultivated with green harvested plants in Romania represents an important category of agricultural crops, which includes species such as hay and forage grasses, which are harvested before reaching full maturity (usually for use as animal feed). These crops are essential for the production of organic fodder and may include pasture grasses, alfalfa, clover or other perennial and annual species that are harvested for use either fresh or preserved as hay or silage. The increase is a sign that there is a growing demand for such crops, which can be used for feed, biomass production or other ecological purposes. The coefficient of variation of 0.753 (Table 1) indicates a large variation in area from year to year, which may signal rapid changes in market or production requirements. In 2012, the area with other arable land crops was small, and subsequently large fluctuations in these indicators occurred. This may reflect a variety of crops that are not large consumers of land and are strongly influenced by market conditions and market requirements for more diverse crops.

The area dedicated to permanent crops: orchards, vines, shrubs, nuts has steadily increased from 7,781 ha in 2012 to 22,001 ha in 2023 (Fig. 3), which represents an increase of 182.7%. This increase shows a trend of development and diversification of organic agriculture in Romania, including for permanent crops, which require a longer production cycle and sustainable management. The increase can be explained by the demand for organic products (e.g. nuts, fruits) and by the stability that these crops offer compared to more perishable ones. The coefficient of variation of 0.354 indicates moderate volatility.

Calculating the annual growth rate (CAGR) for the period 2012-2023, an average increase of 9.91% per year is observed for the area cultivated with permanent crops. This suggests that organic farming for these crops has solid development potential, and farmers are increasingly encouraged to switch to these practices due to the economic, environmental benefits, and the demand for organic products.

Data on the area cultivated with permanent grassland and hay crops in Romania between 2012 and 2023 indicate a significant increase, with a constant expansion during the analyzed period. In 2012, the area was 105,836 ha, and in 2023 it reached 284,331.59 ha. Thus, the area dedicated to grassland and hay has increased considerably, which suggests a sustainable growth trend of this type of organic farming. This expansion is accompanied by a gradual increase starting with 2017 and continuing until 2023, which reflects a long-term adaptation and transition to organic farming.

The calculation of the annual growth rate (CAGR) for the period 2012-2023 shows an expansion of 9,400 ha per year, which represents an average growth of approximately 9.4% annually. This growth rate indicates that organic grasslands are an attractive and sustainable option for farmers, due to their economic and ecological benefits, but also to the growing demand for organic products [20]. This growth also suggests a positive direction in terms of soil conservation and biodiversity support.

Although there is a general upward trend, the data also shows a high annual variability, with a coefficient of variation of 0.537. This suggests that there are significant fluctuations in farmers' decisions related to cultivated areas, influenced by economic, political or climatological factors. For example, in 2015-2016, the cultivated area decreased significantly, reaching 57,611 ha, but in the period 2020-2023 it experienced a spectacular increase, signifying a possible return of interest in these crops. The standard deviation of 74,851.16 ha reflects the significant differences between annual values, indicating a considerable variability in the extension of meadows and hay in agriculture. This is an important significance in the analysis of the data, as it shows that, despite the general upward trend, there are years in which the cultivated area fluctuated significantly, depending on market conditions and farmers' decisions.

A SWOT analysis of organically cultivated areas in Romania can provide an overview of the advantages and challenges of this sector. Data on various types of organic crops for the period 2012-2023, such as cereals, legumes, industrial crops, green plants and permanent crops (orchards, vineyards, grasslands), are essential in assessing the trends and prospects of this sector.

Strengths:

• During the period 2012-2023, the total area cultivated organically increased significantly, from 288,261 ha in 2012 to 693,998 ha in 2023, which shows an increased interest in organic practices and an alignment with global market requirements [20].

• The area dedicated to various crops, such as cereals (whole grains), dry legumes, industrial crops, green plants, permanent crops and grasslands suggests a diversification of organic production, which can ensure the stability and sustainability of the agricultural sector.

• Organic farming has a positive impact on the environment, contributing to the conservation of biodiversity, improving soil quality and more efficient water management, which makes it increasingly attractive as environmental concerns grow [20].

• Organic farming policies and subsidies offered by the European Union directly support the expansion of organic areas, encouraging farmers to adopt sustainable practices [2].

Weaknesses:

• There is significant variability between crop years, with notable decreases in certain periods (e.g. 2015-2016 for organic grassland). This indicates an instability of the sector, which may be influenced by economic, political or climatological factors (the coefficient of variation of the total organically cultivated area is 0.537).

• The transition from conventional to organic farming involves higher costs and an adaptation period that may discourage small or medium-sized farmers. It may also reduce production in the short term, leading to lower profitability in the first years [20].

• Although organic farming is developing, small farmers may face difficulties in gaining access to the resources and technology needed to implement organic standards [2].

Opportunities:

• There is a growing demand for organic products in the European Union and on the global market, which may represent a significant opportunity for Romania to become a major player in the organic market [20].

• The steady increase in the areas dedicated to permanent crops, such as orchards, vineyards and nuts, suggests an opportunity to capitalize on land in the long term. Permanent crops are attractive for organic farming due to their ecological and economic benefits (e.g. soil and water conservation) [22].

• Technological innovations in agriculture, such as the use of technologies for more precise monitoring of crops and soils, can improve the efficiency and sustainability of organic farming practices [22].

Threats:

• Climate change may have a significant impact on organic farming, especially on crops sensitive to extreme weather conditions. Droughts, heavy rains or extreme temperatures can negatively affect the production of organic crops [22].

• Fluctuating global market prices can put pressure on the incomes of organic farmers, who may become more vulnerable to economic instability. This could discourage investment in organic agriculture, especially during periods of economic crisis.

• The domestic market for organic products in Romania may be affected by imports of cheaper organic products, making local producers less competitive [20].

CONCLUSIONS

The analysis of the growth of organic agriculture in Romania from 2012 to 2023 reveals a notable expansion of organically cultivated land, despite variations in the number of certified operators. The total area dedicated to organic farming grew by 140.7%, reflecting growing interest among farmers, supported by European subsidies, national policies, and increasing consumer demand for organic products. This growth aligns with global trends promoting sustainability, biodiversity conservation, and soil health improvement. However, challenges such as certification costs, administrative burdens, and market volatility remain obstacles to further growth and widespread adoption of organic practices.

The statistical analysis indicates that certain categories of organic crops, such as legumes, industrial crops, and green harvested plants, have experienced remarkable growth, driven by economic incentives, sustainability benefits, and increased consumer awareness. The rise in demand for healthier food options and eco-friendly farming methods has encouraged more farmers to transition to organic agriculture. Meanwhile, other crops, like tuber plants, have shown fluctuating trends due to economic constraints, climatic factors, and lower financial incentives. The expansion of permanent crops, including orchards, vineyards, and pastures, suggests a long-term commitment to organic farming, driven by the high value of organic fruits, wine, and livestock products in both domestic and international markets.

The SWOT analysis highlights that organic farming in Romania has strong potential for future development, benefiting from favorable policies, an expanding market, and Romania’s relatively low production costs compared to other European Union (EU) countries. The sector is also supported by EU financial aid programs that encourage conversion to organic farming and help farmers manage risks associated with certification and market fluctuations. However, the industry faces several weaknesses and threats, including limited processing and storage infrastructure, gaps in the supply chain, and a lack of consumer education regarding the benefits of organic products. Moreover, the complexity of certification procedures and inconsistent policy support may deter small and medium-sized farmers from transitioning into the organic sector.Tosupportand accelerate thegrowth of organic agriculture in Romania, it isessentialtoinvest in research, innovation, andinfrastructuredevelopment.

Policy adjustments should aim at reducing bureaucratic obstacles, increasing subsidies for organic farmers, and improving access to training and technical support. Strengthening local and international distribution networks and promoting organic products through targeted marketing campaigns will also help improve competitiveness in the European organic market.

Future research should explore strategies to improve farmers' access to organic certification, identify cost-effective technological advancements, and analyze consumer behavior trends to better align production with market demand. Additionally, further investigation into the economic viability of organic farming and its long-term sustainability will be essential to ensure the sector's resilience and continued growth.

By overcoming these challenges and capitalizing on its strengths, Romania has the potential to emerge as a major player in the European organic agriculture sector, supporting environmental sustainability and fulfilling the growing demand for high-quality organic products.

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ECONOMIC IMPACT OF BIRDS' ATTACKS ON SUNFLOWER CROPS - CASE STUDY

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Abstract

The economic impact of birds on sunflower crops is less studied in Romania and worldwide. In the present study, three sunflower crops established near Timisoara were analysed. The aim of the study was to highlight the economic losses produced by birds during the emergence of seedlings or immediately after sowing as well as before harvesting. The hybrids cultivated were NK Neoma and SY Futura AR. Yield damage was estimated both after emerging and before harvest. Bird flocks were visually assessed by direct field observations during feeding. The birds species identified were Columba livia livia and Corvus frugilegus. Economic losses were calculated considering all technological elements. Damage was 100% in the plot A521 (2.5 ha) and 90% in the plot A519 (6.5 ha). The plot A136 (14.84 ha) was not attacked by birds. The expenses were 3,826.7 lei/ha in 2024. The yields were 0 kg (plot A521), 277 kg (plot A519) and 2670 kg (plot A136). Profit was achieved on plot A136 in the amount of 1,342.3 lei. The selling price for sunflower seeds was 1.8 lei/kg in 2024.

Key words: *sunflower, Columba livia livia, Corvus frugilegus, economic loses, birds*

INTRODUCTION

In recent years, birds have become a real problem for many agricultural areas in Romania. The greatest damage is most often recorded in agricultural fields placed near urban and rural settlements, roads, forests, woodlands, hedgerows, and parks [11]. In these areas, there are shrubs and trees where birds can nest peacefully and food is accessible. Among cultivated plants, the sunflower crop is the most susceptible to attack, preferred by sparrows, blackbirds, pigeons and different species of crows [17]. The preference of birds for sunflower crop instead of other cultivated plants (maize, wheat, barley, etc.) was also reported by Klosterman *et al.* [12].

Studies on bird attacks on sunflower crops are few because estimating damage is often difficult, especially if the birds are not seen at feeding time. Most refer to bird attacks after flowering and during seed ripening, and very few to the damage during germination and sprouting of sunflower plants [13]. The same authors indicate that, worldwide, the species of birds that attack sunflower crop belong to the families *Corvidae*, *Columbidae*, *Icteridae*, *Psittacidae*, *Passeridae* and *Cacatuidae*.

In Europe, damage is caused to sunflower crop by *Passeridae* (*Passer montanus*, *Passer hispaniolensis*), *Columbidae* (*Streptopelia decaocto*, *Streptopelia turtur*) and *Corvidae*. Mentions of damage by birds to sunflower crop during sunflower emergence occur in France, Italy and Switzerland [11]. In France, attacks by birds of the families *Corvidae* and *Columbidae* during sunflower emergence have been reported. Sausse *et al.* [18] show that in recent years reported damage is increasing during crop establishment.

In Romania, Arion [2] mentions several species of birds harmful to agriculture: *Corvus cornix* L. (western grey crow), *Corvus cornix sardomus* Kleinem (eastern grey crow), *Corvus frugilegus* L. (the rook), *Pica pica pica* L. (corncrake), *Passer montanus* L. (field sparrow) and *Passer domesticus* L. (house sparrow). The same species are also mentioned by Rădulescu & Săvescu [15]. Perju [14] mentions *Columba livia livia* L. (domestic pigeon) and *Streptopelia turtur* L. (house pigeon).

Among the *Columbidae* species, the most common in agricultural areas in Romania are *Columba livia livia* and *Columba palumbus* and among the *Corvidae*, *Corvus frugilegus* [7, 8]. These birds cause significant damage to sunflower crop and maize during seedling emergence and before harvest in the southern, southeastern and western areas of Romania. Georgescu *et al.* state that between 2021 and 2022, *the rook* massively attacked maize and sunflower crops, causing significant damage (unpublished data).

While in Europe bird attacks are less studied, on the American continent, much research is being done on damage assessment methods and how to remove them from agricultural areas. Ernst *et al.*[6] assessed economic damage to sunflower crop by birds in a study in North Dakota. It shows that yield losses ranged from 5 - 15% (considered significant). In financial terms, the damage was $28.6 million [6].

In Argentina, losses between 5% and 20% in yield are reported when sunflower plants are attacked at maturity. The incidence of attacked plants is 21 - 35% [3; 20].

Farmers in Romania rarely report bird damage during sunflower plant emerging. Damage is most often reported during ripening when birds are feeding heavily. Bird control is often lost by farmers who cannot control them with any known method. In the past, neonicotinoid insecticides used to treat seeds provided brief protection during emerging. Now, these substances are banned, and damage is increasing. Farmers are sometimes forced to abandon sunflower cultivation because of hungry birds [1].

This study was based on an exceptional situation registered in 2024, when two sunflower plots established near Timisoara were compromised by birds immediately after sowing. This situation was analysed in comparison to a sunflower plot that was not attacked by birds and was established at a greater distance from the inhabited area. Pre-harvest damage was also estimated. The aim of the study was to highlight the damage in production, the costs of sowing and subsequent reseeding and other technological links. The conclusion of the study was that the economic impact of bird attacks during the planting period is major.

MATERIALS AND METHODS

In this study, three plots cultivated with sunflower crop in the spring of 2024 in the perimeter of the Didactic Station of the University of Life Sciences "King Mihai I" from Timisoara were observed. Two fields were established near the university at a distance of about 150 m from each other and the third one about 20 km from Timișoara (Cioreni farm).

The GPS coordinates of the three fields were:

- plot A521 - BF 741: latitude 45.783857, longitude 21.210318;
- plot A519 - BF 340: latitude 45.786061, longitude 21.212773;
- plot A136 - BF 639: latitude 45.815479, longitude 21.144063.

The altitude in the analysed areas is 87 m.

The area of the three sunflower plots differed as follows:

- plot A521 - BF 741 – 2.5 ha (Timișoara);
- plot A519 - BF 340 – 6.5 ha (Timișoara);
- plot A136 - BF 639 – 14.84 ha (Cioreni).

The hybrids used for sowing were: SY Futura AR and NK Neoma. The sowing date differed for each plot, as were the dates on which reseeding was done.

Dates on which sowing was done, number of germinable seeds/ha and hybrid used:

- plot A521 - seeded at 11.04.2024, hybrid SY Futura AR, 67,000 germinable seeds/ha; reseeded I at 25.04.2024, hybrid NK Neoma, 67,000 germinable seeds/ha; reseeded II at 10.05.2024, hybrid NK Neoma, 67,000 germinable seeds/ha - Timișoara (Photo 1).

- plot A519 - seeded at 20.04.2024, hybrid Futura, 67,000 germinable seeds/ha; reseeded I at 29.04.2024; hybrid NK Neoma, 67,000 germinable seeds/ha; reseeded II at 25.05.2024, hybrid NK Neoma, 67,000 la 25.05.2024/ha -Timișoara.
- plot 136 - seeded at 13.04.2024, hybrid SY Futura AR, 67,000 germinable seeds/ha - Cioreni.

Photo 1. Plot seeding, A 521, hybrid SY Futura AR, Timișoara
Source: Original photo by Cotuna Otilia, 2024.

The size of flocks was determined by visual observations directly in the field when birds were present and feeding. It is quite difficult to count birds if you don't have a drone as birds are always in flight. Birds could not be accurately quantified but numbers were estimated to be around 400 - 500 *Columbidae* (*Columba livia livia*) and *Corvidae* (*Corvus frugilegus*).

Damages during emerging of seedlings were assessed according to the following scale: 0 - undamaged seedlings; 1 - seedlings with two cotyledons but damaged; 2 - seedlings with one cotyledon; 3 - seedlings without cotyledons (hypocotyl only) - [16]. The gaps remaining after the attack were measured, ranging in size from 20 to 100 m^2.

Damage during plant maturation was estimated according to the following scale: 0 - unattached caladium; 1 - 10% achenes consumed; 2 - 11% - 20% achenes consumed; 3 - 21% - 30% achenes consumed ... [16].

The economic damage was estimated by referring to the average/ha of the plot yield not attacked by birds, the market price in 2024, the costs of the applied technology and the damage caused by the birds. The profit was calculated considering the total area, total production, average production, selling price (lei), sales revenue and total costs/ha.

Plot A136 was harvested on 28.02.2024 and A519 at 10.09.2024 (Photo 2).

Photo 2. Plot harvesting, A 136, hybrid SY Futura AR, Cioreni
Source: Original photo by George Doru Laieș, 2024.

RESULTS AND DISCUSSIONS

In plots located near Timisoara (A519 and A521), the severity of bird attacks was very high in 2024.

Plot A521 was the first to be attacked by *Columbidae* (*Columba livia livia*) and *Corvidae* (*Corvus frugilegus*). Immediately after sowing, hundreds of hungry birds consumed the seeds (Photo 3). Within a few days, the future sunflower crop was totally compromised. The same happened after the first and second reseeding. This plot was not cultivated with any plants in 2024 due to the birds' aggressiveness.

Photo 3. Birds attack in the plot A521, Timișoara
Source: Original photo by Cotuna Otilia, 2024.

Table 1. Yield, expenses, profit - plot A521, 2024

Total surface ha	2.5
Total yield kg per plot	0
Average yield kg/ha	0
Selling price lei/kg	1.8
Selling income lei/ha	0
Total expenses lei/ha	3,826.7
Profit lei/ha	-3,826.7

Source: Own calculation.

Analysing the Table 1, it can be seen that the yield was 0 in plot A521, the expenses/ha amounted to 3,826.7 lei and there was no profit but only losses (Table 1). In the present case, the attack at the emerging stage totally compromised the crop (an exceptional situation). According to Clark *et al.*[4], the birds are attacking sunflower crops by feeding on seeds and young seedlings in the cotyledonal phase. The food of birds of the *Columbidae* family consists of seeds and grasses, whereas the *Corvidae* are omnivorous and opportunistic, being closely related to plant culture cropping systems, season as well as the resources available in the environment.

Early destruction of sunflower seedlings is an important problem for farmers in Europe, because they may stop growing sunflower crop [19].

Plot A519 located close to plot A521, was attacked by birds equally aggressively. After sowing, the seeds were consumed by birds.

The same happened after reseeding, similar to the neighbouring plot. After the second reseeding, the birds did not fully consume the seeds and cotyledons. The density at sowing was 67,000 germinable seeds/m^2, which means a density per m^2 of 6.7 plants. The evaluation made after the seedlings emerged, when the plants had regular leaves, showed that the plant density/m^2 was 1.6 plants. For satisfactory yield, the density should be at least 5 plants/m^2. For the experiment, the crop was maintained.

As a result of the attack during the seedlings' emergence period, 75% of the plants were lost. The remaining plants (25%) vegetated very well and formed large calatidia (heads). After flowering, birds (predominantly Corvidae) started to consume the achenes. A first assessment was made on 04.08.2024 when it was found that all the heads were attacked, with birds consuming the achenes at the edges. The percentage of attacks during this period was between 20 - 30%, missing seeds from the heads. The second assessment was conducted on 04.09.2024, before harvesting. The heads were missing 80% - 90% seed, some even 100%. Yield/ha was 277 kg/ha and total yield was 1,800 kg (on 6.5 ha).

Costs/ha were 3,826.7 lei and losses 3,328.2 lei. The sale was made at market price (1.8 lei/kg), yielding 498.5 lei/ha (Table 2).

Table 2. Yield, expenses, profit - plot A519, 2024

Total surface ha	6,5
Total yield kg per plot	1800
Average yield kg/ha	277
Selling price lei/kg	1,8
Selling income lei/ha	498,5
Total expenses lei/ha	3826,7
Profit lei/ha	-3328,2

Source: Own calculation.

Photo 4. Gaps remained after the attack during the emerging of seedlings - plot A519, Timișoara
Source: Original photo by Cotuna Otilia.

The crop gaps were numerous and varied in size from a few m^2 to 100 m^2 (Photos 4 and 5).
Bird attacks were as aggressive as in spring (Photos 8, 9 and 10).

Photo 5. Gaps remained after the attack during the emerging of seedlings - plot A519, Timişoara
Source: Original photo by Cotuna Otilia, 2024.

In comparison to the average yield obtained in the 14.84 ha plot at Cioreni (2,670 kg/ha) which was not attacked by birds, the harvest of 277 kg/ha represents 10.37% of the crop potential under the climatic conditions of 2024.
Plot A136 of 14.84 ha from Cioreni was considered for the present study for comparison. The distance between this plot and the two near Timişoara was about 20 km. The plants emerged evenly and were not attacked by birds.

Photo 6. On each head is a bird, plot A519, Timişoara
Source: Original photo by Laieş Doru, 2024.

7

8

Photo 7 and 8. Heads before and after the attack at 6 August 2024, plot A519, Timişoara
Source: Original photo by Cotuna Otilia, 2024.

9

10

Photo 9 - 10. Heads without achenes on 4 Septembe 2024, plot A519, Timişoara
Source: Original photo by Cotuna Otilia, 2024.

The average yield/ha was 2,670 kg and the total yield was 39,623 kg. Under the conditions of 2024, when the sunflower yields at the national level were low, the one obtained in Cioreni was satisfactory bringing also profit (Table 3). Profit per hectare was 1,342.3 lei.

Table 3. Yield, expenses, profit - plot A136, 2024

Total surface ha	14.84
Total yield kg per plot	39,623
Average yield kg/ha	2,670
Selling price lei/kg	1.8
Selling income lei/ha	4,806.0
Total expenses lei/ha	3,463.7
Profit lei/ha	1,342.3

Source: Own calculation.

Statistical analysis was performed by calculating the standard error. The results are presented in Figures 1, 2 and 3.

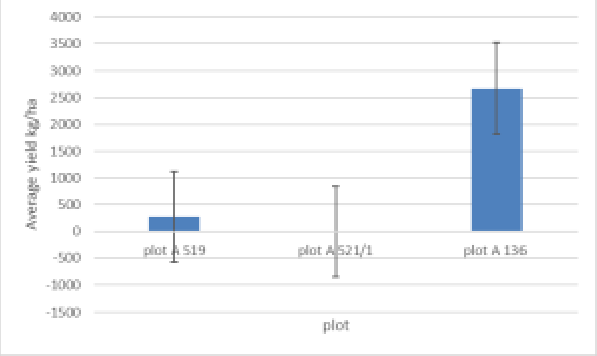

Fig. 1. Average sunflower yield (kg/ha) in the analysed plots - standard error displayed
Source: Own calculation.

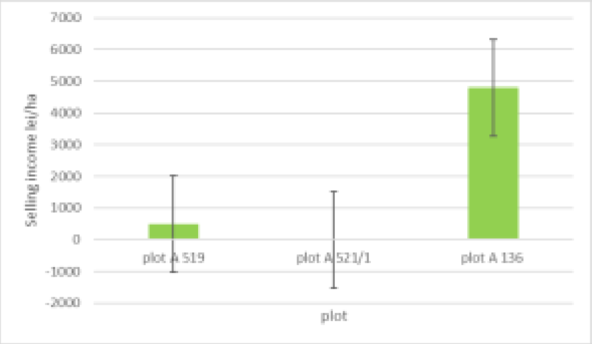

Fig. 2. Selling income (lei/ha) in the analysed plots - standard error displayed
Source: Own calculation.

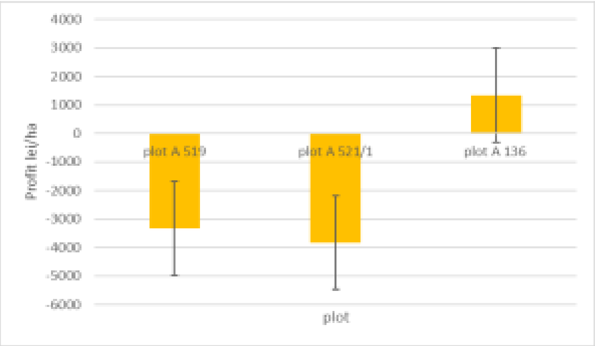

Fig. 3. Profit (lei/ha) in the analysed plots - standard error displayed
Source: Own calculation.

Bird damage to sunflower plots was 100% on 2.5 ha and 90% on 6.5 ha. Their location in the peri-urban area, nearby forest cover, and afforestation of some areas to create a natural habitat for birds are factors that led to the increase in bird populations. Birds are known to cause damage in all agricultural areas of the world. The results of the present study agree with the findings of other researchers. Gül *et al.* [9] reported damage ranging from 10 to 51.19% in sunflower crop.

According to Ilter [10], damage can increase by as much as 60% when crops are placed close to forests, hedgerows, and urban and rural settlements. Usually, damage does not exceed 38% according to Ilter [10].

In Romania, in the West, South and South-East [7, 8], in the last five years, bird (*Columbidae* and *Corvidae*) damage to sunflower crops (and not only) during germination and emerging is frequently reported. Whereas in the past birds were known to attack plants at maturity, consuming the achenes in the heads, damage during germination is now increasingly common. Farmers are often forced to reseed or even stop growing sunflower crop in certain areas, especially near urban settlements.

Saussa & Levy's review, published in [17], states that in Western Europe, "*damage that was once confined to mature sunflower plants is now becoming visible at seedlings emerging*". The same authors highlight from extensive documentation that we see a phenomenon in this regard. They argue that global climate change is influencing agricultural technologies and hence, the activity of agricultural pest birds. We agree with these points.

A current problem in the Banat Plain is that areas of agricultural land near towns often remain uncultivated due to bird attacks. Predominantly sedentary and opportunistic species of the families *Corvidae* and *Columbidae* have overpopulated and are continually multiplying because they easily find feeding and nesting sites in the areas around urban and rural settlements (households, garbage dumps, agricultural land, pastures, meadows, parks *etc*.).

The control methods used to remove birds from fields are no longer working. Nothing scares them anymore. *Corvidae* species that are recognized for their intelligence are coming to the fore. They can find freshly sown seeds with precision. They eat seeds and seedlings immediately after they've germinated. When the sunflower plants are mature, they eat the seeds and leave the husks in the heads and on the ground. By comparison, *Columbidae* species do not excel cognitively, relying more on their senses.

After sowing they consume young seedlings and cotyledons [5].

The economic losses in the fields studied are closely related to their establishment on land near Timisoara where birds are present year after year. Added to this is the fact that there is a nearby hedgerow where the birds can nest undisturbed.

CONCLUSIONS

The economic impact of birds on sunflower crops is huge in the vicinity of towns, villages, forests, heaths etc. Year after year, farmers complain of economic losses, smaller or larger. The financial losses are closely linked to the location of the crops, the bird flocks in the area and their feeding sources.

Bird damage to two sunflower crops near Timisoara has been high, the crops being compromised. In the analysed area, such events occur yearly, irrespective of the crops. Attacks by *Corvidae* and *Columbidae* have become more frequent and aggressive in recent years in Banat, as populations have increased, especially those of *Columba livia livia* and *Corvus frugilegus*. Sunflower crops are much more vulnerable to bird attack and should, therefore, not be grown near inhabited areas.

In Romania, studies on the damage caused by birds to crops do not exist or if they do, they are not public, although the nesting areas of different bird species are known and maps exist.

Future studies are needed in all agricultural areas of Romania to estimate bird populations and the damage caused.

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ANALYSIS OF THE AGRICULTURAL SECTOR IN THE NORTH-WEST REGION OF ROMANIA FROM THE POINT OF VIEW OF CLUSTER EXCELLENCE

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Abstract

The cluster of excellence in the agri-food sector could function as a significant driver for promoting innovation and advanced technologies throughout all aspects of the supply chain. This collaboration can facilitate the exchange of knowledge and experiences, promoting innovation and the development of efficient solutions. Innovative clusters have an impact on regional growth because they enable new technology applications, cost savings, and research. Romania's North West area is well-known for having the highest number of gold-certified clusters in a variety of disciplines, including the lone gold-certified cluster in the agro-industrial sector. For the gold clusters in the North West region, the study finds less meaningful indicators for the agro-industrial sector using the ESCA standard technique for management excellence indicator evaluation.

Key words: *agro-industrial clusters, ESCA excellence indicators, management performance*

INTRODUCTION

As instruments for promoting economic transformation and enhancing productivity and business competitiveness, clusters are firmly on the political agenda of the European Union [19]. A cluster's success is assessed based on three factors: objective attainment, cluster size, and innovation and global competitiveness [18]. The cluster idea has been warmly welcomed by the European Commission, particularly in relation to the creation of the Lisbon agenda and the execution of regional policy [21]. Innovation clusters facilitate the use of contemporary technology, cost reduction, and innovation implementation, all of which have an impact on regional growth [10, 11]. The agro-industrial logistic cluster is traditionally seen as a means to enhance the competitiveness of a region [5]. Clusters have become a crucial element in promoting the development of value chains in the agricultural and agri-food industry in Romania [16].

Choosing a competitive economic model to maximize available potential is challenging, especially given the need to improve the economic efficiency of regional agro-industrial complexes. The principles of clusters, which have proven effective globally, may offer the best solution to this issue. The placement of agro-industrial clusters is determined by factors such as a high degree of strategic planning and management, above-average performance indicators, participation in technical, innovative, international, logistical, and workforce activities, and a large number of employees. Establishing a management structure and identifying critical elements from the agro-industrial cluster's internal and external environments are crucial steps in implementing cluster policy.

Based on existing scientific literature and the exploration of successful case studies in the global sector [6], the identified factors influencing territorial agro-industrial development are: short supply chains, protection of agri-food products with territorial identity, family farming, local food systems, and agribusiness [9].

The agro-food industry's clusters of excellence offer favorable conditions for cooperation between farmers, processors, distributors, universities, research centers, and other players [3, 8]. Agro-food industry participants may get access to new markets and economic prospects [7], both domestically and globally [15], through the excellence cluster [20].

Despite their lack of a formal status and differences in population and size, Romania's eight development areas are united by one thing: agriculture, which is one of the primary industries contributing to the country's overall output [4]. 12 clusters are registers in Romania, in the agro-industrial sector as follows: AgroTransilvania Cluster in the North-West region, Cluster AGRO-FOOD in the Central region, Bio Oltenia Cluster in the South-West region, IND AGRO VEST Cluster in the West region, Inomar Cluster, Bio Danubius Cluster, Innovative Agro-Industrial Cluster "Dunarea de Jos" in the South-East region, Bio Concept Valea Prahovei Cluster in the South Muntenia region, IND-AGRO Competitiveness Pole in the Bucharest Ilfov region, BioNest, bioRone Cluster, and the Innovative Regional Bioeconomy Cluster Suceava-Botosani in the North-East region (Fig. 1). Romania has to create clusters in every region to boost competitiveness and create a single value chain for exports in order to promote the expansion of the agri-food industry [17].

The Romanian clusters operating in the agri-food sector have merged to form a cooperative structure within the National Network of Clusters in the Agri-Food Sector. This structure aims to facilitate discussions on shared topics of interest and find workable solutions to the problems faced by the agri-food industry. AgroTransilvania Cluster is the only agro-industrial cluster in Romania to receive gold accreditation for management excellence.

The cluster that performs best among all clusters in a nation is designated as an "excellent cluster."

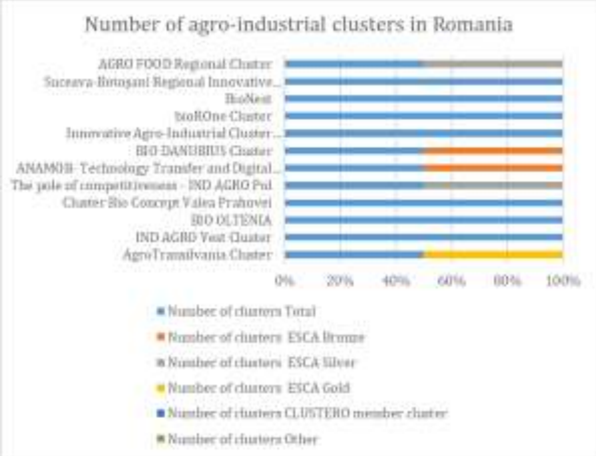

Fig. 1. Romania's agro-industrial clusters' current state
Source: Own determination.

The objective is to create independent, voluntary evidence of cluster management excellence that is accepted across Europe and beyond, according to ECEI [14].

By benchmarking against the best and learning from their techniques, cluster managers may improve their performance by participating in "mutual evaluation" and "mutual learning" at the same time [12].

Innovation clusters facilitate the use of state of the art technology, increase the efficiency of production and innovation implementation, all of which have an impact on regional growth [10].

This research aims to analyse and classify the ESCA indicators based on their relevance to the specific needs identified in the Northwest Region of Romania as being relevant for the agro-industrial sector. Additionally, it seeks to adapt these indicators to be more suitable for the agro-food sector, utilizing feedback from cluster managers and sector analysis

MATERIALS AND METHODS

Referencing the ESCA standard approach on the indicators for measuring management excellence [13], the primary goal of the research is to determine the least relevant indicators for the agro-industrial sector for gold clusters in the North West area. Gold audit report for AgroTransilvania Cluster, Romanian clusters, analysis of EU cluster policies, and a study of methods supporting cluster development were among the resources utilized in the research. Utilizing data from relevant sources including, at European level: the European Secretariat for Cluster Analysis (ESCA) and, respectively, the European Cluster Collaboration Platform (ECCP), and, in Romania, the North West Region's Smart Specialization Strategy in 2021–2027 were used as research techniques.

A high-quality pre-audit was conducted for AgroTransilvania Cluster through the use of the ESCA methodology [13].

In the view of the authors, the set of the indicators can be been updated to be more relevant for the specificity of the agri-industrial sector, especially for Romanian realities.

The subsequent proposed methodological actions were:

1. The ESCA evaluation methodology has been revised. The exact indicators utilized for performance evaluation were identified by analyzing and selecting the original ESCA methodology.
2. Modification of the indicators. We have changed or replaced the indicators that did not apply to the agro-industrial sector. This required coming up with new metrics that more accurately capture the industry's particular difficulties and success.
3. Data collection. Relevant data was obtained from AgroTransilvania Cluster via member satisfaction questionnaires and analysis of internal documents
4. Data analysis: The collected data was analyzed using statistical and analytical techniques to identify the strengths and weaknesses of ATC in the agro-industrial setting.
5. Systematizing the results. The results of the analysis were presented in a clear and concise way, organized in tables.

RESULTS AND DISCUSSIONS

The only agro-industrial cluster in Romania to get the gold accreditation for management excellence is AgroTransilvania Cluster [2].

At the moment, the management team plans, oversees, and evaluates all of the cluster's operations in a methodical manner.

To ensure effective coordination, these tasks entail scheduling meetings of the Board of Directors, the General Assembly, and the management team.

Certain ESCA indicators pertaining to the certification of management excellence may not be as applicable to Romania's agro-industrial sector, or they may need to be modified to more accurately reflect the demands and reality of this industry.

This research aims to analyze and classify the ESCA indicators according to their relevance for the specific needs of the agro-industrial sector in the Northwest Region of Romania, based on the feedback received from the cluster managers and the sector analysis. Indicators are classified into two categories:

"Blue" indicators denote the relevant metrics for the North-West Region of Romania.

These indices are crucial for evaluating management excellence in agro-industrial clusters from various perspectives, including local cooperation and partnerships, the adoption of sustainable technologies, education and professional training, and the availability of financing.

They are considered pertinent to the North-West Region of Romania.

The less significant metrics for Romania's agro-industrial sector are represented by "orange" indicators.

The degree of advanced digitization, membership in international research networks, internationalization, and the density of innovation clusters are some of these indicators that may need to be adjusted to better represent local circumstances.

For these metrics, Romania's agro-industrial sector is thought to be less significant.

1.Findings about how well the AgroTransilvania Cluster represents a broader population.

Representativeness in a cluster refers to how well its members reflect the range and significance of interests and skills within the cluster's specific industry or subject. Ensuring sufficient representativeness is crucial for promoting fair and effective involvement of all stakeholders and maximizing the opportunities for innovation and cooperation.

Table 1. Evaluation of the AgroTransilvania Cluster's management effectiveness in 2024

Crt. no.	Suggestion for the agro-industrial sector indicator	Superior standard of excellence	Moderate standard of excellence with potential for improvement
I. Cluster Representativity			
1	The involvement of farmers and agro-industrial companies in the cluster, with emphasis on active participation and cooperation in joint projects.	x	
2	Diversity of participants in the cluster, including farmers, agricultural equipment manufacturers, researchers and agricultural educational institutions.	x	
3	Total number of farmers, agro-industrial companies and partner institutions involved in the cluster.	x	
4	The geographical distribution of participants in rural and agrarian areas, assessing the proximity of farms and processing facilities.		x
II. Typology, governance, cooperation			
5	The level of experience and expertise of the management team in the agro-industrial field.	x	
6	The quantity and background of personnel managing the cluster, with a focus on experience in the food and agricultural industries		x
7	The management team's degree of expertise in biotechnology, agriculture, and agricultural management.	x	
8	Initiatives to provide the management staff with professional development opportunities and ongoing training in new agriculture technology and techniques.		x
9	The staff retention rate in the management team and succession plans to maintain continuity.	x	
10	The clarity of the roles and responsibilities of the participants and the active involvement of farmers and companies in decision-making processes.	x	
11	The regularity and worth of face-to-face communication between the management group and agricultural companies.	x	
12	Direct communication between members in the cluster and the cluster management team	x	
13	The level of cooperation between farmers, companies and institutions in the projects and initiatives of the cluster.	x	
14	The degree of integration of the cluster into the agricultural innovation system and partnerships with research and development institutions.	x	
III. Financing			
15	The financial projections of the cluster, including funds available for agricultural and technological projects.		x
16	The proportion of private funding, such as investment by agro-industrial companies and farmers' contributions.	x	
IV. Strategy, objectives, services			
17	The process of developing the cluster strategy, focusing on the needs and challenges of the agro-industrial sector.	x	
18	Comprehensive record of the cluster plan, with particular goals for the food and agriculture industries.	x	
19	The cluster strategy's implementation plan outlines the steps required to achieve the goals in the food and agricultural industries.	x	
20	The cluster's financial control system, designed specifically for managing investments in agricultural infrastructure and initiatives.	x	x
21	The procedure of routinely reviewing the strategy and implementation plan and making modifications in light of the agro-industrial sector's growth.	x	
22	Keeping track of how well the management group is doing in reaching the sector-specific goals for the agro-industrial sector.	x	
23	Prioritize cluster approach in conjunction with a long-term food and agriculture plan.	x	
24	The cluster offers a range of services and activities, including training, technical support, and agricultural consulting.	x	
25	Assessment of the cluster management's effectiveness in coordinating agricultural projects and activities.	x	
26	Formation and work of specialized working groups in various areas of agriculture and food industry.	x	
27	The effectiveness of internal and external communication of the cluster, including with farmers, companies and partner institutions.	x	
28	Group information on the agro-industrial industry on your website and social media accounts, as well as other online spaces.	x	
V. Achievements and recognition			
29	Recognition and visibility of the cluster in specialist media and agricultural publications.	x	
30	Success stories of farmers and companies in the cluster, highlighting good practices and innovations.	x	
31	Assessment of satisfaction of participants and clients of the cluster	x	

Source: Own determination.

The AgroTransilvania Cluster now has 90 members and operates on the quadruple helix paradigm. In order to guarantee and sustain the inclusion and fairness of the cluster, it is crucial to consistently prioritize the variety of members and stakeholders, foster equal opportunities, and actively engage and encourage the participation of all relevant individuals. The cluster members are actively involved in the projects due to the projects' specialization, financing level, and the members' enthusiasm in participating. As a result, indication 1.1.4 - Geographical concentration of cluster participants is given an orange grade due to the fact that over 65% of members are situated within a 150 km radius.

2. Discoveries concerning the classification, management, and collaboration within the AgroTransilvania Cluster

The cluster's maturity is evidenced by its extensive track record of over a decade after its establishment. Indicator 2.2.3 emphasizes the need of lifelong learning in cluster management. This is because staff turnover is impacted by the participation and financial support of certain initiatives for a set period of time. The level of expertise of the workforce varies depending on the specific characteristics of each project.

The AgroTransilvania Cluster is confronted with the issue of worker turnover, which can have a substantial influence on operational efficiency and stability. Key factors of staff turnover within the cluster are team instability, depletion of experience and knowledge, disruption to project continuity, increased expenses and resources allocated to recruiting and training, and potential adverse consequences on employee morale and engagement.

In order to address staff turnover within the cluster, it is crucial to implement efficient employee recruiting and retention methods, enhance team communication and engagement, offer chances for professional growth and progression, and foster a good and stimulating work environment. Furthermore, implementing explicit rules and procedures for performance management and awards may effectively mitigate employee attrition and enhance the overall stability of the firm.

3. Discoveries pertaining to the funding aspect inside the AgroTransilvania Cluster

At present, the cluster's financial resources consist of membership fees, acquired grants, revenue generated from research and development laboratory operations, and sponsorships from partners. Nevertheless, the financial insurance for the future only provides coverage for a maximum duration of 1.5 years, as the funding from the funded initiatives guarantee this timeframe. This condition results in acquiring the yellow indication. To mitigate financial risks and provide more budget stability, it is advisable to get money for a minimum of two years in advance.

The financial assistance gained through grants within the AgroTransilvania Cluster plays a crucial role in providing a substantial portion of the resources required for the conducted activities. Project grant reliance refers to the scenario in which a cluster or organization largely relies on external money in the form of grants to sustain its ongoing activities and operations. This interdependence can have both advantageous and disadvantageous characteristics and can greatly impact the financial stability and long-term sustainability of the cluster.

4. Discoveries about the strategy, aims, and services inside the AgroTransilvania Cluster.

The most current update to the AgroTransilvania Cluster strategic plan was made in 2022. It offers a clear path for development and advancement through suggested activities and is in line with the potential and demands in the agro-industrial sector. The goals are quantifiable, reachable, and aligned with the mission and vision of the cluster, which is to provide national economic players in the agro-industrial sector with an engaged and sustainable partner and to serve as a model of successful international collaboration.

The services provided to members should be evaluated to determine if they bring additional value both within the cluster and to a broader audience.

Quarterly assessments should be conducted to evaluate the utilization of human, financial, and technology resources, as well as identify any potential gaps or needs that may require attention in order to enhance the organization's capability.

We can ensure that the AgroTransilvania Cluster remains relevant and effective in fostering the creative and sustainable expansion of the agro-industrial sector in the Transylvania area by consistently evaluating and improving the cluster's objectives, strategy, and services.

These observations can provide important guidance for improving the cluster's effectiveness and impact on the surrounding area.

5. Discoveries on accomplishments and acknowledgment inside the AgroTransilvania Cluster

The primary means of evaluating the impact of the AgroTransilvania Cluster on the agro-industrial sector and its surrounding community is through national and international evaluations and recognition, which are deemed essential.

These findings might emphasize the noteworthy contributions, innovations, and recognition attained by the cluster, both at the local and national or worldwide levels.

The cluster's most significant accomplishments in this area are the identification and documenting of successful projects and initiatives that have been executed.

Examples include research, development, and innovation projects, corporate growth efforts, training programs, and promotion and communication campaigns.

AgroTransilvania has achieved significant recognition over the course of its 10 years of operation. Its most notable achievement is the Gold label certification, along with ISO certifications. Additionally, it has received numerous awards and forms of appreciation that validate its contributions and performance.

By assessing and emphasizing accomplishments and accolades inside the AgroTransilvania Cluster, the cluster's reputation and beneficial influence on the agro-industrial sector and its community may be enhanced.

These insights can also offer important direction for recognizing and taking advantage of future growth and partnership prospects.

Table 2. Differences between the agro-industrial sector's recommended procedure and ESCA's actual methodology

No	Change	ESCA standard methodology	Methodology recommendations for the agro-industrial sector
1.	**Relevant Indicators**	It makes use of generic indicators that work across a range of service and industrial industries.	It covers metrics unique to the food business and agriculture, such crop production, the degree of ecological sustainability, the degree of technological advancement in agricultural operations, and the efficiency with which natural resources are used.
2.	**Measuring Economic Performance**	It focuses on broad economic metrics such operational expenses, revenue growth, and profitability.	Modify economic statistics to take into account certain factors like the price volatility of agricultural products, the effect of subsidies, and the expenses related to climate change.
3.	**Sustainability and Environmental Impact**	It takes a broad approach to sustainability, avoiding intricacies unique to any one industry.	It contains certain sustainability metrics including greenhouse gas emissions, fertilizer and pesticide use, and biodiversity damage.
4.	**Technology and Innovation**	The demands of the agro-industrial sector are not taken into consideration in the general evaluation of technology and innovation.	It focuses on the use of cutting-edge agricultural technologies, including biotechnology, automated agricultural processes, and precision farming.
5.	**Infrastructure and Logistics**	It assesses logistics and infrastructure without considering industry-specific factors.	It contains metrics for certain infrastructure, such the ability to store agricultural products, the effectiveness of the supply chain, and market accessibility.
6.	**Climate Change Adaptation Capacity**	It doesn't give climate change adaptation any special attention.	Examine how well agriculture and industrial facilities can adjust to the changing environment, taking precautions against harsh weather included.
7.	**Community Relations and Social Responsibility**	In general, it emphasizes social responsibility.	It looks at interactions with rural communities, the effects of agriculture on society, and community development programs.

Source: Own determination.

The pre-audit offered a comprehensive and precise assessment of ATC's performance, enabling the establishment of specific initiatives for ongoing enhancement and growth. The approach that was suggested for the agro-industrial sector after the AgroTransilvania Cluster study differs significantly from the present one (the standard ESCA methodology) in that it takes into account the unique requirements and characteristics of this industry. As per the stance of the Clustero Association, agro-industrial clusters will be able to make meaningful comparisons with other clusters across Europe if they conform with the ESCA metrics.

Similar to this, the suggested indicators' applicability must encompass important domains including innovation and research, economic development, networking and cooperation, the quantity of international relationships and the degree of cooperation among cluster members, education, and sustainability. The main differences identified can be found in Table 2.

By making the recommended adjustments, the evaluation is more accurate and pertinent for evaluating the production and quality in the agro-industrial sector, which aids in problem identification and the creation of workable solutions.

CONCLUSIONS

A cluster of excellence in the agri-food industry has the potential to be a potent instrument for fostering innovation, competitiveness, and sustainability in this crucial domain for the economy and society. By consolidating resources and knowledge inside specialized groups, we can foster fruitful interactions and enhance the development potential of the overall agri-food business.

The AgroTransilvania Cluster, the sole agro-industrial cluster in Romania to have received gold management excellence accreditation, embodies the quadruple helix model, guaranteeing significant variety among stakeholders [1]. The cluster's longevity of over 10 years is apparent, but, the issue of personnel turnover continues to pose a significant difficulty, impacting the continuity and efficiency of projects. The AgroTransilvania Cluster plan's 2022 version closely corresponds with the demands of the agro-industrial sector. Although the goals are clear and measurable and the services offered are relevant, it is still important to regularly evaluate the extra advantages they deliver.

The agro-industrial sector's performance and quality may now be more accurately and suitably assessed thanks to the changes made to the ESCA indicators. This makes it possible to identify and put into action effective strategies that will support and maintain this sector's growth. This is a positive outlook, and the Clustero Association fully supports an effort to standardize the indicators unique to clusters in the agro-industrial sector.

With its wide range of projects and excellence certification, the AgroTransilvania Cluster is a very successful role model in Romania's agro-industrial sector. However, the challenges presented by employee turnover, dependence on subsidies, and the need to diversify funding sources.

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DIRECTIONS FOR TRANSFERRING FOREIGN EXPERIENCE OF SUSTAINABLE DEVELOPMENT OF THE AGRO-FOOD COMPLEX TO THE RUSSIAN ECONOMY

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Abstract

Sustainable development of agriculture is a prerequisite for increasing food volumes and implementing technological transformations. The paper presents an assessment of various concepts and mechanisms for managing sustainability in agriculture in developed countries. The purpose of the work is to study foreign experience in managing sustainable agricultural development and to develop directions for transferring positive experience to the agricultural sector of the Russian economy. The important role of digital technologies in agriculture is confirmed and the need to stimulate their implementation in various sub-sectors is substantiated. The main options, models and technologies for achieving sustainable development of agriculture in advanced countries are studied. The need to apply a multi-level strategy for managing sustainable development of agriculture in Russia is substantiated. The foreign experience of sustainable development of the agro-food complex is generalized and systematized, the author's models are presented: European, American, Latin and Japanese. Based on these models, directions for transferring positive foreign experience of sustainable development of the agro-food complex to the Russian economy are proposed. The practical value of the results obtained lies in the possibility of their use in the development of programs, strategies and mechanisms for the sustainable development of the agro-food complex of the country and regions to increase food production and introduce advanced technologies.

Key words: *agro-food complex, foreign experience, investment policy, regulatory mechanisms, development strategy*

INTRODUCTION

The main directions of sustainable development of agriculture can be implemented by achieving a high level of science and technology.

Modern challenges of the growth of the world population, the complication of global food chains, and the growing anthropogenic load increase the attention of scientists in the world scientific community to the problems of sustainable development.

The main directions of sustainable development of agriculture can be implemented by achieving a high level of science and technology. Sustainable development is aimed at the production of high-quality environmentally friendly food products, rational use of production resources, and growth of the well-being of the rural population [19]. The development of national agro-food systems along the path of sustainability creates the prerequisites for solving the global problem of food security [15]. The growing global demand for food, especially meat and milk, affects the problem of using limited water and land resources. An increase in greenhouse gas emissions will cause irreversible climate change [1, 3, 8, 18, 25]. In European countries, programs and strategies for the sustainable development of agricultural sectors are being developed [20]. For example, in the Netherlands, an innovative technology is used to reduce emissions as a result of the reuse of production resources [2].

Analytical materials of FAO and the UN confirm the undeniable role of innovative technologies in achieving sustainability parameters in agriculture.

Digitalization of agriculture is a priority area in the EU countries.

Many foreign scientists are studying such sustainability factors as the use of innovations and advanced production technologies. Khan, N., Ray, R. L., Kassem, H. S., Lykas, K., emphasized the importance of using agricultural land, reducing losses during processing, and introducing waste-free production. The authors studied the possibilities of using innovations at various stages of production. They noted the different innovative activity of enterprises in developed and developing countries [17, 24].

An important role in achieving sustainability of agricultural production has been identified for such digital technologies as intelligent agriculture, gene technology, artificial intelligence, robotic fertilization and weed removal systems, precision farming and selection [13,16]. Digital technologies such as robotics and blockchain are widely used in animal husbandry in European countries in the development of feed rations, monitoring animal health and regulating reproduction processes [22, 23]. Nigerian agricultural enterprises are activelyadopting various digital technologies [4]. R Laurett, A / Paco, E Mainardes studied sustainability factors in Brazilian agriculture, taking into account the opinions of farmers. The results of a questionnaire survey of more than 200 farmers confirmed the importance of the investment factor for technological transformations and achieving environmental safety [14].

Foreign authors note that entrepreneurs should take an active part in the formation and application of innovative business models in practice. This will achieve «strong» sustainability.

At the same time, the use of innovations in agriculture does not always correspond to the main priorities of sustainable development. An effective solution is to strengthen the interaction of enterprises at the intersectoral level, as well as improve regulation and management methods [9].

In his study, J. Björklund assessed the advantages and difficulties of implementing a sustainable business model by entrepreneurs in the Swedish agricultural sector. For the country's agriculture, the implementation of environmental measures to achieve ecological balance is of particular importance. The difficulties faced by many farmers in the country have been noted.

The number of small and medium-sized farms in Sweden has decreased significantly. The results of sociological studies have shown that small farmers have difficulty competing with large cooperatives, point to insufficient financial support from the state and weak advisory assistance. Small farmers also have significant concerns about changes in the institutional framework. The noted difficulties hinder the development of effective management decisions on running a business that meets the goals of sustainable development [5]. Scientists from the universities of Qatar and Sassari point to financial barriers and technical difficulties in the use of agricultural robots by Italian farmers [26]. Scientists from the University of Lisbon studied the implementation of new technological innovations in water resource management in individual regions [21]. Sustainable development management mechanisms are also constantly being improved. The experience of Germany is interesting, where various methods and tools are used: the Criteria System for Sustainable Agriculture (KSNL) in Thuringia, the Sustainable Agriculture Certificate of the German Agricultural Society (DLG) and the Swiss Sustainability Assessment. According to a sociological online survey of 600 farmers in Germany, many of them showed insufficient awareness of the Sustainable Agriculture Certificate (DLG), which contains nitrogen balance requirements for the farm [11].Thus, in developed countries there are many tools, approaches and methods for regulating agricultural production in the direction of sustainability.

The purpose of the work is to study foreign experience in managing sustainable agricultural development and to develop directions for transferring positive experience to the agricultural sector of the Russian economy.

MATERIALS AND METHODS

Various research methods were used. Using the analytical method, the main approaches to studying sustainability issues by scientists from different countries of the world were studied. It was revealed that certain provisions of the European countries' policies are also relevant for Russian agriculture (saving production resources, efficient use of waste). Various mechanisms for managing sustainable development were compared. This method made it possible to determine the most effective practices and methods used in different countries, as well as to identify the factors that determine the possibility of successful adaptation and implementation of these approaches. The study also conducted a forecast assessment of changes in agricultural production volumes and technological development indicators in Russia in the next 5 years. Features of the use of innovative technologies in different sectors of Russian agriculture were identified.

RESULTS AND DISCUSSIONS

Digitalization processes play a positive role in achieving sustainability criteria for Russian agricultural sectors.

Table 1. Use of digital technologies by Russian agricultural organizations in 2023, units

Digital Technologies	Agriculture	Including:					
		Grain Oilseeds	Oilseeds	Vegetables	Dairy farming	Pig farming	Poultry farming
	Number of enterprises using relevant digital technologies, units						
Total number of digital technologies	4,091	979	161	145	986	192	298
Including:							
Digital platforms	698	182	17	53	155	38	30
Geographicalinformationsystems	929	273	62	19	180	51	69
Artificial intelligence	128	25	12	0	34	13	6
technologies for collecting, processing and analyzing big data	684	173	19	41	146	34	57

Source: Own calculations based on data [12].

Table 1 presents the main indicators of the use of various digital technologies in Russian agriculture. It was revealed that their use was not uniform in enterprises of various types of agricultural activity. For example, all of the above-mentioned digital technologies were actively used in grain production and dairy farming.

For example, digital platforms were used by 182 grain production organizations and 155 dairy farming organizations); geoinformation systems were used, respectively, by 273 and 180 organizations; technologies for collecting, processing and analyzing big data - by 173 and 146 organizations. Artificial intelligence technologies are slowly being introduced in poultry farming (6 organizations) and growing oilseeds (12).

By 2030, Russia plans to create a single digital platform for the agro-industrial complex; this will allow for quick and effective decisions on managing the sustainable development of the agricultural sector. A forecast assessment of changes in agricultural production volumes and investments in the modernization of production processes for the period up to 2030 was carried out (Fig. 1).

The trend of gross added value of agriculture reflects a linear dependence with positive dynamics, which suggests a certain impact of financial support for producers and innovative structural shifts. A sufficiently high coefficient of determination (0.95) confirms the reliability of a sustainable increase in gross added value.

Calculations have shown that with continuing trends in innovative development, gross added value will reach 6,770 billion rubles by 2030, an increase of 13.3% compared to 2022.

At the same time, the level of investment in agricultural modernization processes remains low, which hinders economic growth and innovative development. Therefore, further growth in the agricultural sector is largely determined by investments in technological innovations. It is also necessary to constantly improve the mechanisms for managing sustainable agricultural development, using the best practices of foreign countries. A study of various options for sustainable agricultural development has been conducted, and the most effective models have been selected that can be used in the Russian agro-food complex.

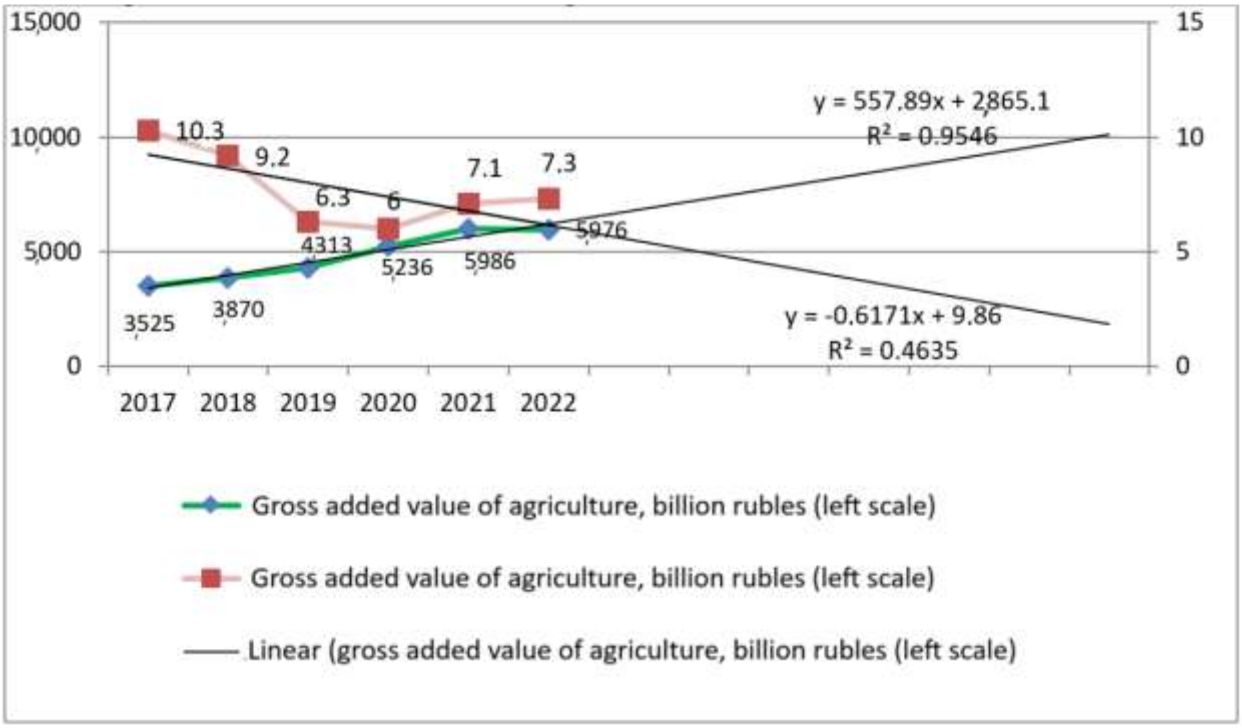

Fig.1. Analysis and forecasting of trends in economic growth and modernization of agriculture in Russia (2012-2022)
Source: Own calculations based on data [10, 12, 28].

The foreign experience of sustainable development of the agro-food complex is generalized and systematized, the author's models are presented: European, American, Latin and Japanese. Based on these models, directions for transferring positive foreign experience of sustainable development of the agro-food complex to the Russian economy are proposed.

Figure 2 shows the classification and transfer of foreign sustainable development options.

An analysis of foreign models of sustainable agriculture showed the widespread use of innovative and digital methods and technologies. The Japanese and American models are implemented mainly at the production stage. A distinctive feature of the Japanese model is the use of labor-saving technologies due to the reduction in the number of farmers. For example, "autonomous farming" is represented mainly by self-driving tractors and mowers, as well as remotely controlled rice planting machines. The Wagri digital platform operating in Japanese agriculture contains the necessary information for farmers on crop management and the state of the equipment market.

The American model with a predominance of large farms is characterized by the active use of technologies for monitoring yields and adjusting the application of fertilizers and agrochemicals, GPS soil mapping. Artificial intelligence technologies are actively used in the production process. Most farmers use irrigation sensors when cultivating fruit and berry crops.

Unlike the models considered, the sustainable development of European countries is associated with increasing the productivity of agricultural production and optimizing processes in the value chain, including logistics. In Germany, crop yield monitors are used; in Greece, precision farming technologies are used in growing olives and potatoes. In the agricultural sector of France, digital methods for the consumption of plant protection products are being introduced. In the Netherlands, greenhouse products are export-oriented due to the widespread use of digital technologies for climate and moisture control. The Food Valley program addresses the task of forming a knowledge transfer infrastructure.

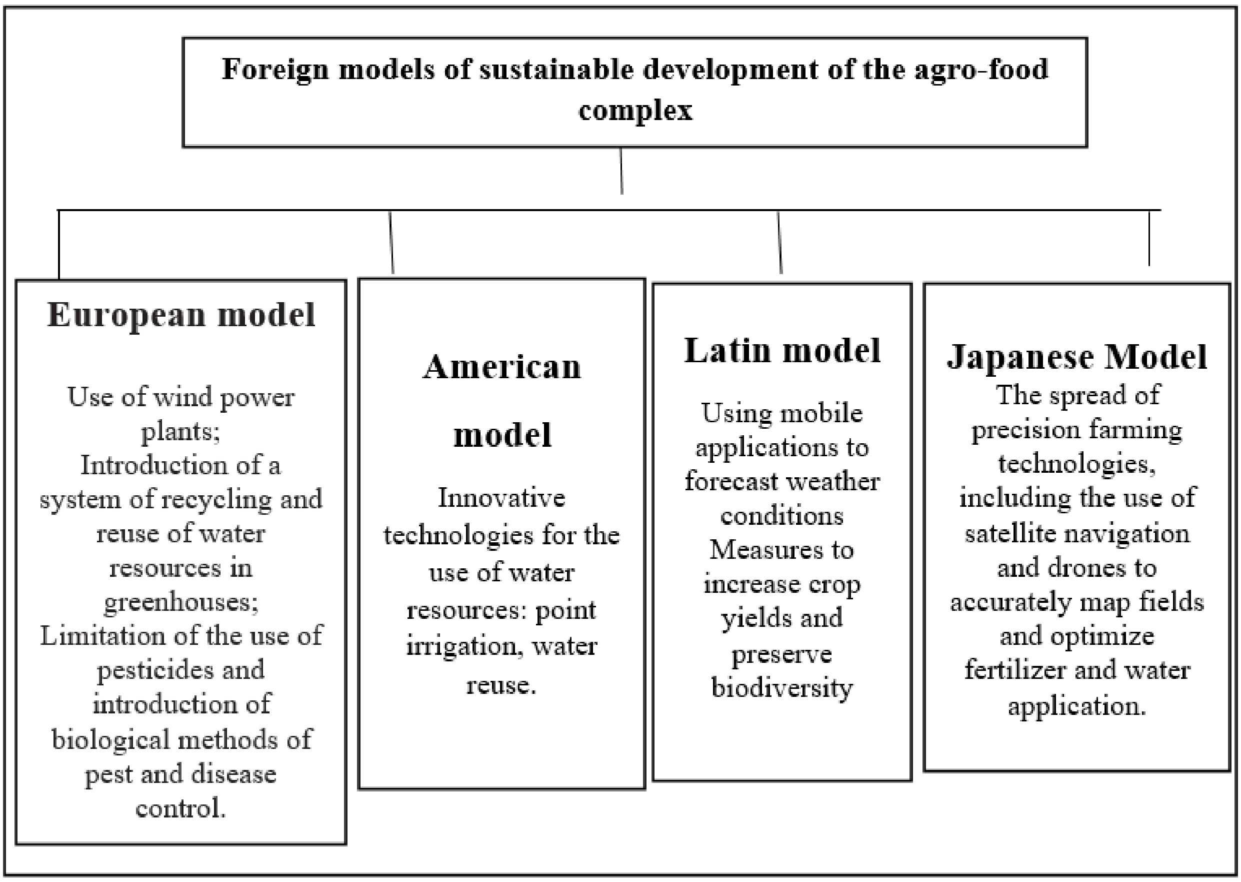

Fig. 2. Scheme of transfer of experience of foreign models of sustainable development of agro-food complex to the Russian economy
Source: Own conception.

In Germany, technologies called "digital fields" are quite widespread. The main ones are digital technologies in milk production (Digimilch); digital technologies in crop production with remote sensing (Agrisens-DEMMIN 4.0), as well as digital technologies in viticulture (DigiVine).

The digital development directions "Upstream" and "Downstream" are being developed in a number of European countries on the basis of technology startups with the corresponding financial support from the state.

The study showed that many countries view technological innovations and resource-saving technologies as the most important sustainability factors that contribute to the successful solution of environmental problems, the achievement of high production indicators and the reduction of production costs. It is necessary to carry out a continuous transfer of knowledge, advanced methods and technologies, including at the international level [6,7]. Innovations of the future should include genetically modified organisms adapted to natural changes, as well as innovative methods of weed and plant pest control.

To achieve sustainable development of the agro-food complex of Russia, it is necessary to develop a multi-level strategy.

It is based on close communication between scientists-developers and users of advanced technologies, which is possible as a result of training, knowledge exchange, and the formation of appropriate digital competencies among management and employees.

An increase in public funds is required to create new scientific and educational centers. It is also necessary to form a system of package solutions of digital technologies between stakeholders ready for implementation in agricultural production, as well as the creation of sustainable and adaptive agricultural systems. Only through the joint efforts of the state, business and science can we overcome the difficulties of forming a sustainable agricultural sector and increase the level of well-being of the population in the near future. The practical value of the results obtained lies in the possibility of their use in developing programs, strategies and mechanisms for the sustainable development of the agro-food complex of both the country and individual regions to increase food production and introduce advanced technologies [27].

CONCLUSIONS

Sustainable development of agriculture is a prerequisite for increasing food volumes and implementing technological transformations.

The paper presents an assessment of various concepts and mechanisms for managing sustainability in agriculture in developed countries.

The important role of digital technologies in agriculture is confirmed and the need to stimulate their implementation in various sub-sectors is substantiated.

Forecasting the gross added value of agriculture showed a linear dependence with a positive trend. However, further growth in the agricultural sector is largely determined by investments in technological innovations. It is also necessary to constantly improve the mechanisms for managing sustainable development of agriculture, using the best practices of foreign countries. The main options, models and technologies for achieving sustainable development of agriculture in advanced countries are studied.

A study of various options for sustainable agricultural development has been conducted, and the most effective models have been selected, which are recommended for use in the Russian agro-food complex.

The foreign experience of sustainable development of the agro-food complex is generalized and systematized, the author's models are presented: European, American, Latin and Japanese. Based on these models, directions for transferring positive foreign experience of sustainable development of the agro-food complex to the Russian economy are proposed.

The use of technological innovations and economical consumption of production resources will reduce production costs and reduce the impact on the environment, while ensuring high yields and product quality. It should also be noted that stimulating sustainable growth involves a constant exchange of knowledge, experience and best practices at both the regional and international levels.

The practical value of the results obtained lies in the possibility of using them in developing programs, strategies and mechanisms for sustainable development of the agro-food complex of the country and regions to increase food production and introduce advanced technologies.

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A MATHEMATICAL-STATISTICAL EVALUATION OF CULTURAL TOURISM DEMAND AND OFFER - A CASE STUDY ON THE ATTRACTION OF THE MUSEUMS AND ITS ECONOMIC IMPACT IN BULGARIA

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Abstract

The current article presents a mathematical-statistical evaluation of cultural tourism demand in Bulgaria in terms of museum visits by region in the period 2013-2022. In parallel, the information related to the number of museums and exhibits is also examined. These indicated data are stored in a built relational database. The necessary information, for each of the six regions considered, is searched and extracted from it. Three sets of indicators are calculated and evaluated in connection with the subsequent processing of the studied elements. Hierarchical cluster analysis is also applied to the surveyed data. The results show that the pace of growth of the indicator (museum visits) in five of the mentioned regions is relatively fast in 2021-2022. The studied indicator decreases only in the North-West region during 2021, but there is an increase of about 24% in 2022. In the time interval 2016-2022, the number of museums does not change. The situation for this indicator in the period between 2018- 2022 is similar for the North Central region. The number of museums grows by about 26.67% and 12.50% for the South-East and South Central regions, respectively, in 2022. The largest number of exhibits is in five regions in 2022. Grouping the regions according to the number of museum visits presents two clusters. Grouping the regions according to the number of museums and exhibits leads to forming three and four clusters, respectively.

Key words**:** *database, mathematical-statistical evaluation, museum visits, regions, time series*

INTRODUCTION

Tourism is a driving force in the Bulgarian economy, according to Penchev P. and Kenarova-Pencheva, I., 2018 [11]. The significance of cultural tourism for the overall development of the tourism sector is indisputable (Todorova L., 2018 [14]). The study of Vasileva V., 2010 [15] notes also that the growing popularity of cultural tourism today is connected with the overall increase in the educational level of the population [15].

Cultural tourism, and in particular museum visits, is not only an indicator of cultural engagement but also a reflection of broader social and economic dynamics. Exploring these trends provides valuable insights for cultural institutions, and researchers aiming to enhance the role of museums as drivers of sustainable tourism development.

The current work investigates data from a time series of museum visits in Bulgaria. They are presented on the website of the Bulgarian National Statistical Institute (NSI) [9], [10]. The information on the number of museums and exhibits [9], [10] is also examined. These data from time series are extracted from the website of the indicated organisation. The above-listed elements are organized in a relational database containing the following eight tables:

- Districts (id_d, district, id_r);
- Museums (id, visits, exhibits, id_d, year, number);
- Personnel (id, total, researchers and curators, id_d, year);
- Regions (id_r, name, id_c);
- Revenues (id, total, year, id_r);
- Expenditures (id, expenditure, year, id_r).
- Country (id_c, name);
- Summary_objects (total number, year, id_c).

The data on respective revenue, expenditure and personnel of the museums by regions in Bulgaria is saved in the following three tables: Revenues, Expenditures and Personnel.

The Districts table is related to two tables - Museums and Personnel. The Regions table is related to three others - Districts, Revenues and Expenditures. The Country table is related to tables Regions and Summary_objects. The relationships between the mentioned tables are of one-to-many type.

Information from the relevant database tables can be used to explore regional differences and factors influencing museum visits.

The database can be updated [7], [1] annually by entering new objects [2], [3] into indicated tables. It should be pointed out that there are cases when it is also necessary to design new tables [4], [12].

The current article aims to present a mathematical-statistical evaluation of museum visits data by region in Bulgaria. By focusing on quantitative analysis, the study seeks to reveal regional trends and key factors influencing cultural tourism, ultimately offering actionable insights for cultural and economic policymakers.

MATERIALS AND METHODS

The created relational database is the source from which the examined data is searched. The studied period covers ten years, from 2013 to 2022. The indicated data concerning museum visits by regions (North-East, North-West, North Central, South-West, South-East as well as South Central) in Bulgaria are extracted from four database tables (Country, Regions, Districts and Museums). The information related to the number of museums and exhibits is also searched from the listed tables. In connection with the subsequent processing of the considered elements, the following three sets of indicators are calculated and evaluated for the mentioned six regions:

Tourism demand for visiting museums (X, S, C, L, Q, V)

- $X_p = x_{p1} + x_{p2} + ... + x_{p5}$;

$S_p = s_{p1} + s_{p2} + ... + s_{p4}$;

$C_p = c_{p1} + c_{p2} + ... + c_{p5}$;

$L_p = l_{p1} + l_{p2} + ... + l_{p5}$;

$Q_p = q_{p1} + q_{p2} + ... + q_{p5}$;

$V_p = c_{p1} + c_{p2} + ... + c_{p4}$;

where X_p, S_p, C_p, L_p, Q_p and V_p - the sum of museum visits in the districts of each of the considered regions - North-West, North-East, North Central, South-West, South Central and South-East region respectively, for p^{-th} year; $p = 1 \div 10$;

Tourism offer of museums (Y, A, D, W, N, U) and exhibits (Z, B, F, J, T, R):

- $Y_p = y_{p1} + y_{p2} + ... + y_{p5}$;

$A_p = a_{p1} + a_{p2} + ... + a_{p4}$;

$D_p = d_{p1} + d_{p2} + ... + d_{p5}$;

$W_p = w_{p1} + w_{p2} + ... + w_{p5}$;

$N_p = n_{p1} + n_{p2} + ... + n_{p5}$;

$U_p = u_{p1} + u_{p2} + ... + u_{p4}$;

where: A_p, Y_p, W_p, D_p, U_p and N_p - the total number of museums for the considered districts from the respective regions (North-East, North-West, South-West, North Central, South-East and South Central) during a given year of the time interval; $p = 1 \div 10$;

- $Z_p = z_{p1} + z_{p2} + ... + z_{p5}$;

$B_p = b_{p1} + b_{p2} + ... + b_{p4}$;

$F_p = f_{p1} + f_{p2} + ... + f_{p5}$;

$J_p = j_{p1} + j_{p2} + ... + j_{p5}$;

$T_p = t_{p1} + t_{p2} + ... + t_{p5}$;

$R_p = r_{p1} + r_{p2} + ... + r_{p4}$;

where: B_p, Z_p, F_p, J_p, T_p and R_p - the total number of exhibits in museums for the districts in the respective regions (North-East, North-West, North Central, South-West, South Central and South-East) for p^{-th} year; $p = 1 \div 10$;

The current work investigates the pace of change [8] of the variables from these three mentioned sets for the considered regions from 2013 to 2022.

The percentage change in the number of museums and exhibits, number of museum visits and museum personnel, as well as the revenues and expenses of museums for each year of the period compared to the previous year is calculated. The aim is to assess these 6 indicators in order to track the development of cultural tourism in the country.

Hierarchical cluster analysis [5], [6], [13], [16] is applied to the obtained information about museum visits, number of exhibits and museums by regions in Bulgaria. The presented results are discussed and summarised.

RESULTS AND DISCUSSIONS

The necessary data for calculating the indicators from the above sets are searched and extracted from the database.

Tourism demand for visiting museums by region

Graphical analysis of the data shows that in the North-West and North Central regions, a smooth increase in variables X_p and C_p is established until 2019 (Fig. 1). The variable S_p related to the studied information for the North-East region increased intensively (over 1.3 times) until 2016, after which its values gradually increased in the period 2018-2019.

As a result of the performed calculations, it can be summarised that the museum visits in the North-West, North Central and North-East regions increased by about 24.10%, 25.79% and 37.19% respectively, for these 7 years.

During the first three years of the surveyed period, a specific decrease in the values of V_p is observed in the South-East region. However, the growth pace of this variable is relatively smooth in the time interval 2014-2019.

Overall, it can be noted that the museum visits in the indicated region in 2019 are about 0.6% smaller compared to those for the first year (2013) of the examined period.

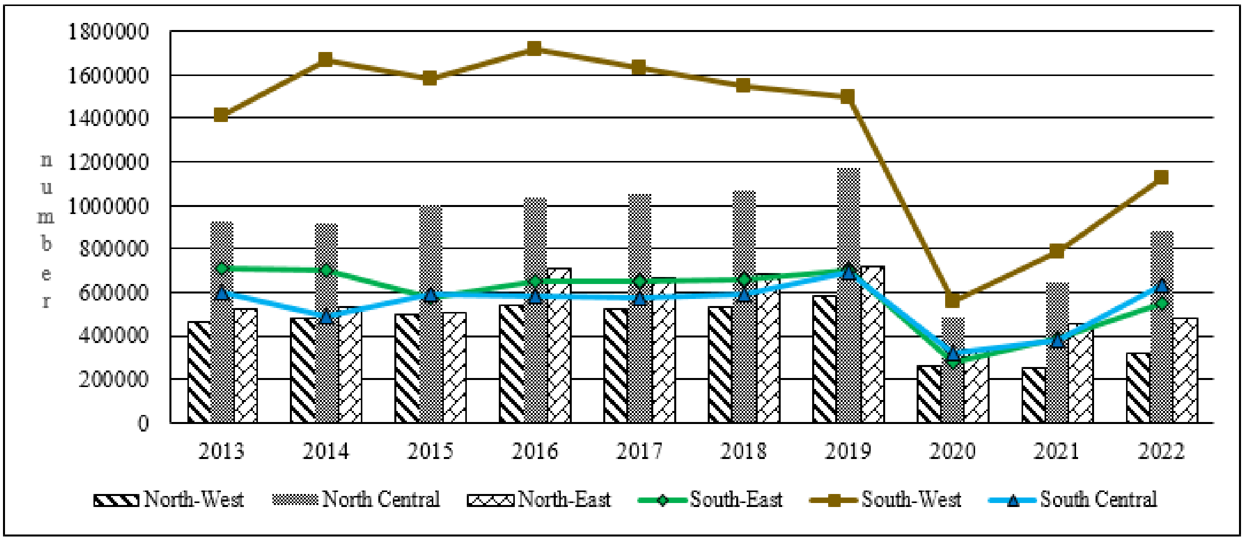

Fig. 1. Results for the museum visits by regions during 2013-2022
Source: Own calculations based on the data from NSI [9, 10].

The obtained results for the following two variables L_p and Q_p are also analyzed. The first of them L_p increased in 2014 and 2016. A decline is observed between 2017 and 2020. In this case, the museum visits in the South-West region during the mentioned four years continuously decreased (Fig. 1). A decrease in the values of the second variable Q_p is obtained in three non-consecutive years: 2014, 2016-2017. However, the reverse process was observed in 2018-2019. Here, the pace of growth for museum visits in the South-West region for these two years is relatively fast.

As can be assumed, the studied indicator (museum visits) for the six regions is significantly reduced in 2020. This is the time segment where the Covid-19 pandemic has already appeared. In the next two years, the pace of growth of the mentioned indicator in five regions (North-East, North Central, South-West, South Central and South-East) is relatively fast. It should be noted that this indicator only in the North-West region is reduced during 2021, but in the next year, an increase of about 24% is obtained.

Tourism offer in terms of number of exhibits and museums by region

Offer in terms of the museums number

The processed data from the second studied subset concerning the total number of museums are presented in Fig. 2. The variable Y_p does not change in a 7-year period from 2016 to 2022. In this case, the number of museums remains unchanged for the indicated time interval in the North-West region.

The situation is similar to the other studied variable D_p in the period from 2018 to 2022 for the North Central region.

The change in the two variables A_p and W_p is significant at the end of the considered time segment. In this case, a reduction in the number of museums is established. The decline of the studied indicator is about 31.25% for the North-East region and 21.15% for the South-West region (Fig. 2).

An entirely different situation is observed for the studied data concerning two other regions. The values of the variables U_p and N_p have an inevitable increase.

The examined indicator (number of museums) increases by about 26.67% and 12.50% for the South-East and South Central regions, respectively, in 2022 (Fig. 2).

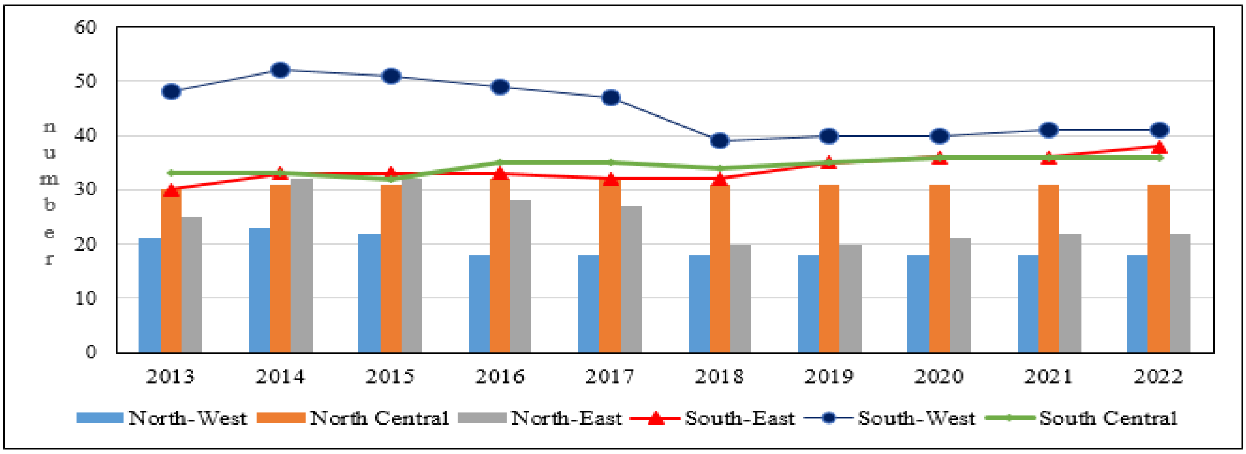

Fig. 2. Results concerning the examined indicator - number of museums
Source: Own calculations on the basis of data from NSI [9, 10].

Offer in terms of the number of exhibits in the studied museums

The obtained results for the values of the considered variables (Z_p, B_p, F_p, J_p, T_p and R_p) from the third group show that they are constantly changing in the segment 2013 - 2022. In this case, they increase and then decrease for specific years or vice versa (Fig. 3). Therefore, the number of exhibits during the mentioned 10-year time interval in the studied regions constantly varies. In addition, it should be noted that the number of exhibits in 2022 is the largest in the five surveyed regions.

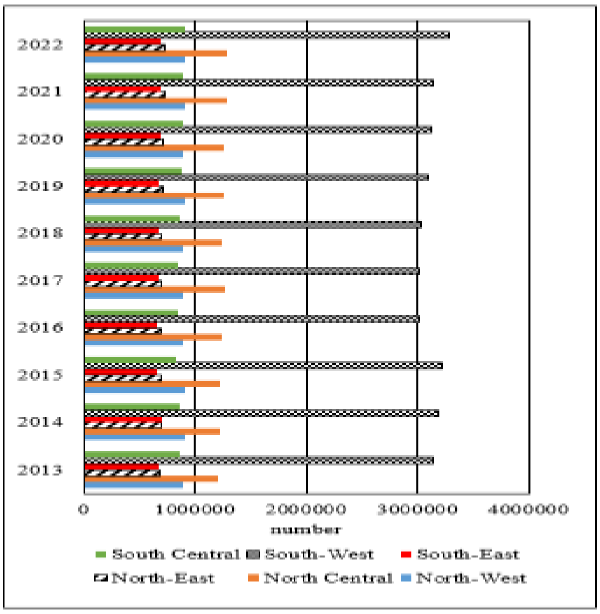

Fig. 3 The change in number of exhibits in the museums by region for the period 2013-2022
Source: Own calculations based on the data from NSI [9, 10].

In this case, they are North-West, North-East, North Central, South-West and South Central regions.

However, the most significant value of the indicator (number of exhibits) for the South-East region is obtained in 2014 (Fig. 3).

The decline of this indicator for the mentioned region at the end of the examined period is about 3%.

Evaluation of the development of cultural tourism in the museums

The article studies the dynamics of cultural tourism in the interval 2013-2022. In this connection, the percentage change of six indicators for each year of the time period compared to the previous one is calculated. These indicators include:

- number of museums.
- number of exhibits in museums.
- number of museum visits.
- number of museum personnel.
- revenues of museums.
- expenditures of museums.

Summarizing the results of Table 1, it can be seen that the change in two of the indicators (number of exhibits and personnel) is relatively smooth. They grow almost throughout the studied period. The values of the both variables decrease only in two of the considered years. For the first indicated variable, the interval includes 2014-2015, while for the second these are the years 2015 and 2020.

The pace of growth of the next variables - revenues and expenditures of museums is relatively faster, especially in the segment 2021-2022. But it should be pointed out that during 2017 compared to 2016, the expenditures of museums decreased by 10.03%. The calculations also show that in 2020 compared to 2019, the revenues of museums decreased by about 4.51%.

In general, a certain decline in the number of museums is observed for the time interval from 2015 to 2018. Over the next four years, the increase in the values of this indicator is gradual , as can be seen from Table 1.

Table 1. Percentage change of the examined six indicators during the considered time period

Year	Museums (%)	Exhibits (%)	Museum visits (%)	Revenues (%)	Expenditures (%)	Personnel (%)
2014	9.09%	1.93%	2.97%	2.93%	5.53%	8.60%
2015	-1.47%	-0.79%	-0.37%	13.59%	9.51%	-2.74%
2016	-2.99%	-2.39%	9.79%	12.52%	14.70%	4.27%
2017	-2.05%	0.63%	-2.30%	9.93%	-10.03%	2.35%
2018	-8.90%	0.17%	-0.48%	11.14%	6.73%	2.23%
2019	2.87%	1.48%	5.32%	6.68%	11.94%	3.34%
2020	1.68%	0.28%	-58.24%	-4.51%	4.23%	-1.20%
2021	1.10%	0.99%	30.37051	13.89%	26.88%	0.36%
2022	1.09%	2.37%	37.26019	38.18%	36.72%	0.44%

Source: Own calculations based on the data from NSI [9, 10].

A more moderate rate of decrease in the number of museum visits is observed for the period 2015, 2017-2018, while in the years 2014, 2016 and 2019 a certain increase in the values of this indicator is established. The case for the remaining three years of the investigated period is quite different. During 2020, as compared to 2019, the number of museum visits is reduced significantly by about 58.24%. This indicator grows at a relatively fast pace in 2021-2022 (Table 1).

The present work also analyzes the percentage change of the listed six indicators by regions in 2022 (the last year of the time interval) compared to the first year of the period -2013 (Table 2). The calculations show that the indicators -revenues and expenditures of the museums grow significantly in the examined regions. The values of two studied indicators (number of personnel and number of exhibits) are also increasing.

The case is very different for the other two surveyed indicators - number of museum visits and number of museums. The number of museum visits decreased in five of the regions in 2022 compared to the first investigated year of the interval (2013). A growth in the values of this indicator by about

5.78% is calculated only for the South Central region, as can be seen from Table 2.

The number of museums decreases in 3 of the considered regions (North-West, North-East and South-West). In the other three regions, the reverse process is observed. It should be mentioned here that the increase in the indicator is the largest for the South-East region (Table 2).

Table 2. Percentage change of the studied indicators by regions

Indicator	North-West region	North Central region	North-East region	South-East region	South-West region	South Central region
Museums:- (%)	-14.29%	3.33%	-12.00%	26.67%	-14.58%	9.09%
Museum visits:- (%)	-31.85%	-4.59%	-8.14%	-21.92%	-20.30%	5.78%
Exhibits:- (%)	1.95%	7.41%	7.22%	1.35%	4.23%	5.89%
Personnel:- (%)	1.83%	19.22%	36.72%	17.17%	8.41%	30.90%
Revenues:- (%)	140.90%	127.90%	188.00%	164.04%	147.61%	217.81%
Expenditures:- (%)	119.27%	124.58%	146.91%	139.66%	183.40%	182.67%

Source: Own calculations based on the data from NSI [9, 10].

The dynamics observed in the examined indicators reflect both internal museum policies and external influences. The significant decrease in museum visits during 2020 highlights the profound impact of the COVID-19 pandemic on cultural tourism. The strong rebound in museum revenues and expenditures during 2021–2022 likely reflects recovery efforts and increased public and private support for the cultural sector. These findings underline the importance of adaptability and targeted investments in ensuring the resilience of museums as key cultural and educational institutions.

Hierarchical cluster analysis

A hierarchical cluster analysis was also applied to the considered data in the current work.

Grouping the regions according to the number of museum visits is presented in Figure 4.

In this case, the following two clusters are obtained:

- South Central, North-East, and South-East regions form one cluster. Subsequently, the North-West region is joined to it.
- South-West and North Central regions are included in a separate cluster. Here, the values of the studied indicator are much higher compared to those in the other 4 regions.

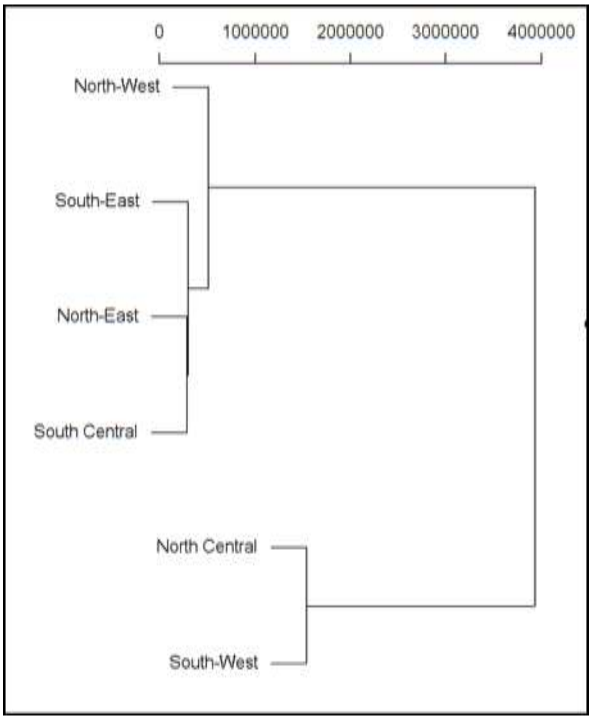

Fig. 4. Grouping the number of museum visits by regions according to their values
Source: Own calculations based on the data from NSI [9, 10].

This clustering suggests that the South-West and North Central regions serve as cultural hubs, attracting a larger number of visitors. This could be due to their larger population, better-developed infrastructure or the presence of flagship museums and events that draw more interest. The other regions, while grouped together, likely share similar characteristics in terms of museum attendance, possibly due to lower population density or fewer high-profile cultural institutions.

Clustering the considered regions according to the indicator's values (number of museums) is shown in Fig 5. Here, the following three clusters are presented:

• North-West and North-East regions form one cluster. The values of the indicator in these two listed regions are relatively lower compared to the other considered regions.

• South Central and South-East regions are included in a separate cluster. Subsequently, the North Central region is joined to it.

• The South-West region is presented in one cluster. It should be noted that this region has the most museums.

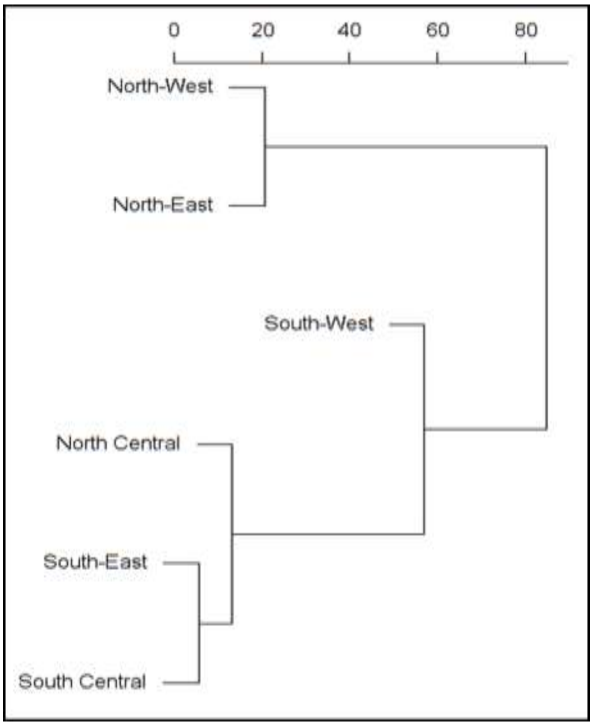

Fig. 5. Grouping the number of museums in the considered regions according to the values of the studied indicator
Source: Own calculations on the basis of data from NSI [9, 10].

The South-West region stands out from the rest, given its high concentration of museums - a phenomenon influenced by the capital city Sofia's role as home to a significant portion of the nation's museum institutions. The grouping of North-West and North-East regions with lower values for this indicator likely reflects economic and demographic challenges in these regions that limit museum development.

Clustering the considered regions according to the indicator's values (number of exhibits in the museums)

The studied regions are grouped according to the values of the number of exhibits. In this case, the results are visualised in the dendrogram of Fig 6. The obtained four clusters are the following:

• Two regions (South Central and North-West) are included in one cluster;

• South-East and North-East regions are presented in a separate cluster;

• The North Central region forms the third cluster;

• The South-West region is presented in a separate cluster. The surveyed indicator in this region has the highest values.

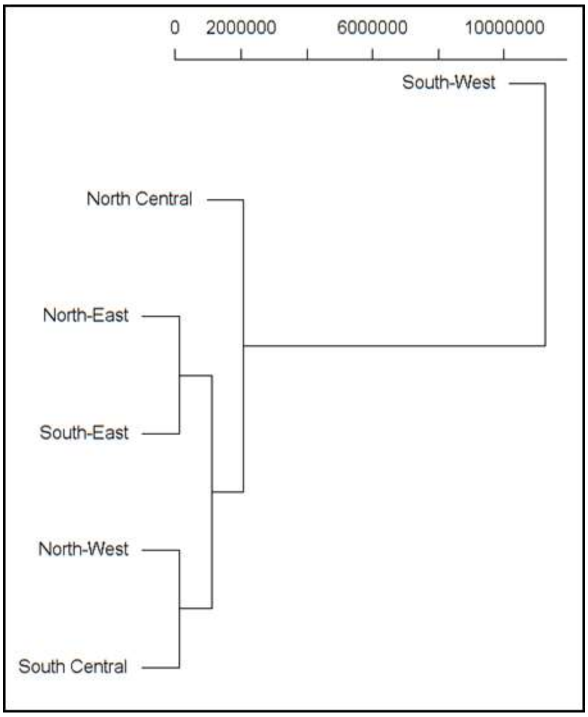

Fig. 6. Visualization of the dendrogram
Source: Own calculations on the basis of data from NSI [9, 10].

The clustering based on the number of exhibits highlights the South-West region as a leader in terms of museum collections, which aligns with its role as a national cultural center. The grouping of South-East and North-East regions reflects their relatively balanced development, while the grouping of South Central and North-West regions suggests similarities in their collection strategies or funding for exhibits. This analysis underscores the regional disparities in cultural resources, which may require targeted policies to support museum development in underrepresented areas.

CONCLUSIONS

The current work presents a mathematical-statistical evaluation of data on museum visits by regions in Bulgaria from 2013 to 2022. The indicated elements are searched and extracted from the built relational database. In parallel, the information on the number of museums and exhibits is also examined. Three sets of indicators related to the mentioned objects are calculated and evaluated. Hierarchical cluster analysis is also applied to the investigated data. The performed analyses show the following:

- The museum visits in North-West, North Central and North-East regions increased by about 24.10%, 25.79% and 37.19%, respectively, for the time interval 2013-2019. In general, museum visits in the South-East region are about 0.6% smaller in 2019 than in 2013. The growth of the mentioned indicator in five regions (North-East, North Central, South-West, South Central and South-East) is relatively fast in 2021-2022. The indicator is reduced only in the North-West region during 2021, but an increase of about 24% is obtained in 2022.
- The number of museums in the North-West region in 2016-2022 remains unchanged. A similar result for the North Central region is obtained for this indicator in 2018-2022. The examined indicator (number of museums) increased by about 26.67% for the South-East and 12.50% for the South Central region in 2022.
- The number of exhibits is the largest in five considered regions (North-West, North-East, North Central, South-West and South Central) in 2022.
- Grouping the regions according to the number of museum visits presents two clusters. Grouping the regions according to the number of museums and exhibits leads to forming three and four clusters, respectively.

The findings underline the importance of regional differences in cultural tourism development and provide valuable insights into the dynamics museum attendance and infrastructure. The significant growth in museum visits in 2021–2022 highlights the sector's resilience and recovery following the COVID-19 pandemic, likely supported by targeted policies and increased interest in domestic tourism.

The results of the study suggest the following recommendations:

- Focused investment in cultural tourism infrastructure in underperforming regions to stimulate museum visits and support local economic development.
- Encouragement of innovative approaches, such as digitalization and interactive exhibits, to attract more visitors, particularly in regions with lower attendance.
- Further analysis of factors influencing museum visits, such as population density, accessibility, and marketing strategies, to inform region-specific development plans.

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THE ECONOMIC VALUE OF FOREST FRUITS. A BIBLIOMETRIC ANALYSIS RESEARCHED DURING THE PERIOD OF 1978 TO 2023

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Abstract

Forest fruits, an important component of non-wood forest products, have significant ecological and economic importance, bringing numerous material benefits to small landowners as well as companies specialised in their commercialization. This bibliometric study analysed their economic value using data extracted from the Web of Science and processed with Excel and Vosviewer programs. The results show that, since 1978, a significant number of articles on this topic have been published annually in the fields of Forestry, Environmental Sciences, Plant Sciences, and Ecology. This is done by authors from numerous countries, most notably from China, Brazil, the USA, and India, in various journals across different domains, particularly in Forestry, Ecology, and Economics. The most represented journals are Forest Ecology and Management, Economic Botany, and Agroforestry Systems. The most frequently used keywords were conservation, forest and biodiversity. Initially, more general keywords were used, but in recent years they have focused more on food security for the population. Although there are numerous types of forest tree fruits harvested around the globe, their harvesting can have a negative impact on the environment, while the monetary advantage of harvesting them is very low, and their commercialisation is scarce. In addition to certain forest fruits used in various regions around the world (marula, almonds, uppage, Brazil nut, baobab fruits), two other categories of fruits (berries and wild cherries) are frequently harvested, processed into high-value products (jams, preserves, yogurts, juices, liqueurs), and marketed.

Key words**:** *forest fruits, bibliometric research, economic value, biodiversity*

INTRODUCTION

Forest fruits are part of non-wood forest products (NWFPs) [62, 60, 12, 20]. NWFPs encompass all biological materials found in forests, except timber. This includes wild food plants, honey, resin, spices, wildlife products, fuel wood, charcoal, and materials for handicrafts like rattan, vines, bamboo, and grasses [33, 67].

Globally, especially for low-income households, NWFPs can constitute 10–60% of household income [1, 4, 18], serving as a crucial subsistence source [6, 40, 15]. They also enhance food security by compensating for seasonal food shortages and play a significant cultural and spiritual role [32, 26].

In Europe, gathering NWFPs is a key part of cultural heritage [53, 26], closely connected to forest recreational activities [26, 61], and can be used for improving degraded lands [16].

Recently, global climate change, overgrazing, tourism development, insect pests, plant diseases, and other factors have endangered the ecological environment of wild fruit forests [59]. Land managers need to understand how fruit availability varies across forest types, seasons, and years [29].

Forest fruits are vital for the profitability of numerous small and medium forest-based enterprises [29].

Wild fruit varieties are consumed raw by rural communities and are rich sources of protein, starch, fat, and other nutrients. Compared to cultivated fruits, they haven't been extensively considered as alternative food sources. Many countries' rural populations use these wild fruits as income sources, particularly for poor rural inhabitants and unemployed youth, by making various edible products like jam, juice, and sauce [3].

Forest fruit trees are crucial for biodiversity conservation and enrichment, as well as in the food chain [21, 27, 48, 27].

Economic fruit forests are vital in agriculture, playing an irreplaceable role in increasing farmers' income, promoting green agriculture, and fostering rural revitalization [32].

The integration among knowledge domains, various theoretical perspectives, and axes contributes to the development of bibliometric indexes that help refine and understand scientific output with a focus on its practical applications.

In this context, bibliometry serves as a method to evaluate scientific activities on particular subjects, enabling the anticipation of trends identified through the analysis and study of literature that best represents the current state of the field.

Advancements in constructing scientific knowledge, derived from academic literature, are influenced by the growth rate and interest in bibliometric studies. These methods assess national and international academic production, highlighting the most relevant articles, authors, and themes. They also examine trends in thematic and methodological approaches in leading journals, fostering better alignment between researched themes and available academic output.

Bibliometric studies are crucial for synthesising findings from a diverse range of authors, contexts, and reflections, collectively forming comprehensive research conclusions through the amalgamation of results from multiple sources.

Many articles of this type are published in the fields of economics [29, 17, 51] or environment [70, 23, 11]. Regarding the topic chosen for this article, we have identified only one bibliometric review article that studied non-timber forest products in Brazil [56].

The purpose of the presented work was to deliver a systematic review and evaluation of the economic value of forest fruits over the 1978–2023 period, using a bibliometric method. The analysis included publication types, scientific fields, the distribution of articles by year, the authors and their countries of origin, the institutions they are affiliated with, the journals and their editors, and the main keywords used.

MATERIALS AND METHODS

The bibliometric analysis followed several steps, from keyword selection to analysis criteria (author, citations, country). Data for the analysis were extracted from the academic databases within the Science Citation Index, Science Citation Index Expanded, and Web of Science citation index databases, which offer extensive citation information across various disciplines. This database is user-friendly and has the advantage of English language accessibility compared to national databases and other sources. The topic/keyword "the economic value of forest fruits" was selected to access publications related to this topic from the Web of Science Core Collection.

Data were processed using resources from the Web of Science Core Collection [13], Excel [44] and the Vosviewer program, version 1.6.20 [65].

RESULTS AND DISCUSSIONS

The bibliometric study has revealed a total of 372 publications related to the economic value of forest fruits.

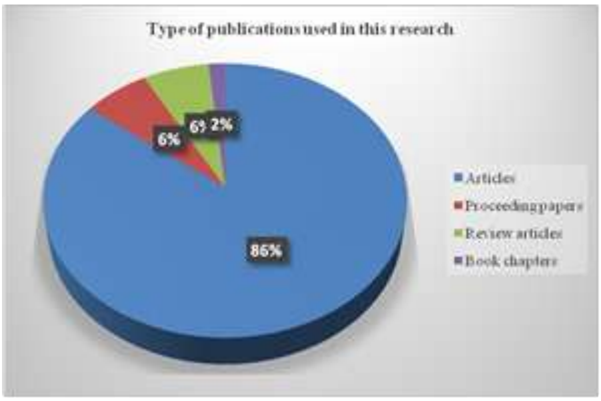

Fig. 1. Distribution of the main types of publications used in the bibliometric analysis.
Source: our own graph.

Their classification is as follows: 318 are articles (86%), 24 are proceeding papers (6%), 24 are review articles (6%), and 6 are book chapters (2%) (Figure 1).

Concerning the scientific fields to which the articles about the economic value of forest fruits belong, the most representative are: Forestry (88 articles-24%), Environmental Sciences (66 articles-18%), Plant Sciences (62 articles-17%) and Ecology (59 articles-16%), and Economics (Fig. 2).

Fig. 2. Distribution of the main 10 scientific fields of publications used in the bibliometric analysis.
Source: Web of Science [6, 13].

The first article on this topic was published in a renowned scientific journal in 1978. The number of published articles has grown relatively steadily over the years, with the peak (44 articles) recorded in 2022 (Figure 3). As with other topics [18, 45], an exponential increase in the number of articles published on the economic value of forest fruits has been observed over the last 20 years. This is due to the growing interest in this topic, as well as the increasing number of authors and high-impact journals available for publication.

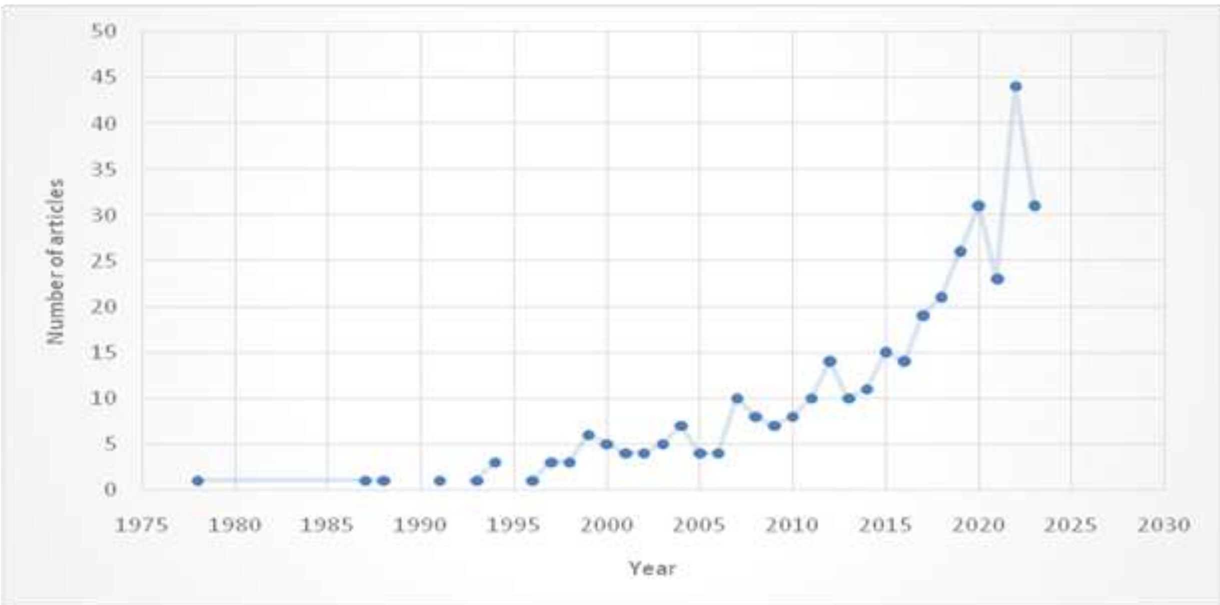

Fig. 3. Distribution of published articles by year.
Source: own graphic based on the data from Web of Science [6, 13].

A total of 196 authors have published articles on this topic, with the most articles (5 each) written by Alexandra Klein and Teja Tscharntke.

From a total of 84 countries where the authors of these articles come from, the most representative countries are: China (51 articles), Brazil (49), the USA (46), and India (30). Besides the four countries mentioned above, Spain, France, Kenya, Mexico, Australia, and Canada are also represented.

The topic has been studied by researchers from all over the world, with authors from all continents publishing articles in this field.

The top four countries are large territories with significant forest areas: China (208.3 million hectares of forest land), Brazil (493.5 million hectares), the USA (100.9 million hectares), and India (80.9 million hectares). Additionally, these countries have a great diversity of forest fruits [41, 6, 55, 68, 69, 57, 22].

Regarding the connection between these articles/countries, the strongest total link strength is recorded for England, the USA, and Brazil (Table 1 and Figure 4).

Table 1. The most representative countries of authors who published articles on the economic value of forest fruits

	Review	Documents	Citations	Total link strength
1	England	24	998	43
2	USA	46	5,745	43
3	Brasil	49	989	41
4	Germany	21	4,616	38
5	Indonesia	17	273	21
6	Spain	18	329	19
7	France	13	4,263	18
8	Kenya	10	215	17
9	Mexico	15	479	17
10	Netherlands	9	422	16
11	Australia	9	4,175	15
12	Canada	10	366	14
13	India	30	486	13
14	Switzerland	7	135	
15	China	51	604	15

Source: own data obtained with VOSviewer [33, 65].

The countries can be grouped into four clusters: the first includes Brazil, England, Spain, Colombia, and Mexico; the second includes China, Canada, Italy, and the Czech Republic; the third includes India, Germany, Pakistan, and Saudi Arabia; and the fourth includes South Africa, Kenya, Argentina, Sweden, Finland, and Poland.

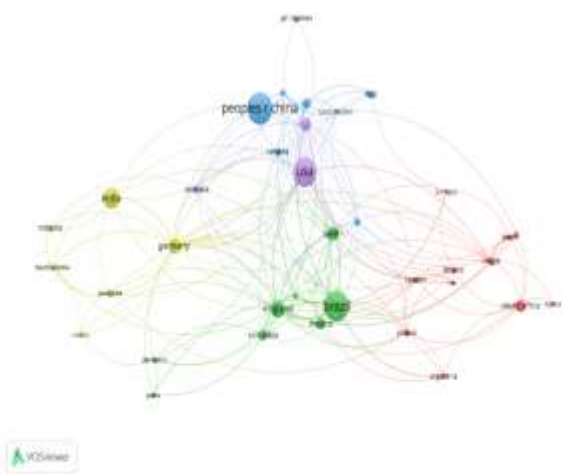

Fig. 4. Countries with authors of articles on the economic value of forest fruits. The node size and thickness of the connecting lines are proportional to the number of documents assigned to each country. The connections represent the collaboration network among research institutions.

Source: own graphic obtained with VOSviewer [33, 65].

The institutions represented by the authors of these articles with the most publications are: Consortium of International Agricultural Research Centres – CGIAR (14 articles), Chinese Academy of Sciences (11 articles), Center for International Forestry Research - CIFOR (8 articles), Universidad National de Colombia (8 articles), and Universidade de São Paulo (8 articles).

Articles published on this topic are found in 215 journals, with most articles appearing in Forest Ecology and Management (16 articles), Economic Botany (13 articles), and Agroforestry Systems (11 articles). Based on total link strength, the most important journals are Forest Ecology and Management, Biodiversity and Conservation, and Economic Botany (Figure 5).

The journals can be grouped into two major categories: Forestry journals – the most numerous - (Forest Ecology and Management, International Forestry Review, Tree Forestry and People, Forests, Austrian Journal of Forest Science) and general Ecology journals

(Ecological Applications, Ecological Economics, Human Ecology, Biodiversity and Conservation).

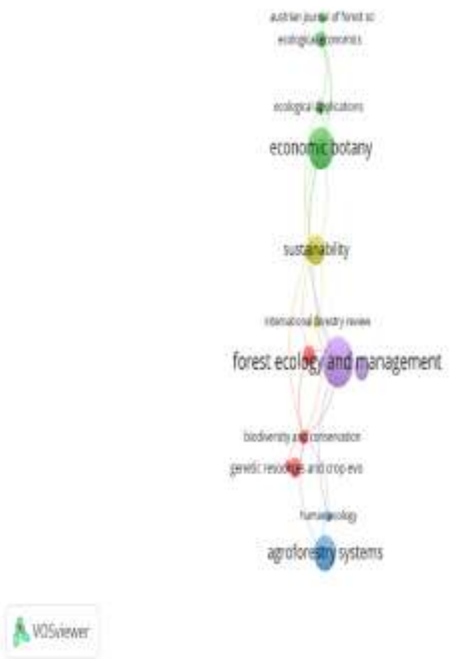

Fig. 5. The main journals where articles on the economic value of forest fruits were published.
Source: own graphic obtained with VOSviewer [33, 65].

Table 2. The most representative journals where articles on the economic value of forest fruits were published

	Review	Documents	Citations	Total link strength
1	Forest Ecology and Management	16	466	12
2	Biodiversity and Conservation	4	241	10
3	Economic Botany	13	383	9
4	Sustainability	9	69	6
5	Ecological applications	4	247	4
6	Ecological economics	5	190	4
7	Human Ecology	3	15	4
8	Ethnobiology and Ethnomedicine	6	236	4
9	International forestry	3	56	3
10	Tree forestry and people	5	36	3
11	Agroforestry systems	11	199	2
12	Forests	7	71	2
13	Sustainable forestry	3	4	2
14	Austrian J. of forest science	3	4	2

Source: own data obtained with VOSviewer [33, 65].

The most representative publishers who have published articles on the economic value of forest fruits are Elsevier (81 articles), Springer Nature (74 articles), and MDPI (33 articles).
The most frequently used keywords are conservation, forest, and biodiversity (Figure 6 and Table 3).

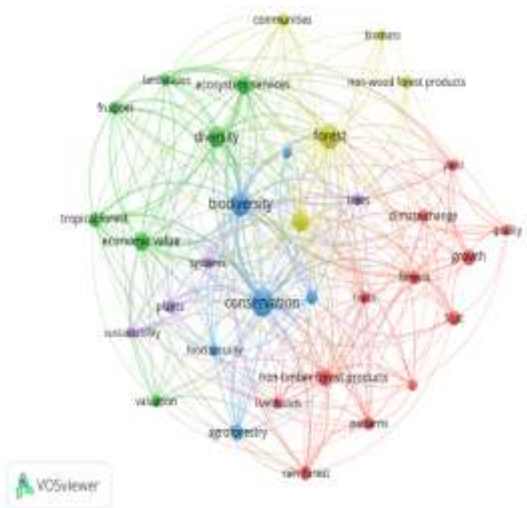

Fig. 6. Authors' keywords concerning the economic value of forest fruits. The node size and thickness of the connecting lines are proportional to the number of documents in which the keyword appears. The colours indicate the cluster the item belongs to, and the connection line between nodes represents co-occurrence; the shorter the distance between the different nodes, the stronger the relationship between the keywords.
Source: Own graph, obtained with VOSviewer [33, 65].

Table 3. The most used keywords in articles published about the economic value of forest fruits

	Key word	**Occurrences**	**Total link strength**
1	conservation	60	141
2	biodiversity	44	124
3	forest	48	107
4	diversity	34	88
5	economic value	27	82
6	management	32	80
7	ecosystem services	27	78
8	tropical forest	18	57
9	fruit-set	14	55
10	ethnobotany	16	50
11	non-timber forest products	23	46
12	landscape	11	43
13	rain-forest	16	38
14	trees	13	37
15	agroforestry	19	34
16	patterns	14	31

Source: own data obtained with VOSviewer [33, 65].

Three main clusters of keywords can be observed: the first includes non-timber forest products, fruits, forests, climate change, and rain-forest; the second includes diversity, ecosystem services, economic value, and landscape; the third includes conservation, biodiversity, agroforestry, and food security.

Regarding the distribution of keywords over the years, it is noted that in the early years, the most used keywords were general and related to forest types where the fruits appear (non-timber forest products, economic value, tropical forest, rain-forest), while in the last three years, keywords are more focused on population and food security (communities, food security) (Figure 7).

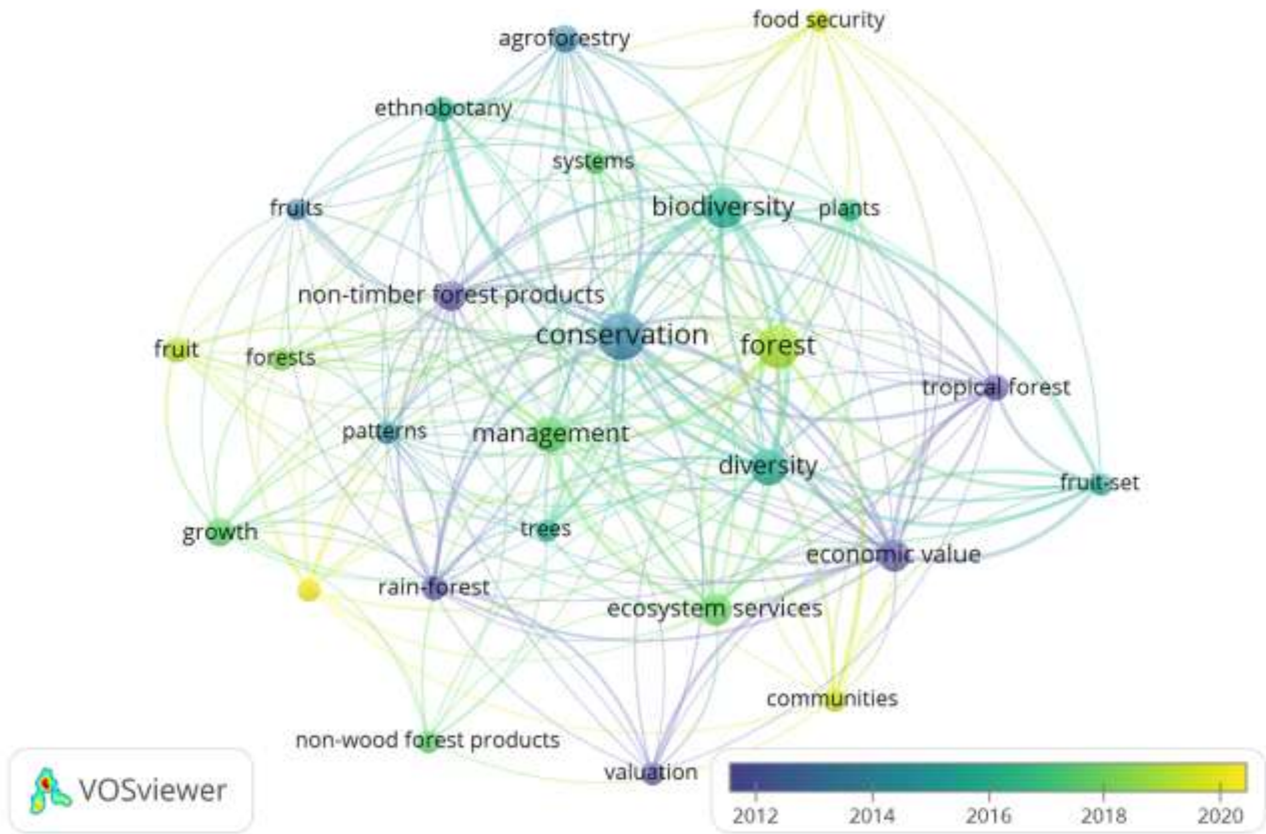

Fig. 7. Distribution of keywords over the years regarding the economic value of forest fruits. The node size and thickness of the connecting lines are proportional to the number of documents in which the keyword appears. The colours indicate the cluster the item belongs to, and the connection line between nodes represents co-occurrence; the shorter the distance between the different nodes, the stronger the relationship between the keywords.
Source: our own graph, obtained with VOSviewer [33, 65].

The economic value of forest fruits

Investigating the effects of fruit harvesting is crucial, as fruits serve as reproductive organs for plant species. However, excessive harvesting can negatively influence species sustainability, particularly over the long term, as noted by Peres et al. [49].

Some authors have concluded that there is no direct environmental risk posed by some fruit species collection (especially those that are widespread and have a high production); this is the case for marula [39], tagua (*Phylephus seemannii* O.F. Cook), [7], *Garcinia lucida* Vesque [24]. Unlike them, Boot and Gullison [10] and Peters [50] argued that other species with abundant fruiting have shown marked reduction in recruitment and changes in size structure profile as a result of fruit harvesting.

Research indicates that although forest fruits hold significant economic value, small-scale collectors, producers, and processors receive a very small share of the final sale price, resulting in low profitability. One major reason for the limited profitability of NTFP enterprises is the absence of a structured information system to assist producers in organizing production, setting prices, selecting markets, understanding supply and demand, or promoting products. Even when market data exists, it is often not shared with small-scale producers.

Forest fruit commercialization frequently faces challenges. Marketing and sales are generally identified as the most significant barriers to success [43]. The price received by the collector depends on the length of the marketing chain and the political context of the market [8].

Examples of forest fruits: harvesting, usage and economic value.

Pentadesma butyracea Sabine is a tree that appears in riparian forests, and which produces fruit almonds that can be transformed into butter for cooking and cosmetics. An analysis of this species from Benin [2] has shown that, although the net present value of fruit harvesting and almond processing activities showed both activities were financially profitable, fruit harvesting was significantly more profitable than almond processing. In addition, the people involved in this activity can recuperate between 49% and 80% of the price paid by the consumer, depending on the quality of the product and the length of commercial channel used.

Sclerocarya birrea (A. Rich.) Hochst is a tree species from South Africa with a variety of uses including the consumption of the fresh fruit (marula), the usage of the fresh fruit to make juice, jam and beer. The high fruit yield, planting practices and density of marula trees make it likely that in the near-term future commercialization of marula fruit will be limited not by fruit availability but more probably from market forces [19]. Today, the most known product of the marula fruits is Amarula cream, an alcoholic beverage produced from the fruit pulp [25]. The total value of the commercial marula trade to rural communities in South Africa was estimated to be worth $160,000 a year in 2001/2002 season [42]. The trade resulted in an average annual income of $85 per trader per year.

In India, the harvest of fruits from the rain forest tree uppage (*Garcinia gummigutta*) has increased in the mid 1990's. The fruit of this tree is harvested by villagers, who, after removing the seeds and pulp, sell the dried rind to traders. Starting with 1990, the fruits' price has increased because of the interest of drug manufacturers from the United States of America. However, the price started to decrease after 2000 [52].

Brazil nut (*B. excelsa* Humb. and Bonpl.) has fruits that have been collected for decades, and in 2002 in Brazil alone, was worth over US$ 10 million [28]. Harvesting and processing this fruit generates income for thousands of families in Bolivia, Brazil, and Peru [14]. Studies have been realized on how to manage natural populations for increasing Brazil nut production [31, 66, 47].

Uapaca kirkiana (Muell. Arg.) is a valued indigenous fruit species from Malawi. Harvesting this fruit is in progress in the southern Africa region, and form part of a global initiative to promote indigenous fruit trees in agroforestry for community livelihood benefits [36]. On average, fruits were saleable for only 3–4 days, this being attributed to inherent fruit characteristics combined with immaturity at harvest, and damage during harvesting and storage in hot dry conditions [30].

Baobabs (*Adansonia digitata*) produce fruits that are requested for subsistence purposes and traded to generate cash. The fruit comprises two distinct parts: the seed and the surrounding pulp. The seed can be pressed to extract oil for cosmetics or consumed roasted and pounded, while the tart pulp, a dry powder encasing the seed, is also used as a food ingredient [54]. Non-timber forest products (NTFPs) contribute 14% and 33% to annual income, with baobab fruit accounting for 38% and 4% of these figures, respectively. Expanding the commercialization of baobab fruit can have significant benefits, with secured tree access and investment in local processing further enhancing its value for marginalized communities in southern Africa [64].

Berry fruits, including raspberries, blueberries, strawberries, blackberries, and cranberries, are harvested from forests worldwide. These fruits are sold fresh or, more commonly, transformed into high-value products such as juices, jams, yogurts, liqueurs, and more. Recently, berries have attracted growing attention as functional food ingredients as they have numerous health benefits and various industrial and nutraceutical usages. Traditionally, raspberry crops were predominantly sold to processors for freezing, jam-making, canning, and flavorings in ice cream and yogurt. However, fresh market production has significantly grown, becoming a key industry sector [5]. Wild strawberries are harvested for home use and utilized in the pharmaceutical and cosmetic industries. Their unique aroma and taste make them ideal for confectionery, jams, and liqueurs [34]. Blueberries are enjoyed fresh but are also widely processed into juices and wine [37]. Blueberry fruits are highly valued for their health benefits, with over a billion tons harvested globally each year [35]. Bilberries are consumed fresh or processed into juices, jams, preserves, purees, and nutraceuticals [9]. Blackberries, too, are versatile, enjoyed fresh or used in making jams, syrups, teas, desserts, and baked goods [71].

In Iran the mean annual income derived from the harvest and sale of reddish blackberry in the sample rural household incomes was USD 142 [22].

Cherry (or wild cherries in plural form) is another category of forest fruits with a high economic value. The importance of cherry fruits is mentioned in Belgium [46], Great Britain [63], Romania [58], Iran (Ghanbari et al., 2022), and Chile [38].

CONCLUSIONS

So far, 372 materials related to the economic value of forest fruits have been published, most of them (86%) being articles. The main scientific fields in which the published articles are categorised are Forestry, Environmental Sciences, Plant Sciences, and Ecology. The first article was published in a recognized journal in 1978, while most articles were published in 2022. The authors who have published such articles come from numerous countries (which can be grouped into four clusters) from all continents, with the most representative being China, Brazil, the USA, and India. The institutions represented by the authors with the most published articles are the Consortium of International Agricultural Research Centres (CGIAR) and the Chinese Academy of Sciences. The journals with the most publications on this topic are Forest Ecology and Management, Economic Botany, and Agroforestry Systems; these belong mainly to the fields of Forestry or Ecology and are associated with the main publishers Elsevier, Springer Nature, and MDPI. The most frequently used keywords are conservation, forest, and biodiversity, which can be grouped into three major clusters. The evolution of keyword usage over time shows that, after an initial use of general keywords or those referring to the types of forests where the fruits appear, in the last three years, the keywords have focused more on the population and food security. There are numerous fruit species of forest trees that are harvested around the globe (some examples include: the Brasil nut; marula in South Africa; the baobab fruits; fruits almond of *Pentadesma butyracea* in Benin; *Uapaca kirkiana* in Malawi; uppage (*Garcinia gummigutta* in India). However, their excessive harvesting may have a negative impact on species sustainability as well as on the environment. The proportion of the final sale price for the collector is small, while commercialisation is scarce due to lacks in product marketing and sales, especially as these fruits are mainly harvested in subdeveloped countries.

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STRUCTURAL TRANSFORMATIONS OF AGRICULTURE FARMS IN BULGARIA IN THE CONTEXT OF PRODUCTION SPECIALISATION AND DIVERSIFICATION

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Abstract

The increasing capitalization, specialization and intensification of the agrarian sector leads to a number of adverse impacts on rural areas, the environment, natural resources, etc. A growing number of researchers believe that structural trends in agriculture are unlikely to be reversible. In this context, research on farmers' intentions and their development strategies is becoming increasingly relevant. This article aims to analyze and evaluate the strategic intentions of farm owners in three regions of Bulgaria with different regional product specialization and farm structure in the context of the current Common Agricultural Policy. On the basis of a conducted survey in the regions of Dobrich, Blagoevgrad and Pazardzhik,, the state and reasons for the current specialization and the direction of the future strategic intentions of the farmers towards deepening production specialization or diversification with an emphasis on their impact on the development of rural areas are assessed. The survey results reveal attitudes towards production specialization and diversification by farms of different sizes, degrees of specialization and other characteristics.

Key words*: production specialization; diversification, structural transformations, rural areas*

INTRODUCTION

The number of agriculture farms is decreasing worldwide. Following the market logic (regardless of the applied agriculture policies), agriculture farms are more and more decreasing in number while growing in size [4, 17, 21, 28]. According to Eurostat [13], 2.2 million farms disappeared as a result of the Common Agricultural Policy (CAP) for the period 2007-2013. Small and medium-sized farms are declining fastest, despite EU support measures [33]. Under the current CAP, structural change is likely to continue or even accelerate [36]. The increasing capitalisation, specialisation and intensification of the sector is leading to a number of adverse impacts on rural areas, the environment, natural resources, etc. All these have raised public concern and criticism as structural trends in agriculture are unlikely to be reversible [16]. In this context, research on farmers' intentions and their development strategies has become increasingly relevant not only for researchers and policy makers, but also for society as a whole.

In this context, the paper aimed to analyze and assess the strategic intentions of farm owners in three regions of Bulgaria with different regional product specialization and farm structure in the context of the current Common Agricultural Policy.

Literature review

Research on strategies of rural household and implications for the role of agriculture in rural areas [10, 19, 32, 38] provides valuable results on the types of farms that manage to survive and the direction in which they are changing. In their attempt to summarize structural change, the authors [41] distinguish two main approaches to farm development. The first is observed in farms that are oriented towards economies of scale in terms of farming activities. The second approach is chosen by farms that aim for "economies of scope" by diversifying income with farm-related activities [27; 38]. The use of economies of scale is seen as the most financially rewarding strategy [35]. Income diversification along with farm pluriactivity are assessed as the determinants of farm viability and the sustainability of small- and medium-sized family farms and of slowing structural change [3; 7; 18]. Some researchers [16; 38] stress that through income diversification, farms can cope with "increasing pressure" on farming activities and ensure continuity.

There are studies in the literature [27] that assess differences between diversification activities depending on their factor intensity in terms of labor and capital. They conclude that engaging in labor-intensive activities is a typical "survival strategy" for small farms that lack the ability to grow and expand their farm activities based on land and capital-intensive non-farm activities. Hence, labour-intensive diversification is highly akin to "the search for - and ... the simultaneous deployment of a practically new model of agricultural development" [38, p. 40)] which is different from that of agricultural industrialisation and therefore a deviation from the growth paradigm.

Capital-intensive diversification complements growth in terms of scale expansion and in this sense does not deviate from the industrial logic and growth paradigm, unlike different types of income diversification (“extension”) activities [39].

Agricultural industrialization is limiting the social functions of agriculture [15, 20, 25, 34], as fewer residents of rural areas earn an income from it. At the same time, it has caused the “expansion” or shifting boundaries of farming [40], strengthened farm linkages with the “countryside” [38, 39] and increased the multifunctionality of rural areas and farms [8; 9, 22, 37]. The decreasing number of farms not only limits the socio-economic function of agriculture, but also has a negative impact on socio-ecological functions. A number of authors [5, 16], link the decreasing number of farms to a decreasing share of rural residents associated with agriculture. In this way the connection of regional residents to agriculture, as well as their general attachment to place, is becoming weaker. In some statistical regions of Bulgaria, this is among the main causes of negative demographic processes and depopulation [11].

MATERIALS AND METHODS

The concept of multifunctional agriculture (MFA) forms the basis of our analytical perspective. MFA has been adopted by a number of researchers as a broad frame of reference for depicting the multiple interactions between agriculture and its social, economic, and ecological environment and role in different aspects [30; 42, 43]. At the same time, it mainly focuses on the diversification of the rural economy, which is why some researchers are tending to broaden the focus to the multifunctional rural space [31].

The dynamics of structural change, as well as the multifunctionality of agriculture, are always specific in time and place and take into account the unique combination (for each rural area) of natural and climatic conditions, soil and water resources, population density, etc. [27].

In the context of regional development, some authors [6] view farms as spatially anchored organizational units that have specific resources, engage in different activities, act according to complex motivations, and as a result are deeply embedded in socio-ecological systems.

The activities include food (agricultural) production as well as farm-related activities. Thus, the growing number of farms engaged in income diversification and the implicit impact on the multifunctionality of agriculture are recognized [1, 29; 39]. The functions of agriculture are deployed through farm activities and characterize the ways in which social goals and demands are met [8, 26].

The great diversity of types of activities as well as the differences between rural areas in Bulgaria are the reason for researching transformational changes in several regions. The methodological approach of the research conducted in 2022 includes several stages, shown in Figure 1.

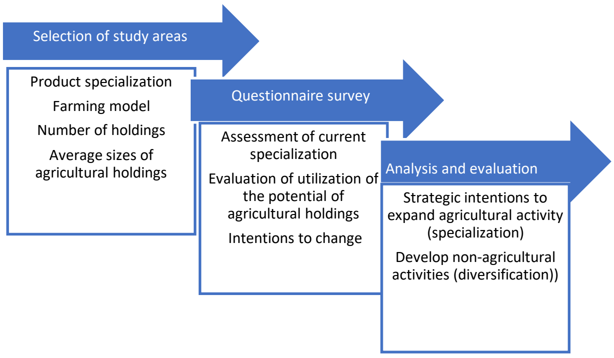

Fig. 1. Methodological approach and stages of the research
Source: own research.

In the first stage, indicators for assessment of the diversity of regions in Bulgaria were selected. Emphasis was placed on the production specialization of agriculture, the model of farming formed and the number and size of farms. Thus, three districts in the country were identified in which (in the second stage) a survey was conducted. The structure of its questions created opportunities to examine the current production structure of farms, to assess the reasons for its formation and to explore the intentions of farm owners and managers for their development over a ten-year period.
In the first stage of the research, three regions of the country - Blagoevgrad, Pazardzhik and Dobrich (Level NUT3) - were selected on the basis of statistical areas (Map 1). The first two differ significantly from Dobrich district (Table 1), both in terms of average sizes of farms and their production specialization and formed model of agriculture [23].
In the surveys and structured interviews conducted with owners of farms of different regions, production specialization and economic size, the focus was mainly on their strategic intentions and which prevails among them - attitudes towards specialization or diversification of farm activities. For this purpose, a wide range of farm development options were used.

Table 1. Indicators for selecting of regions

	Regions (Level NUT3)		
	Blagoevgrad	Dobrich	Pazardsgik
Number of holdings	13,569*	5,377	8,989
Average size of used agricultural land (ha)	9.6	76**	10.1
Farming model	Southern	Northern	Southern
Share of farms of physical persons (%)	96.9	84.3	94.5
Share of farms specialising in arable crops (%)	25.93	55.22	25.22
Share of farms specialising in the production of vegetables, fruit and grapes (%)	22.34	7.49	32.52
Share of mixed farms (%)	10.87	20.92	15.82
Share of livestock farms (%)	35.65	14.73	25.13

Source: [24].
Note: *Highest number in the country.
**The size ranks second among regions in the country.
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Map 1. Researched regions on the administrative map of Bulgaria
Source: https://cadis.bg [43].

RESULTS AND DISCUSSIONS

The survey of agricultural holdings was carried out in the territory of the rural areas of Blagoevgrad, Pazardzhik and Dobrich regions. The survey covered 168 agricultural farms.
Mixed farms were the most numerous in Blagoevgrad and Pazardzhik regions - 33% and 33.5% respectively. In the first region they are followed by livestock farms - 28.57 % and crop farms - 23.81 %, and in Pazardzhik region - by crop and vineyard farms. In both regions, the relative share of farms specialised in fruit and vegetable production is the lowest.

In Dobrich region, the majority of farms is specialised in arable crops - 41.67% and livestock breeding - 33.3%. Next are mixed farms - 25%.

Regarding the legal status, in Blagoevgrad and Pazardzhik regions, the most numerous farms surveyed are those of individuals who are registered as farmers (86% and 83% respectively). In Dobrich region, half of the respondents are registered under the Commercial Law as sole traders, limited liability companies or sole limited liability companies.

Depending on their economic size, the farmers surveyed classified their farms into income groups as shown in Table 2. The first income group (up to 4,000 BGN) included 3.84% of the respondents in Pazardzhik region and no farms from the other two regions.

In Blagoevgrad region, the largest presence of surveyed farmers is in the groups between BGN 25,000 and BGN 50,000 and between BGN 50,000 and BGN 100,000, while in Pazardzhik region the majority of farms are in the groups BGN 15,000-25,000 and BGN 25,000-500,000. In contrast to these regions, in Dobrich the largest number of respondents were with farms with production volume between 50,000 and 100,000 BGN (41.67%) and above 100,001 BGN (33.3%).

Table 2. Distribution of farms by economic size.

Economic size	Blagoevgrad	Pazardzhik	Dobrich
over 100,001 BGN	4.76	5.68	33.33
50,001-100,000 BGN	30.95	11.53	41.67
25,001-50,000 BGN	33.33	25.00	8.33
15,001-25,000 BGN	19.05	28.84	12.50
8,001-15,000 BGN	7.14	15.38	4.17
4,001-8,000 BGN	4.76	9.62	
up to 4,000 BGN		3.84	
Total	100.0	100.0	100.0

Source: own research.

The average number of permanent employees in the surveyed farms from Blagoevgrad district is 2.33, including 2.05 family members. Seasonally employed workers range from 1 to 10. In Pazardzhik region, the average number of permanent employees was 3, with 2.54 family members, and seasonally employed workers ranged from 2 to 16. Respondents in Dobrich region indicated a different number of permanent employees, which formed an average of 7.3 employees, while the average number of working family members was 3.1.

On the basis of the above data we can generalize that in Dobrich region there are predominantly specialized and relatively larger in size farms in contrast to the other two studied regions.

The diversification processes of the activities of the farms have different dimensions in the three regions. In Blagoevgrad region, the highest relative share of farms is of farms conducting direct sales - 42.86%, followed by those performing activities related to environmental protection and ecosystem services - 38.1% (Table 3). Among these, the number of farms that grow bees and fruit is significant.

In Dobrich region 66.67% of farms do not develop any other activities. The next largest group with 33.3% are farms providing mechanised services and/or ecosystem services and environmental protection activities.

Tourist activities are carried out by 14.29% of the surveyed farms in Blagoevgrad region, 16.67% in Dobrich region (all in Balchik municipality) and only 3.8% in Pazardzhik region.

In Blagoevgrad region, the same relative shares (9.52%) were occupied by farmers providing mechanised services, developing crafts or renting agricultural land under lease or rental contracts. The smallest number of farms are those processing agricultural production (4.76%).

In Pazardzhik region, the highest proportion of farms is in processing (48.1 %), followed by direct sales. 33.3% of producers do not carry out any other activities.

The above data show that in comparative terms the greatest interest in diversification of production is in the surveyed farms from Pazardzhik region, followed by Blagoevgrad region. The last place is occupied by Dobrich region, where only one in three farms develops some activity outside agriculture.

Table 3. Agricultural farms with non-agricultural activities (%)

Regions and non-agricultural activities	Dobrich region	Pazardzhik region	Blagoevgrad region
I do not develop other activities	66.7	21.2	33.3
Crafts	8.33	3.8	9.5
Renting or leasing of land	0	1.9	9.5
Environmental protection and ecosystem services	33.3	11.5	38.1
Processing of agricultural production	16.7	48.1	4.8
Direct sales	25.0	19.2	42.9
Mechanised services	33.3	7.7	9.5
Tourism services	16.7	3.8	14.3

Source: own research.

The object of research interest are the reasons and the evaluation of the chosen production specialization of farms. A five-point positive scale was used for this purpose. In Dobrich region the owners rated the role of markets in the choice of production specialization of farms 3.8, while the ratings of other regions were lower - Blagoevgrad region with 3.07 and Pazardzhik region with 2.8, respectively (Table 4). In general, the role of direct payments and other Common Agricultural Policy instruments in shaping production specialisation is rated higher. It is rated 3.85 in Pazardzhik, 3.8 in Blagoevgrad and 3.4 in Dobrich.

More significant are the differences in the assessments of the importance of direct payments and production specialisation for the stability of the financial situation of the farm. In Dobrich the score is the highest 4.0, in Pazardzhik 3.36, and in Blagoevgrad only 3.0.

Production specialisation and participation in network structures are not perceived as prerequisites for sustainable farm development. The scores are very low, ranging from 2.0 in Dobrich to 3.7 in Pazardzhik and 2.93 in Blagoevgrad. The higher score in Pazardzhik district is related to the experience over the last two programming periods in establishing the different network structures in this part of the country.

Table 4. Farmers' assessment of the reasons for the production specialization of their holdings

Reasons for the production specialization and regions	Dobrich region	Pazardzhik region	Blagoev-grad region
The main reason for the current production specialisation of my farm are the markets for agricultural products and the raw materials for their production.	3.8	2.8	3.1
The main reason for the current production specialisation of my farm are the direct payments and other instruments of the EU Common Agricultural Policy.	3.8	3.9	3.4
Production specialisation and direct payments are prerequisites for the stable financial situation of your farm.	4.0	3.4	3.0
Production specialisation and participation in various network structures are prerequisites for the sustainable development of your farm.	2.0	3.7	2.9
To what extent the plant and animal production technologies used have a beneficial impact on the environment.	2.8	3.9	3.6
To what extent the production specialisation of my farm ensures that its production potential is fully exploited (I obtain maximum income from the production factors at my disposal).	4.0	3.6	2.9
To what extent the current production specialisation of your farm exploits the comparative advantages of the area (my specialisation is appropriate to the conditions of the area).	4.5	4.1	3.8

Source: own research.

A higher score was formed in Pazardzhik district in terms of the favourable environmental impacts of the applied technologies. It is 3.9 in Pazardzhik region against 2.8 in Dobrich region. In Blagoevgrad the score is 3.6.

Of particular interest are the estimates of the extent to which the production specialisation of farms ensures that the production potential is fully exploited. Obtaining maximum income from the production factors available to the farm is rated highest in Blagoevgrad region (4.0). This is followed by Pazardzhik region (3.63) and Dobrich region (2.93).

The extent to which the current production specialisation of the farm exploits the comparative advantages of the region (the specialisation is suitable for the conditions of the region) is rated lowest in Blagoevgrad region - 3.8, followed by Pazardzhik region - 4.09 and highest in Dobrich region - 4.5.

6.67% of the farms in Blagoevgrad region have implemented projects under the SAPARD programme and the first Rural Development Programme (2007-2013). Their number doubled in the period of implementation of the second Rural Development Programme (2014-2020) - 13.33%. The activity of producers in Dobrich region is higher. There, 16.67% of the farms surveyed had implemented modernisation projects in the period of the first Rural Development Programme (2007-2013) and 25.0% in the period of the second national Rural Development Programme (2014-2020).

Comparatively, the lowest percentage of those who implemented projects was in Pazardzhik - only 7.7% in the first and 11.5% in the second Rural Development Programme.

Of particular interest are the answers about the future development intentions of the farm owners. Expected changes in farm specialisation and diversification are of research interest. In all three areas, the highest proportion of farmers will invest in environmental protection activities and the provision of ecosystem services. Such are the intentions of 47.62% of respondents in Blagoevgrad region, 55.5% of those in Pazardzhik region and 33.33% in Dobrich region.

In the next place with the same relative share (14.47%) in Blagoevgrad region are the intentions to develop rural and ecological tourism and to conclude long-term contracts with processing enterprises. In Pazardzhik district, farmers are most likely to invest in primary processing activities and in activities related to preparation and/or marketing of production (11.5%).

The relative share of farmers intending to develop tourist activities or offer rooms to tourists in Dobrich region is significantly lower - 8.35% and 4.17% respectively.

Plans to invest in collective processing facilities were not reported by respondents in Blagoevgrad region, while in Pazardzhik and Dobrich districts they were measured at 7.7% and 8.35% respectively.

In Pazardzhik region, there is a high relative share of farmers who intend to retire from the business and hand it over to the next generation to manage. This answer was chosen by 23% of respondents. Some of them (3.85%) also indicated the likelihood of the farm being closed down.

In terms of maintaining or changing the production specialization of farming, there are differences among respondents in the three regions. Farmers in Dobrich region are the most numerous who intend to keep their production specialization (58.34% of respondents). The majority of those with grain specialization and mixed farms intend to increase the concentration of production (33.33% of all respondents). Second are the farmers who intend to move towards organic farming (16.67%) and only 8.33% are targeting a significant change of production specialization mainly in the direction of reducing the types of animals produced.

In Blagoevgrad and Pazardzhik regions, 33.34% and 28.84%, respectively, plan to change their production specialization. In both regions the predominant intention of producers is to develop organic crop and livestock production.

Of particular interest are the responses to the question on farmers' intentions to participate in producer organisations (Table 5). The answer "very likely" was chosen by 19.05% of respondents in Blagoevgrad and 15.38% of those in Pazardzhik.

In Dobrich region the answer "very likely" was not indicated by any respondent. The next level "likely to participate" was indicated by 28.84% of respondents in Pazardzhik region, 16.67% of those in Dobrich region and 14.29 of respondents in Blagoevgrad region.

38.1% of farmers in Blagoevgrad region, 28.84% of those in Pazardzhik region and

25% of those in Dobrich region categorically expressed that they would not participate.

Overall, the comparison by regions shows that there are no significant differences by region between those who are willing to do so and those who are firm in their non-participation or did not answer the question.

The problem of creating producer organizations is more significant for Blagoevgrad and Pazardzhik districts, where small farms predominate with serious problems in selling their products.

They are also the districts with the lowest average size of agricultural land used per farm.

Table 5. Future intentions to participate in producer organisations (%)

Regions and	Blagoevgrad	Pazardzhik	Dobrich
Very likely	19.05	15.38	
Likely	14.29	28.84	16.67
Unlikely	33.3	32.69	41.67
I will not do it	38.1	28.84	25.00
No answer provided	14.76	11.53	16.67

Source: own research.

Respondents' answers about the ecosystem services provided by their farms were mixed (Table 6).

Table 6. Ecosystem services provided by farms (%)

Regions and ecosystem services provided by farms	**Dobrich region**	**Pazardzhik region**	**Blagoevgrad region**
Landscape	25.0	26.1	40.0
Biodiversity	31.2	13.0	26.7
Water quality	12.5	4.4	13.3
Soil quality	18.7	32.6	26.7
Food security	56.2	15.2	40.0

Source: own research.

For producers in the Blagoevgrad region, the highest relative proportion of farms considered this to be landscape (40%) and food security (40%). Soil quality and biodiversity came next at 26.67%.

In Pazardzhik region, soil quality (32.61%) ranked first, followed by landscape impacts (26.09%) and food security (15.22%), while in Dobrich region the highest number of farmers chose food security (56.25%), biodiversity conservation (31.25%) and landscape impacts (25.0%).

Water quality was chosen by the least number of farmers, with scores ranging from 4.35% in Pazardzhik to 13.33% in Blagoevgrad.

In summarizing the results by region and comparing them, the following trends and expected directions for strategic change emerge:

-For Dobrich region, economies of scale and the development of specialised farming are of leading importance. Over the last 15 years, the vast majority of farms have increased the amount of agricultural land used, modernized their farms, and shifted to growing crops with higher production potential and income. One possible explanation is the relatively high self-assessment of larger farms of their income from their activities. Those that have expressed plans to diversify are focusing on ecosystem services and capital-intensive diversification (building renewable energy sources), etc. Even in coastal municipalities, farmers' interest in agro-tourism is limited.

-The diversity of the topography, the border character of some of the rural municipalities, the natural assets, etc. in the rural areas of Blagoevgrad region are the basis of the farmers' plans for structural transformations. Producers consider that their current production specialisation is largely determined by the Common Agricultural Policy and that it does not allow them to make sufficient use of the comparative advantages of the area in which they operate.

The future plans of producers are dominated by producers who are likely to turn to environmentally friendly practices and organic production, as well as to the development of tourism services. These intentions are more strongly expressed in the areas with mineral springs and near traditional tourist routes in the mountains of Rila, Pirin, Osogovo, etc. Therefore, there is a predominance of farms that will apply labour-intensive diversification and contribute to the development of the rural communities in which they operate.

-Farmers in Pazardzhik region have also increased the amount of used agricultural land and modernized their farms. Compared to the other two regions, the largest number of respondents here have changed their production specialization in the last 15 years.

A number of small farms have stopped producing fruit and vegetables and raising animals. The strategic plans of a significant proportion of them are to invest in environmental protection activities and the provision of different ecosystem services, organic production, and to build processing facilities.

A multifunctional agricultural sector that contributes to the realisation of multiple objectives is at the heart of the European Union's agricultural model [14]. It affirms not only the various functions of agriculture, but also tries to develop additional activities and productions in specialized farms [12]. On the basis of the benefits of farm specialisation and diversification that have been repeatedly studied, this study confirms the results of other authors that the type of agricultural production, the size and legal status of farms influence their choice of development. Among the larger specialised farms, attitudes towards deepening production specialisation and continued concentration of production (economies of scale) prevail. Thus, whole regions (in our case the Dobrich region) are developing specialised industries. Although relatively rare, farms are diversifying their activities, often in the direction of the capital-intensive diversification encouraged by the current Common Agricultural Policy.

In the other two studied regions, there is increased interest in diversification, and mainly labour-intensive diversification. It provides employment not only to household members but also to residents in the rural area. In this way, as some authors rightly point out [27] socio-ecological and socio-cultural functions are strengthened. Tourism offerings from farms and ecosystem services have a positive effect on the recreational value of the region, as well as on the transfer of knowledge about agriculture and sustainable rural development [2, 3]. Labour-intensive diversification is a means for farms to expand their importance in the local economy.

The results of the present study are a challenge for future research aimed at changes in the behavior of agricultural holdings and their impact on the rural areas in which they operate. These changes are particularly important for municipalities with low population density, mountain municipalities and areas with unfavorable natural conditions.

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ABIOTIC STRESS MANAGEMENT IN POTATO CROP: EVALUATION OF ANTHOCYANIN ACCUMULATION FOR SALAD BLUE CULTIVAR

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Abstract

The present work follows the reactions of ``Salad Blue`` variety to abiotic stress factors (high temperatures and precipitation deficit in the area of the experimental fields) through the amount of anthocyanins accumulated in tubers. The experimental fields were located on the territory of Mandra in Brasov county and Rusciori in Sibiu county, both localities in Romania. The experiments took place over a period of two years, 2023 and 2024. The two years had a high climatic variability. The results show an inversely proportional relationship between the accumulation of anthocyanins in potato tubers and the abiotic stress present in the experimental plots. The highest accumulation of anthocyanins was identified in the experimental field of Rusciori locality of 2023, under less stressful conditions and the lowest amount of anthocyanins was identified in Mandra locality of 2024, where the most stressful climatic conditions were present. The compound Cyanidin-3-caffeoylsophosphorosid-5-glucoside had the highest weight in all the analyses performed regardless of environmental conditions. These results show the impact of abiotic stresses on the nutritional quality of ``Salad Blue`` potato variety and emphasize the need for increased attention to adaptive agricultural practices to mitigate the effects of climate change.

Key words: *Salad Blue potato, anthocyanins, abiotic stress, climatic conditions, nutritional quality.*

INTRODUCTION

Purple-fleshed potato varieties may be a very good choice for introduction into the human diet because they are nutritionally valuable compared to other potato varieties due to their high anthocyanin content [24]. Anthocyanins are natural pigments found in fruits and vegetables. They are responsible for their intense color, as in the case of ``Salad Blue`` potato tubers [26]. Interest in potato varieties with colored flesh has increased in recent years due to their benefits in human nutrition. Consumption of these anthocyanin-rich vegetables actually means a higher intake of antioxidants introduced into the body with anti-inflammatory effects, which reduce chronic inflammation and oxidative stress at the cellular level [38]. These compounds support the health of the cardiovascular system by improving endothelial function and reducing the risk of cardiovascular disease. Anthocyanins are stimulants of the immune system and help the body to fight infections, supporting good health [22], [29]. The relatively recent presence of these varieties in potato cultivation may bring challenges in terms of the level of public knowledge about the significant nutritional value of these colored potatoes. Even if there is a well-documented scientific basis, consumer information remains an important tool to increase interest and demand for these and also other food by-products [7], [4]. Studies suggest that the promotion of potato varieties high in anthocyanins may have a positive impact on public health [23]. Finally, the cultivation and promotion of purple-fleshed potatoes offers an agronomic advantage by diversifying supply and improving consumer health by accessing a natural source of essential bioactive compounds. Another theme of global value is climate change which presents a challenge for areas such as agriculture and for their develeopment under sustainability and circular economy concepts [14], [4]. These climate changes were directly affecting agriculture by increasing abiotic stress in established and ideal cropping areas decades ago. Increased abiotic stress can be manifested by the intensification and prolongation of periods of extreme events such as droughts and above-average temperatures, or at the other extreme by short but intense rainfall or floods. In addition to direct actions on crops through the intensification of extreme events, climate change also indirectly influences agriculture by requiring the adoption of global sustainable policies that have as main objective strategies to reduce the carbon footprint [17], [30], [13]. Abiotic stress in agriculture can be a major risk factor for food security. This phenomenon can reduce the quantity and quality of agricultural products. Moreover, agricultural areas are vulnerable to degradation, being exposed to different types of erosion. Consequently, the land can be placed in categories such as infertile or degraded, which makes it difficult to cultivate them with agricultural crops valuable for human food [34], [1], [21]. The environmental conditions, such as altitude, temperature, humidity and soil composition, are decisive factors in the accumulation of anthocyanins in plants.

The literature emphasizes that at higher altitudes anthocyanin levels increase because plants are exposed to more intense UV radiation.

As a result, plants react by producing more protective pigments to reduce radiation stress. In the same defense scenario, plants can produce more pigments under high temperatures and water stress.

The role of these pigments in plants, in the above mentioned scenarios, is to protect cells against damage caused by reactive oxygen species [20].

In the literature, researches have been identified showing variability in terms of anthocyanin accumulation in plants due to abiotic stress experienced. This variability in fact means that some varieties may accumulate more or less anthocyanins. Depending on the variety, anthocyanin biosynthesis may change. Some varieties may accumulate a higher amount of anthocyanins, while other varieties, under the same stress conditions, may decrease the amount of anthocyanins accumulated in the control. These findings show the importance of research, utilization and adaptation of specific varieties for specific cropping areas [16], [28]. For potato crops where colored-fleshed varieties are used, it is necessary to identify and develop stress resistant varieties to maintain a high quality and quantity of production while maintaining their outstanding nutritional benefits. Therefore, in this context, the present work highlights the interaction between ``Salad Blue`` genotype, environmental conditions and anthocyanin accumulation, being a part of a wider research started in the two localities of Mandra [11] and Rusciori [10].

The aim of this study is to determine and evaluate the reaction of ``Salad Blue`` variety to abiotic stress factors by measuring the amount of anthocyanins in potato tubers.

The objectives of this study are:

i. To analyze the reaction of ``Slad Blue`` variety to hydric and thermal stress by evaluating the amount of anthocyanins;

ii. To identify the trends of increase or decrease in accumulation according to the intensity of abiotic stress;

iii. Comparison of anthocyanin levels as a function of environmental conditions at the two locations to highlight differences in stress response of ``Salad Blue`` variety.

MATERIALS AND METHODS

Description of the experimental site

The present study was conducted in two experimental fields, in two different localities. Mandra locality, in Brasov county and Rusciori locality in Sibiu locality, both localities being on the territory of Romania.

Climatic conditions

The climatic conditions (temperature and precipitation) for both experimental years are shown in Table 1.

Tabel 1. Climatic conditions in the two locations of the experimental fields

	Sum of degree (°C)		Rainfall (mm)	
	2023	2024	2023	2024
Rusciori	3,211	3,728	251	272
Mandra	3,140	3,311	381	217

Source: original.

Description of biological material

Tubers of the ``Salad Blue`` variety were analyzed in the experiment (Figure 1). The planting material was obtained from the Agricultural Research and Development Station Targu Secuiesc in Romania. The variety `Salad Blue` is native to Scotland and is suitable for both organic and conventional cultivation. The tuber shape is elongated oval, the rind is purple and the flesh is purple. The inflorescence consists of simple buds with blue-purple flowers. The variety belongs to the early maturity group. It is resistant to the pathogenic golden nematode RO1. The culinary quality is good, its utilization group is A/B.

Anthocyanin analyses were performed on tubers harvested from the two experimental camps in which these seed tubers were used.

The experimental procedure

During the growing season the potato plants received no fertilizer and precipitation was not supplemented by irrigation. A detailed description of the experimental design and experimental procedure can be found in previous papers [11], [10].

Data collection and analyzing

After harvesting the potato tubers, six medium-sized tubers were randomly selected, washed (Fig. 1) and sliced.

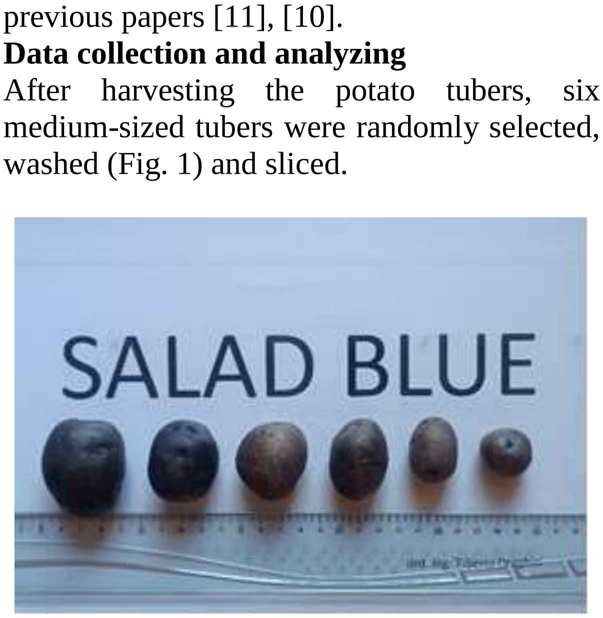

Fig. 1. Salad Blue tubers ready for extraction
Source: original.

Then the slices were dried in a lyophilizer (Ilshin Lab Co. Ltd., South Korea). After drying the slices, the potatoes were mashed in a Grindomix GM 200 knife mill (Retsch, Germany) to powder.

Anthocyanins extraction

Anthocyanin extraction was done from one gram of sample extracted with 5 ml of methanol acidified with 1% HCl at 37% concentration by vortexing for 1 min at Heidolph Reax top vortex for 1 min, followed by a sonication bath for 15 min. In Elmasonic E 15 H sonication bath, followed by centrifugation at 10,000 rpm for 10 min and a temperature of 240°C on Eppendorf AG 5804 centrifuge. The supernatant was collected, and the above operations were repeated until complete decolorization of the sample. The extract was concentrated by vacuum evaporation at 400°C on the Heidolph Hei-VAP Expert Heidolph rotaevaporator to a final volume of 1 ml, then filtered through a 0.45 µm Chromafil Xtra nylon 0.45 µm Chromafil Xtra nylon filter and 20 µl was injected into the HPLC system.

Chromatographic conditions

The Agilent 1200 HPLC system equipped with quaternary pump, solvent degasser, autosampler, UV-Vis photodiode array detector (DAD) coupled with Agilent model 6110 single quadrupole mass detector (MS) (Agilent Techologies, CA, USA) was used for chromatography of the samples. The separation of the compounds was performed on a Kinetex XB C18 column, size 4.6 x 150 mm, with 5 µm particles (Phenomenex, USA), using the mobile phases (A) water + 0.1% acetic acid and (B) acetonitrile + 0.1% acetic acid in the gradient below, for 30 min, at a temperature of 250 °C, at a flow rate of 0.5 ml/min. Gradient (expressed in % B): 0 min, 5% B; 0-2 min, 5% B; 2-18 min, 5%-40% B; 18-20 min, 40%-90% B; 20-24 min, 90% B; 24-25 min, 90%-5% B; 25-30 min, 5% B. Spectral values were recorded in the 200-600 nm range for all peaks. Chromatograms were recorded at wavelengths λ = 520 nm. For the MS, full scan ionization positive ESI mode was used under the following working conditions: capillary voltage 3,000 V, temperature 3,000°C, nitrogen flow rate 7 l/min and m/z 120-1,200. Data acquisition and interpretation of the results was done using Agilent ChemStation software, version B.02.01 SR2.

Chemical reagents and materials

Acetonitrile, of HPLC purity, was purchased from Merck (Germany) and ultrapure water was purified with the Direct-Q UV system from Millipore (USA). Cyanidin standard was purchased from Sigma-Aldrich (USA).

Identification and quantification of anthocyanins

Anthocyanins were identified by comparing retention time, UV-Vis absorption and mass spectra with those of standard compounds and literature data.

For the quantification of anthocyanins, a calibration curve was performed by injecting 5 different concentrations of standard cyanidin dissolved in methanol (Fig. 2).

The equation of the curve was used for the quantitative calculation for each anthocyanin, and the result was expressed as cyanidin equivalent.

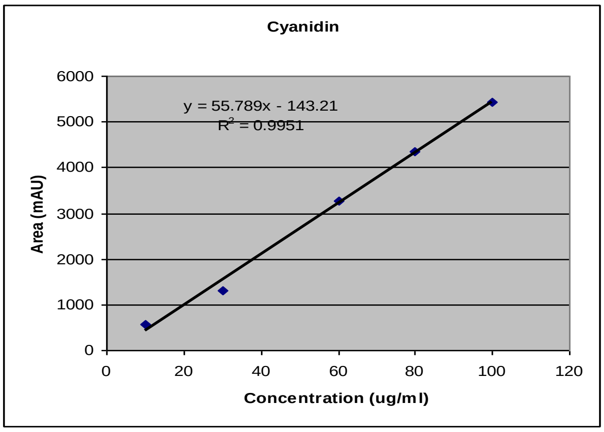

Fig. 2. Curba de calibrare pentru diferite concentratii de cyanidina
Source: original.

Data analysis

All data collected from the laboratory analyses were interpreted by IBM SPSS program, applying Tukey's test, using a one-way analysis of variance with two variables. The variables being represented by each experiment (year+location) and the anthocyanin levels in the tubers.

RESULTS AND DISCUSSIONS

Climatic conditions

According to the literature, the sum of degrees in terms of potato crop is in the range of 1,500 - 3,000°C [36], [5], [18], [8]. In the present experiment, the sum of degrees in both years exceeded the theoretical maximum threshold of 3,000°C, even exceeding the threshold of 3,700°C in 2024, in the locality of Rusciori (Figure 2 (up)), which means that the potato plants in that experiment suffered severe heat stress [35], [32] [6], [19].

(a)

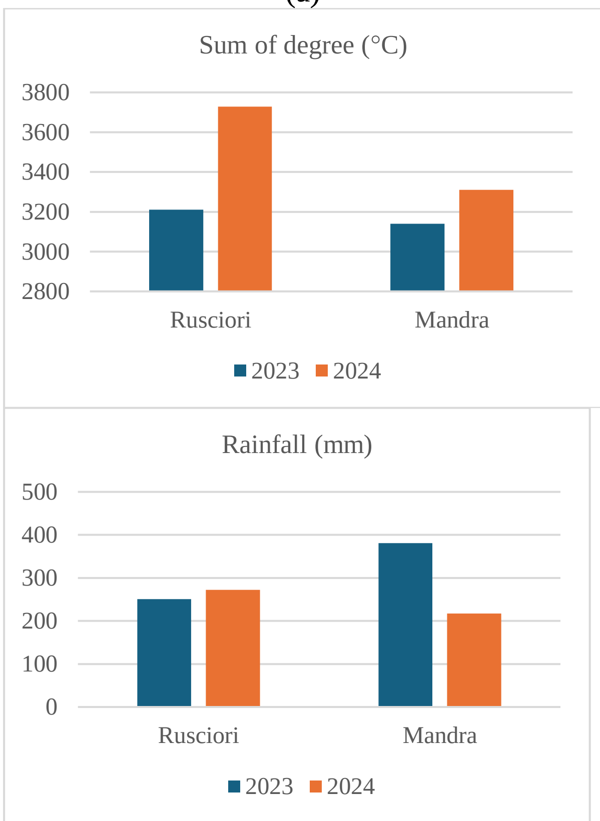

Fig. 3. Sum of degrees plotted in the four experimental years (Up) and Sum of precipitation plotted in the four experimental years (Down).
Source: Original.

In terms of precipitation, the water stress of potato plants was accentuated, because during the growing season, potato crop requires precipitation between 500 and 650 mm [25], [9], [27]. In the experimental fields, the highest amount of precipitation was recorded in 2023, in the locality of Mandra, reaching just over 380 mm, and the lowest value was observed in 2024, also in the locality of Mandra, when precipitation was below 220 mm (Figure 2(b)). These conditions resulted in severe water stress for the experiment [15], [31], [2].

Identification and quantification of anthocyanins

The results on the average amount of anthocyanins for each experimental field and each year were centralized in Table 2.

Table 2. Average anthocyanin compounds in potato tubers from experimental fields (mg/100g)

Experimental site	**Mandra 2023**	**Mandra 2024**	**Rusciori 2023**	**Rusciori 2024**
Means	352.643[b]	428.544[c]	413.139[a]	291.196[d]

Note: *p<0.5*
Source: original.

At the same time, the types of anthocyanins identified in potato tubers of ``Salad Blue`` variety in the four experimental years were centralized and classified, the means of the results being centralized in Table 3.

Table 3. Average of each anthocyanin compound in potato tubers from experimental fields (mg/100g)

Compound	**Cyanidin-3-caffeoylsophoroside-5-glucoside**	**Peonidin-3-caffeoylsophoroside-5-glucoside**	**Peonidin-3-dicaffeoylsophoroside-5-glucoside**
Means	244.518[a]	161.696[c]	201.546[b]

Note: *p<0.5*
Source: original.

Stress reaction

Analyzing the total results obtained from the two years of experience with ``Salad Blue`` in the two localities, an inversely proportional accumulation of anthocyanin compounds with the climatic stress experienced by the plants can be observed.

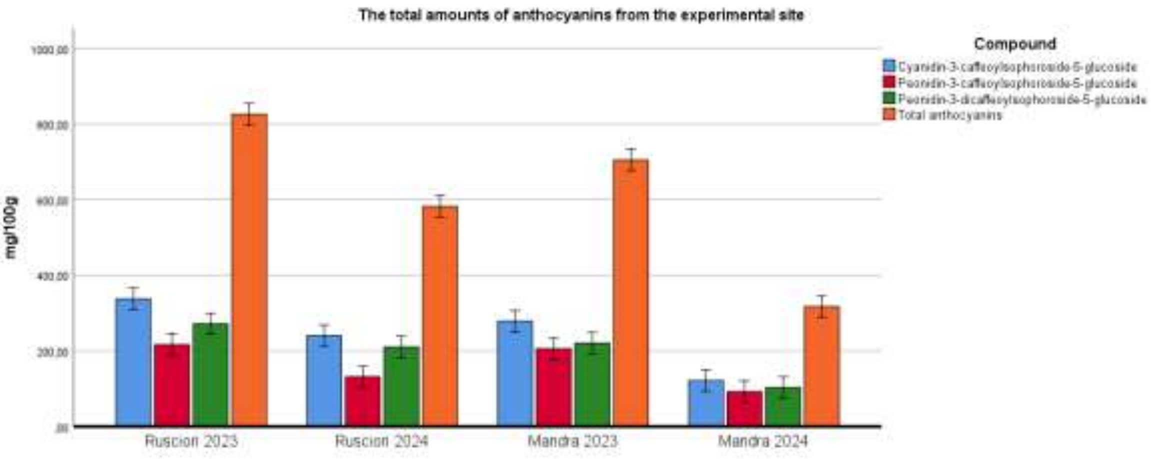

Fig. 4. Graphic representation of anthocyanin compounds within the experimental fields
Source: original.

According to Figure 4 the highest amount of accumulated anthocyanins was identified in the locality of Rusciori, in the year 2023 with a total mass over 800 mg of anthocyanins per 100g. The experiment in Rusciori locality of year 2023 coincides according to Figure 2 (Up) and (Down) with less stressful climatic conditions compared to other years. At the opposite pole are the biochemical analyses of anthocyanins for the experiment in the locality of Mandra, year 2024, which has the lowest accumulated anthocyanin mass, below 400 mg/100g (Figure 3) and coincides with the most stressful conditions from the hydric point of view, accumulating the least precipitation (Figure 2 (Down)). In the

literature it is specified that the accumulation of anthocyanins under abiotic stress conditions may lead to an increase in their accumulation in potato plants or to their reduction, depending on the traits [37], [12], [33], [3]. In our case the total amount of anthocyanins decreased due to climatic stress.
Observing each anthocyanin compound studied, according to Figure 3 and Table 3, regardless of the year and location studied, there is a consistency in the size of the accumulated masses. The highest accumulated mass in all 4 experiments was Cyanidin-3-caffeoylsophoroside-5-glucoside, and the lowest mass was Peonidin-3-caffeoylsophoroside-5-glucoside.

CONCLUSIONS

In conclusion, the present study confirms and demonstrates that the accumulation of anthocyanin compounds is closely related to environmental conditions, as is the case in the literature.
For the ``Salad Blue`` variety, the accumulation of anthocyanins is inversely proportional to the intensity of heat and water stress.
The 2023 experiment, in the Rusciori locality, had a lower intensity of abiotic stress, and the accumulation of anthocyanins was the highest within the experiment.
At the opposite pole, the 2024 experiment was identified, in the Mandra locality, where the intensity of abiotic stress was the most pronounced and the accumulation of anthocyanins was the lowest.
Regarding the distribution of accumulated anthocyanin compounds, we identified a consistency in the mass stability as follows: Cyanidin-3-caffeoylsophoroside-5-glucoside had the highest mass, followed by Peonidin-3-dicaffeoylsophoroside-5-glucoside and Peonidin-3-caffeoylsophoroside-5-glucoside, with the lowest mass.
This ranking, in terms of the accumulation of the three anthocyanin compounds, was not influenced by the abiotic stress during the field experiments.
Regardless of the environmental conditions, the proportion of the three compounds remained the same.
These findings highlight the impact of abiotic stress on the nutritional quality of “Salad Blue” potato soils and emphasize the need for adaptive agricultural practices to mitigate the effects of climate change.

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DEMOGRAPHIC TRANSFORMATIONS WITH EMPHASIS ON RURAL AREAS IN GIURGIU COUNTY, ROMANIA

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Abstract

This study uses census data from the National Institute of Statistics to investigate the evolution and structure of the employed population in Giurgiu County and Romania. The dynamic and structural analysis was used to detect important trends in labour market participation, demographic transitions, and sectoral employment distribution. The findings for rural areas show a fall in the active population, with rural areas witnessing a greater reduction. Structural analysis of data from 2021 census reveals shifts in employment sectors, with agriculture declining while industry and services rising. In addition, we examine migratory trends and their effects on local economies. The findings shed light on the difficulties and opportunities in workforce development.

Key words: *demographic trends, employed population, structural changes*

INTRODUCTION

Romania is encountering a concentration of resources in major urban areas. The industry, construction, and commerce sectors serve as polarising forces for the labour market, evidenced by a notable decline in agricultural employment [5] [13]. Also, Romania is facing an ageing population as a result of demographic and economic changes over the last three decades, such as the deindustrialisation of cities [15]. Due to occupational restructuring, younger people tend to migrate to cities, abroad, or settle in peri-urban areas [9]. The situation is even more evident in the southern and eastern regions of the country, especially in rural areas, where structural changes have led to an increase in the number of pensioners and a high pressure on social protection systems [11] [14].

The South-Muntenia region, for example, shows a negative population trend, accompanied by a negative natural increase and an increase in life expectancy and the number of people over 60 [3]. Giurgiu County from this region is one of the least affected by migration due to its proximity to Bucharest job poles [10]. However, we must draw attention to the fact that Giurgiu has always been considered an agricultural county due to its geographical conditions [2, 6], but, despite this, in recent years, the population employed in agriculture has decreased considerably due to changes in the labour market [8]. The shift from subsistence agriculture to more modern forms of employment has been slow, mainly due to the ageing population and the low attractiveness of rural jobs for younger generations [1].

Additionally, the fragmentation of agricultural land and insufficient investment in infrastructure have limited the county's ability to capitalise on its fertile soil and favourable climate conditions [4]. In parallel, the urbanisation trends in Romania have led to an increase in polarisation between urban and rural areas. While cities like Bucharest continue to attract a significant workforce, rural counties like Giurgiu struggle with depopulation and economic stagnation [7].

Overall, the demographic and economic transformations in Giurgiu County reflect broader national trends: rural areas experience significant challenges due to labour migration, ageing populations, and structural economic shifts. Addressing these issues requires a comprehensive approach.

MATERIALS AND METHODS

Our research throws light on the complex socio-economic dynamics in Giurgiu and Romania, focusing on key challenges and opportunities for the labour market.

This analysis uses statistical research methods to consider demographic and economic trends in Giurgiu County and Romania by using data published by the National Institute of Statistics from population and housing censuses. The study incorporates both dynamic and structural analyses, thereby giving a complete overview of time changes and the distribution of employed people. The dynamic study considered the employed and inactive population changes in different reference periods by comparing between different censuses to detect trends of importance such as increase or decrease of certain demographic categories. The structural analysis discussed employed people distributions by economic sector, social category, and residential area, thereby accentuating the disparities between rural and urban areas and different fields of activity as well. In this manner, we identified the dominant economic sectors and trends in labour force specialization.

RESULTS AND DISCUSSIONS

The evolution of the population in Romania after 1948 was characterized by a sharp dynamic over two decades and a continuous decrease in the last 40 years. Urbanization started to take shape between 1948 and 1956, and the collectivization process reached its conclusion between 1956 and 1966. Compared to 1948, according to the 2021 census, the population of Romania increased by 20% (Table 1).

Table 1. Population between 1948 and 2021, Romania and Giurgiu County

	Romania			Giurgiu		
	Total	Urban	Rural	Total	Urban	Rural
1948	15,872,624	3,713,139	12,159,485	313,793	30,197	283,596
2021	19,053,815	9,939,102	9,114,713	262,066	75,117	186,949
1956/1948	110.2	147.4	98.8	103.6	108.0	103.1
1966/1956	109.2	133.5	98.2	98.5	120.2	96.1
1977/1966	112.9	128.6	103.1	102.3	131.5	98.2
1992/1977	105.8	131.9	85.6	95.7	180.6	79.8
2002/1992	95.1	92.3	98.3	95.1	95.1	95
2011/2002	92.8	95.0	90.4	94.5	92.8	95.2
2021/2011	94.7	91.5	98.4	93.1	91.4	93.8
2021/1948	120.0	267.7	75.0	83.5	248.8	65.9
2021/1992	83.5	80.2	87.5	83.6	80.7	84.9
2021/2011	94.7	91.5	98.4	93.1	91.4	93.8

Source: Own calculation on the basis of data from NIS [12].

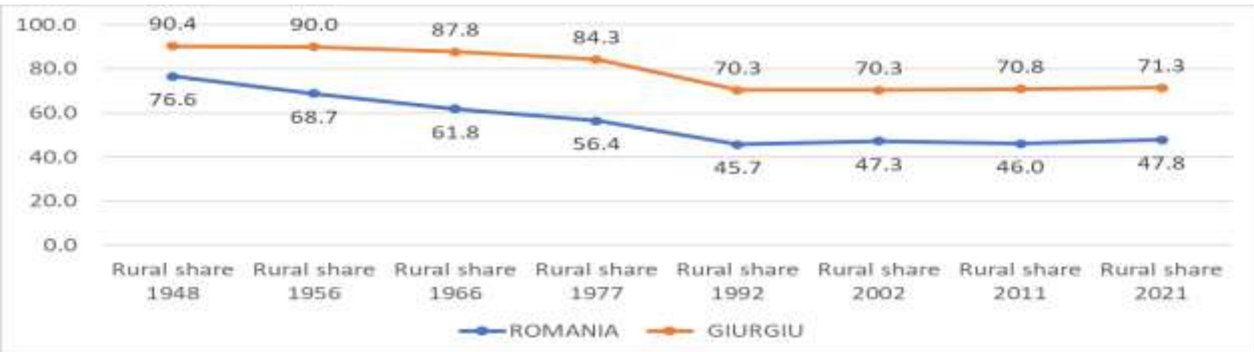

Fig.1. Share of rural population in Romania and Giurgiu County
Source: Own design and calculation based on the data from NIS [12].

However, very large gaps are observed in terms of residence areas, namely an increase of 167.7% in urban areas and a decrease of 25% in rural areas. The largest increases in urban areas were during the industrialisation period, and they continued until 1992. Each census in the following decades recorded decreases of about 5-7% after this year.

In Giurgiu, the urban population grew greatly until 1992 (even by 80% between 1977 and 2002). Although there were decreases in the following decades, data show that in 2021 the urban population was almost 150% higher than in 1948. However, the high share of the rural population, which was in continuous decline after 1956, led to a depopulation of the county, especially in rural areas (in half a century the rural population decreased by almost 35%). From Figure 1, we can see that the major changes occurred between 1977 and 1992; after this year, the rural population was about 71%. Given that the population decreased by 16.4% between 1992 and 2021 (by 19.3% in urban areas and 15.1% in rural areas), this means that demographic changes have affected the entire county (migration, immigration, negative natural increase, etc.)

The active and employed population have the same characteristics, namely a higher share in rural areas in Giurgiu County, unlike the national average. Additionally, the majority of the unemployed reside in rural areas, accounting for 65% nationally and 80% in Giurgiu County. A very important aspect from a demographic point of view is the share of over 57% of the inactive population, which reaches 61% in rural areas nationally and 58.1% in Giurgiu County (Table 2). Structurally, the inactive population does not show major differences; over 40% are pensioners, about 30% are students, and about 10–14% are housewives.

Table 2. Population between 1948 and 2021, Romania and Giurgiu County

	Total	Urban		Rural		Total	Urban		Rural	
		2021	%	2021	2021/2011 %, +/-		2021	%	2021	2021/2011 %, +/-
Total	**19,053,815**	**9,939,102**	**52.2**	**9,114,713**	**98.4**	**262,066**	**75,117**	**28.7**	**186,949**	**93.8**
Active population	**8,185,019**	**4,628,651**	**56.6**	**3,556,368**	**87.1**	**111,685**	**33,340**	**29.9**	**78,345**	**86.5**
%	**43.0**	**46.6**		**39.0**	**-5.1**	**42.6**	**44.4**		**41.9**	**-3.5**
Employed population	7,689,171	4,453,915	**57.9**	3,235,256	83.9	104,513	31,951	**30.6**	72,562	83.0
%	93.9	96.2		91.0	-3.4	93.6	95.8		92.6	-4.0
Unemployed	495,848	174,736	**35.2**	321,112	139.4	7,172	1,389	**19.4**	5,783	188.2
%	6.1	3.8		9.0	3.4	6.4	4.2		7.4	4.0
Inactive population	**10,868,796**	**5,310,451**	**48.9**	**5558345**	**107.3**	**150,381**	**41,777**	**27.8**	**108,604**	**99.9**
%	**57.0**	**53.4**		**61.0**	**5.1**	**57.4**	**55.6**		**58.1**	**3.5**
Students	3,288,575	1,707,631	**51.9**	1,580,944	113.2	41,120	11,851	**28.8**	29,269	104.0
%	30.3	32.2		28.4	1.5	27.3	28.4		27.0	1.1
Pensioners	4,410,077	2,373,577	**53.8**	2,036,500	116.1	61,853	17,052	**27.6**	44,801	107.6
%	40.6	44.7		36.6	2.8	41.1	40.8		41.3	2.9
Housewives	1,169,565	334,790	**28.6**	834,775	128.5	20,928	4,914	**23.5**	16,014	112.8
%	10.8	6.3		15.0	2.5	13.9	11.8		14.7	1.7
Dependents on other persons	1,163,594	580,456	**49.9**	583,138	71.3	15,263	4,706	**30.8**	10,557	69.2
%	10.7	10.9		10.5	-5.3	10.1	11.3		9.7	-4.3
Dependents on organizations	100,422	28,291	**28.2**	72,131	56.3	1,288	298	**23.1**	990	36.6
%	0.9	0.5		1.3	-1.2	0.9	0.7		0.9	-1.6
Dependents on other sources	237,679	56,041	**23.6**	181,638	145.7	3,636	555	**15.3**	3,081	232.7
%	2.2	1.1		3.3	0.9	2.4	1.3		2.8	1.6
Other economic situation	498,884	229,665	**46.0**	269,219	87.6	6,293	2,401	**38.2**	3,892	71.9
%	4.6	4.3		4.8	-1.1	4.2	5.7		3.6	-1.4

Source: Own calculation on the basis of data from NIS [12].

In Giurgiu County, the employed population registered a decrease compared to 2011 both at the county level and in the rural area. The decrease is mainly due to the reduction of people employed in agriculture, forestry, and fishing. In fact, this branch came to represent only 16.1% of the employed population in the rural area in 2021, 41.5 percentage points less than in 2011 (Table 3). If we follow the changes in the structure through activities, we observe a greater increase in the share of people in construction, trade, the processing industry, and transport and storage.

There are 51 localities in the rural area. In 24, we do not find any population employed in the extractive industry, and in 7, there are no people employed in financial transactions, real estate, or insurance (Fig. 2). Otherwise, in each locality, there are people employed in different branches of the national economy. We can say that in each branch we find less than 10% of the employed population.

Table 3. Changes in the structure of the employed population by branches of the national economy in Giurgiu County

	Total		Rural	
	2021	2021/2011	2021	2021/2011
	104,513 (100.0%)	-15,961.0 (86.8%)	72,562 (100.0%)	-14,889.0 (83.0%)
Agriculture, forestry and fishing	11.9	-31.7pp	16.1	-41.5 pp
Mining and quarrying	0.3	-0.2 pp	0.4	-0.3 pp
Manufacturing	14.1	6.7 pp	13.7	9.3 pp
Electricity, gas, hot water and air conditioning supply	1.3	0.0 pp	1.4	0.6 pp
Water supply; sanitation, waste management, remediation activities	2.5	1.8 pp	2.8	2.3 pp
Construction	14.6	3.1 pp	16.3	4.5 pp
Wholesale and retail trade; repair of motor vehicles and motorcycles	16.2	7.3 pp	15.0	8.6 pp
Transportation and storage	10.8	6.6 pp	9.3	5.9 pp
Hotels and restaurants	1.7	1.0 pp	1.7	1.2 pp
Information and communication	0.9	0.2 pp	0.8	0.3 pp
Financial and insurance intermediation	0.9	0.1 pp	0.7	0.4 pp
Real estate transactions	0.2	0.1 pp	0.2	0.1 pp
Professional, scientific and technical activities	1.8	1.0 pp	1.5	1.1 pp
Administrative service activities and support service activities	5.2	0.3 pp	5.9	1.7 pp
Public administration and defence; public social security	5.7	-0.7 pp	4.1	1.1 pp
Education	3.7	1.2 pp	2.9	1.1 pp
Health and social work	4.8	2.0 pp	4.1	2.1 pp
Entertainment, cultural and recreational activities	0.6	0.2 pp	0.4	0.2 pp
Other activities of the national economy	2.7	1.1 pp	2.7	1.4 pp

Source: Own calculation on the basis of data from NIS [12].

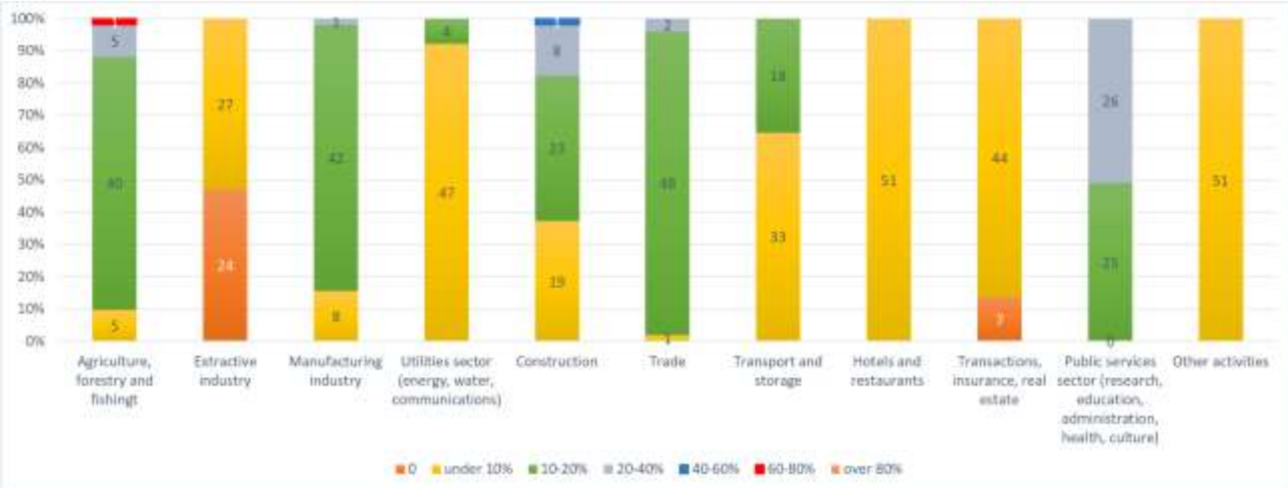

Fig. 2. Distribution of communes in Giurgiu County by economic branches depending on the degree of participation of the employed population
Source: Own design and calculation based on the data from NIS [12].

However, there are branches that generate more jobs, as follows: in the public administration sector, in half of the localities, we have percentages of 10–20%, and in the other half, percentages between 20% and 40%. Additionally, about 10-20% of the population works in trade, the manufacturing industry, and agriculture in about 40 localities. There are also exceptions. In 6 localities over 40% of the population is employed in agriculture (in one of the localities the percentage is between 60% and 80%); in 9 localities over 20% of the population works in construction (in one of the localities the percentage is between 40% and 60%); in one locality the manufacturing industry exceeds 20%, and in 2 localities trade exceeds 20%.

From Figure 3, we can see that the construction industry is growing the fastest in the north of the county. This is likely because these areas are close to Bucharest and have a better economy, which has caused a lot of people to move there. In localities such as Gaiseni, Ulmi, or Floresti-Stoenesti, the percentage of the population employed in construction reaches 40% (Fig.3). The areas coloured in green, in the centre and east of the county, show the areas where agriculture represents an important economic branch. In Colibasi, there is obviously intense agricultural activity because our population is predominantly employed in this field (65%). Moreover, in this locality, there is a very developed vegetable-growing sector,

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including a local cooperative. In Schitu, 23.4% of the population works in the processing industry (metal, wood, plastic, and textiles). Thus, as can be seen, only about 20% of the localities have a business environment that creates jobs and employment, which makes it very difficult to find jobs. Of the employed population, about 1.8% have opted to find a job abroad, and around 2% do not have a permanent job (they are probably day laborers) (Table 4).

Approximately 57% of the county-level population and 48% of the rural population engage in labor activities in their locality of residence. About 5–7% work in neighboring localities, with half opting for urban areas (Bolintin Vale, Giurgiu, or Mihăilești). However, the proximity to Bucharest and the towns of Ilfov means that 40.5% of the rural employed population commute to a job in another county.

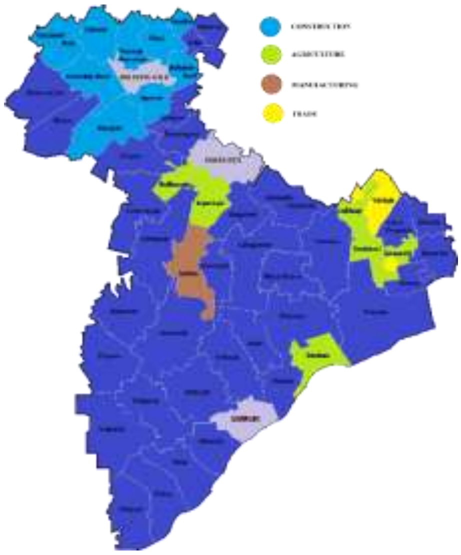

Fig. 3. Communes from Giurgiu County where the population employed in a certain branch exceeds 20% of the total employed persons
Source: Own design and calculation based on the data from NIS [12].

Table 4. The location of the workplace of the employed persons in Giurgiu County

	GIURGIU	%	RURAL	%
Resident population employed	104,513	-	72,562	
Census location	59,523	57.0	34,845	48.0
Other location in the county	6,044	5.8	5,108	7.0
Urban	3,289	54.4	3,223	63.1
Rural	2,755	45.6	1,885	36.9
Another county	34,774	33.3	29,385	40.5
Urban	30,364	87.3	25,546	86.9
Rural	4,410	12.7	3,839	13.1
Other country	1,899	1.8	1,333	1.8
Without a permanent job	2,273	2.2	1,891	2.6

Source: Own calculation on the basis of data from NIS [12].

CONCLUSIONS

At the national level, urbanization has been the primary driver of population growth; however, the shift after 1990 led to widespread population decline. Depopulation, particularly in rural areas, has significantly affected Giurgiu County. Economic transformations in recent years have resulted in a decrease in traditional activities, a shrinking active population, and limited economic diversification in rural parts of the county.

This research has led to the following conclusions: The county’s population is experiencing a significant decline, with most of the inactive population consisting of retirees, especially in rural areas. The active and employed population has decreased substantially, creating a pressing need for jobs, particularly in rural sectors. Unemployment is rising, and the number of employed individuals is declining, leading to increased dependence on social assistance and other external resources.

Several key trends have emerged regarding occupational shifts. Agriculture, a crucial component of the rural economy, continues to decline steadily. Meanwhile, sectors such as healthcare, construction, trade, and manufacturing show only modest growth, highlighting the limited economic diversification in rural areas. Many working-age individuals are migrating to urban areas or other counties in search of better opportunities.

The leading localities in the county exhibit notable differences due to their economic and geographic characteristics. While the northern areas have seen improvements driven by construction, industrial, and logistical activities, the eastern parts remain predominantly agricultural. These variations contribute to the diverse economic landscape of Giurgiu County.

Most employed residents of Giurgiu County work within the same locality. Of the total workforce, 57% are employed in urban areas and 48% in rural areas. Around 33.3% work in other counties, primarily from rural areas, indicating a high level of dependence on urban centers for employment.

Overall, Giurgiu County's employment patterns reveal significant labor mobility, with many rural residents migrating to urban centers or other regions in search of stable employment. The economic reliance of rural areas on urban centers, combined with increasing labor migration, highlights the challenges facing the county's labor market. Addressing these issues requires targeted policies to create more stable and attractive employment opportunities within the county.

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PRECISION FARMING TECHNOLOGIES AND THEIR POSITIVE EFFECT ON CLIMATE CHANGE MITIGATION

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Abstract

The management of agriculture in recent times is enabling entirely new approaches to keep up with the times and to tackle one of the greatest challenges of our time, namely the climate change we are witnessing, with average temperatures rising much faster than in the last century. Nanotechnology, the Internet of Things, Big Data, Artificial Intelligence, and other technologies are making steady inroads by farmers so that they can plan more accurately for fertilisation, irrigation, yield forecasting, disease management, and risk management. These innovations, the data they collect and the solutions they present, combine to promote a variety of positive effects - economic, social and environmental. In recent decades, with the improvement and implementation of these agricultural technologies, they have contributed to environmental protection by reducing soil, water and atmospheric gas pollution, and economically enabled farmers to achieve better sustainability and financial results. The aim of this study is to assess the potential of these technologies to contribute to positive environmental impacts, food security and sustainability. The methodology of this study is to review and summarize literature, articles, reports, etc. and to compare different methods and analyze the results. The results clearly show that digital technologies will play a major role in combating climate change, but also reveal serious challenges for their mass integration due to high costs and limited access, especially observed in developing countries.

Kay words: *precision agriculture, technologies, Climate change*

INTRODUCTION

The population is projected to grow over the next 50 to 60 years, rising from 8.2 billion in 2024 to approximately 10.3 billion in the 2080's. [33]. Agriculture plays a key role in feeding a growing population and ensuring food security on a global scale. As the number of people on the planet increases, the need for efficient and sustainable agricultural practices becomes increasingly urgent. The main function of agriculture is to produce enough food to meet growing demand. This includes not only quantitative but also qualitative aspects of production, such as ensuring access to diverse and nutritious food for all social groups. Ensuring food security requires the adoption of innovative agricultural practices, including advanced farming techniques, sustainable technologies, and strategies to adapt to changing climate conditions. Technologies such as drones, sensors and automation allow more efficient use of resources and reduced losses. In addition, agricultural development also includes improving supply chains, minimizing food waste and supporting local producers. This can contribute not only to the stability of food systems but also to economic development in rural areas. Addressing the challenges of feeding a growing population and securing food for future generations will rely on a blend of innovation, sustainable methods, and global collaboration [16].

Climate change's impact on agricultural production and food security represents a significant global challenge [4]. The global agri-food system generates an estimated 16 gigatonnes of greenhouse gases per year, accounting for around a third of global emissions. Greenhouse gas emissions are expected to continue to rise, making it impossible to achieve the Paris Climate Agreement's goal of limiting global warming to 1.5°C by 2050. Scientific research underscores the urgency of fundamentally transforming food production and consumption systems to minimize environmental harm and ensure a sustainable future for our planet [31]. There is a clear consensus amongst the scientific society that climate change is happening and inevitably will result in negative consequences to our planet if not addressed. This study aims to evaluate and summarize the perspective positives of using precision technologies in agriculture and their impact related to climate change specifically to slow down and overturn negative processes.

MATERIALS AND METHODS

The methodology is based on a framework developed by C. Parra-Lopez et al [23]. The focus of the study is on digital technologies applied in precision agriculture. Considering their role in mitigating climate change. The methodology includes a literature review, including documents, reports and articles, to explore different models and interactions between stakeholders in the development of new technologies used in agriculture. [20]. It includes a systematic review of the literature using the methods described in the study [28].

RESULTS AND DISCUSSIONS

Feeding the population is the main task of agriculture. Over the past decades, to achieve higher yields, we have been using more and more mineral fertilizers, and chemicals such as insecticides, herbicides, pesticides, etc., the situation is similar in animal husbandry. All this leads to negative consequences for the environment: pollution of water resources, pollution and degradation of soils, air pollution, a decrease in biodiversity and disruption of natural ecosystems are observed.

On the other hand, huge advances in digital technologies are increasingly entering agriculture, modernizing the sector, and leading to improved efficiency and sustainability of the sector. Precision technologies allow for the optimization of water and fertilizer use, improve soil management methods, and can lead to a reduction in negative environmental impacts. These technologies are changing the face of the entire sector, making it attractive to younger generations. Combining traditional agriculture with new technologies is the foundation for achieving sustainable practices that support climate change adaptation efforts.

Number of studies Parra-Lopez [21], [25], [30] and [35] summarized that the definition of climate change should include global warming, extreme weather events, changes in precipitation patterns and changes in other climatic phenomena over time, which can lead to significant and permanent changes in the climate and weather of the Earth. These changes are already happening and knowing that a significant part of this is caused by agriculture, we should look for practices to reduce its impact. Climate change caused by agricultural practices is a topic of discussion and part of the bigger picture set out in the EU Green Deal [6].

The agricultural and food system in Europe, backed by the Common Agricultural Policy, is recognized worldwide for its leadership in safety, reliable supply chains, nutrition, and quality. However, it now faces the challenge of setting a global benchmark for sustainability. Transitioning to a more sustainable food system, while maintaining food accessibility and affordability, can deliver significant environmental, health, and social advantages, along with promoting fairer economic outcomes [14].

The latest UN report on the emissions gap emphasizes that limiting the global temperature rise to 1.5°C above pre-industrial levels is essential to prevent severe and far-reaching consequences of climate change. Achieving this target requires reducing greenhouse gas (GHG) emissions by 42% by 2030 and by 56% by 2035. Specifically for agriculture and the food industry, the targets are as follows: The amount of greenhouse gas emitted per calorie of food produced must be reduced by 28% by 2030 and by 35% by 2035, while yields per hectare must increase by 16% by 2035 and by 22% by 2035 [9]. The European Union's bold climate policy aspires to make Europe the first continent to achieve net-zero CO2 emissions by 2050. To achieve the ambitious goal, an interim target of reducing emissions by at least 55% by 2030 compared to 1990 levels has been set by the European Green Deal. This strategy attempts to ensure a sustainable food system is functioning in the European Union (EU). The main strategic achievements are to ensure that food production and food consumption are contributing to environment protection and public health and also are creating a better environment for economic growth in the agricultural sector [3].

There is a set of specific targets and timeframes in place:

- 25% of EU agricultural land to be organic by 2030
- 50% reduction in the use of chemical pesticides by 2030
- 30% reduction of mineral fertilizers by 2030 [3].

New modern technologies and their application in agriculture are key factors for achieving the targets set in the Green Deal [7]. Production experience alongside the implementation of the technologies of Precision agriculture can transform the current situation leading to more efficient processes, better production quality and mitigating the negative impacts and risks to the environment [22].

In recent years, precision agriculture has made significant progress and can be described as a sustainable systemic solution that increases the quality and quantity of production, while reducing costs, human intervention and the uncertainty caused by natural variability [18]. This concept emphasizes key challenges such as risk mitigation, environmental sustainability, and ecological degradation, which are critical in the 21st century. Precision agriculture is increasingly recognized as a valuable management strategy, aligning closely with global objectives like sustainable food production [15]. Precision agriculture is a modern scientific approach in the agricultural sector that integrates advanced technologies and innovative methods to optimize the management of agricultural activities. By using tools such as global navigation systems (GPS), satellite and remote sensing, unmanned aerial vehicles (drones) and analytical platforms for data processing, this approach aims to increase the productivity and economic efficiency of agricultural systems, while reducing costs and minimizing risks associated with the production process. A basic principle of precision agriculture is sustainable resource management, which includes the efficient use of water, soil, fertilizers and energy. By localizing the specific needs of individual areas in agricultural areas, the system optimizes the allocation of inputs, reducing ecological footprints and helping to protect the environment. The scientific value of precision agriculture also extends to its ability to provide solutions for adaptation to climate change and variable weather conditions. Thanks to real-time monitoring systems and adaptive management, this approach ensures the sustainability of agricultural systems and the long-term stability of production. Precision agriculture represents a transformational model in agricultural science that not only supports sustainable development and food security but also provides a practical basis for building a sustainable global food system.

C. Parra-Lopez et al. examine Digital technologies in agriculture for climate change adaptation and mitigation, analyzing the key digital technologies used in precision agriculture: Remote Sensing, Big Data, Artificial Intelligence, Internet of Things, Nanotechnology, Robots, and Blockchain. They explore how the application of these technologies contributes to addressing the challenges posed by climate change [21]. The integration of digital technologies with agriculture offers a transformative solution to the dual challenges of climate change and global food security.

Remote Sensing (RS)

Remote sensing (RS) involves collecting information about objects or areas without physical contact, using airborne or satellite platforms. These platforms carry sensors that operate across optical, thermal, and microwave spectral ranges [30]. Remote sensing (RS) plays a significant role in modern agriculture by providing valuable data and insights that improve productivity, efficiency, and sustainability. By using satellite, drone, or aircraft-based sensors, farmers and agricultural managers can monitor and manage crops, soil, and environmental conditions more effectively.

Table 1. Digital technologies- Contribution to climate change and mitigation

Digital technology	Contributions to climate change and mitigation
Big Data	1. Enhances the efficiency of resource utilization and supports precision agriculture practices 2. Reduces environmental impact and promotes sustainable soil management 3. Customizes environmental monitoring to address targeted requirements 4. Strengthens crop resilience by enabling genetic improvements 5. Optimizes water usage and enables early detection of stress factors 6. Lowers greenhouse gas emissions by advancing residue management techniques
Remote Sensing	1.Boosts efficiency in water usage 2. Promotes decision-making through data-driven farm management 3. Enables monitoring of environmental trends and changes effectively 4. Enhances the resilience of crops and ensures stable yields. 5. Facilitates accurate and sustainable utilization of agricultural inputs and resources. 6. Advances yield prediction and minimizes potential risks 7. Strengthens protection of crops against soil erosion
Internet of Things	1. Facilitates accurate land suitability analysis and optimal crop placement 2. Integrates real-time weather data to support precision farming practices 3. Safeguards forests and promotes the preservation of biodiversity 4. Enhances crop monitoring and ensures consistent yield stability 5. Minimizes fertilizer waste and mitigates environmental impact 6. Strengthens disaster preparedness and resilience in agriculture
Artificial Intelligence	1. Optimizes irrigation systems and promotes efficient water conservation 2. Improves the precision of climate modeling and supports informed farm management decisions 3. Decreases reliance on pesticides and herbicides 4. Enhances environmental sustainability practices 5. Speeds up the development of crops resistant to climate stress
Nanotechnology	1. Enhances carbon sequestration efforts and contributes to climate change mitigation 2. Boosts nutrient use efficiency while minimizing greenhouse gas emissions
Robots	1. Lowers emissions from pesticides and fertilizers 2. Enhances safety measures on farms 3. Ensures precise harvest timing to reduce waste 4. Speeds up the detection and management of crop diseases
Blockchain	1. Promotes sustainable agricultural practices 2. Enables carbon trading and contributes to climate change mitigation efforts 3. Optimizes land management practices to minimize environmental impact 4. Enhances food quality and ensures greater transparency across the supply chain

Source: Own figure based on [21].

Remote sensing has revolutionized agriculture over the past decade by providing advanced tools to monitor, manage, and improve agricultural practices. It supports precision agriculture by providing accurate and actionable insights, enabling better decision-making and resource optimization.

The main applications include: Crop Monitoring, Assessing Windbreak Effectiveness, Water Management and Climate Monitoring, Intelligent real-time data collection, Yield forecasting and many other applications.

Crop Monitoring- Remote sensing technology enables real-time monitoring of crop health by detecting common issues such as stress, nutrient deficiencies or diseases through spectral data analysis. This helps optimize the use of agricultural inputs such as fertilizers and pesticides, ensuring they are applied effectively and sustainably. As a result, crop resilience improves, yields become more consistent and crop improvement programs benefit from targeted insights.

Assessing Windbreak Effectiveness- Remote sensing technology provides valuable data to assess the effectiveness of windbreaks in protecting soil health and preventing erosion. By analyzing this data, farmers can optimize water use efficiency and improve the effectiveness of other farming practices, such as mulching and contour farming, leading to better resource management and sustainable agricultural outcomes.

Water Management and Climate Monitoring- Remote sensing provides essential data for effective water resource management, including mapping irrigation systems and optimizing water use, which is of utmost importance to farmers. It also tracks environmental trends and climate-related changes, providing insights that support the development of effective adaptation strategies in agriculture. This helps farmers respond to climate variability and manage water resources much more sustainably.

Intelligent real-time data collection- When combined with other digital technologies used in precision agriculture, remote sensing enables real-time, data-driven management of agricultural operations. This integration improves soil health management, supports and optimizes water use efficiency, and ensures the sustainable application of agricultural inputs such as precision irrigation systems, leading to more efficient and environmentally friendly agricultural practices.

Yield forecasting- By predicting yields with precision, remote sensing helps farmers plan better and mitigate risks associated with market or environmental uncertainties. This makes the planning process easier and a very practical tool [21]. It helps make informed decisions regarding input management and resource allocation, increasing the efficiency and profitability of the farm as a whole.

Big Data (BD)

Big Data refers to huge and complex volumes of data that cannot be effectively managed, processed, or analyzed through traditional information management methods and tools. It involves the processes of collecting, storing and analyzing data that is generated at high speed, comes from various sources and is often unstructured or semi-structured. Big Data (BD) involves gathering, storing, processing, and analyzing vast volumes of information from varied and diverse sources [12].

In agriculture, BD offers numerous opportunities to address climate change through its applications in crop, water, climate and soil management. By enabling precision agriculture, data-driven decision-making, smart farming and predictive modelling [27]. BD can improve productivity and support climate change adaptation and mitigation strategies. Big data is transforming agriculture and environmental management, enabling more precise, efficient, and sustainable practices. It has enabled agriculture to become a sector where decisions are made based on information. Here are some key applications and their benefits: Early Detection of Water Stress in Orchards, Predictive Modeling for Water and Pest Management, Genomics for Crop Improvement, Regenerative Management of Crop Residues, Environmental Monitoring and Predictive Modeling, Sustainable Soil Resource Management.

Predictive Modeling for Water and Pest Management- The use of big data allows for accurate prediction of water shortages, which are a major problem for farmers in many parts of the world, as well as the prediction of pest outbreaks. By analyzing patterns and trends, it helps optimize resource allocation, ensuring efficient water use and targeted pest control. This data-driven approach supports precision agriculture, reducing waste and preventing the overuse of agricultural resources, leading to sustainable agricultural practices.

Early Detection of Water Stress in Orchards- The use of technology, based on collected data, helps indicate early signs of water stress and therefore helps with better and more precise irrigation control, which leads to yield improvements and better plant development.

Genomics for Crop Improvement- The large database of genetic information about plants is used to analyze and improve their qualities. It also contributes for better crop performance in severe weather conditions – droughts, colds and diseases.

Regenerative Management of Crop Residues- Using Big Data can help with better management of residues. Avoid burning and implement new methods. Considering the amount of Greenhouse gases coming from agriculture, using these methods can significantly decrease the Carbon footprint.

Environmental Monitoring and Predictive Modeling- Environmental Monitoring and Predictive Modeling - This approach, like the previous one, uses Big Data to tailor strategies to accurately track environmental changes. Analyzing trends and predicting future conditions, helps reduce emissions and supports the creation of integrated management plans that ensure adequate environmental protection and sustainability

Sustainable Soil Resource Management- Within this approach Big Data can be used to track models of behavior and based on the collected information to create models for the future. This can be strategically integrated in businesses to reduce emissions and promote sustainability.

RS and BD technologies are emerging as key tools for improving agricultural practices and environmental monitoring. They enable crop monitoring, yield prediction, and real-time data collection, supporting both adaptation (e.g., crop improvement) and mitigation (e.g., sustainable use of inputs). By providing accurate and timely information, these technologies help farmers make data-driven decisions to increase resilience, stabilize yields, and optimize resource use. Beyond farm management, BD applications address broader environmental challenges, such as water scarcity, pest outbreaks, and climate change. Furthermore, BD in genomics offers the potential to improve crop resilience through genetic adaptation.

Internet of Things (IoT)

The Internet of Things (IoT) has emerged as a key tool in addressing climate change. IoT-enabled devices, such as sensors, gather extensive data on soil moisture, weather patterns, and fertilizer levels. This data empowers farmers to optimize irrigation systems and enhance the overall efficiency of agricultural production [13].

Automated agricultural machines, like precision tractors, simplify essential tasks such as planting, sowing, and pesticide application, reducing the need for manual labour and optimizing resource use.

IoT is essentially an advanced system of computing devices, mechanical components, and digital machines, all equipped with unique identifiers [17].

Internet of Things (IoT) technology collects, transmits, and analyzes data from various sensors and devices embedded in precision agricultural equipment, machinery, and environmental systems. This technology helps farmers optimize their operations, and increase efficiency and productivity while promoting farm sustainability. Here are some key applications: Automated Crop Monitoring, Natural Disaster Early Warning, Weather Monitoring Systems, Soil Quality Assessment, Precision Fertilizer Management, Weather Monitoring Systems, and Forest Monitoring Systems.

Automated Crop Monitoring- It improves crop monitoring, leading to more stable yields and ensuring the implementation of effective and sustainable agricultural practices. This approach allows for timely interventions, when needed, leading to optimized crop health and effective resource management.

Natural Disaster Early Warning- Improves farmers' preparedness and response to natural disasters by helping communities and farming systems become more resilient to climate-related events such as floods, droughts storms, and hailstorms. This proactive approach minimizes damage and supports faster recovery.

Weather Monitoring Systems- Provides real-time weather data, enabling precision farming, and helping farmers make informed decisions about crop planting, irrigation, and resource management, leading to more efficient farming practices.

Soil Quality Assessment- It contains valuable information about soil qualities such as health and land suitability. This data gives the farmers the opportunity to make informed decisions, so they can maximise performance.

Precision Fertilizer Management- A useful tool, where precise fertilizer use is essential. Helps to ensure that the plants are receiving the right amounts of nutrients and at the same time reduce costs and minimize waste and environmental impact.

Forest Monitoring Systems- It is a tool used for the protection of forests, biodiversity preservation etc. Playing a key role in reducing risks for the environment [21].

Artificial Intelligence (AI)

Artificial Intelligence (AI) in recent years has become one of the most widely used tools to resolve problems and improve processes in agricultural businesses. The algorithms used in the process analyze large volumes of data, which enables farmers to make more informed decisions. AI though relatively new is more and more used by the farmers. Usually described as a system with a certain degree of autonomy. The applications of AI have a significant potential to address climate change [26].

The application of AI-based technologies has significant potential to address climate change and its impacts. The development of these technologies in agriculture is at a very early stage compared to other production sectors [11]. Artificial intelligence-based applications in agriculture: Pest identification and monitoring, climate forecasting and management, weed management, genomic and phenotypic analysis for crop breeding, water use optimization and irrigation efficiency.

Pest Identification and Monitoring- Pest Identification and Monitoring - AI helps to more accurately identify and monitor pests and diseases, enabling precise control. This reduces the need for widespread pesticide use, promoting environmental sustainability and more effective disease and pest management, supporting the sustainable use of agricultural resources.

Climate Forecasting and Management- The use of AI significantly improves the accuracy of climate models, providing farmers with much more accurate weather forecasts. This allows for better planning and informed decision-making, helping them adapt to changing climate conditions and anticipate and mitigate potential risks.

Weed Management- The use of artificial intelligence helps reduce the use of herbicides by ensuring precise weed control, which inevitably leads to reduced environmental impact and improved crop protection.

Genomic and Phenotypic Analysis for Crop Breeding- AI accelerates the process of growing climate-resistant crops (cold-resistant, drought-resistant, resistant to certain diseases, etc.) by analyzing genetic and phenotypic data, which allows for more precise and effective selection of characteristics that improve the adaptability of crops to changing environmental conditions.

Water Use Optimization and Irrigation Efficiency- The use of artificial intelligence in precision irrigation leads to efficient use of water resources, which is very applicable in the context of water shortages in many regions of the planet [21].

IoT and AI represent the future of precision agriculture, which is set to develop very rapidly in the future. Artificial intelligence applications, such as pest detection, weed control, and genomic analysis for crop breeding, support the sustainable use of raw materials and crop improvement. Importantly, these technologies reduce environmental impact and accelerate the development of climate-resilient crops. IoT enhances AI by offering real-time monitoring through a network of sensors and automated systems. From crop monitoring to precision fertilizer management and early warning systems for disasters, IoT improves both adaptation and mitigation efforts, enabling timely interventions that reduce waste, and emissions, and increase farm resilience.

Nanotechnology:

Nanotechnology in agriculture is used to implement new solutions and improve the efficiency of agricultural practices by manipulating matter at the nanoscale (billionths of a meter), which these technologies provide. By using agricultural nanotechnology to reduce the particle size of biochar, nanomaterials with improved physical properties and better biological efficiency for soil applications are created [24]. This improved product has an increased ability to improve carbon sequestration and reduce the very harmful emissions of methane and nitrous oxide from agricultural activities, contributing to efforts to reduce pollution from agriculture [23]. The use of microorganisms for the production of nanoparticles, which act as ecological nano factories. The use of diverse microorganisms: bacteria, fungi, yeasts, actinomycetes and microalgae, for the synthesis of nanoparticles presents great opportunities in agriculture, in adapting to climate change. With the help of these microorganisms, nano fertilizers and nano pesticides can be created, which provide a controlled release of active components in the process. [1].

Based on nanotechnology, innovative solutions have been created to improve soil conditions, which leads to efficient use of agricultural raw materials, hence more effective carbon capture in the soil and reduction of emissions into the atmosphere. The main applications of these technologies in agriculture are the production of nano charcoal and, the development of nano fertilizers and nano pesticides.

Production of Nano char for Soil Enhancement- As mentioned, it helps in capturing and storing carbon in the soil, greatly increasing its carbon storage potential and playing a major role in combating climate change.

Development of Nano fertilizers and Nano pesticides- their use improves sustainable agriculture by maximizing the efficiency of nutrient use and reducing greenhouse gas emissions released into the atmosphere, contributing to environmentally friendly agricultural practices.

Nanotechnology in agriculture offers a variety of opportunities for innovative solutions and sustainable development of agriculture and to address climate challenges such as drought, and extreme temperatures, through effective resource management.

Robotics:

Robotics in agriculture contributes to precision and efficiency, enabling tasks such as targeted spraying, automated harvesting, and disease and pest detection. These technologies reduce the use of pesticides and fertilizers, reduce emissions from agriculture, and improve crop health and yield stability. Robots are used in many sectors, but they are not yet widespread in agriculture, despite the advantages they provide, the main reason for this is their high cost. In recent years, they have increasingly begun to enter agriculture, providing innovative solutions to optimize processes, increase efficiency, and reduce the environmental footprint by reducing greenhouse gas emissions [19]. Robots have begun to find applications in performing various activities in agriculture: weed control [8], harvesting [29], disease recognition in large fields and their rapid treatment [17], pest control, etc. Robots Applications in Agriculture: Targeted Spraying, Disease Detection in Crops, Automated Harvesting.

Targeted Spraying- Robots with precision spraying capabilities minimize pesticide emissions, reduce fertilizer use, and ensure accurate dosing and precise application. This technology increases environmental safety and protects workers while promoting efficient use of resources. This leads to sustainable use of agricultural resources, fewer chemicals, higher efficiency, and many other benefits.

Disease Detection in Crops- Advanced robotic systems help in crop diagnostics and management, leading to improved overall plant health and promoting environmentally responsible farming practices. These systems use precision systems for early detection and management of plant diseases using advanced technologies such as computer vision, artificial intelligence, and a wide array of sensors.

Automated Harvesting- Automated harvesting robots are transforming modern agriculture by improving efficiency, reducing waste and ensuring optimal harvest times.

They go a long way towards addressing the acute labour shortage in agriculture. Robots replace or enhance traditional manual harvesting processes. Automated harvesting is an important step towards sustainable and resource-efficient agricultural systems that offer solutions to the challenges of modern agriculture [21].

The introduction of robots in agriculture provides opportunities for more precise and efficient management of agricultural processes. Precision spraying, precise detection of diseases and harvesting. The use of these innovations allows for to reduction of the need for the use of pesticides and fertilizers, which leads to lower emissions, while improving crop health and yield stability, which is the main goal of farmers. Another big advantage is the automation of agricultural processes, thus reducing the need to hire people. This can help solve the problem of labour shortages in agriculture.

Blockchain:

Blockchain is a technology that provides a reliable and transparent way to store and exchange data in the agricultural sector. It uses a decentralized network of computers to record information in a chain of blocks that is difficult to change or manipulate. Each block contains a record of information about the previous block. The main advantage of blockchain technology is the ability to create and store a digital history of transactions, providing increased immutability, transparency, and traceability.

Blockchain technology improves transparency and traceability in food production, and supports climate change mitigation through carbon offset projects and adaptation strategies, while promoting quality in the agricultural supply chain [10].

Blockchain technology in agriculture is transforming supply chain management by improving transparency and traceability, ensuring trust in quality and ethical practices. Blockchain allows for real-time traceability of raw materials, which prevents fraud and improves food safety, which is of utmost importance. Smart contracts automate agreements between farmers, suppliers and traders, accelerating the speed of payments and significantly reducing administrative costs. According to [34]: technologies such as Blockchain are very important for farmers, offering opportunities to support their adaptation to climate change through climate finance. The opportunities are for small farmers through easy access to tokenized credit platforms, microinsurance, group lending, collective financing, etc. In addition, blockchain can be used to easily monitor investments and assess the results of improved climate change adaptation management techniques. In the context of climate change mitigation, blockchain can help create a global carbon data community that can facilitate the monitoring and evaluation of carbon reduction efforts, as well as support the development of carbon markets. Blockchain Applications in Agriculture: Soil Improvement and Nutrient Management, Enhancing Food Production Transparency and Traceability and Monitoring Carbon Offset Initiatives.

Soil Improvement and Nutrient Management- The application of optimized land management techniques and the rational use of resources leads to significant improvements in soil health. These approaches minimize the negative impact on the environment, contributing to increasing the sustainability of agrarian ecosystems. ***Enhancing Food Production Transparency-*** By using traceability systems, promotes improved food quality and provides transparency throughout the supply chain. This approach supports sustainable agricultural practices and contributes to broader climate change adaptation goals. ***Monitoring Carbon Offset Initiatives-*** It supports the effective monitoring and evaluation of carbon offset projects, ensuring transparency in carbon trading. Accurate measurement and management of carbon emissions are important for reducing the impact of climate change. In food production, Blockchain technology offers opportunities to improve transparency and traceability of processes. By implementing greenhouse gas emission compensation projects and good adaptation strategies, these precise innovations indirectly lead to climate change mitigation and environmental protection. On the other hand, they shorten the supply chain of agricultural products, contribute to better quality and promote transparency [4].

The introduction of digital technologies into precision agriculture not only brings a step forward in solving the food security problems facing humanity, but it is increasingly clear that limiting the environmental impact of the sector is increasingly important. Digital technologies provide greater opportunities for this. Table 1 illustrates how digital technologies in precision agriculture contribute to reducing the effects of climate change. The introduction of digital technologies into agriculture is leading to increased efficiency and sustainability of agricultural systems while reducing their environmental footprint and contributing to global efforts to address climate change. Key to progress is expanding access to these technologies, especially in developing countries and to smallholder farmers. This includes improving infrastructure, reducing technology costs, and increasing farmers' digital skills, which will enable them to better take advantage of new technologies [2].

The development of digital technologies provides many options for improving traditional agricultural practices, which enhance sustainability in the long term The implementation of digital technologies in agriculture is also imperative in the context of the global challenges facing humanity[5]. On the other hand, precision technologies can lead to a transformation of rural areas that can lead to economic growth [14].

CONCLUSIONS

Based on the study, the following conclusions can be drawn:

The introduction of digital technologies in agriculture can be a major factor in reducing the impact of climate change and protecting the environment.

Precision agriculture has undergone development in the last decade due to the rapid introduction of new or improved technologies. Despite its undeniable benefits, there are many limiting factors to its implementation in developing countries, where technology uptake has been very slow compared to developed countries. The main reasons are high costs, lack of sufficient information, and trained professionals.

The aforementioned factors are also limiting the use of these technologies by smallholder farmers.

Digital technologies will be a key resource for sustainable development in the future and the modernisation of Agriculture. The transformation of the sector is making it more attractive to young people. The automation of processes leads to a reduction in the sector's dependence on labour, which is a major challenge for the farmers.

The potential of precision technologies to increase production efficiency and optimise the resources used plays an essential role in the growth of the sector.

The advent of digital technologies has an impact in the fight against climate change and will allow for more accurate measurement of reduced greenhouse gas emissions from the sector.

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ORGANIC FARMING POTENTIAL FOR CLIMATE CHANGE RESILIENCE AND ADAPTATION IN BULGARIA

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Abstract

Climate change is a global challenge, reshaping and transforming production and consumption patterns. In order to meet the EU Green Pact's ambitious objectives, agriculture has to reduce energy consumption and improve resource efficiency. Organic farming is a sustainable approach with a significant role in climate adaptation strategies, offering possible pathways for resilience and mitigation of climate change effects. The paper focuses on exploring the potential of organic farming in the context of climate change efforts. Given the complex influences, the study emphasizes the need to assess the benefits and challenges of organic farming while identifying opportunities for mitigating climate change. The survey is based on data from EUROSTAT and European Environment Agency methodogy. It conducts a systematic literature review on the prospects of organic farming in addressing climate change through resilience and mitigation. The results show that organic farming provides prospects for greenhouse gas emissions reduction, an adaptation of the farming system, soil fertility improvement and biodiversity maintenance. On the other hand, there are some challenges related to organic practices, such as lower productivity, market access and economic barriers, certification requirements and costs, and knowledge and research issues. The EU makes efforts to achieve climate neutrality, and agriculture is at the centre of the policies and regulations, which presents its essential role in green transformation.

Key words**:** *sustainable farming, greenhouse gas emissions, Green Deal*

INTRODUCTION

Climate change is a global challenge that is transforming the production and consumption systems. The Intergovernmental Panel on Climate Change (IPCC) report states “the global average temperature has increased by 1.09°C in the last decade compared to the pre-industrial period between 1850 and 1900”. [48]. Greenhouse gas emissions from human activities, including the agricultural sector, are considered major drivers of the temperature rise [4, 28, 47, and 78]. Agriculture significantly contributes to the issue while being highly vulnerable, particularly related to the crop production results. The sector is defined as the cause and victim of climate change by [64]. In order to achieve the goals presented by the EU Green Deal, agriculture has to minimize energy consumption and be more resource-efficient. [21, 93]. The EU Farm to Fork Strategy included “a reduction of the use of fertilizers by at least 20% and the use of chemical plant protection products by 50% “[22].

Climate change leads to new patterns of production closely linked to sustainable development. Climate-resilient paths of adaptation are essential steps toward a climate-neutral Europe. Sustainable agriculture systems are needed to help the agricultural sector transform and adapt to the changing weather conditions. Organic agriculture is defined as a sustainable way to produce food [77].

The EU Organic action plan targets “25% of the EU utilized agricultural area to be organic by 2030” [23].

The paper aims to outline organic farming potential in the context of climate change paths of resilience and adaptation. Due to the complexity of climate change impact, there are no simple answers.

Therefore, it is important to observe the benefits and challenges related to organic farming and to highlight future opportunities for climate change mitigation.

MATERIALS AND METHODS

The study is based on EUROSTAT data and follows the methodology provided by European Environment Agency [26].

The survey aims to present a systematic literature review directed towards the potential and prospects of organic farming in climate change adaptation, resilience, and mitigation. The methodological framework is based on the survey of [92]. The keywords used in the survey are: organic farming, climate change, adaptation, and resilience. Specific search criteria are applied to filter and sort the research terms. Articles, reports and documents that met the criteria are reviewed, with those outside the study's scope excluded.

RESULTS AND DISCUSSIONS

Agriculture's contribution to greenhouse gas emissions

Paris Agreement tend to combat climate change and boost the low-carbon economic development [29]. The document discusses two major aspects - emission reduction and capturing CO2 from the atmosphere [73]. In order to follow the Paris requirements, the European Climate Law is presented in 2021.

Greenhouse gas emissions from economic activities are related to anthropogenic climate change. The EU has an essential role in the attempts and steps to combat climate change by reducing greenhouse gas emissions and achieving climate neutrality [21].

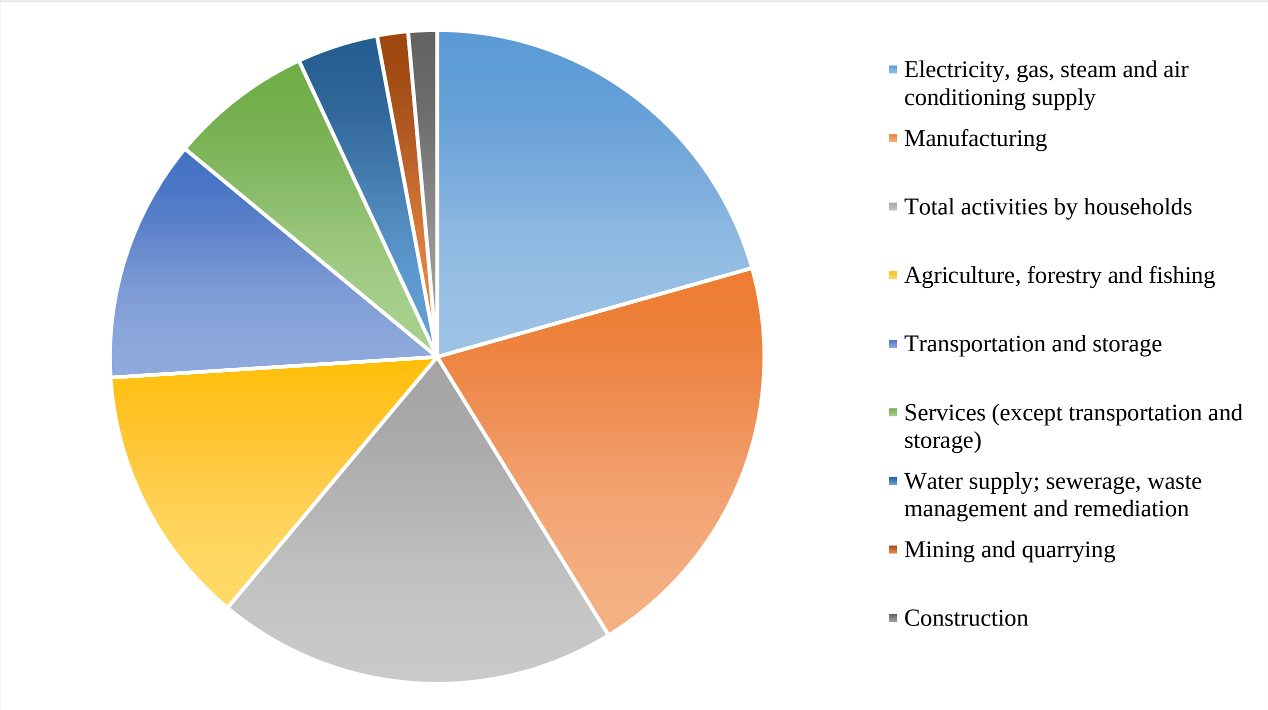

Fig. 1. Greenhouse gas emissions by NACE classification in the EU, 2022.
Source: [26].

According to Eurostat [26], greenhouse gas emissions decreased from 1990 to 2022. The latest data from 2022 shows that they are 3.5 billion tons of CO_2-equivalent, a reduction of almost 30% for 1990-2022.

Due to the COVID-19 crisis, the indicator dropped significantly in 2020, followed by a slight increase in 2021 and 2022. The target proposed for 2030, a reduction in emissions by 55% compared with 1990 levels, is still an ambitious goal.

At the national level, the highest decrease is registered in Germany (-485 million tons), Romania (-147 million tons) and France (-139 million tons). On the other hand, in three Member-states, a growth is recorded – Spain (+17 million tons), Ireland (+7 million tons) and Cyprus (+3 million tons). In Malta and Portugal, no difference is observed.

According to Eurostat data [26], greenhouse emissions are decreasing in almost all sectors, except fuel combustion in transport. The highest absolute reduction is recorded in the energy sector connected to electricity generation. Significant reduction is registered in fuel combustion in manufacturing industries and construction.

In 2022, the highest share of greenhouse gas emissions is concentrated in electricity, gas, steam supply and manufacturing, with around 21% (Figure 1). Agriculture, forestry and fishing generate 13% of the greenhouse gas emissions. It can be concluded that agriculture still remains a major contributor to the emissions and a cause of climate change and global warming. Mining and construction represented the lowest share of greenhouse gas emissions.

Based on the United Nations Framework Convention on Climate Change methodology, greenhouse gas emissions in agriculture represented 11% of all recorded in 2022 [26]. From 1990 to 2022, the sector decreased emissions by 117 million tons of CO_2-equivalent, or around a 24% reduction.

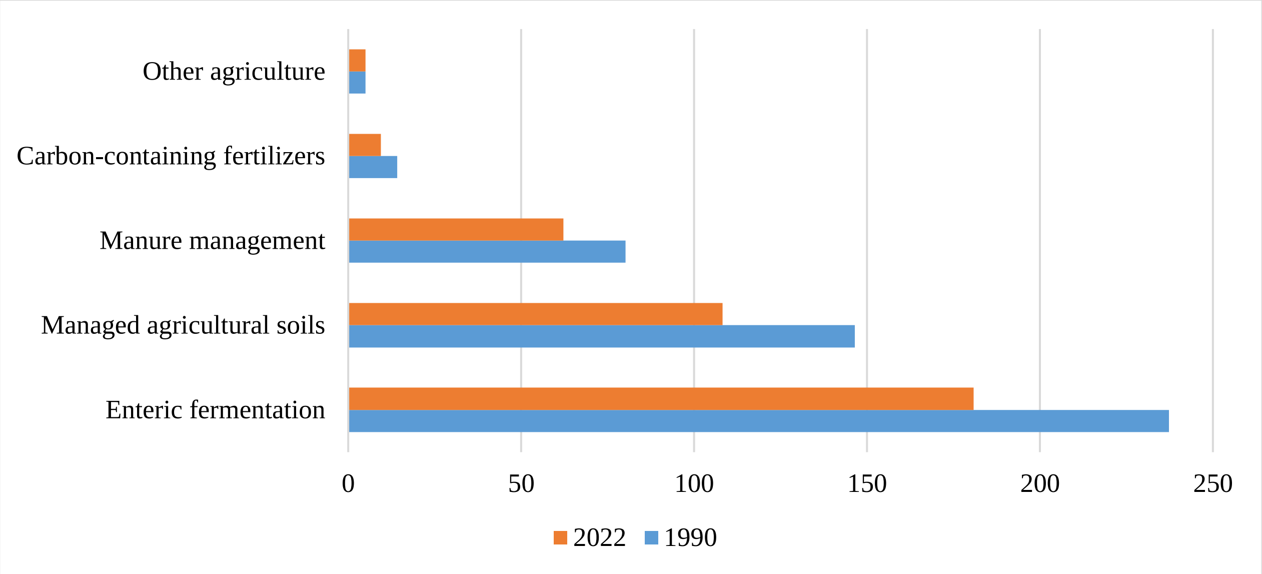

Fig. 2. Greenhouse gas emissions from agriculture, 1990/2022 (million tons of CO_2 equivalent)
Source: [26].

Methane emissions from enteric fermentation (49%) are the primary source of emissions, followed by managed agricultural soils (29%) and manure management (17%) (Fig. 2).

According to Eurostat data [26], for the period 1990-2022, enteric fermentation decreased by 24%. The main part of the emissions comes from cattle digestion. The highest decrease in this direction emerged during the first decade, and the emission dropped only 8% from 2001-2022.

Managed agricultural soil emissions decreased by 26% and carbon-containing fertilizers by 33%.

The EU archived serious progress in reducing emissions and has adopted several regulations, such as the Regulation on binding annual GHG emission targets by Member States for 2021-2030 and the Regulation on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework [26].

The agricultural sector is the centre of the global, European and national effort to adapt to climate change and improve resilience.

European Environmental Agency published a comprehensive study on climate change adaptation in the agricultural sector in Europe [19]. The document emphasized the policy context in fighting climate change effects and developing adaptation and mitigation measures (Figure 3).

International agreements and policies play a crucial role in setting the framework and shaping future patterns in climate change adaptation. The Paris Agreement is a major effort towards adaptation measures and

mitigation actions directed at achieving less vulnerability in food production systems [91].
The Paris Agreement highlighted the importance of resilience fostering and lowering greenhouse gas emissions targets in agriculture without endangering food security. [66]. The Paris Agreement led to the countries' commitments related to their priorities and measures. Most countries participating in the United Nations Framework Convention on Climate Change place agriculture at the core of their mitigation targets and adaptation strategies [19].
The Sendai Framework for Disaster Risk Reduction and the Sustainable Development Goals are other major milestones in global efforts for climate change mitigation, adaptation and resilience. The Sendai Framework for Disaster Risk Reduction establishes targets and outlines four key priorities for action related to deserter risk reduction, governance and responses [89]. The 2030 Agenda for Sustainable Development [90] is another substantial attempt to mitigate climate change, putting agriculture in different SDGs aspects. In addition, FAO (2018) also published a guide for the agricultural sector's transformation to achieve the UN targets [30].
On the other hand, agriculture can lead to negative impacts on soil, water, biodiversity, air quality [18]. Therefore, a number of regional and national adaptation strategies are developed.
At the EU level, policies are made to address the issues related to agriculture's environmental impact. At the national level, EU Member States implemented adaptation strategies and/ or action plans linked to their specific features and needs.
After 2013, in 2021, the new EU adaptation strategy was adopted. It included four principle objectives: “to make adaptation smarter, swifter and more systemic, and to step up international action on adaptation to climate change.” [24].
The Common Agricultural Policy (CAP) developed the main policy framework for the agriculture.

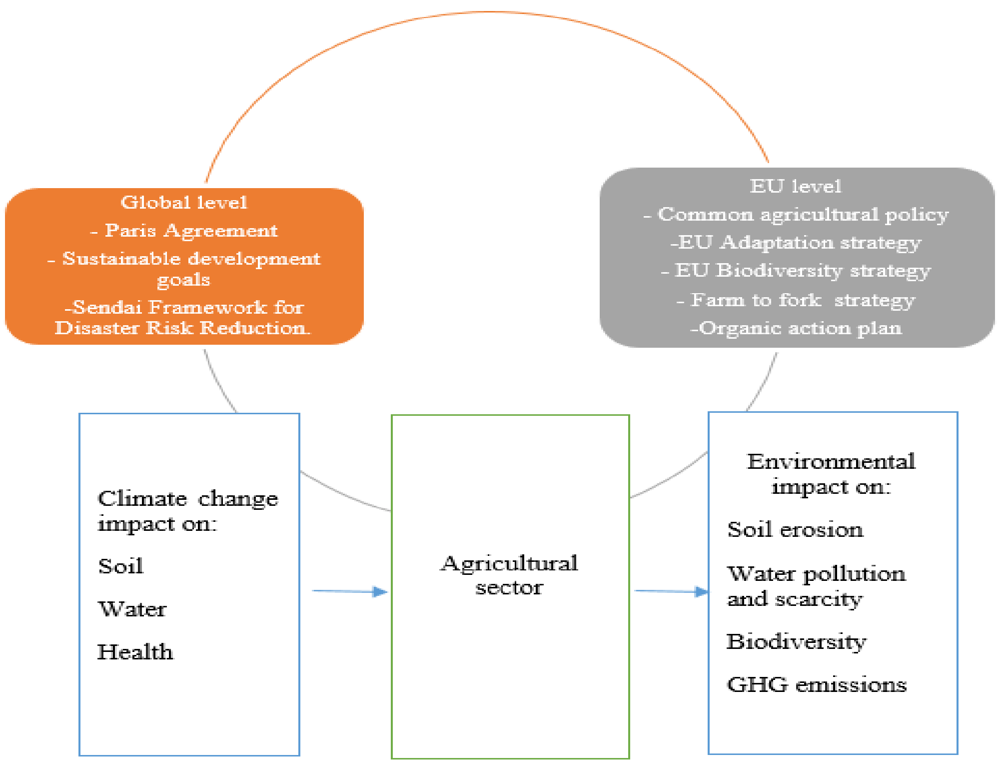

Fig. 3. International and EU policy framework for climate change adaptation in the agricultural sector
Source: Own survey based on [19, 50]

In the new programming period 2023-2027, the policy implemented higher greener ambition and efforts to achieve the Green Deal targets. In addition, there are eco-schemes (25% of the budget), and 40% of the CAP budget is climate-relevant [25]. Studies assessed the potential of CAP Strategic plans under Pillar II to help mitigate and adapt to climate change [12, 16, 60].

The EU adaptation strategy and the CAP allow Member States to help the agriculture sector adapt and be more resilient to climate change. Environmental policies on water management and biodiversity further support these efforts.

In addition, the Green Deal presented the Farm to Fork Strategy in order to ensure sustainable food production [22].

The 2019 report of EEA [19] proposed several measures for adaptation and mitigation to climate change. They include adapted crops, cover crops, crop diversification and rotation, no-tillage and minimum tillage, precision farming and organic farming. According to the document, organic agriculture has the potential to increase resilience toward extreme weather conditions [19].

Organic farming and climate change resilience and adaptation

Organic agriculture is a farming system that focuses on "biological pest control, crop rotation and composts to maintain soil fertility, with no use of synthetic pesticides and fertilisers" [45]. In recent decades, surveys have compared organic and conventional agriculture results and effects. At the beginning of the new century, a number of studies analyse the potential and impact of organic farming in mitigating climate change [39, 45, 51, 85].

There are serious efforts and global support for promoting organic agriculture as an option for climate change resilience [10, 70]. Its potential is linked to reducing greenhouse gas emissions while increasing soil carbon sequestration [45].

Recently, IFOAM EU and FiBL [44, 46] published two reports related to the role of organic farming in climate change mitigation and adaptation. Based on the literature review and surveys, the documents highlighted the main benefits of organic farming (Figure 4). The reports outline three groups of benefits linked to the organic farming systematic approach: (1) Mitigation of climate change; (2) Supporting adaptation to climate change; (3) Creation of resilient farming systems.

Based on the advantages highlighted by FIBL and IFOAM reports [44, 46], a literature review is made to observe the main features of organic farming's potential for climate change adaptation and resilience.

Long-term field experiments concluded that organic farming maintained and/or increased soil organic carbon and soil productivity [65, 71]. In the United States, studies indicated that organic amendments and cover crops led to a bigger accumulation of soil organic carbon [55, 62, 75].

According to [39], which show similar to the latest FIBL reports [44, 46], organic farming practices that can reduce greenhouse gas emissions and increase soil carbon sequestration are associated with (1) Lower fossil fuel consumption and reduced energy inputs. (2) Substitution of fossil fuels with organic biomass (3) Higher soil carbon sequestration in organic farms (4) Reduced carbon losses due to decreased soil erosion. According to some studies [58, 68, 72, 81, 86], organic farming systems reduce energy dependence and improve energy efficiency. Some authors outlined that energy inputs for organic production are 30% lower than for conventional farms [68, 69]. In organic farming, energy consumption is lower due to the lack of mineral fertilization [58]. Organic livestock farms are more energy-efficient than conventional ones [1], consuming 70% less energy due to reduced reliance on imported feed [54]. A study found that while organic farming relies more on machinery, the energy demand per hectare was 21% to 35% lower than conventional systems [67].

The improved agricultural practices and techniques in organic agriculture can lead to better soil structure, higher soil water infiltration [38, 57], and decreased soil erosion and carbon loss [38, 59]. Some authors [9, 79], considered that organic farming improves soil fertility.

Soil organic matter across the EU has declined due to land management in farms and climate conditions [84]. By improving soil quality and fertility, organic farming can help counteract this decline and significantly increase soil organic carbon sequestration compared to conventional agriculture [41, 52].

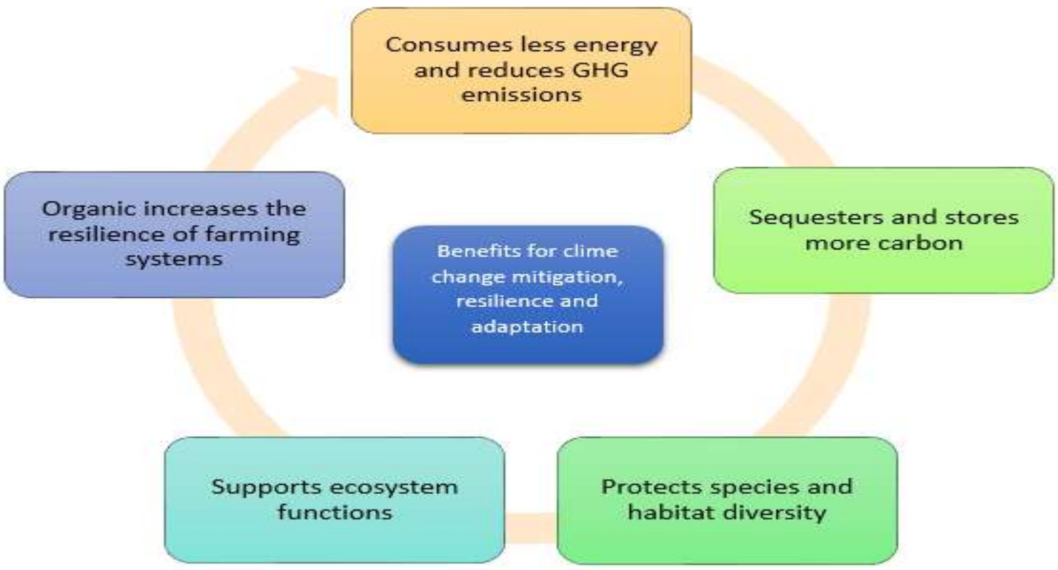

Fig. 4. The multiple benefits of organic farming for climate change
Source: Own survey based on [44, 46].

Organic agriculture is linked to a diverse range of crops, rotations, and farming practices [64], which improves farm resilience [7, 33, 35, 51, 59], and pest prevention [71, 96]. In addition, it optimises the use of soil water and nutrients [2].

Surveys concluded that fertilisation significantly impacts the carbon footprint in crop production [32, 49]. Several authors highlighted that organic farming can minimise nutrient losses [11, 13]. In addition, studies indicate that eliminating synthetic fertilisers can reduce global greenhouse gas emissions by about 20 % [77]. Organic farming could close the nutrient cycles and optimise nutrient availability to lower nitrogen levels. Some authors reveal that organic systems emit around 40%-45% less nitrous oxide per hectare compared to conventional [80].

Methane from enteric fermentation is a significant source of agricultural emissions, alongside nitrous oxide. Organic farming is related to strict limits on the number of animals per hectare to match the land's holding capacity [46].

According to Eurostat data [26], manure management concentrate around 16 % of the agricultural emissions. Manure composting has the potential “to reduce nitrous oxide by 50% and methane by 70% “[46].

Studies indicate that organic farming is capable of adapting to challenging environmental conditions while producing lower greenhouse gas emissions [5, 82, 95]. Skinner et al. [80] pointed out that that organic farms can produce significantly fewer emissions than conventional ones.

Furthermore, research shows that organic farming can help improve soil fertility, decline emissions, and boost climate resilience [94]. Some authors [34, 37] highlighted that organic agriculture leads to less emissions and is also environmentally friendly.

Climate change's consequences can be global challenges and probably will increase in the future. Healthy soils and higher soil organic matter improve water retention, reduce erosion, and enhance the resilience of organic farming to changing weather conditions.

Sustainable resource use, diversified production systems, and innovation are essential for building socio-economic resilience. Some authors outlined that organic farming can help farmers to adapt to climate change and be more resilient to extreme weather and land degradation [3, 39, 76].

Organic farming is an alternative that is closely linked to the concept of sustainable development [15]. The fight against hunger and poverty requires agricultural practices that preserve healthy ecosystems [15]. Several studies have analysed the relationship between organic production and the preservation of the environment [20, 82, 88].

The positive impact of organic farming systems on biodiversity is investigated in the scientific literature [7, 38, 59, 90, 87, 91]. Several studies show that organic farming promotes species diversity [43, 53] and supports rare insects [56]. Biodiversity in species and habitats strengthens adaptability to extreme weather events and environmental issues [17, 40].

Along with the benefits related to organic farming, there are number of challenges [42, 64, 83]. According to some authors, the major weaknesses of organic agriculture are lower yields and lower productivity. [8, 14, 63]. The lack of pesticides and herbicides in organic farming can make crops more vulnerable to pests, diseases, and weeds, especially as climate change has increased these threats. [64]. Certification costs present another challenge for organic farming, creating barriers, especially for small farmers due to the lack of resources [72]. In addition, there are some issues related to the procedures and administration of organic certification process [6, 38]. The market challenges are linked to the higher price of organic products [74].

Organic farming knowledge and best practices need more investment and funds. In addition, there are difficulties in knowledge transfer and sharing [77].

Organic farming in the EU and Bulgaria-trends and perspectives

Organic farming in the EU is essential to the EU Green Deal and Farm to Fork strategy [21, 22]. These strategic documents outlined ambitious targets. Although there are undoubling benefits related to organic farming, as provided by different studies, trends in the EU show that the established targets are unlikely to be achieved.

Different member states have diverse paths of development.

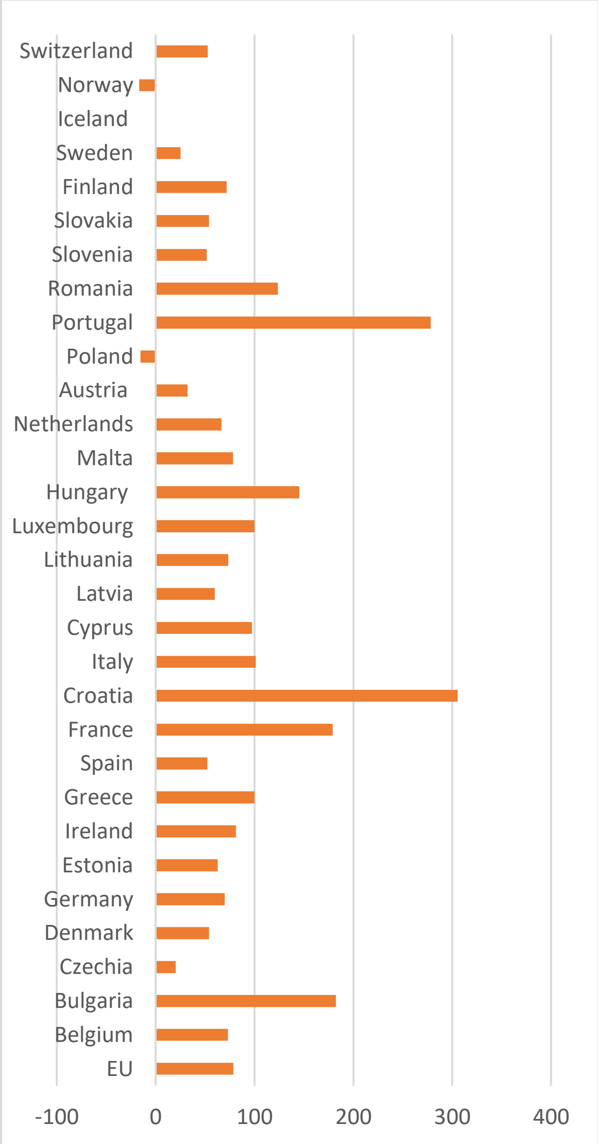

Fig. 5. Total organic area 2012/2022 (% change)
Source: [27]

The organic area in the EU continues to rise. In 2022, it is 16.9 million hectares (10.5% of the total UAA) [27]. For 2012-2022, the organic area increased in almost all member states. The highest share is registered in Croatia, Portugal and Bulgaria.

Austria, Estonia, and Sweden recorded the most significant shares of the total UAA organic area. On the other hand, five Member-states have a share below 5%, with the lowest level of indicator registered in Malta, Bulgaria and Ireland.

Based on Eurostat data, countries can be divided into: (1) close to or above the 2030 targets (Austria, Estonia, Sweden); (2) Likely to achieve the target -Italy, Portugal, Finland, Czechia, Denmark, Latvia; (3) The lagers with share between 7-10%; (4) six countries, the share of organic farming area was below 5% which have to consider prioritizing the sector.

Table 1. Indicators for organic farming and food processing in Bulgaria (in numbers), 2018-2022

Indicators	**2018**	**2019**	**2020**	**2021**	**2022**
Total producer operators	6,822	6,660	6,405	6,476	4,913
Farmers	6,471	6,213	5,942	5,313	4,352
Processors	181	234	249	330	286
Others (traders)	130	171	185	207	275
Importers	NA	26	22	27	43
Exporters	NA	4	2	5	5
Food processors	202	222	241	256	266
Fruit and vegetable processors	74	85	76	77	47
Dairy processors	12	24	26	23	19
Grain/ milling processors	5	5	3	8	6
Bakery processors	10	9	8	15	13
Vegetable Oils and Fats	23	30	47	52	37
Other food processors	58	59	78	127	140
Beverage processors	15	12	8	22	20
Wine makers Producers	11	12	8	14	9

Source: [61].

The Ministry of Agriculture database (2023) reports trends in organic farming in Bulgaria. The number of organic operators (farmers, processors and traders) decreased by 15% between 2021-2022 [36].

The number of organic farms in 2022 also reduced by 19 % compared to 2021.

The number of organic food processors also decreased by 14%. On the other hand, the number of traders continues to grow by 34 % to 275 companies, showing higher dynamics in the consumer market compared to local production and processing. This development was encouraged by consumer demand for processed organic products.

Organic farmers face number of challenges: labour shortage and administrative issues, insufficient capacity, despite official policies aiming to prioritize the organic farming and industry [36]. These key drivers have hinder the potential and production capacity of organic farming, making it less attractive.

According to the Ministry of Agriculture Report, the Bulgarian organic industry is not keeping pace with the growth of the broader organic markets in the EU [61].

Table 2. Organic retail sales (million €)

Years	EU	Austria	Romania	Bulgaria	Germany	France
2012	18,753	1,064.7	11.75	7	6,970	4,020
2013	20,068	1,064.7	14.15	7	7,420	4,383
2014	21,707	1,260	24.84	7	7,760	4,830
2015	24,924	1,360	24.84	15.05	8,620	5,534
2016	28,455	1,541.6	40.65	28.01	9,478	6,736
2017	32,162	1,723.2	40.65	29.21	10,340	7,921
2018	35,819	1,810	40.65	30	10,910	9,959
2019	38,994	1,920	40.65	30	11,970	11,295
2020	45,043	2,265	40.65	33.27	14990	12831
2021	46,665	2,397	40.65	32.97	15,870	12,659
2022	53, 100	2,657	41	38	16,080	12,018

Source: [31].

In 2022 the organic market in the EU is 53.1 billion €. Germany is the largest market in the EU (16.1 billion euros) and the second globally [31]. From 2012 and 2022, the EU organic market doubled by size.

In Bulgaria the organic industry is still developing. However, the higher consumer demand for organic products and the new lifestyle, alongside with the new EU policy supporting organic are drivers for growth and expansion.

Although the challenges should be outlined, organic farming provides a sustainable agricultural system with significant environmental and human health benefits and the potential for climate change mitigation and adaptation. Furthermore, organic farming promotes rural development and strengthens resilient communities.

CONCLUSIONS

Agriculture significantly contributes to greenhouse gas emissions while being influenced by climate change and extreme weather.

International and EU policies are directed towards agricultural sectors in order to mitigate climate change impact and build adaptive capacity. In this regard, organic farming has significant potential for enhancing resilience.

The literature review in the study shows number of benefits related to organic farming practices: reduction of greenhouse gas emissions, higher resource efficiency, improved soil structure and fertility, reduced soil erosion, maintaining biodiversity, and ensuring long-term agricultural sustainability.

Organic farming integrates sustainable practices to strengthen farming systems, enhance resilience, and adapt effectively to the challenges of climate change.

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MATHEMATICAL MODEL TO PREDICT OF THE SINGLE SCREW EXTRUDER DESIGN SPECIFICATIONS FOR FISH OIL EXTRACTION

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Abstract

Mathematical and prediction models provide solutions for designing machines and help determine the design factors for many models of different capacities and sizes. Fish oil extrusion machines play a crucial role in the production of fish oil, a valuable commodity widely used in various industries, including pharmaceuticals, food, and cosmetics. The design and performance of these machines significantly impact the efficiency and quality of fish oil extraction processes. In this study, we explore the predictive outcomes of scaling up design of a fish oil extrusion machine by different capacities and sizes. This scaling-up process aims to assess the feasibility and potential benefits of increasing the size and capacity of the extrusion machine. The results obtained from the program provided a lot of data on the geometric design of different sizes and capacities of the cold-press fish oil extraction machine. the mathematical model was predicted with design specifications as the hopper volume, discharge rate, capacity of screw conveyor, in the barrel, diameter of shaft, and power required by screw conveyor of the extruder based on the main dimensions, inlet diameter, hopper outlet size, and hopper height values, 0.06m^3, 0.3kg/s, 91.68kg/h, 0.13m ,18.4kw, 0.7m, 0.55m, 0.75m.

Key words: *mathematical models*, *oil extracting, extruder machine, design specifications*

INTRODUCTION

Engineering design and performance evaluation are important, especially for the cold-press fish oil extraction machine. Fish oil is primarily sourced from whole fish or their livers. However, certain fish by-products, particularly from processing fatty fish, can provide excellent-quality fish oil for human consumption. These by-products, such as trimmings, heads, tails, and skins, are often discarded in traditional processing methods.

Utilizing these by-products maximizes the output of vital nutrients such as omega-3 fatty acids while reducing waste. These by-products can be transformed into high-quality fish oil fit for human consumption with the right processing methods. This strategy provides an environmentally responsible and sustainable way to get this advantageous dietary supplement [7].

Often known as ω−3 or n−3 fatty acids, omega-3 fatty acids are a well-known type of polyunsaturated fatty acids that are known to have possible health advantages. The three main omega-3 fatty acids are docosahexaenoic acid (DHA), eicosapentaenoic acid (EPA), and alpha-linolenic acid (ALA). Both linoleic acid and ALA are classified as essential fatty acids, meaning they are necessary for human health but cannot be produced by the body [1].

In order to efficiently extract and process valuable omega-3 fatty acids and other vital nutrients from fish and fish by-products, fish oil extruder machines are a crucial part of the fish oil production process.These machines play a critical role in the aquaculture and seafood industries, providing a means to convert raw fish materials into high-quality oils used in various applications, including dietary supplements, pharmaceuticals, and food additives [14].

Usually installed on splined shafts, extruders have one or two intermeshing screws that can rotate either counter-rota tingly or co-rota tingly. All of these parts are included in a modular barrel. The extruder can operate as a positive displacement pump due to its special intermeshing, co-rotating twin screw design. Regardless of screw speed and pressure, this feature guarantees a steady throughput.Additionally, this design promotes efficient mixing of materials within the extruder. This module enables the collection of a liquid filtrate expelled from the material during compression [9].

Various extraction methods are employed to obtain fish oil, each yielding different productivities depending on the waste sources utilized. For instance, oil productivity from head, skin, off cuts, trimmings, viscera, and backbone frames ranges from 86 to 210 g oil per 1,000 g of waste. In the case of salmon by-products, oil productivity varies between 8.60% and 21.00% under constant pressure conditions. Furthermore, fish oil extracted from these sources is rich in functional EPA (eicosapentaenoic acid, 20:5 ω-3) and DHA (docosahexaenoic acid, 22:6 ω-3), making it highly beneficial for human consumption [4].

Cold pressing is widely preferred due to its versatility, simplicity, minimal manpower requirement, cost-effectiveness, environmental friendliness, and the absence of harmful organic solvents. This method offers high-quality oil production without subjecting the raw material to heat treatment, preserving its natural properties and Flavors. In cold-pressed extraction, pressure alone is used to extract oil, with little to no heat applied to the paste. Typically, cold presses are mechanized, often employing a screw device tightened against the paste to extract oils efficiently. While cold pressing may result in a lower yield compared to other methods, it ensures a superior quality of oil, making it a preferred choice for various applications [14].

Cold press extraction is not only energy-efficient but also environmentally friendly, making it a preferred method for obtaining fish oils. This process minimizes energy consumption compared to conventional extraction methods, contributing to sustainability efforts. Additionally, cold press extraction ensures the production of high-quality oils with enhanced purity. By avoiding high temperatures, which can degrade the oil's nutritional content and introduce unwanted compounds, cold press methods preserve the natural integrity and freshness of the extracted oil. As a result, fish oils obtained through cold press extraction are renowned for their exceptional purity and nutritional value, making them highly desirable for various applications [5].

During the cold pressing process, the weight of oil extracted from salmon by-products increased with longer pressing times, leading to higher oil productivity. Optimal conditions were achieved with a pressing time of 180 minutes, resulting in an oil weight of 93 g per 500 g of salmon by-products, an oil productivity of 18.00%, and an extraction efficiency of 98.46% at constant pressure [3].

The performance test conducted on the extruder demonstrated its effectiveness in extracting oil from Catfish (*Clarias gariepinus*) with high efficiency.The extruder's straightforward design made it easier to fabricate, operate, repair, and maintain locally. The extruder, which was driven by a 5 hp single-phase electric motor, demonstrated an outstanding average extraction efficiency of 90.40 percent.It was observed that the machine's performance parameters generally improved with an increase in machine speed, indicating its adaptability and responsiveness to varying operating conditions. Overall, the extruder's performance highlights its suitability for small-scale oil extraction operations, offering a reliable and efficient solution for local processing [2].

It is possible to divide the available configurations of the conveyor into four basic categories: Low-work screws (These screws are characterized by their gentle handling of materials, making them suitable for delicate or fragile products), Standard screws (versatile and cost-effective, making them a popular choice for general-purpose conveying tasks), High-shear screws (designed to exert greater force on the material being conveyed, resulting in more intense mixing or shearing action). and Vented screws (feature special configurations that allow for the release of trapped air or gases during conveying) [13].

Screw extruders are essential for processing highly viscous and multiphase systems, like fish oil extraction. Mixing is crucial in fish oil extrusion to ensure consistent quality. The extruder's screw configuration and parameters are carefully designed for efficient mixing, ensuring uniformity. Additionally, the modular barrel design allows precise control overtemperature, pressure, and residence time, enhancing mixing efficiency and optimizing oil extraction conditions. Operators can adjust these parameters to achieve the desired oil yield and quality [10].

utilizing Solidworks software to design and analyze extruder elements using the Finite Element Method (FEM) and fatigue evaluation of a press's single screw for obtaining fish oil. A feeder, nozzle (barrel), filter mesh, pressure chambers, screw axis, and waste output are among the machine's operational components [6].

The study aims to design a simulation to provide complex data to improve manufacturing processes for fish oil extraction extrusion machines.

MATERIALS AND METHODS

Development ofsimulation model to design and fabrication of extruder for fish oil extraction. The simulation model was designed and analyzed using the Solidworks program at the Department of Agricultural Engineering, Faculty of Agriculture, Tanta University, as shown in Fig. 1to extract fish oil by cold pressure to obtain Omega 3.

Fig. 1. Fish oil extruder machine
Source: Authors' designed.

1-Screw axis terminology and design assumptions.

The screw axis has a tapered shape with a pitch length twice the diameter of the screw, which increases in diameter in the initial half of the screw axis. In addition to viscosity and pressure, fish mixtures experience centrifugal forces of gravity and inertia. The screw axis extracts fish oil in three stages: the feed, compression, and metering stages. The feed stage, which has the same channel width along its length, collects the fish mixture in the screw extruder. The compression stage, in which the diameter of the screw gradually increases, further combines the fish mixture. The metering stage, which has a constant channel width, homogenizes or mixes unmixed fish pieces before pressing them into a homogeneous composition. As a result, this knowledge was used to drive the current design to improve both design and performance as shown in Fig. 2.

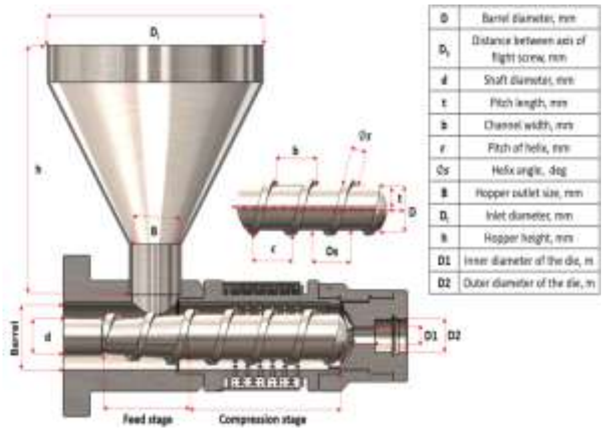

Fig. 2. Principle dimensionsof extruder machine design
Source: Authors' drawing.

1-1-Screw axle with tapered shaft and variable pitch.

Tapered Shaft: The shaft of the screw is tapered, meaning it gradually narrows or widens along its length. The tapering can be in either direction, depending on the specific design requirements. A tapered shaft can help control the compression and flow of the material being processed as it moves through the extraction chamber. It can also contribute to increased pressure and improved extraction efficiency.

Variable Pitch: The pitch of the screw refers to the distance between successive threads. In a screw with variable pitch, this distance changes along the length of the screw. This variation in pitch can serve several purposes:

- It can optimize the material flow and compression within the extraction chamber.
-It can provide varying degrees of pressure and shearing forces on the material, facilitating efficient oil extraction.
-It can help prevent material build up and clogging, ensuring the smooth operation of the extraction machine.

2-The conical type of choke mechanism.

-Conical Shape: The choke mechanism is shaped like a cone, with a gradually decreasing diameter from the wider inlet end to the narrower outlet end. This conical shape creates a narrowing pathway through which the material flows as it exits the extraction chamber.

-Flow Control: The conical choke mechanism serves to regulate the flow of material leaving the extraction chamber. As the material moves towards the discharge end of the chamber, it encounters the conical choke mechanism. The narrowing pathway created by the conical shape causes a constriction in the flow, effectively controlling the rate at which the material exits the machine.

-Pressure Regulation: In addition to controlling the flow rate, the conical choke mechanism also helps regulate the pressure within the extraction chamber. By creating a choke point where the material experiences increased resistance to flow, the mechanism can maintain optimal pressure conditions for the extraction process.

This pressure regulation is important for ensuring the efficient extraction of oil from the material.

-Residual Material Separation: The conical choke mechanism can also aid in separating the extracted oil from the residual material as it exits the extraction chamber.

The narrowing pathway created by the conical shape can cause the heavier residual material to settle and separate from the lighter oil, facilitating easier collection and further processing of the extracted oil.

3-Design of the Fish Oil Extractor

According to Khurmi and Gupta (2011)[8],Ngwu et al (2013) [11], and Olaniyan et al (2007) [12], the extruder parts are designed as follows:

3-1-Hopper

3-1-1Hopper outlet diameter, m

$$B = \frac{\sigma_C \, H_a(\theta)}{\rho g} \quad (1)$$

$$\sigma_c = \frac{F}{A} = \frac{\pi^2 E}{(\frac{L_u}{r_l})^2} \quad (2)$$

where:

σ_C= consolidated stress generated in an arch at the outlet, KPa
E=young's modulus, KPa
L_u=unsupported length of column, m
r_l=least radius of column, m
$H_a(\theta)$=Function
ρ=bulk density of material, kg/m^3
g=acceleration due to gravity, m/s^2

3-1-2 Hopper volume, m^3

$$V_h = \pi \frac{(D_i{}^2 - B^2)h}{12} \quad (3)$$

Weight of hopper, Kg=V_h x ρ ....(4)

where:

D_i= Inlet diameter, m
B= Hopper outlet diameter, m
h= Height of hopper, m

3-1-3 Barrel volume, m^3

$$V_{barrel} = \frac{1}{3} h(A_f + \sqrt{A_f A_c} + A_c \quad (5)$$

where:

A_f=The area at the feeding section, m^2
A_c =The area at the compression section, m^2

4- Stress in the conical part of the hopper

$$P_v = (\frac{\gamma_p . g . d . \mu_f . K}{4})(1 - \exp\left(-\frac{4 . H . \mu_f . K}{D_h}\right) \quad (6)$$

$$P_W = K \, P_V \quad (7)$$

$$\tau = \mu \, P_W \quad (8)$$

where:

P_v=Theoretical vertical pressure, N/m^2
$P_{w=}$Jansson pressure equivalent, N/m^2
τ = Shear stress in the conical part of the hopper, N/m^2
γp = bulk density of the powdered solids, Kg/m^3
μ_f=coefficient of friction of the material

H=height of the hopper, m
K=Janssen coefficient
d=shaft diameter, m
g=Earth's acceleration of gravity, m/s^2, and
D_h=diameter of the hopper, m

5- Screw axle and barrel design.

$\frac{a}{D_s} \leq \frac{\sqrt{2}}{2}$……………………………………(9)

$\alpha = 2\cos^{-1}(\frac{a}{D_s})$………………………....(10)

$\beta = \frac{\pi}{i} - \alpha$………………………………...(11)

$\emptyset_s = \tan^{-1}(\frac{t}{\pi D_s})$………………………....(12)

$b_{max} = t\cos\emptyset_s - \epsilon_{max}$…………………(13)

$h_{max} = D_s - a$…………………………...(14)

$t = 2\pi L_{Kn}/\delta j_{Kn}$…………………………(15)

$\epsilon_{max} = t\beta\cos\emptyset_s/2\pi$……………………...(16)

a=$\frac{D}{2}$…………………………..………...(17)

i=k×D…………………………………...(18)

H_{feed}= 0.11(D+25)…………………….…(19)

$H_{metering}$= 0.04(D+25)……………………(20)

where:
a=Distance between axis of flight screw, m
D_s=Barrel diameter, m
Dr=Root diameter, m
D= diameter of the screw, mm
K=A constant, typically ranging from 0.8 to 1.5 depending on the design and material properties.
H_{feed}=Channel depth in the feed stage, m
$H_{metering}$=Channel depth in the meter stage, m
α=intermeshing angle, degree
t=pitch length, m
L_{kn}=right-handed standard screw
J_{kn}=standard screw element
t=Screw pitch, m
Øs=Pitch angle, deg/ rad
ϵ_{max}=Flight width, m and
b_{max}=Channel width, m

6- Extrusion and die design.

Q= $15n\emptyset p\gamma(D^2 + d^2)\pi$………….……...(21)

$P_{sc} = 0.7355\ CIQ$………………….……(22)

$P = P_{sc}/Q_f$………………………………(23)

$F_w = PA$……………………………....(24)

$F_\theta = F_w \tan\emptyset_s$…………………………...(25)

$P_{die} = W/A_{die}$…………………………......(26)

$A_{die} = n\frac{\pi}{4}(D2^2 - D1^2)$…………………(27)

$\gamma = \frac{3n+1}{4n}(\frac{4Q_m}{\pi R^3})$…………………………...(28)

where:
P=operating pressure in the barrel, KPa
P_{sc}=power required by screw conveyor, kw
Q_f=flow rate of material, kg/s
γ= shear rate of the dough before the die, s^{-1}
n=power index=0.61
R= radius of the die hole, m
F_w=thrust force in the barrel, KN
A= area of extrude, m^2
F_θ=tangential force in the barrel, KN
$\emptyset_s$=pitch angle, Deg/ rad
Q=capacity of screw conveyor in the barrel.t/h
C=constant coefficient for conveyed material
I=length of the screw conveyor, mm
D_1=inner diameter of the die, m
D_2= outer diameter of the die, m
A_{die}=area of annular die, m^2
P_{die}=theoretical pressure on composite through die, KPa and
n=number of the holes of extruder.

7-Shaft design.

$Do^3 = \frac{16}{\pi\tau max}\sqrt{(Km\ x\ M)^2 + (Kt\ x\ T)^2}$...(29)

T=$\frac{P\ X\ 60}{2\pi N}$…………………….....................(30)

M=$\frac{W\ X\ L}{4}$…………………………………..(31)

$Te = \sqrt{(Km\ x\ M)^2 + (Kt\ x\ T)^2}$…………(32)

τ=$\frac{T_{ro}}{j}$……………………………………...(33)

$D_p = \frac{2}{3}D_o$………………………………...(34)

where:
Do^3= diameter of shaft, mm
P=energy, W
T=torque transmitted by the shaft, N.mm
N=rotational speed of electric motor, rpm
K_m=combined shock and fatigue factor for bending
K_t=combined shock and fatigue factor for torsion
T=internal torque of shaft, N.mm
W=central load, N
D_p=pitch diameter, m
L=length between supported bearings, m
M=maximum bending moment, N.mm

τ=torsional loading, Mpa
D_o= external diameter of shaft (worm shaft), m
J=the polar moment of inertia for a solid shaft, m^4, and
T_e=equivalent twisting moment, N.mm

8-Torqueof screw axle.

$T=\frac{P}{\omega}$……………………………………(35)

$\omega=\frac{2\pi N}{60}$…………………………………….(36)

where:
T=torque of screw axle, W
P=power requirement, W
ω=angular frequency, rad/sec
N=rotational speed of electric motor, rev/min

9-Power requirement.

Pe = 0.7355*Q*C*L…………………….……(37)

where:
Pe=Power required by screw conveyor, Hp
Q=capacity of screw conveyor in the barrel, Kg/h
C=constant coefficient for conveyed material
L=length of the screw conveyor,m

10-Discharge rate, Kg/h.

$W=0.58\rho_b g^{0.5}(B-k\ d_p)^{2.5}$…………...(38)

where:
B=Hopper outlet diameter,m
d_p=Particle diameter,m
K=coefficient of the frictional interaction between the material and the screw or barrel ranges from 0.1 to 0.3.
g=acceleration due to gravity, m/s^2
ρ_b=bulk density of material (kg/m^3)

The C++ programming language was used to build a set of algorithms to determine and predict the design specifications of the fish oil extraction device and predict the specifications of higher productivity with distinction of the design specifications.

The C++ plusProgramming Language is a general-purpose parallel programming language that includes all of C++ plus six new keywords. The processor object is a mechanism for controlling the area. An account may contain one or more processor objects. Inside the Handler object, serialized C++ code can be executed without modification. In particular, it can access local data structures.

Fig. 3. Flowchart of mathematical model for design of extruder machineto estimate the design specifications of fish oil extraction equipment. This program can compute hopper volume, m^3, Discharge rate, Kg/h, Capacity of screw conveyor in the barrel, kg/h and diameter of shaft, m. Also estimate vertical pressure acting downwards, N/m^2, Jansson Pressure Equivalent, N/m^2 , Shear stress in the conical section of hopper, N/m^2 and power required by screw conveyor, Kw.

It calculates the design specifications through known equations, through which the specifications can be given according to the design conditions.

Fig. 4, Flowchart of prediction model for design of extruder machine It predicts specifications at different production levels, distinguishing design specifications through linear equations and others derived from interrelated factors through which specifications can be given according to design conditions.

The hopper outlet diameter and discharge rate, the screw conveyor's power requirements and length, the material flow rate, and the barrel's operating pressure.

Additionally, the barrel's capacity for a screw conveyor, the number of screws rotating, the material hold-up, the extruder's reaction volume, barrel thrust force and area, barrel tangential force, and barrel thrust force.

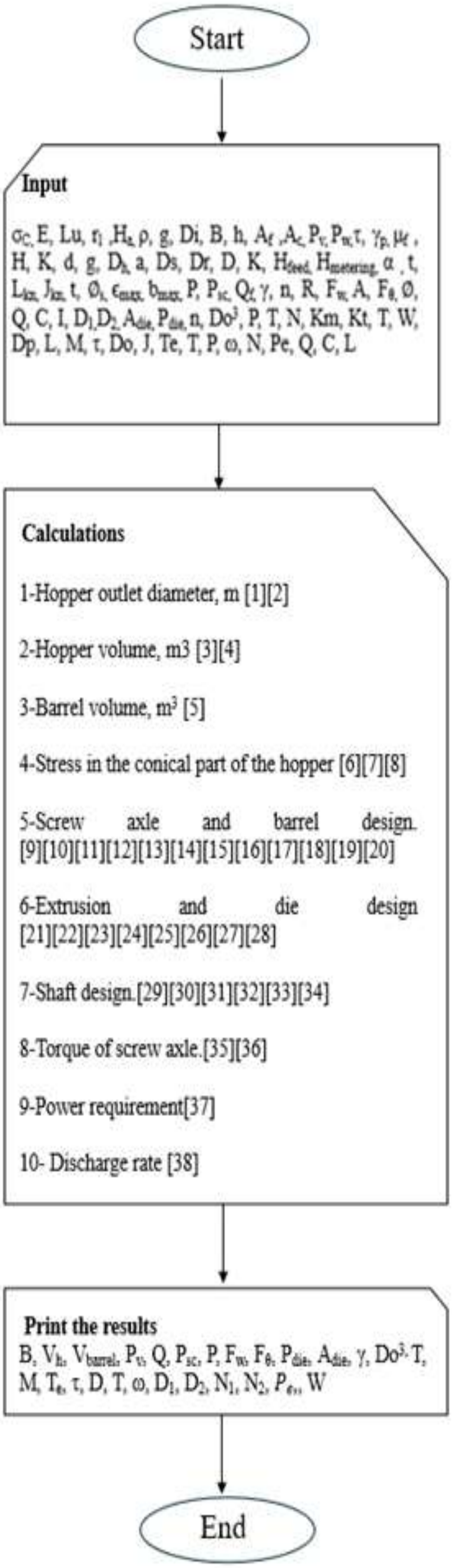

Fig. 3. Flowchart of mathematical model for design of extruder machine
Source: Author's determination.

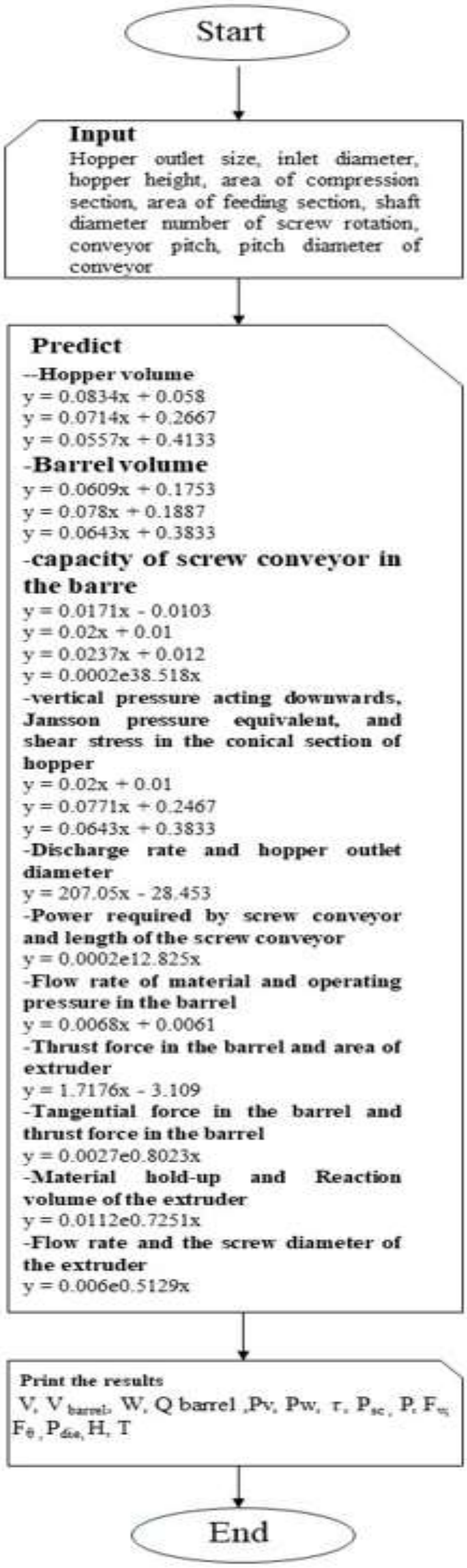

Fig. 4, Flowchart of prediction model for design of extruder machine
Source: Author's determination.

RESULTS AND DISCUSSIONS

It was possible to predict the hopper volume of the extruder based on the main dimensions, inlet diameter, hopper outlet size, and hopper height values, the results were shown in Fig. 5 the maximum value of hopper volume for the extruder machine was 0.068, with inlet diameter, hopper outlet size, and hopper height values were 0.70, 0.55, and 0.75 m, and the minimum value was 0.021 m^3, with the same principal dimensions were 0.30, 0.15, and 0.40 m, respectively.

The simulation model capable to predict with value of barrel volume and compression section in Fig 6.

The results showed a gradation of values between value of barrel volume was 0.08 m^3 with the area of feed, compression section vales were 0.25, and 0.20 m^2 and that with hopper height 0.40 while value of the same indicator was 0.39 m^3 with same previous principal dimensions of design were 0.64, and 0.52 m^2 with a high hopper value 0.75 m respectively.

The model can predict many values in Fig.7showed the values of capacity of screw conveyor in the barrel were 91.68 and 0.48 kg/h with values of conveyor pitch, pitch diameter of conveyor, and shaft diameter were 0.10, 0.16, and 0.13 m for maximum, and for minimum, the values of same indices were 0.015, 0.04 and 0.03m respectively.

As illustrated in Fig. 8, 9, and 10, the hopper height, shaft diameter, and hopper diameter were 0.75, 0.13, and 0.70 m. The vertical pressure acting downward, the Jansson pressure equivalent, and the shear stress in the hopper's conical section were, respectively, 54.79, 26.38, and 15.03 N/m2 at their maximum and 5.21, 2.08, and 1.19 N/m^2 at their minimum.

Fig.11 demonstrated that when the hopper outlet size increased from 0.15 to 0.55 m, the discharge rate results increased from 0.017 to 0.303 kg/h.

Also, Fig. 12 showed an increase in the power required by the screw conveyor from 0.04 to 18.40 kw with an increase from 0.45 to 0.91 mm for the length of the screw conveyor.

As illustrated in Fig 13, the material flow rate increased from 0.012 to 0.043 m3/h while the barrel's operating pressure increased from 0.003 to 0.089 Kpa.

Fig. 14showed an increase inarea of extruder values, the maximum value was 119.39 cm^2 with previous heights value of thrust force in the barrel 9.021 kN, and the minimum value for the same indicator was 0.014 m^2 with lowest values of second indicator 0.014 kN.

Fig. 15 demonstrated an increase in the intangential force in the barrel values. The lowest value for the same indicator was 0.004 kN, while the lowest values of the second indicator were 0.014 kN. The greatest value was 0.254 kN, with the prior height of thrust force in the barrel being 9.021 kN.

There is an increase in the results of material hold-up and reaction volume of the extruder and the minimum values were (0.056, and 0.08), and the maximum values of the same indices were (0.72 m^3, and 0.20) as shown in Fig. 16 respectively.

Fig. 1**7** shows an increase from 0.012 to 0.24 m^3/h, and from 0.03 to 0.13 m for flow rate and the screw diameter of the extruder respective.

Fig. 18 shows an increase from 0.2 (model 1 with 9kg/h) to 0.34 m/s (model 6 with90 kg/h as a production) for the number of screw rotations with the same increase in capacity of the screw conveyor in the barrel.

Mathematical model It calculates the design specifications through known equations, through which the specifications can be given according to the design conditions.

Table 1 shows thetechnical parameters of the single screw extrude, the design specifications of different production models of extruders. This program can compute for model M1(9kg/h)hopper volume, was 0.021m^3,Capacity of screw conveyor in the barrel was 0.480 kg/h and diameter of shaft was 0.030 m.Shear stress in the conical section of hopper was1.190N/m^2 and power required by screw conveyor0.047Kw.

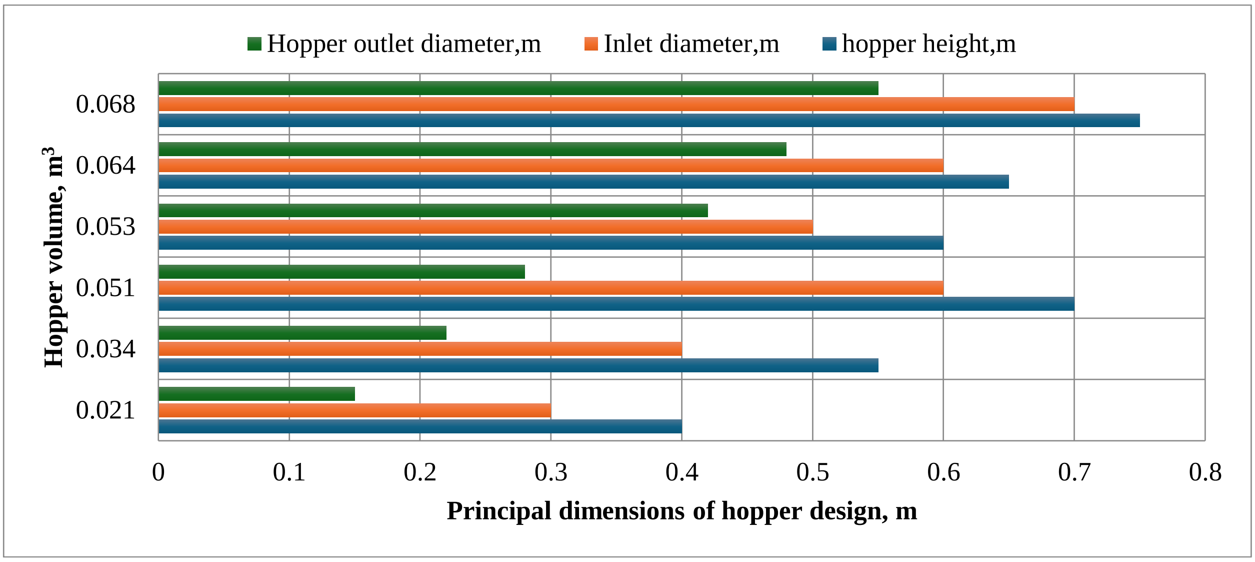

Fig. 5. Relationship between principal dimensions and hopper volume of hopper design
Source: Author's determination.

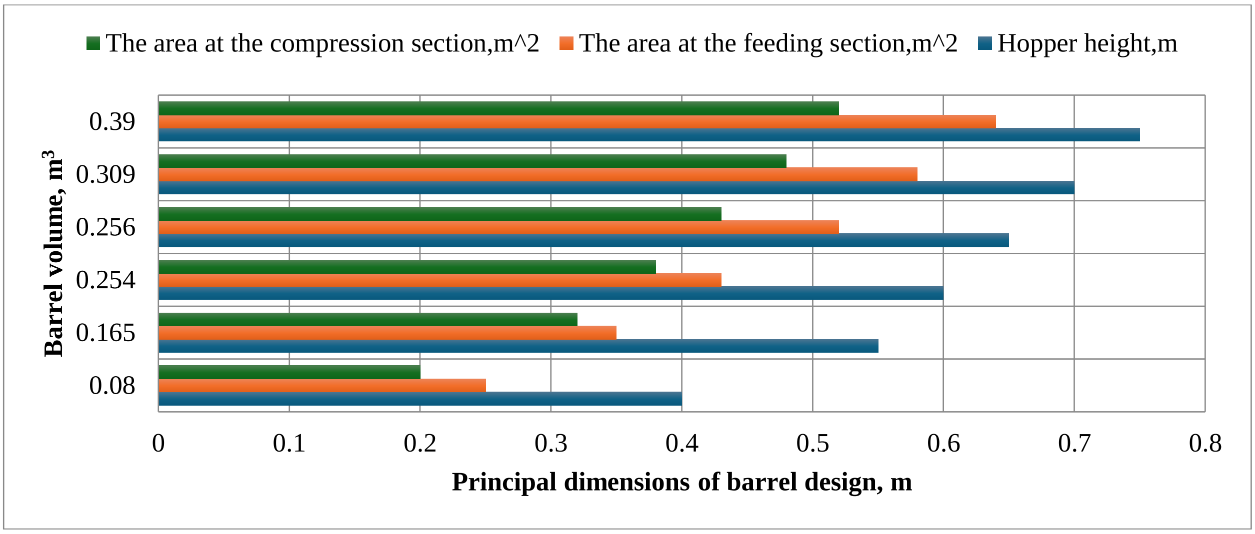

Fig. 6. Relationship between principal dimensions and barrel volume of barrel design
Source: Author's determination.

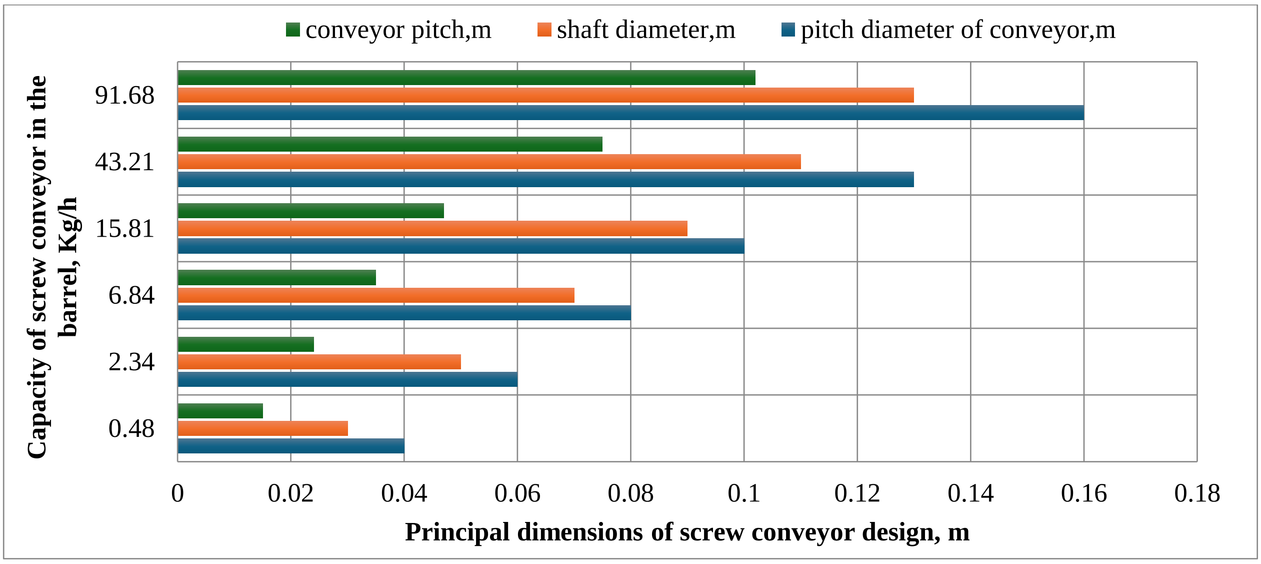

Fig. 7. Relationship between screw conveyor capacity and key screw design dimensions
Source: Author's determination.

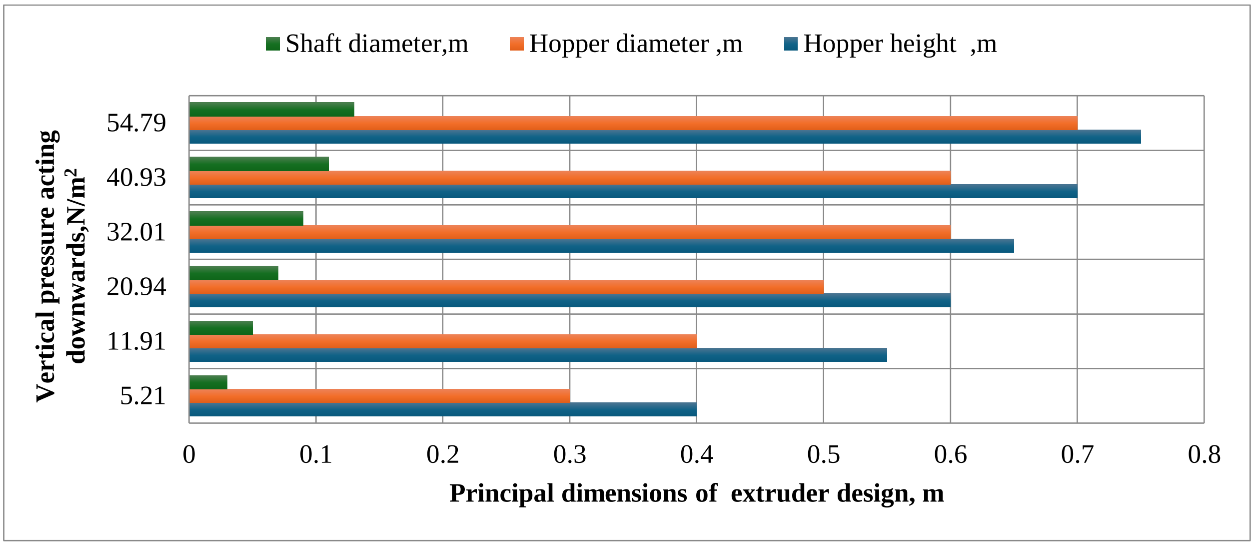

Fig. 8. Relationship between the main extruder design dimensions and vertical pressure acting downward
Source: Author's determination.

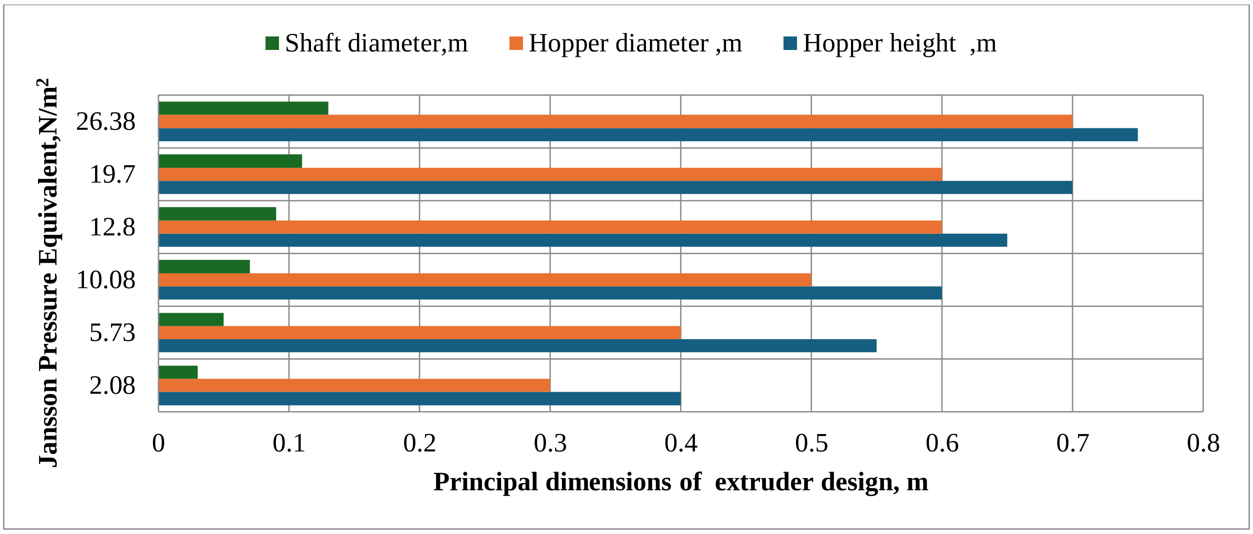

Fig. 9. Relationship between Jansson pressure equivalent and the main extruder design dimensions
Source: Author's determination.

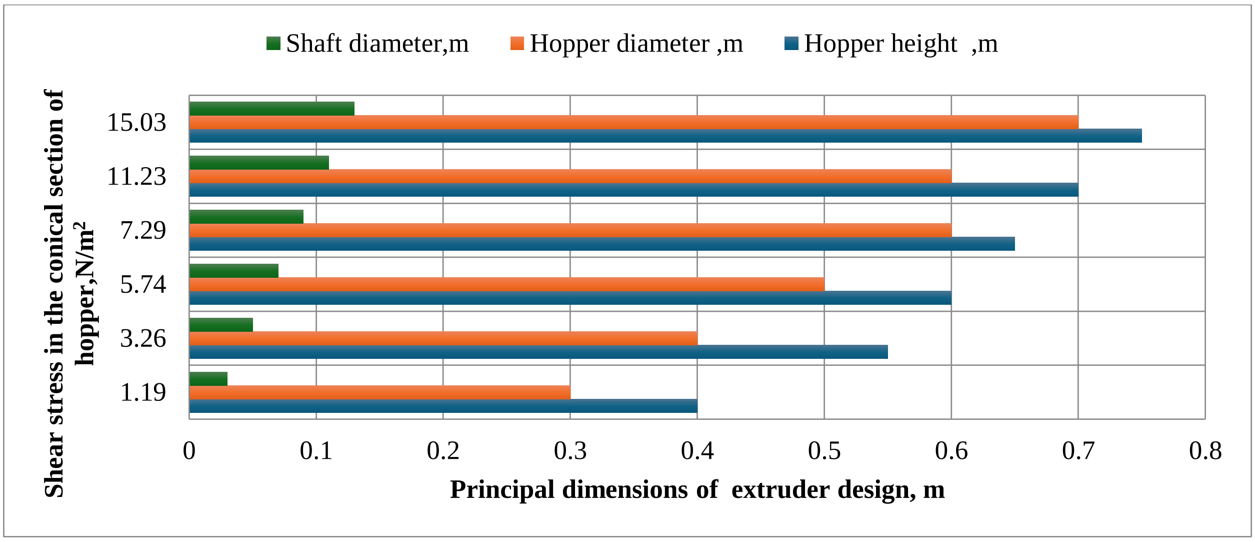

Fig. 10. Relationship between shear stress in the conical section of hopper and principal dimensions of extruder design
Source: Author's determination.

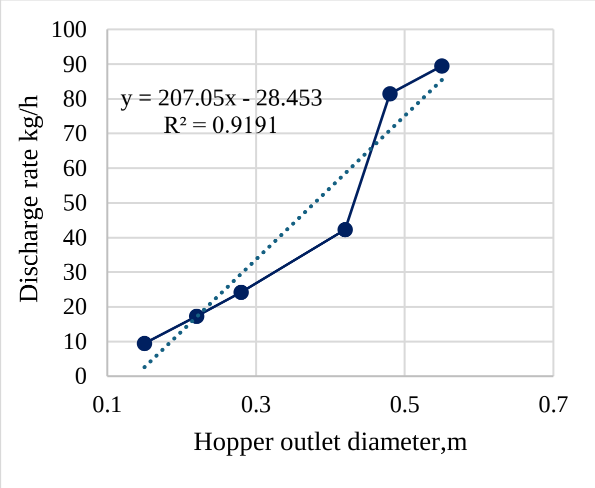

Fig. 11. Relationship between hopper outlet and diameter discharge rate
Source: Author's determination.

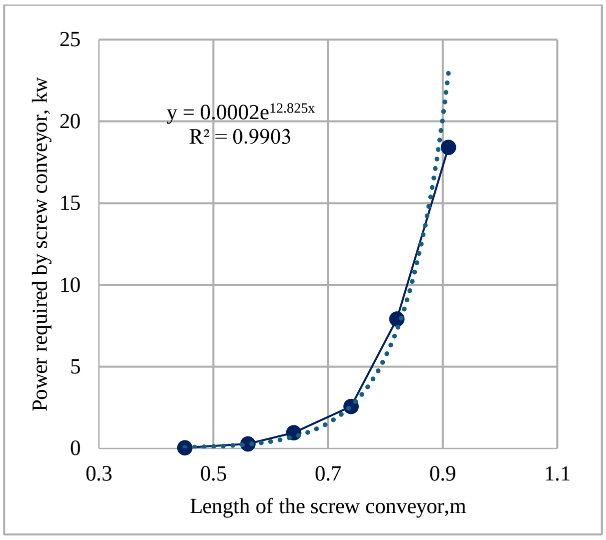

Fig. 12. Relationship between length of the screw conveyor andPower required by screw conveyor
Source: Author's determination.

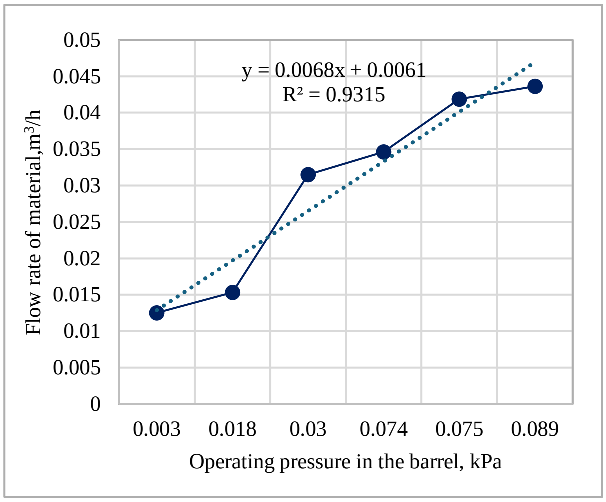

Fig. 13. Relationship between flow rate of material and operating pressure in the barrel
Source: Author's determination.

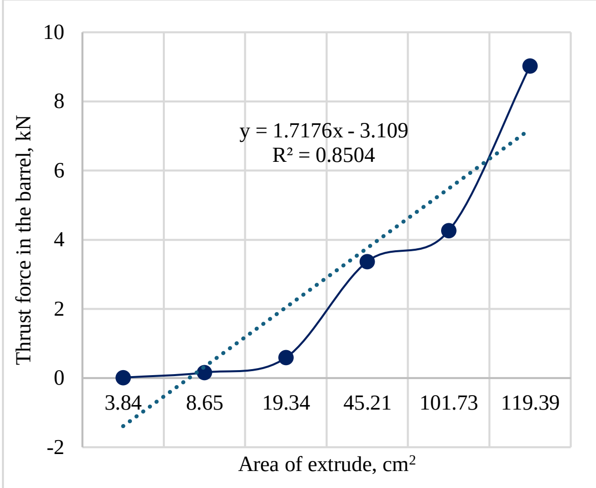

Fig. 14, Relationship between area of extruder and thrust force in the barrel
Source: Author's determination.

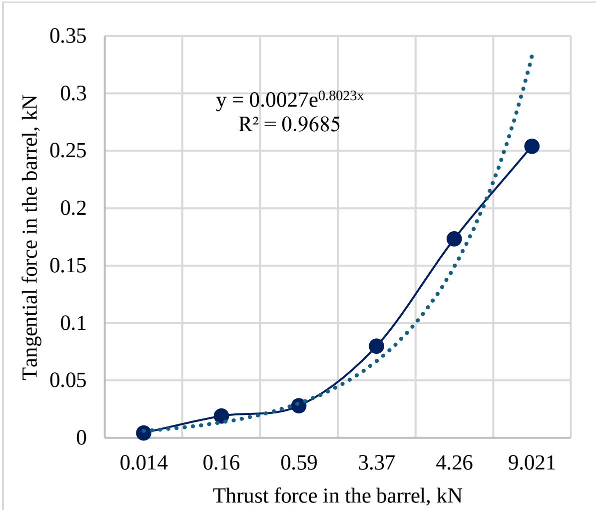

Fig. 15. Relationship between tangential force in the barrel and thrust force in the barrel
Source: Author's determination.

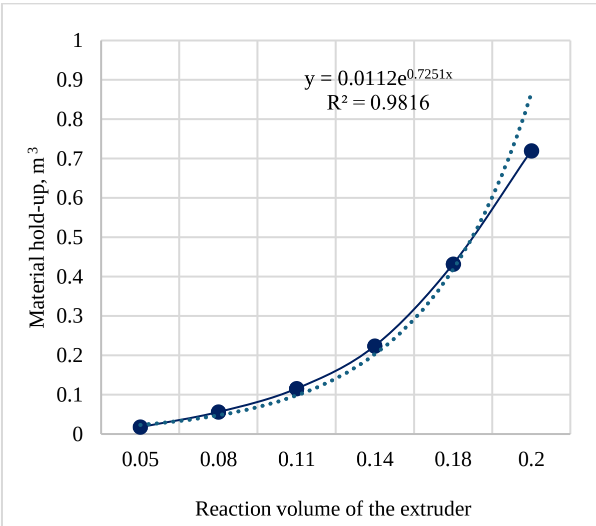

Fig. 16. Relationship between Reaction volume of the extruder and material hold-up
Source: Author's determination.

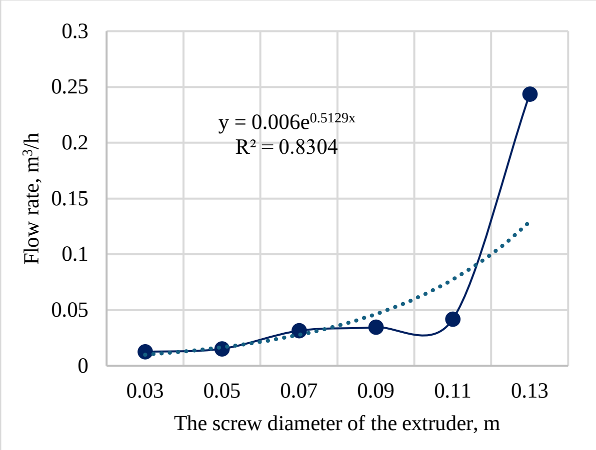

Fig. 17. Relationship between flow rate and the screw diameter of the extruder
Source: Author's determination.

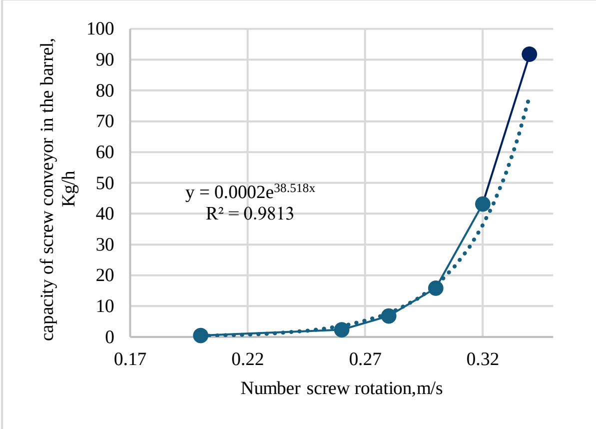

Fig. 18. Relationship between barrel screw conveyor capacity and screw rotation number for six extruder machine models
Source: Author's determination.

Table 1. Technical parameters of the single screw extruder

Indices	Acronym	M1(9)	M2(17)	M3(24)	M4 (42)	M5 (81)	M6(90 kg/h)
Hopper outlet size, m	*B*	0.15	0.22	0.28	0.420	0.480	0.550
Hopper volume, m^3	V	0.021	0.034	0.051	0.053	0.064	0.068
Volume of the barrel, m^3	V_{barrel}	0.080	0.160	0.250	0.250	0.300	0.39
Discharge rate, Kg/h	W	9.477	17.314	24.182	42.245	81.402	90.457
Capacity of screw conveyor in the barrel, kg/h	Q barrel	0.480	2.34	6.84	15.810	43.21	91.68
Diameter of shaft, m	Do^3	0.030	0.050	0.070	0.090	0.110	0. 130
Vertical pressure acting downwards, N/m^2	Pv	5.210	11.910	20.940	32.010	40.930	54.790
Jansson Pressure Equivalent, N/m^2	Pw	2.080	5.730	10.080	12.800	19.700	26.380
Shear stress in the conical section of hopper, N/m^2	τ	1.190	3.260	5.740	7.290	11.230	15.03
Power required by screw conveyor, Kw	P_{sc}	0.047	0.289	0.965	2.581	7.926	18.408
Operating pressure in the barrel, KPa	P	0.003	0.018	0.030	0.074	0.075	0.0890
Thrust force in the barrel, kN	F_w	0.014	0.160	0.590	3.370	4.260	9.021
Tangential force in the barrel, kN	F_θ	0.004	0.019	.0.27	0.080	0.173	0.254
Area of annular die, Cm^2	A_{die}	3.768	8.478	19.004	45.059	97.340	219.015
Theoretical pressure on composite through die, kPa	P_{die}	3.879	19.260	31.280	41.190	74.838	197.917
Material hold-up, m^3	H	0.017	0.056	0.115	0.224	0.432	0.720
Torque, Nm	T	0.047	0.289	0.965	2.581	7.926	18.408
Flight angle, Deg/rad	$\boldsymbol{\beta}$	40.381	42.500	46.390	49.464	54.019	58.288
Screw pitch, m	t	0.007	0.011	0.016	0.036	0.056	0.249
Pitch angle, Deg/ rad	Øs	0.357	0.535	1.239	2.277	6.654	16.554
Flight width, m	ϵ max	0.071	0.122	0.310	0.492	0.500	1.959
Channel width, m	b max	0.028	0.048	0.145	0.255	0.464	1.884
Cost, USD	$	80.42	130.78	209.82	302.57	425.19	628.58

Source: Author's prepared.

Table 2. Regression equations of the single screw extruder design

Indices		Regression	R^2
Hopper volume	Hopper outlet size	y = 0.0834x + 0.058	$R^2 = 0.9855$
	Inlet diameter	y = 0.0714x + 0.2667	$R^2 = 0.8242$
	Hopper height	y = 0.0557x + 0.4133	$R^2 = 0.7047$
Barrel volume	Area at the compression section	y = 0.0609x + 0.1753	$R^2 = 0.9576$
	Area at the feeding section	y = 0.078x + 0.1887	$R^2 = 0.9906$
	Hopper height	y = 0.0643x + 0.3833	$R^2 = 0.9382$
Capacity of screw conveyor in the barrel	Conveyor pitch	y = 0.0171x - 0.0103	$R^2 = 0.9413$
	Shaft diameter	y = 0.02x + 0.01	$R^2 =0.9578$
	Pitch diameter of conveyor	y = 0.0237x + 0.012	$R^2 = 0.9891$
Vertical pressure acting downwards	Shaft diameter	y = 0.02x + 0.01	$R^2 = 0.9827$
	Hopper diameter	y = 0.0771x + 0.2467	$R^2 = 0.9613$
	Hopper height	y = 0.0643x + 0.3833	$R^2 = 0.9382$
Jansson pressure equivalent	Shaft diameter	y = 0.02x + 0.01	$R^2 = 0.9827$
	Hopper diameter	y = 0.0771x + 0.2467	$R^2 = 0.9613$
	Hopper height	y = 0.0643x + 0.3833	$R^2 = 0.9382$
Shear stress in the conical section of hopper	Shaft diameter	y = 0.02x + 0.01	$R^2 = 0.9827$
	Hopper diameter	y = 0.0771x + 0.2467	$R^2 = 0.9613$
	Hopper height	y = 0.0643x + 0.3833	$R^2 = 0.9382$
Discharge rate and hopper outlet diameter		y = 207.05x - 28.453	$R^2 = 0.9191$
Power required by screw conveyor andlength of the screw conveyor		$y = 0.0002e^{12.825x}$	$R^2 = 0.9871$
Flow rate of material and operating pressure in the barrel		y = 0.0068x + 0.0061	$R^2 = 0.9315$
Thrust force in the barrel and area of extruder		y = 1.7176x - 3.109	$R^2 = 0.8504$
Tangential force in the barrel and thrust force in the barrel		$y = 0.0027e^{0.8023x}$	$R^2 = 0.9456$
Material hold-up and Reaction volume of the extruder		$y = 0.0112e^{0.7251x}$	$R^2 = 0.9847$
Capacity of screw conveyor in the barrel andnumber screw rotation		$y = 0.0002e^{38.518x}$	$R^2 = 0.998$
Flow rate and the screw diameter of the extruder		$y = 0.006e^{0.5129x}$	$R^2 = 0.81$

Source: Author's prepared.

The prediction model for design of extruder machine. It predicts specifications at different production levels, distinguishing design specifications through linear equations and others derived from interrelated factors through which specifications can be given according to design conditions. As showing Table 2.

Table 1 shows the difference in the costs of extruder screw manufacturing materials according to the productivity of the extruder and the required capacity. The extruder screw manufacturing cost was $80.40 for an extruder with a capacity of 9 kg/hour while it increases to $628 for an extruder with a capacity of 90 kg/hour.

CONCLUSIONS

The possibility of using a Mathematical program based on previously known equations to determine the design specifications for different models of extruder production, as well as a program that can predict through equations calculated from the interconnected relationships to determine the design specifications for different models of extruder production.

The models used in this research provide a suitable tool to unpack this complexity and making the problem solvable.

After giving general definitions for system terminology, model, simulation, prediction and developing appropriate equations to solve the complexities in the design of extrusion machines, especially those used in oil extraction.

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PHYSICAL AND COLOUR PROPERTIES OF SUGAR BEET AND BEETROOT SEEDS

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Abstract

In this study, we conducted a comprehensive analysis and comparison of the physical and colour properties of sugar beet and beetroot seeds. The research involved measuring key parameters alongside evaluating colour characteristics. By employing frequency distribution curves, we visualized the variations in these properties, providing insights into the differences and similarities between the two types of seeds. The findings revealed distinct patterns in the physical dimensions and colour attributes, contributing valuable information for agricultural practices, and seed selection. From the results, it is clear that the little differences in the average of length, volume, geometric mean diameter, surface area, elongation, roundness, shape index, browning index, and yellowness index were 6.29mm, 79mm^3, 5.2mm, 87mm^2, 0.85, 1.27, 1.2, 174, and 28 for beetroot, and for sugar beet the results for same indices were 6.4mm, 74.5mm^3, 5.06mm, 83mm^2, 0.9, 1.19, 1.3, 213.4, and 35.73 respectively.

Key words**:** *beetroot, sugar beet, seeds, physical, shape, colour properties*

INTRODUCTION

Around the world, beetroot is cultivated in temperate climates. Roughly 260–265 million metric tons of sugar beets, including red beets (also known as beetroot), were produced worldwide in 2023. This number hasn't changed all that much in the last few years. Germany, France, the United States, and Russia are among the top manufacturers. Although sugar beets are mainly farmed for their sugar, food products also use some of the world's production, particularly in North America and Europe [7].

Red beetroot has gained popularity recently since it is a rich source of bioactive substances, especially betalains. Because of their many health-promoting benefits, red beetroot betalains have a lot of potential as a functional food ingredient utilized in the medical and culinary fields. Betalains are naturally occurring pigments found in red beetroot, which primarily consist of red-violet betacyanins or yellow-orange betaxanthins. However, betalains exhibit poor stability during processing and storage due to their high sensitivity to heat, pH, light, and oxygen. Therefore, it's essential to comprehend how processing techniques impact beads.[11].

Beta vulgaris, the beet, is one plant in the Chenopodiaceae family. The most well-known of its several grown varieties is beetroot, a purple root vegetable that is also frequently referred to as table garden beet. The root food sugar beet, together with the leafy crops chard and spinach beets,which is crucial for the production of sugar, are examples of additional cultivated strains. Beetroot can be boiled, baked, or used to extract juice. It can also be eaten fresh. Red beets are great roasted, pickled, chopped and added to salads, or simmered and cooked into soup, a favorite in many of the countries of Eastern and Central Europe. Unlike fruits, sucrose is the primary sugar found in beets. Beets have been used in traditional medicine for hundreds of years to treat constipation, dandruff, and joint and intestinal pain. Extracts from red beets exhibit exceptional antioxidant properties, as well as antihypertensive and hypoglycemic properties, according to modern pharmacology. Their phytochemicals' encouraging effects on health protection point to a potential application for them in functional meals [12].

The approximate nutritional values of red beetroot are as follows: total fiber 87.4 g, fat 1 g, carbs 9.6 g, protein 1.6 g, vitamin C 10 mg, thiamine 0.02 mg, riboflavin 0.05 mg, niacin 0.4 mg, calcium 27 mg, iron 1.0 mg, and phosphorus 43 mg. Beet leaves are nutritionally valuable as well as its root, although they are eaten excessively infrequently. But red beets' distinctiveness has nothing to do with how nutritious they are.Alkaloids (128.8 mg), steroids (16.4 mg), glycosides (0.652 mg), flavonoids (6.15 mg), terpenoids (115.5 mg), saponins (3.789 mg), beta-carotene (11.64 mg), vitamins A (2.6 mcg), K (3.2 mcg), C (4.36 mg), E (0.18 mg), B3 (0.03 mg), B6 (90 mg), B2 (0.034 mg), pantothenic acid (0.151 mg), potassium (20 mg), iron (0.76 mg) are present in 100 g of this plant. Because of its high oxalic acid content, beet root may occasionally need to be considered as having less nutritional value. However, the secondary metabolites betalains, betaine, and nitrates are the most significant red beetroot phytochemicals in terms of their functional importance and advantages that go beyond simple health maintenance [4].

A member of the Chenopodiaceae family, which has its origins in Germany, beetroot (*Beta vulgaris* L.) is related to sugar, fodder, and silver beets. Although they are typically planted as annuals, beetroots are biennial plants that produce enlarged roots and green tops during their first growth season. Beetroot can be preserved in a variety of ways, including pickling and canning, or used in salads, pies, and as a hot vegetable combined with fish and meat. In addition to having high quantities of vitamin B1 and micronutrients, beetroot is a wonderful source of minerals, carbs, and protein [6].

When administered at the right rates, a sufficient supply of N fertilizers encourages growth in beetroot and boosts both output and quality. For beets to thrive, nitrogen is essential. This element is crucial for the growth of plants and is present in proteins, enzymes, and vitamins. Excessive application of fertilizer blends can cause crops to contain too much nitrogen. Since vegetables are the main source of nitrate in human nutrition, the accumulation of nitrate in fresh meals is concerning.However, the buildup of nitrate in beetroot can be harmful to human health. Nitrate can be converted to nitrite once it enters the human body, which can then enter the bloodstream and cause methemoglobinemia[13].

Beetroot, which is regarded as a vegetable, may benefit human health in a variety of ways. Beetroot juice has long been known to be good for the blood, heart, and digestive system. It is now recommended as an immune system booster and a cancer preventative. It is best grown in cool weather and can be produced virtually year-round. Cultivating beetroot in chilly, damp circumstances yields the highest quality results. The primary beetroot-producing regions in South Africa are Kwazulu Natal, the Western Cape, Mpumalanga, Gauteng, and the North West.Production locations have different sowing times. Locations with cool summers from the end of August to the middle of March and those with winter rains from August to the end of March are suitable for seeding. [18].

Beetroot farming requires a fertile soil that has all the nutrients essential to support quality, yield, and growth. There are wide variations in the quantity of nitrogen that soils can supply for plant growth. The type of soil, past cropping and fertilization methods, rainfall totals, and irrigation water use are some of the variables that affect how much nitrogen may be provided. Most recommendations for nitrogen fertilizer come from historical data on agriculture and fertilization. Although some of these suggestions appear reasonable, precise fertilizer recommendations for the best beetroot production necessitate the application of both soil and tissue testing techniques [19].

Latorre Consuming fresh fruit and vegetables is becoming more widely acknowledged to have important functional and nutritional benefits for human diets. Red beetroot has received more attention in recent decades because of its biological and nutritional qualities. However, not all customers find it to be pleasant and delectable because of its distinct scent and taste. Red beetroot is often consumed with various fruits and vegetables, such as apples, carrots, tomatoes, sour cherries, or sweet cherries. Red beets can be consumed raw, shredded for salads, thermally processed (by grilling, boiling, steaming, roasting, sautéing, canning, or even making chips), or powdered and added to other fortified goods [15].

Beetroot (*Beta vulgaris* L.), a member of the Chenopodiaceae family, has its origins in both Asia and Europe. Beetroot is recognized for its elevated levels of bioactive substances, including flavonoids, carotenoids, polyphenols, and betalains, which confer noteworthy nutritional and physiological advantages.Betacyanins, which give beetroot its red color, and betaxanthins, which give it its yellow hue, are the two types of betalains, the bioactive compounds present in beetroot. Red beetroot has large amounts of these pigments, which are composed of water-soluble nitrogen.They have been shown to have antimicrobial and antiviral properties, the ability to stop the growth of human tumor cells in vitro, inhibitory activity against cervical, ovarian, and bladder cancer cells, anti-inflammatory properties, and antioxidant and antiradical properties. Red beetroot also has a high nutritional content, including vitamins B and C [3].

Consuming fruits and vegetables on a daily basis has been shown to reduce the incidence of metabolic, degenerative, cardiovascular, and certain types of cancer. They are an essential component of a healthy lifestyle. A high concentration of fibers, vitamins, minerals, and phytochemicals—such as polyphenols, flavonoids, carotenoids, anthocyanins, etc.—as well as their potent antioxidant activity are the primary causes of this. However, because of their high moisture levels (typically above 85% (w.b.)) and metabolic activity, fresh fruits and vegetables are very perishable goods that spoil quickly if not treated properly [5].

Determining the color characteristics of seeds is essential to guaranteeing their safe passage through the cleaning and separation procedures. This study also looks at particular seed characteristics that might help with the creation of multi-seed planting devices.Notably, there are clear differences between faba bean and soybean seeds. The Hue value was 0.626 for faba beans, while it was 0.565 for soybeans. Furthermore, the intensity and browning index were 91.75 and 16.25 for faba beans, compared to 85.33 and 21.79 for soybeans, respectively [1].

This aids in the design of multipurpose equipment since it is necessary to identify the little variations in length, width, and thickness within the same variety of grain as well as grain that differs in variety but has comparable physical characteristics [8].

The average length, width, and thickness of soybean grains ranged from 5.39 to 5.96 mm,4.76 to 5.16 mm and 3.98 to 4.38 mm respectively. The geometric mean diameter increased from 4.66 to 5.05mm. and the sphericity decreased from 86.94 to 85.1%[9].

The study showed the correlation between RGB colour indices and lead concentration in leafy plants to distinguish heavy metal pollution and its effect on vegetative characteristics. The RGB indices provide a method to detect changes in plant health, allowing for early identification of pollution-related stress [10].

The study aims to compare sugar beet and beetroot seeds by examining their physical attributes, shape, and colour properties. This comparison will explain the differences and similarities between the two seed types, providing valuable insights into agricultural practices. Specifically, these findings can inform the design of metering plates for planting, enhancing planting efficiency and accuracy.

MATERIALS AND METHODS

The experiment was carried out through 2024 at the Department of Agricultural Engineering, Faculty of Agriculture, Tanta University, Egypt. The study focused on measuring the physical and shape properties of seeds and verifying differences in colour properties by analysing the RGB colour bands of sugar beet (*Beta vulgaris* var),and beetroot (Beta vulgaris) seeds.Fig. 1 shows the seeds of two types of beets.

Fig. 1. Sugar beet and beetroot seeds
Source: Authors' determination.

-Measurements and determinations.

-Physical properties.

The seeds' physical properties were meticulously measured to understand their fundamental characteristics as follows [16]:

-Geometric mean diameter (Dg), mm:

$Dg=(X.Y.Z)^{\frac{1}{3}}$……………………………(1)

-Arithmetic mean diameter (Da), mm:

$Da=\frac{(X+Y+Z)}{3}$ ……………………………(2)

-Volume (V), mm^3:

$V=\frac{\pi}{6}(X.Y.Z)$……………………………(3)

-Surface area (As), mm^2 :

$As=\pi(Dg)^2$ ……………………………(4)

-Area of flat surface, mm

$A_f=\frac{\pi}{4}(x.y)$……………………………(5)

-Area of transverse surface, mm

$A_t=\frac{\pi}{4}(x.z)$……………………………(6)

-Aspect ratio, mm

$A_r=\frac{x}{y}*100$……………………………(7)

-Sphericity (φ), %:

$\varphi=\frac{(x.y.z)^{1/3}}{x}=\frac{Dg}{x}$……………………………(8)

-Shape properties.

The shape properties of the seeds were examined to detail their geometrical characteristics follow[14]:

-Shape index of ellipse seed (SI):

$S_I=\frac{2\times L}{W+TH}$……………………………(9)

-Projected area (Ap), mm:

$A_p=\frac{\pi}{4}(Dg)^2$……………………………(10)

-Elongation (E):

$E=\frac{X}{Y}$……………………………(11)

-Roundness (R):

$R=\frac{Ap}{Ac}$……………………………(12)

-Flatness index:

$F_I=\frac{L+W}{2H}$……………………………(13)

-Circularity index:

$I=\frac{4\pi x Area}{(Perimeter)^{\wedge}2}$……………………………(14)

-Area of ellipse:

$A=\pi.a.b$ ……………………………(15)

-Perimeter of ellipse:

$P=\pi\sqrt{2(X+Y}$……………………………(16)

where:

x: length of grains (mm),

y: width of grains (mm) and

z: thickness of grains (mm)

-Colour properties

The colour properties of the seeds were analysed using RGB band measurements to capture their colour characteristics accurately and to help in distinguishing between the seeds according to [2]and[17]:

-Hue

$H=\cos^{-1}(\frac{\frac{2R-G-B}{2}}{(R-G)^2+(R-B)+(G-B)^{0.5}})$……………(17)

-Intensity

$I=\frac{1}{3}(R+G+B)$……………………………(18)

-Browning index

BI=

$100\frac{(X-0.31)}{0.17}$……………………………(19)

$X=\frac{(a+(1.75*L)*a}{((5.645*L)+a-(3.012*b)}$………………… (20)

-Yellowness index

YI=142.86*(a/L)……………………………(21)

where:

RGB =Red, Green, Blue Bands

L=lightness of the colour, which range from 0(dark) to 100 (white).

a =indicates green colour.

-b =indicates blue colour

+b =indicates yellow colour.

RGB bands were convert to Lab as shows in Figure 2.

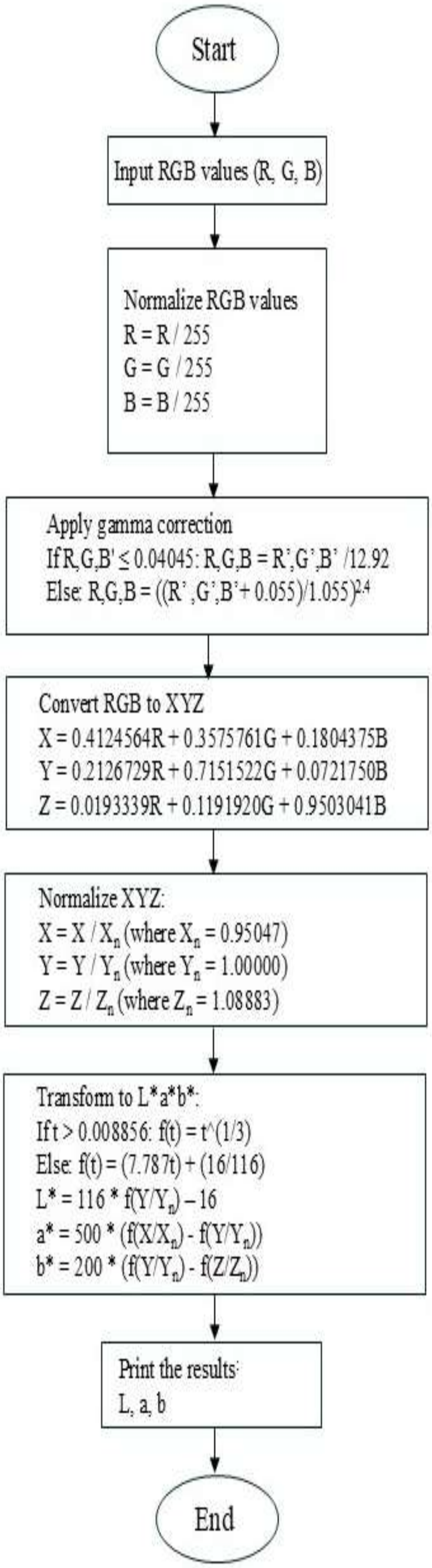

Fig. 2. Flowchart of mathematical model for convert RGB band to L*a*b band
Source: Author's determination.

RESULTS AND DISCUSSIONS

Frequency was used to analyse the physical, shape, and colour properties of the seeds by visualizing the distribution of various measurements, and we could observe that in the results.

Fig. 3 indicates that beetroot seeds generally have a higher frequency at smaller lengths, with the largest seeds measuring around 5.5 mm and representing approximately8% of the total seeds. In contrast, sugar beet seeds exhibit a higher frequency at larger lengths, with the largest seeds being around 7 mm in length and accounting for about 7% of the total seeds according to the frequency distribution. Results show a convergence of seed width values for the two types of beets, where the largest width of beetroot seeds was 8 mm by 14%, and the largest width of sugar beet seeds was 8.5 mm by 11% respectively as shown in Fig. 4.

Fig. 5 shows the similar maximum value of thickness for beetroot and sugar beet were 2.5 for both by 10%, and 15% respectively.

Fig. 6 shows an increase in volume values to 73 mm^3 by 6%for beetroot seeds and by 8% for sugar beet seeds. Geometric, and arithmetic mean diameter ranged from 3.5 to 7.2 mm, and from 4.3 to 7.4 mm for beetroot seeds, also increased from 3.33 to 6.86 mm, and from 4.11 to 7.01 mm for sugar beet seeds as shown in Fig. 7, and Fig. 8, respectively.

For sphericity, the results showed thatbeetroot seeds have their highest frequency at a sphericity range of around 85-90%, while sugar beet seeds peak earlier at around 65-70% as shows in Fig. 9.

Fig.10, Fig. 11, Fig. 12 demonstrate the results of the frequency distribution curve of the area of the flat, transverse surface frequency distribution curve were ranged from 18.8 to 58.4 mm^2, and from 4.86 to 39.5 mm^2 for sugar beet seeds, while ranges from 17 to 63 mm^2 and from 6 to 38 mm^2 for beetroot. Also, for surface area, the value ranged from 34.7 to 148mm^2, and from 39 to 162 mm^2sequentially.

Fig. 13 illustrates the maximum and minimum values of elongation indicator for beetroot, and sugar beet seeds were (1.73, 8.68 mm), and (0.40, 0.49 mm) respectively.

Fig. 14 illustrates the results of the frequency distribution curve for the projected area. The curve for beetroot seeds ranges from 9.7 to 40.38 mm², while for sugar beet seeds, it ranges from 8.68 to 37.54 mm².

Fig. 15, and Fig. 16 showed an increase in the results for flatness from 1.12 to 5.29 and from 1.06 to 5.58 for beetroot and sugar beet seeds, while roundness values were increased from 0.58 to2.47 and from 0.59 to 2.05respectively for two types of seeds.

Figs. 17 and 18 show an increase in circularity index values, ranging from 1.06 to 2.23 for beetroot seeds and from 1.16 to 2.50 for sugar beet seeds. Meanwhile, shape index values increased from 0.57 to 2.04 for beetroot seeds and from 0.63 to 2.11 for sugar beet seeds, respectively.

Fig. 19 showed the different values for beetroot seeds. The red colour band ranged from 75 to 158, in greenband ranged from 32 to 122, and in blue band ranged from 14 to 95, and for intensity ranged from 45.33 to 116. Also, for sugar beet, the redband ranged from 95 to 124, in greenband ranged from 28 to 76, and in blue band ranged from 18 to 58, and for intensity ranged from 60.33 to 76.33 respectively.

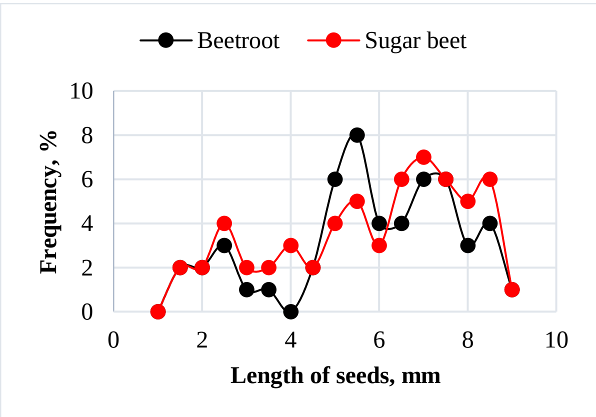

Fig. 3. Frequency distribution curves for the length of beetroot and sugar beet seeds
Source: Authors' determination.

Fig. 20 showed the maximum value of Hue, and red-green ratio of beetroot and sugar beet were (0.65, and4.8), and (0.69, and 4.42). For browning index, the results ranged from 37.02 to 35.5 for beetroot seeds, and from 101.81 to 271.65 for sugar beet seeds. While yellowness index was ranged from 7.32 to 85.4 for beetroot seeds, and from 29.4 to 214.08 for sugar beet seeds respectively as showed in Fig. 21.

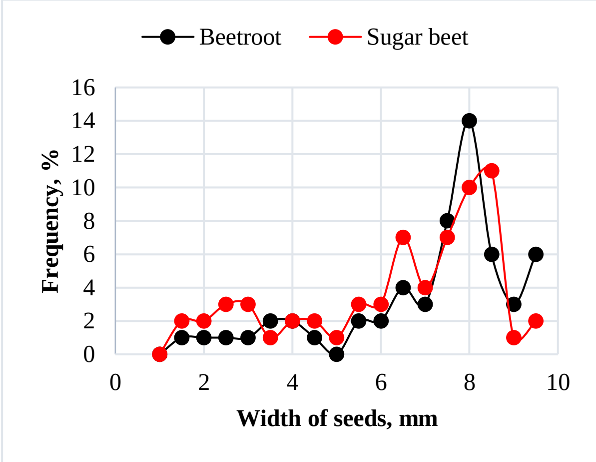

Fig. 4. Frequency distribution curves for sugar beet and beetroot seed width
Source: Author's determination.

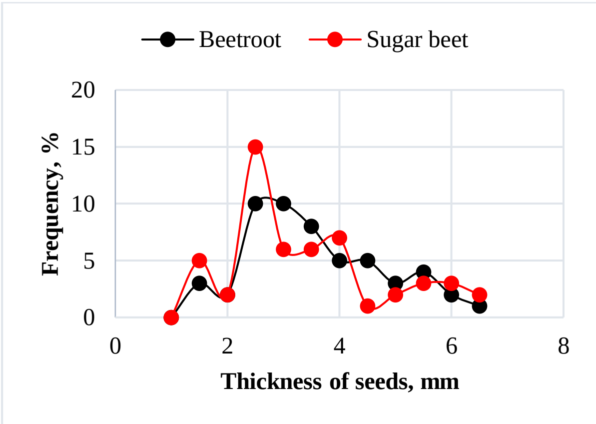

Fig. 5. Frequency distribution curves for sugar beet and beetroot seed thickness
Source: Authors' determination.

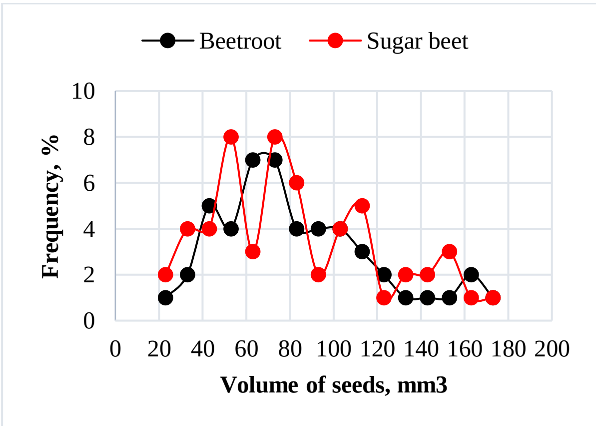

Fig. 6. Frequency distribution curves for beetroot and sugar beet seeds volume
Source: Authors' determination.

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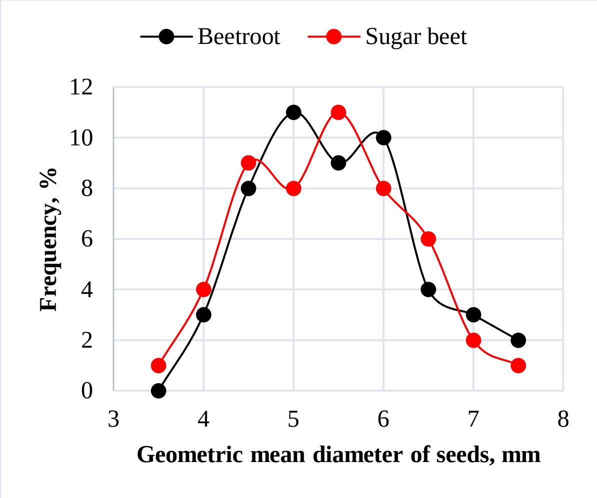

Fig. 7. Frequency distribution curves for beetroot and sugar beet seeds geometric mean diameter.
Source: Authors' determination.

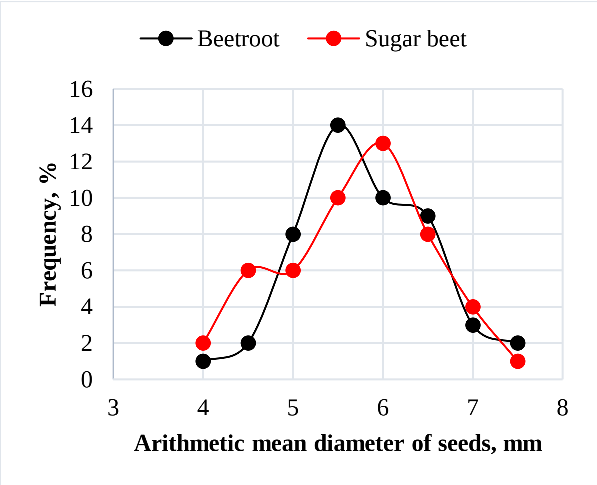

Fig. 8. Frequency distribution curves for beetroot and sugar beet seedsarithmetic mean diameter
Source: Authors' determination.

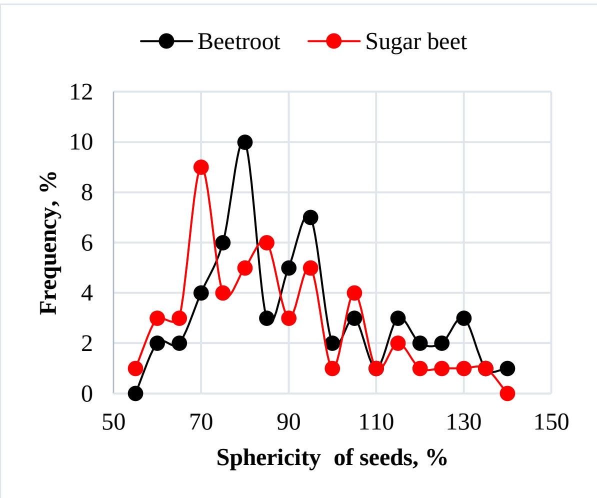

Fig. 9. Frequency distribution curves forbeetroot and sugar beet seeds sphericity
Source: Authors' determination.

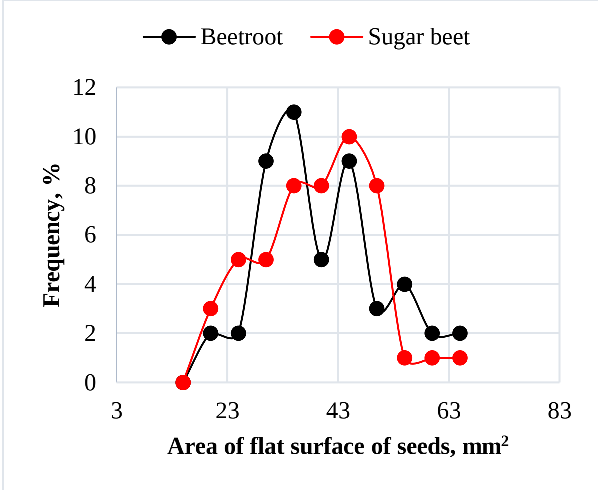

Fig. 10. Frequency distribution curves for the beetroot and sugar beet seeds area of flat surface
Source: Authors' determination.

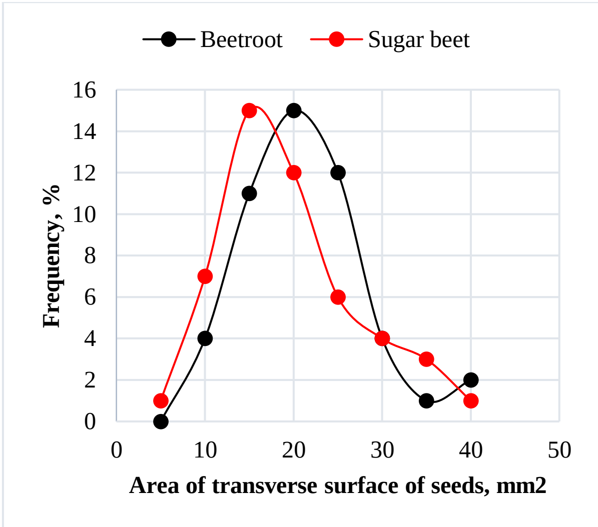

Fig.11. Frequency distribution curves for the beetroot and sugar beet seeds area of transverse surface.
Source: Authors' determination.

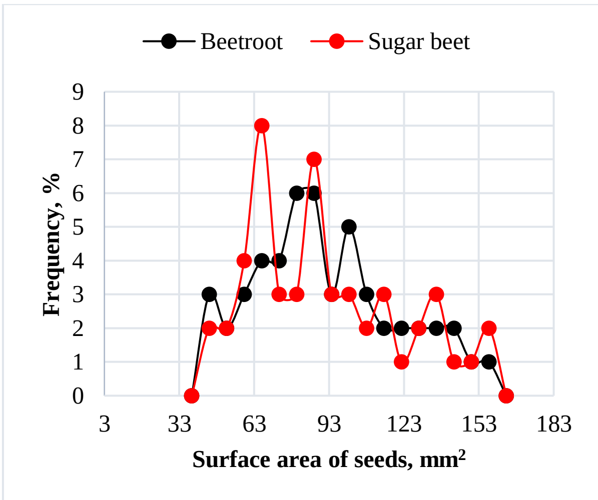

Fig. 12. Frequency distribution curves for sugar beet and beetroot seed surface area
Source: Authors' determination.

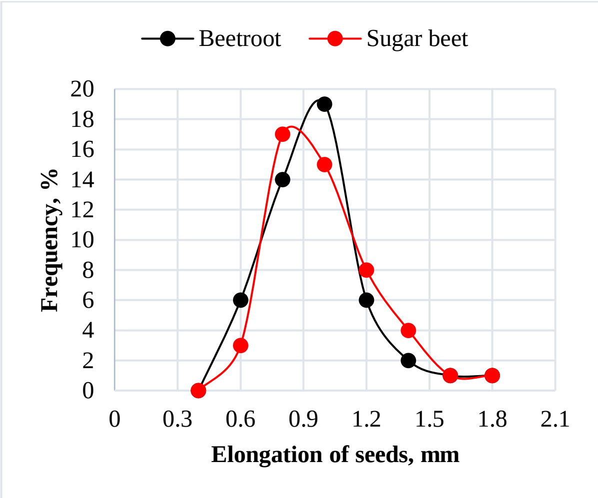

Fig. 13. Frequency distribution curves for beetroot and sugar beet seeds elongation
Source: Authors' determination.

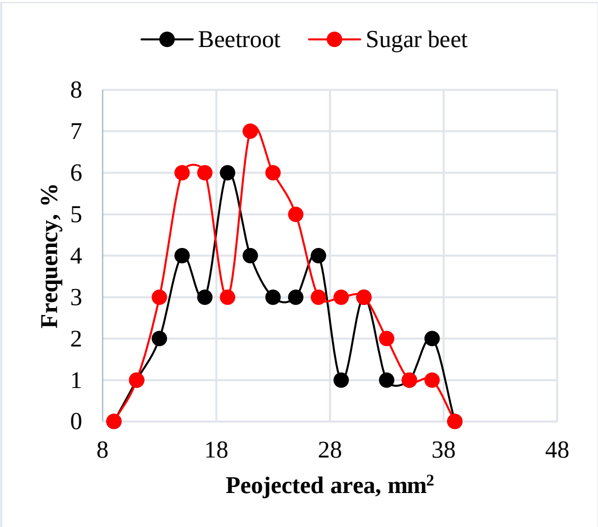

Fig. 14.Frequency distribution curves for beetroot and sugar beet seeds projected area
Source: Authors' determination.

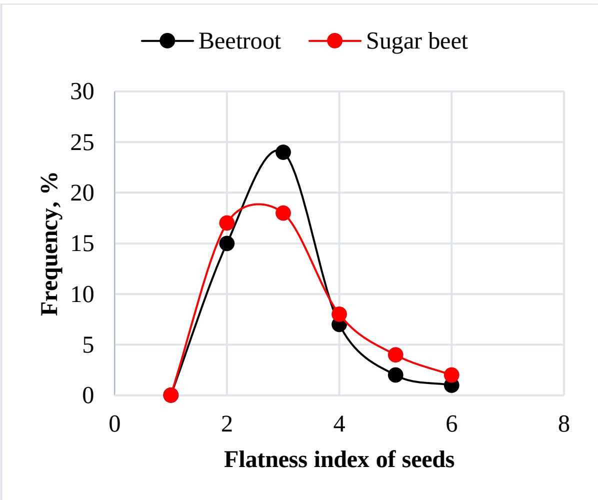

Fig. 15. Frequency distribution curves for beetroot and sugar beet seeds flatness index
Source: Authors' determination.

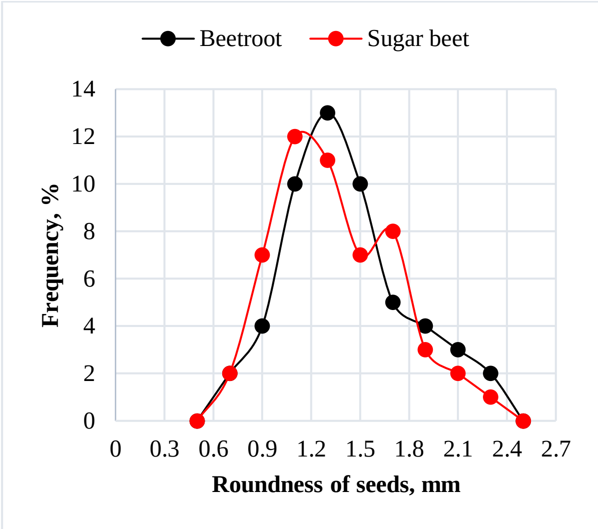

Fig. 16. Frequency distribution curves for beetroot and sugar beet seeds roundness
Source: Authors' determination.

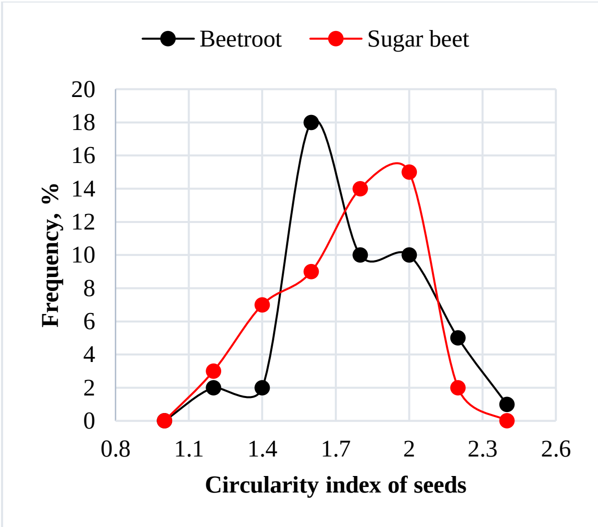

Fig. 17. Frequency distribution curves for beetroot and sugar beet seeds circularity index
Source: Authors' determination.

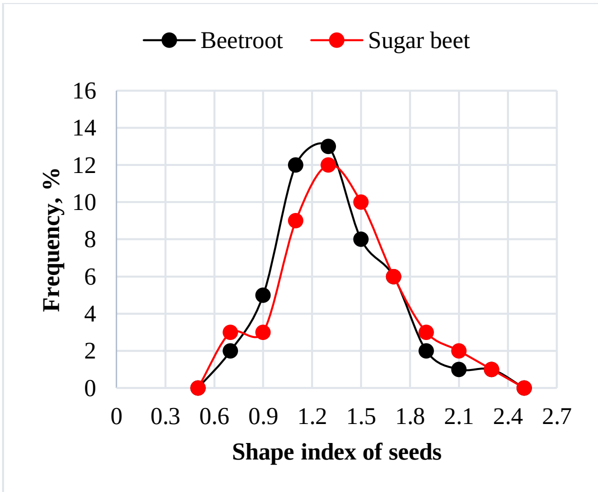

Fig. 18. Frequency distribution curves for beetroot and sugar beet seeds shape index
Source: Authors' determination.

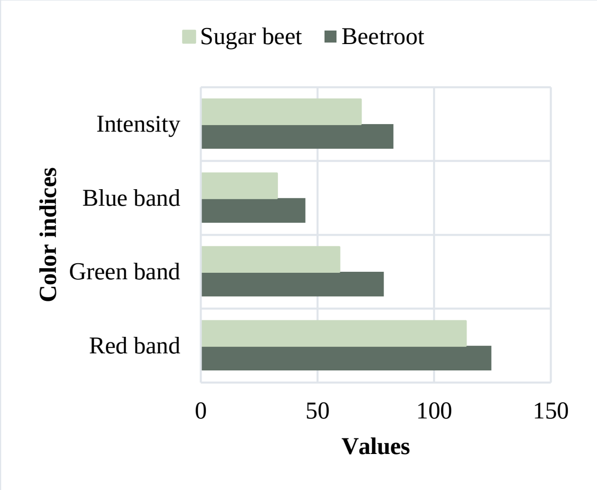

Fig. 19. Relationship between red, blue, green and intensity bands of beetroot and sugar beet seeds
Source: Authors' determination.

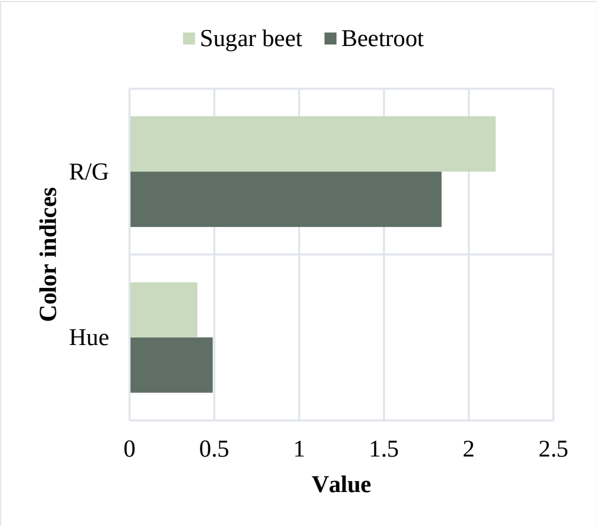

Fig. 20. Relationship between red-green ratio and hue of beetroot and sugar beet seeds
Source: Authors' determination.

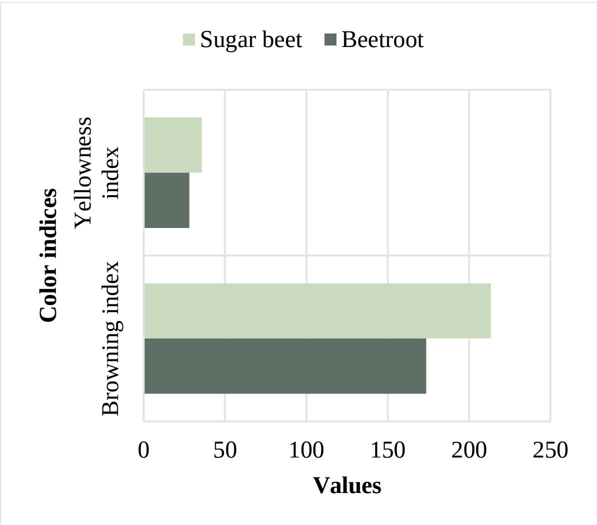

Fig. 21. Relationship between browning, yellowness index of beetroot and sugar beet seeds
Source: Authors' determination.

CONCLUSIONS

The determination and comparative analysis of the physical, shape, and colour properties of sugar beet and beetroot seeds revealed significant differences that have important implications for agricultural practices. The study found that beetroot seeds tend to be more spherical, while sugar beet seeds exhibit greater variability in shape index. Colour analysis highlighted distinct variations in hue, intensity, browning, and yellowness index between the two seed types.

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DEVELOPMENT OF A MACHINE CHOPPING THE ORCHARD TREE REMNANTS, AS A SOLUTION FOR SUSTAINING CIRCULAR ECONOMY AND ENVIRONMENTAL PROTECTION IN HORTICULTURE

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Abstract

The experiments were conducted at Al-Gharbawi Farm in Delingat Center, Beheira Governorate, during 2022 agricultural season. This study aims to develop and evaluate an orchard tree residue shredder to be suitable for shredding large-diameter branches and scattering them between tree rows by doubling the number of knives on the drum shredder, increasing the thickness of the shredder diameter, and adjusting the size of the chairs and ball bearings of the drum shredder. The study was conducted at three forward speeds (1.8 - 3.2 - 4.6 km/h), three levels of moisture content (20 - 30 - 40%), number of knives (16 - 32), and four rotational speeds of the drum shredder (2,000 - 2,200 - 2,400 - 2,600 rpm). The evaluation was carried out in terms of shredder performance, machine productivity (tons/hour), shredding efficiency (%), cutting length ratios (%), machine energy requirements (kW.h/ton), and operating cost (pounds/ton). The results can be summarized as follows: Increasing the cutter head speed from 2,000 to 2,600 rpm increases the cutting length ratio ≤ 3 cm from (55.5 to 61.5%), cutting efficiency from (90.9 to 95.5%), useful power from (25.59 to 22.18 kW) and energy from (9.66 to 9.45 kWh/ton) with the machine before modification at 40.0% moisture content (g weight) and number of cutting knives (original knives). The cutting length ratio ≤ 2 cm increased from (69.5 to 75.3%), cutting efficiency ratio from (87.1 to 95.5%), useful power from (28.12 to 27.18 kW) and energy from (32.7 to 9.43 kWh/ton) with the machine after modification at 40.0% moisture content (g weight) and number of cutting knives (modified knives).

Key words: *a chopping machine, trees remnants in orchards, circular economy*

INTRODUCTION

In Egypt, the agricultural residues, mainly orchard trimming residues, pose a significant environmental and agricultural challenge in the country to reduce environmental pollution and provide organic fertilizers to the soil to improve its physical and chemical properties, reduce the growth of weeds among orchard trees, and increase its ability to keep water for the longest possible period, especially with the limited water resources.

Chopping agricultural residues to feed the remnants is becoming increasingly recognized as a sustainable trend [2], [7], which could contribute to the circular economy and environment protection [5, 6].

Mechanical treatment is the primary approach to utilizing raw materials in various processes. Using pruning residues is beneficial for both the environment and the economy. Horticultural crop production holds a significant position within the various branches of agricultural cultivation.

In contrast to other crops, horticultural trees are perennial plants that require annual or periodic pruning to enhance their production's quality and quantity.

Hence, there has been a growing interest in using pruning residues for energy conversion and environmental concerns, agriculture, and economics [9].

Historically, orchard pruning residues were disposed of by burning or utilizing various machinery.

The immediate combustion process prevents the potential for reutilizing these residual materials and engenders ecological concerns [16].

Consequently, the act of chopping residues not only increases field coverage but also facilitates the recycling of pruning residues in olive orchards. In order to achieve this aim, the pruning residues are systematically aligned in a straight line, consolidated at the central portion of the rows, and then mechanically chopped by a grinder linked to a tractor [18].

Therefore, it is essential to ensure the retention of residues in the soil for the second year. Adequate maintenance and distribution of sufficient residues are necessary to ensure soil coverage, a crucial element in erosion reduction and water balance improvement [14].

Alternatively, the waste from pruning is mulched, left on the ground, or integrated into the soil [13].

Therefore, attempts have been made to utilize pruning residues generated in orchards in various ways.

Once the materials are chopped, they can be mixed directly into the soil to enhance the organic matter ratio and safeguard it against erosion [15].

One commonly employed approach to preserving organic matter in the soil and mitigating rain-induced erosion is using inert coverage, such as recycled crop residues or deceased cover crops [11], after having been chopped and subjected to different processes. For example, a chopping machine can perform on-site processing and effectively mix the soil with the pruning residues. The forefront also highlights operations involving multiple machines and logistics challenges in utilizing them as biomass or industrial raw materials [4].

Implementing these applications causes expensive infrastructures and systems. In nations like Turkey, where the utilization of residues has recently begun, on-site pruning residue chopping and direct integration with soil is a prevailing approach. Chopping machines, primarily powered by the tractor's power take-off (PTO) shaft, are predominantly utilized for this specific purpose.

Machine-chopping residues in orchards and leaving them on the soil surface, then mixing them with soil using ground processing machines, significantly enhances soil properties and facilitates their rapid utilization.

By employing this approach, commonly referred to as on-site utilization, plant residues are combined with soil to enhance the organic matter composition of the soil.

Chopping is one of the critical processes; pruning residues are used in any method. Employing appropriate machinery during the chopping procedure is crucial for reducing residues to the desired particle sizes and minimizing expenses.

Therefore, appropriate cutting machinery and shredder blades hold significant technical and economic importance.

Numerous studies have been conducted regarding the fragmentation of pruning residues in the existing literature.

New pruning equipment has been developed and evaluated for pruning grapevines, as well as fruit trees.

There is a paucity of studies that have explored the effect of different blade types on machine performance [1].

The importance of agricultural crop residues, especially in horticulture, has been highlighted as a pressing environmental and agricultural concern in Egypt.

Therefore, the aim of this study is to ascertain the effect of different blade types on the performance metrics of on-site machines for managing orchard pruning residues. Improper disposal of wood waste has a detrimental impact on both aquatic and terrestrial ecosystems [10].

An analysis of both the adoption and spread of the practice of using chopped pruning residues as mulch in olive groves in the province of Granada, southern Spain [3].

Burning waste from orchard trees releases greenhouse gases into the atmosphere, a range of human health problems. By utilizing technology to divide the cut vine stems and branches into pieces less than 10 cm long and then incorporating them into the soil between rows of plants annually, it becomes possible to reuse the cut pruning material as organic fertilizer.

This approach helps reduce the above-mentioned losses and contributes to environmental conservation.

The objective of the research is the development and evaluation of a tree residue chopper suitable for cutting large diameter branches and distributing them between tree rows.

MATERIALS AND METHODS

The locally developed cutting machine was modified in a private workshop in Al-Shaarawi Village, Al-Delangat Center, Beheira Governorate.

The development of a local cutting machine has a working width of 1,600 mm and has 32 loosely connected blades to chop orchard tree pruning waste suitable for cutting branches of large diameters and scattering them between the rows of trees.

The pruning residue-cutting machine was operated via a PTO pole, and it is suspended behind the tractor between the rows of orchard trees, where it cuts the pruning residue as it moves between the rows of orchard trees and leaves the cut remains on the surface of the soil.

The tractor was used to operate the machine is a Belarusian four-wheel-drive machine with a power of 92 hp.

- The field experiment was conducted on an area of 5 feddans to evaluate the operating parameters that affect the energy and energy requirements for cutting fruit tree waste, and to achieve the aims of this study, the cutting machine was used according to the following variables.

During the present study, machine chopping was evaluated using the new machine chopping in comparison with the original machine chopping.

The following treatments were tested:

(1)The humidity content of residues (20, 30 and 40%) (w.b.).

(2)Three forward speeds of tractor (1.8, 3.2, and 4.6 km/h).

(3)Four speeds of the drum (2,000, 2,200, 2,400, and 2,600 rpm), (41.8, 46, 50.6, 54.3 m/s), respectively. Where: linear speed (v) $=w.r= 2\pi N/60$.

The experiment was conducted and statistically designed as a factorial complete randomized block design with three replications.

Machine chopping

The components include the main frame, cutting drum, cutting knives, and gearbox. The chopping machine's length, width, and height measured 160 cm, 56 cm, and 90 cm, respectively. The cutting drum is fabricated using a steel shaft measuring 50 mm in diameter and 1,400 mm in length. The cutting drum is supported on the frame by two bearings. The mechanism operates through the use of a pulley and belts that are connected to a gearbox.

Two iron flanges were welded on both sides of the cutting drum, with diameters and thicknesses of 25 cm and 12 mm, respectively. Knives of a particular type were employed in the present study to cut the orchard residues. These knives were equipped with 32 sharp edges. They are made from steel sheets. The dimensions of the knife drum length, was 120 cm width, 20 cm and the thickness were 16 mm as shown in Fig 1, 2, 3 and Table 1.

Table 1. The machine chopping specifications

Characteristics	Machine chopping before	Machine chopping after
Overall length, width, height (mm)	1600, 900, 600	1600, 900, 600
Thickness of the roller (mm)	8	16
The internal diameter (mm)	30	60
Diameter of chopper drum (mm)	200	200
Weight (kg)	280	350
Number of knives on cutter head	16	32

Source: Authors' determination.

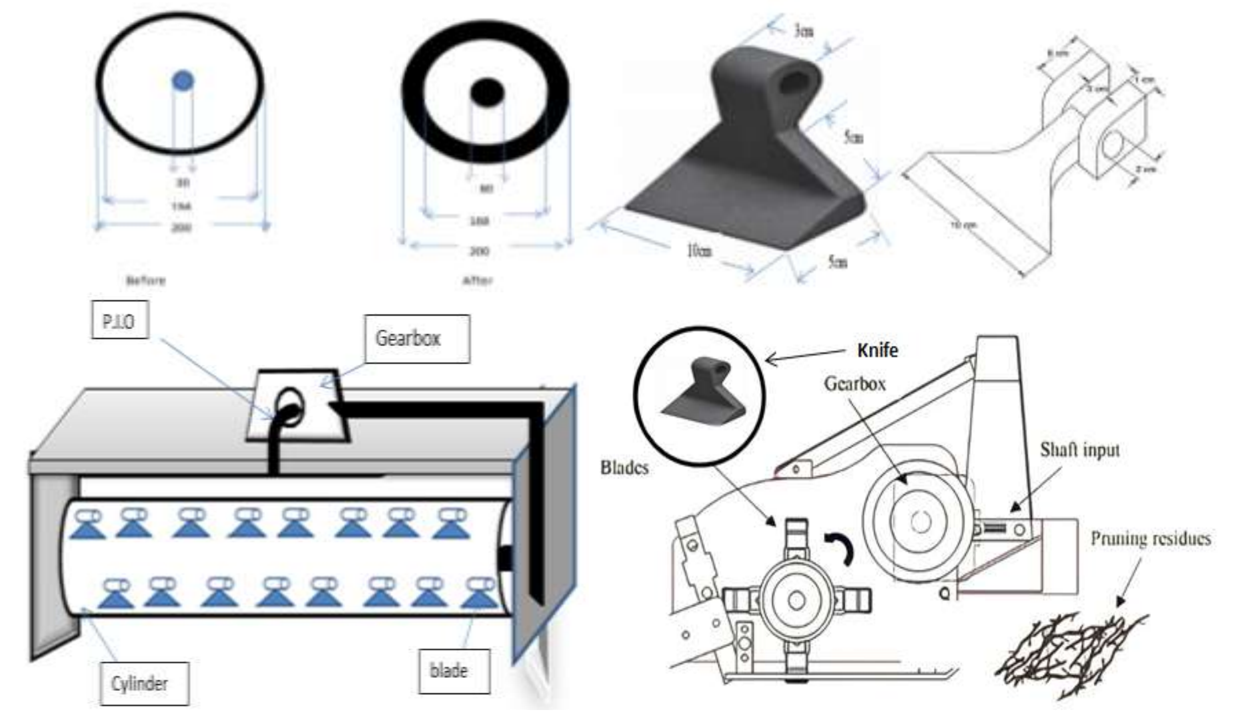
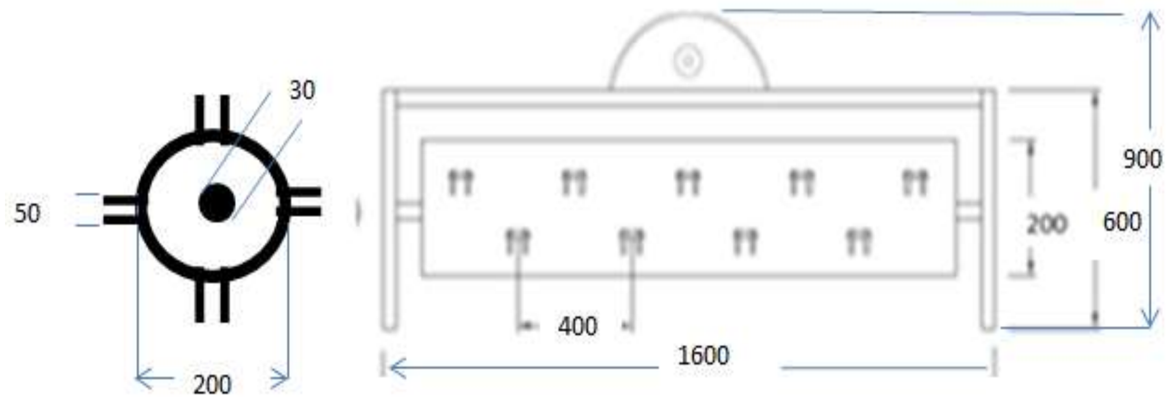
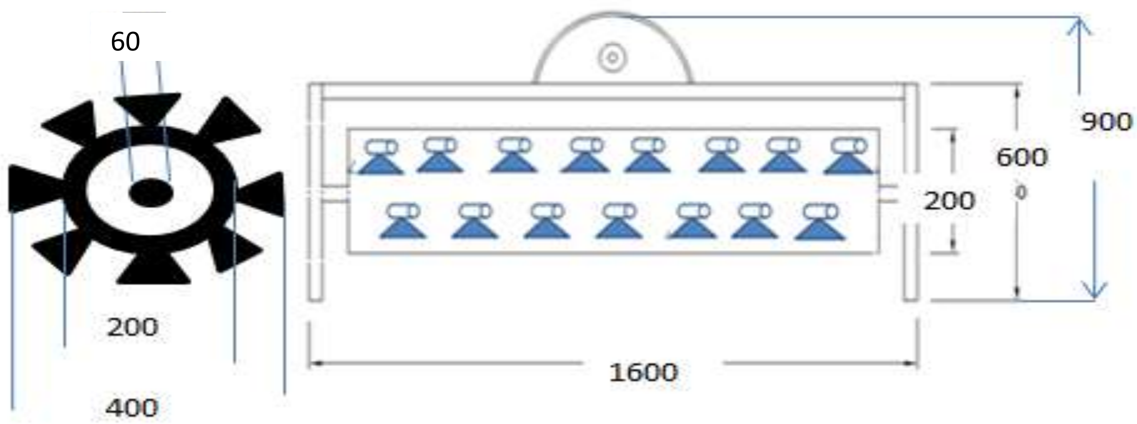


Fig. 1. Illustration of a machine for shredding orchard tree waste
Source: Authors' drawing .



Dimensions in mm, Scale: 1: 10

Fig. 2. Machine chopping before modification
Source: Authors' drawing.



Dimensions in mm, Scale: 1: 10

Fig. 3. Machine chopping after modification.
Source: Authors' drawing.

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Measurements and determinations

-Cutting length percentage.

Theoretical and actual lengths of cut:

The theoretical lengths of cut L_{th} was calculated using equation (1), [17]

$$L_{th} = \frac{60000\ V_f}{N_k n_c} \quad \text{.....(1)}$$

where:

L_{th} = Length of cut, cm;

V_f = The velocity of feeding, m/s (feeding mechanism peripheral speed);

n_C = Rotational speed of Cutterhead, rpm, and

N_K = Knives number on the cutter head.

Following each chopping treatment, laboratory analysis involved random sampling of chopped material in 1 kg increments. The samples were subsequently separated into three categories (<30, 30-50, and ≥50 mm) using sieves to detect the actual average cutting length (Lac). The weight of each cutting length in the sample was measured and expressed as a percentage relative to the total weight of the sample.

- Chopping efficiency

Three samples each of 1 kg of cutting crop material were fed into the chopper for each treatment; after completing the chopping operation, the output materials were weighted, and the chopping efficiency was calculated according to equation (2):

$$\text{Chopping efficiency} = \frac{W_{output} - W_{uncut}}{W_{in}}\% \quad \text{.. (2)}$$

where**:**

W_{out}: output mass, kg

W_{in}: input mass, kg

W_{uncut}: un-chopped mass after chopping process, kg.

Chopping efficiency was determined using equation (3) [8].

Chopping efficiency = 100 – un-chopped remnants .... (3)

-Machine productivity (L_{th})

The productivity of the machine was determined using equation (4).

Machine productivity

$$(L_{th}) = \frac{W}{t} \quad \text{.....(4)}$$

where:

W = Weight at crop residues, ton; t = machine operating time, h.

-Moisture contents:

The moisture contents of the plants were determined using the standard oven method. The samples underwent oven-drying at a temperature of 105°C for 24 hours. The determination of moisture percentages was conducted on a wet basis according to equation (5):

$$\text{Moisture content, \%} = \frac{(M_W - M_d)}{M_W} \times 100 \quad \text{...(5)}$$

where: M_w is the sample's mass before cutting, kg

M_d is the mass of the cut sample, kg.

-Fuel consumption:

In order to calculate the fuel consumption during the harvesting operation, the quantity of fuel necessary to refill the Fuel tank after a working period was measured. A calibrated glass cylinder was utilized to determine the amount of fuel added. The calculation of fuel consumption was determined utilizing equation (6).

$$F_c = C_i - C_c \quad \text{.....(6)}$$

where:

F_c is Fuel consumption, L/h.

C_i is Full tank capacity, L

C_c is the amount of remaining fuel in the tank after a specific period

-Power required:

The power requirement (B_p) was determined by applying equation 7 [12].

$$B_p = 3.163 \times F_c \quad \text{.....(7)}$$

where:

B_p = Power requirement, kW

F_c = Fuel consumption, L/h.

-Specific consumed energy:

The power requirement (kW) was assessed using a wattmeter, and the energy requirements (kW.h/ton) can be calculated by dividing the required power by the productivity of the machine:

The specific consumed energy was calculated from equation (8).

$$\text{Specific consumed energy kW.h/ton} = \frac{\text{Power requirement,kW}}{\text{machine productivity}} \quad \text{.....(8)}$$

RESULTS AND DISCUSSIONS

Cutting length categories:

Figure 4 presents the relationship between the cutting rotor speed, number of knives, moisture content of the pruning waste, and their effect on the cutting length categories. The results showed a positive correlation between the increase in cutting rotor speed, moisture content of the pruning residue (<3 cm and 3-5 cm), and the corresponding increase in cutting length categories. In comparison, the > 5 cm cutting length category decreased. The findings revealed that the increase in the number of knives recorded a high percentage of the category of less than 3 cm when cutting waste. The highest percentage for cutting pruning waste with lengths of less than 3 cm (63.5%) and the highest percentage for cutting pruning waste with lengths of 3-5 cm (34.5%). As well as the lowest percentage of category greater than 5 cm (2%) was obtained under the rotor speed of 2,600rpm and the moisture content of 40% and using the number of cutting knives of 32.

Productivity:

The results obtained and shown in Figure 5 show that increasing the cutting rotor's speed and increasing the pruning residue's moisture content leads to increased productivity when free knives are used, and their number increases from 16 to 32. The results showed that productivity was increased using knives 32. The results also showed that the highest productivity reached 2,755 tons/hour, recorded at a rotating speed of 2,600rpm and a moisture content of 40%, using 32 knives.

Cutting efficiency:

The data in Figure 6 show that the cutting efficiency increased as the cutting rotor speed increased and the moisture content of the pruning residue increased. Also, increasing the number of free knives to 32 records a high value in cutting efficiency compared to the number of knives 18. The results show that using 32 free knives recorded the highest cutting efficiency value of 94.9% at a rotor speed of 2,600 rpm and a moisture content of 40%. This is because pruning residues have high elasticity. More knives are needed, and the cutting area must be cross-sectional. This is available for free knives

Fuel consumption:

Figure 7 reveals a positive correlation between cutting drum speed, number of knives, and fuel consumption. The increased cutting drum speed led to a corresponding increase in fuel consumption. As an illustration, the fuel consumption rose from 8.1 l/h to 8.3 l/h when the cutting drum speed was increased from 2,000 rpm to 2,600 rpm. As the number of knives increases, fuel consumption decreases. This could be attributed to the need for a more comprehensive understanding of the material to reduce consumption, such as a decrease from 8.5 l/h to 8.3 l/h when the knife numbers are increased from 16 to 32 at a cutting drum speed of 2,600 rpm.

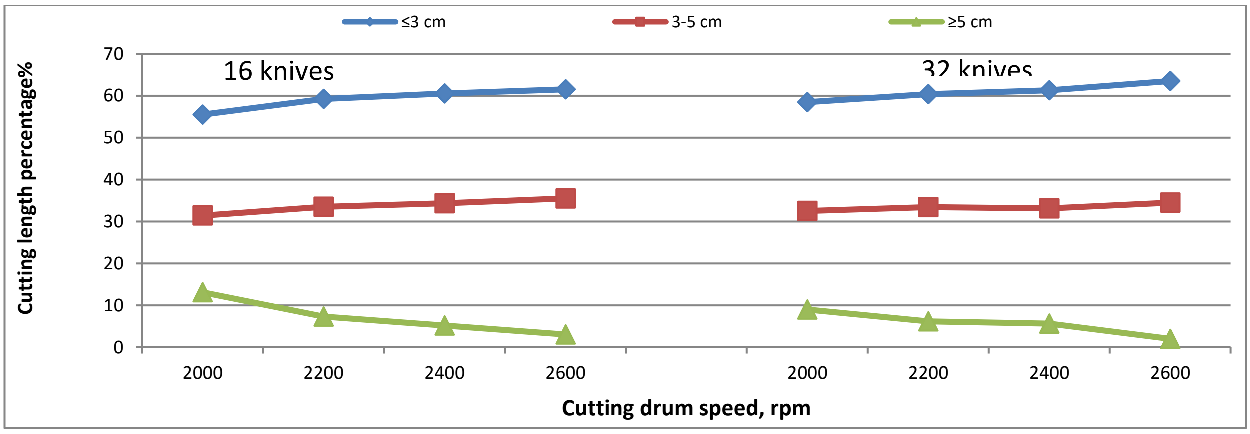

Fig. 4. Effect of chopping drum speed and knives number on cutting length
Source: Authors' determination.

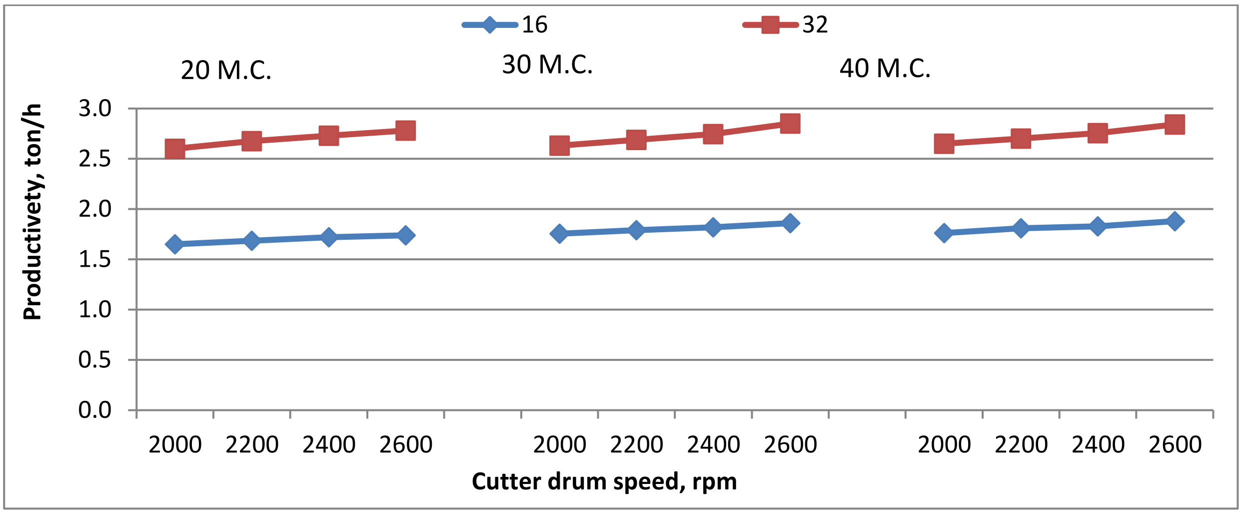

Fig. 5. Effect of chopping drum speed, moisture content, and knives number on machine production
Source: Authors' determination.

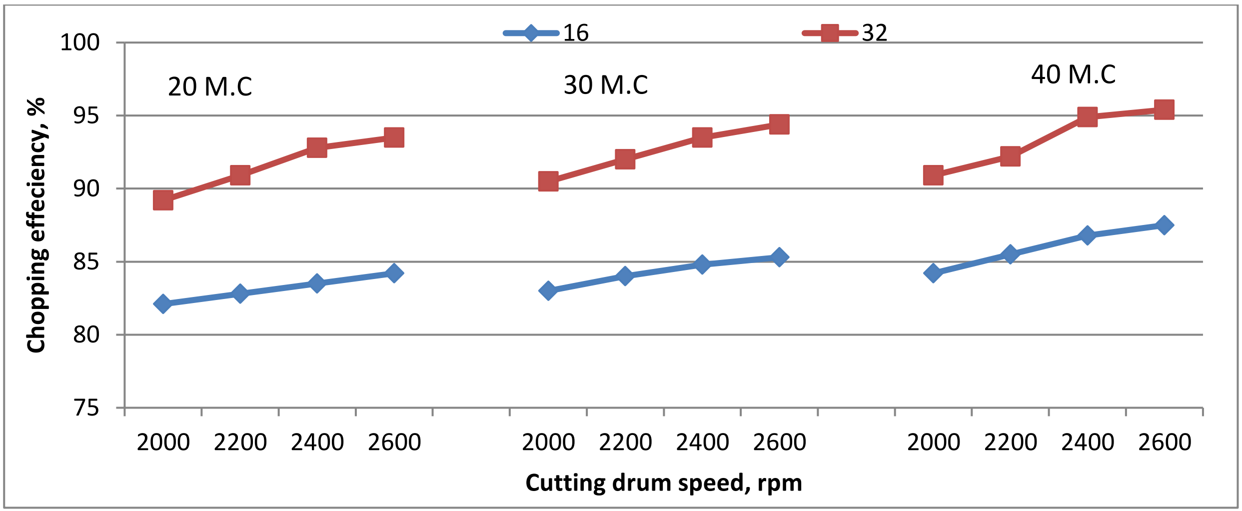

Fig. 6. Effect of chopping drum speed, moisture content, and knives number on chopping efficiency
Source: Authors' determination.

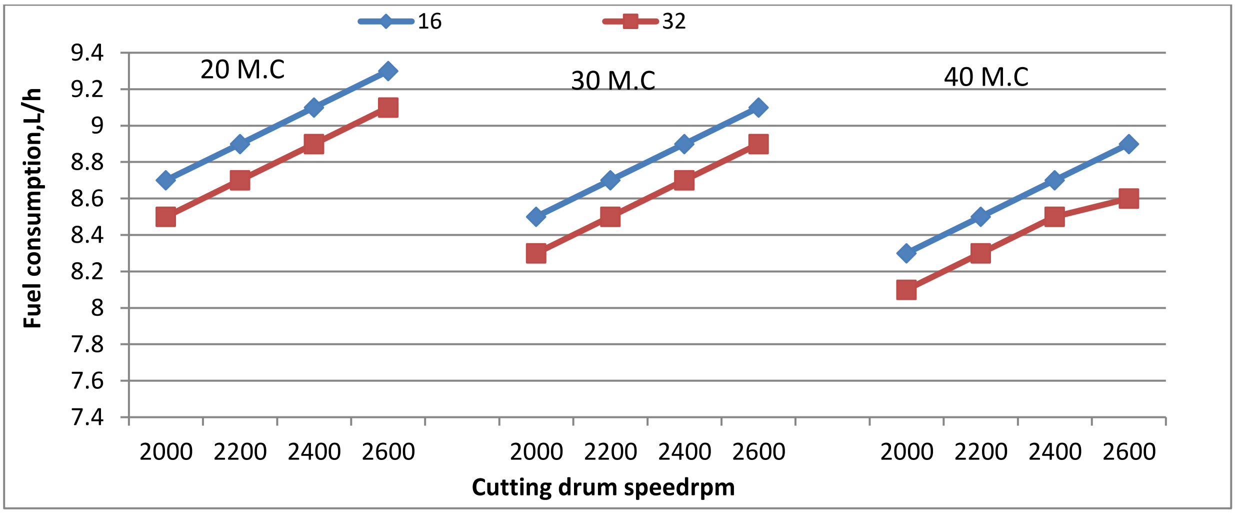

Fig. 7. Effect of chopping drum speed moisture content, and knives number on fuel consumption
Source: Authors' determination.

Energy requirements

Figure 8 illustrates a decrease in energy requirement as the cutting rotor speed and moisture content of the pruning residue increase while using 36 knives. The minimum energy requirement for cutting pruning residue was determined to be 25.04 kW.h/ton. The findings show that a cutting-knives speed of 2,600 rpm and tree branches moisture content of 40% resulted in a minimum specific energy of 9.43 kW.h/Mg. Conversely, a cutting-knives speed of 2,000 rpm and tree branches' moisture content of 40% yielded a maximum specific energy of 9.66 kW.h/ton.

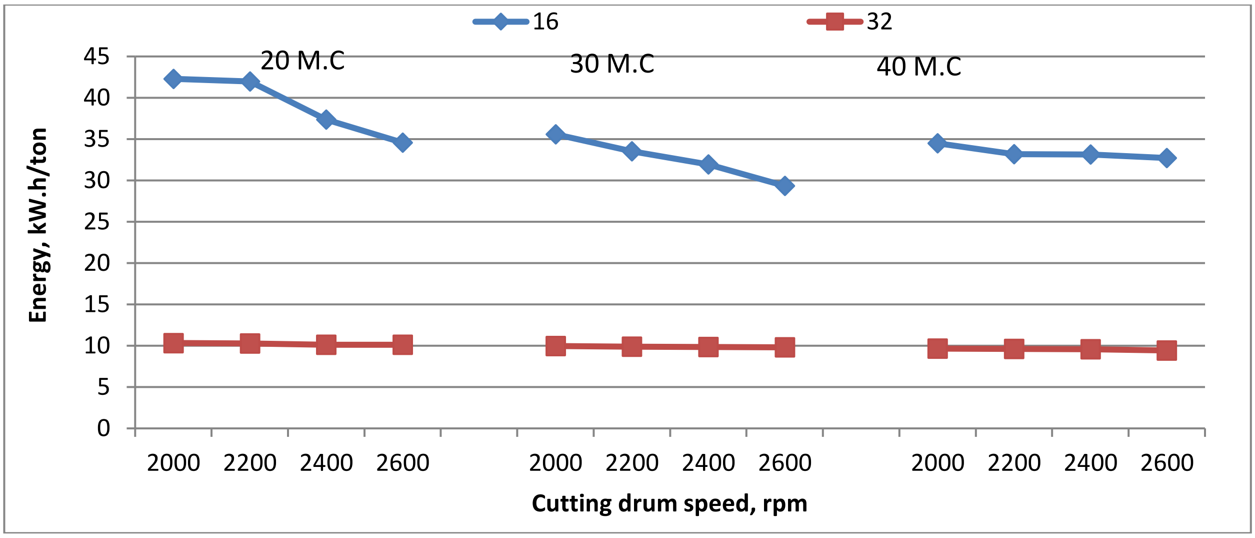

Fig. 8. Effect of chopping drum speed, moisture content, and knives number on energy requirement.
Source: Authors' determination.

CONCLUSIONS

The performance of the residue shredder was affected by many factors such as knife rotational speed, moisture content of the pruning residue, and the number of blades used. Modifying the thickness of the cylinder carrying the knives from 8 mm to 16 mm increases its durability to withstand chopping orchard tree branches up to 5 cm thick and protect them from damage because they operate at a speed of 2,600 rpm. The chairs carrying the cylinder were modified by increasing the inner diameter from 35 mm to 60 mm to withstand the weight of the cylinder and the load on the cylinder when cutting. The knife's weight was increased from 500 g to 1,240 g of 30Mn5 steel alloy. The number of knives was also increased from 16 to 32 knives. After modification of the machine, cutting length ratio ≤ 2 cm increased from 69.5% to 75.3%, cutting efficiency from 87.1% to 95.5%, useful power from 28.12 kW to 27.18 kW, and energy use from 32.7 to 9.43 kWh/ton at 40% moisture content with modified knives.

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TRENDS IN DAIRY PRODUCTS CONSUMPTION AND CONSUMER'S PERCEPTION ON SPIRULINA-ENRICHED COWCHEESE IN ROMANIA

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Abstract

In the context of increasing demand for sustainable and healthy products, the dairy industry is exploring innovative alternatives to meet the needs of consumers concerned about environmental impact. This paper aims to investigate the potential of Spirulina, a nutrient-rich microalga, in enhancing the nutritional value and marketability of dairy products, particularly cheese, while analyzing its acceptance among consumers. The study employed a comprehensive approach, including scientific literature review, statistical analysis of milk and dairy consumption patterns, and a pilot marketing survey to understand consumer perceptions and behavior. The results suggest that Spirulina can bring significant benefits to dairy products by improving nutritional value, offering a competitive marketing advantage, and aligning with consumer priorities related to health and environmental responsibility. Trends indicate a shift towards higher-value dairy products, though the unique flavor profile of Spirulina may pose acceptance challenges. Consumer education about the environmental and health benefits of Spirulina could foster greater acceptance. This integration of Spirulina in dairy products represents a promising step towards more sustainable, health-conscious alternatives in the food market.

Key words*: healthy products, dairy industry, consumer perception, sustainability*

INTRODUCTION

Functional foods are defined as foods that contain biologically active compounds capable of improving health or reducing the risk of diseases when included in the diet [12]. In the context of rising demand for sustainable and health-oriented products, the dairy industry is exploring innovative solutions to address consumer concerns about environmental impact. Beyond focusing on nutrition and sustainability, market dynamics and trade practices within the dairy sector are critical factors. Recent studies have highlighted that perceptions of unfair trading practices can negatively affect contractual relationships and influence farmers' trust in the EU dairy sector [8]. Moreover, analysis of trade dynamics reveals significant shifts in dairy trade linkages within the European Union, reflecting a reorganization of commercial networks and economic flows [10]. These economic insights are highly relevant in a landscape where consumers are increasingly drawn to products that promote health and well-being. Additionally, research on packaging and labeling suggests that oversized geographical indications, such as those on bonus packs, have a limited effect on consumer purchasing decisions [22]. This finding emphasizes the need for more direct consumer education that focuses on communicating the tangible benefits of products, such as the nutritional and environmental advantages of spirulina-enriched dairy products. One example is cow cheese enriched with *Spirulinaplatensis*, a microalga that is not traditionally part of the human diet and is not classified as an essential macro- or micronutrient. However, Spirulina has long been recognized for its beneficial effects, transforming regular dairy products into functional foods [18]. The integration of Spirulina in cheese adds substantial nutritional value, providing a unique combination of vitamins, minerals, proteins, and antioxidants, thus enhancing the health benefits of dairy products [20].

As global awareness of health and environmental sustainability rises, the dairy industry is actively exploring innovative alternatives to cater to an increasingly conscientious consumer base. Spirulina's inclusion in dairy products, such as cow cheese, demonstrates how the sector can meet both nutritional and environmental demands [21], [3]. This research focuses on how Spirulina, a highly nutritious microalga, can transform dairy products, offering a potential solution for both enhanced health benefits and sustainability [28], [14]. The study highlights that while Spirulina fortifies dairy products with key nutrients, it also carries a distinct flavor profile that may hinder its broad acceptance among some consumers. Nevertheless, the integration of Spirulina into dairy products aligns with the growing demand for health-conscious and eco-friendly choices [14], [7].

Milk production is a vital component of Romanian agriculture, second only to meat production in significance. Given milk's perishable nature, it necessitates an efficient and well-organized logistics system to ensure that dairy products reach consumers promptly while maintaining their quality, freshness, and safety [17], [5]. From production to consumption, the milk supply chain plays an integral role in meeting consumer expectations and adhering to the high standards set for dairy products.

Historically, Romanians have been known as a "milk-consuming people," as noted by Dr. Ion Claudian in his 1939 work, Food of the Romanian People. This assertion is rooted in the nation's agricultural heritage, where animal husbandry was tightly intertwined with farming. Milk has long been a staple in the Romanian diet, reflecting cultural traditions that emphasize its nutritional value and importance in daily nutrition. This strong cultural connection underscores the enduring role of dairy in the nation's food practices [25], [9], [11].

Professor Dr. Victor Săhleanu, in his publication Man and Food, identifies three key principles that guide food choices: instinctive guidance, cultural models, and rational nutrition. The principle of instinctive guidance suggests that individuals are often drawn to foods based on sensory cues, such as taste, smell, and color, which indicate nutritional and biological value. Cultural models emphasize the role of tradition and heritage in shaping food preferences, particularly in societies like Romania, where certain foods are deeply ingrained in cultural identity. Finally, rational nutrition highlights the scientific and health-oriented aspects of food selection, encouraging consumers to make choices based on nutritional benefits. These principles demonstrate the complex factors influencing dietary habits and the importance of aligning food production with consumer preferences, especially in a nation where milk consumption remains a central part of the diet.

The incorporation of Spirulina into dairy products is a promising innovation that aligns with both health trends and cultural values [19], [15]. This functional food innovation could meet the rising consumer demand for nutritionally enhanced and environmentally sustainable options. As the dairy industry continues to evolve, Spirulina's potential to offer these benefits could pave the way for a new era of healthier, more sustainable food choices.

The purpose of this paper is to evaluate the potential of Spirulina-enriched dairy products, particularly cheese, in addressing consumer demands for health and sustainability. It aims to analyze consumption trends, assess the impact of Spirulina on nutritional value and marketability, and explore consumer attitudes towards such innovative products.

MATERIALS AND METHODS

This study adopted a comprehensive approach to analyze milk consumption patterns and trends in dairy products in Romania, drawing on diverse data sources to provide an in-depth perspective. The research framework comprised the following components:

Scientific Literature

An extensive review of scholarly articles and research studies was conducted to examine milk consumption, the nutritional value of dairy products, and their societal impact. These publications established a foundational understanding of the health, economic, and cultural importance of dairy products in Romania.

Statistical Data

Data regarding milk and dairy consumption, household food expenditures, and the caloric contributions of dairy products were sourced from the National Institute of Statistics, covering the period from 2017 to 2020. The data were analyzed through tables, comparisons, and statistical correlations to identify consumption trends, highlighting both fluctuations and consistent patterns over time.

Institutional Reports

Reports and statements from European institutions, dairy industry associations, and other authoritative sources were integrated to validate findings and enhance the reliability of the data. These reports provided crucial context on market trends and policy developments affecting dairy consumption.

Historical and Societal Context

This aspect of the research delved into the historical, cultural, and societal influences on milk consumption in Romania. The study explored the role of traditional diets, agricultural practices, and the enduring significance of milk and dairy products in Romanian cuisine, offering a deeper understanding of consumer behavior.

Focus on Data Analysis

The analysis emphasized identifying quantitative trends in milk and dairy product consumption across various demographic groups, including household types (e.g., farming, unemployed, single-person households) and regional differences. Key indicators examined included:

1. Average Monthly Consumption

Per capita monthly consumption of milk, cheese, and cream was analyzed (Table 1) to assess changes in consumption habits over time.

2. Caloric Contribution

The study evaluated the proportion of total caloric intake derived from milk and dairy products, noting variations across different household types and demographics.

3. Expenditure Patterns

Household spending on food, particularly dairy products, was analyzed to understand the economic factors influencing consumption and consumer behavior.

Table 1. Purchase of milk and milk products, on average

Total purchases,	Total households, monthly averages per person, in 2017, kg	Total households, monthly averages per person, in 2018, kg	Total households, monthly averages per person, in 2019, kg	Total households, monthly averages per person, in 2020, kg
Milk, totally	4.461	4.509	4.497	4.523
Cheeses and cream, of which	1.121	1.208	1.219	1.319
- cow's cottage cheese (telemea)	0.357	0.370	0.369	0.387
- sheep's cheese	0.187	0.211	0.204	0.212
- fresh cow's cheese	0.198	0.221	0.227	0.235
- cheese	0.123	0.132	0.136	0.150
- other milk products	0.231	0.245	0.251	0.297

Source: NIS Database, 2022 [29].

Methodological Focus

The research aimed to provide a holistic understanding of the interplay between dietary patterns, economic factors, and societal influences in Romania, with a focus on improving public health and quality of life. Data correlation was conducted to:

-Assess the influence of household characteristics (e.g., farming, unemployed, single-person households) on consumption habits.

-Explore regional and urban-rural disparities in milk and dairy consumption.

-Identify trends in food expenditure, particularly regarding dairy products.

-By combining statistical data with historical and societal insights, the study sought to create a nuanced profile of milk and dairy consumption in Romania, exploring implications for public health and nutritional strategies.

Exploratory Marketing Survey

To complement the quantitative analysis, an exploratory marketing survey was conducted to assess consumer behavior related to dairy products with high biological value. This pilot survey consisted of 15 questions and included 74 participants, conducted between January and February 2022.

The survey focused on qualitative variables such as gender, environment, profession, and perceptions of innovative food products, specifically cow's cheese enriched with *Spirulina platensis*. It aimed to evaluate consumer attitudes towards functional foods, purchase intentions for Spirulina-enriched products, and perceptions of their health benefits.

Qualitative variables were measured using nominal scales, offering categorical insights into the demographics and attitudes of respondents. This qualitative component enriched the broader statistical analysis, providing a more comprehensive understanding of consumer preferences and attitudes toward innovative dairy products.

By integrating diverse methodologies, this study provides a detailed analysis of milk and dairy consumption trends in Romania. The findings offer valuable insights into consumer behavior, economic influences, and cultural factors, helping to inform strategies for promoting functional foods like Spirulina-enriched dairy products. This approach could ultimately contribute to enhancing public health, meeting consumer demands, and fostering innovation within the dairy sector.

RESULTS AND DISCUSSIONS

1. Trends in Milk and Dairy Consumption

Analysis of data from the National Institute of Statistics between 2017 and 2020 highlighted notable trends:

Milk Consumption: Average monthly per capita milk consumption exhibited minor fluctuations, increasing slightly from 4.461 liters in 2017 to 4.523 liters in 2020 [24], [2], [26].

Cheese and Cream Consumption: A more significant rise was observed in cheese and cream consumption, which increased from 1.121 kg per capita in 2017 to 1.319 kg in 2020 [27], [13], [6].

Cow's Cottage Cheese (Telemea): The most widely consumed cheese type, with consumption rising modestly from 0.357 kg in 2017 to 0.387 kg in 2020.

Sheep's Cheese: Consumption increased from 0.187 kg in 2017 to 0.212 kg in 2020.

Fresh Cow's Cheese: Steady growth was noted, with consumption climbing from 0.198 kg in 2017 to 0.235 kg in 2020.

Other Dairy Products: This category experienced the most substantial growth, increasing from 0.231 kg in 2017 to 0.297 kg in 2020 [1] [4].

These trends suggest a gradual shift towards higher-value dairy products, reflecting evolving dietary preferences and potentially increased economic capacity among consumers.

2. Caloric Contributions and Household Characteristics

Caloric Contributions: Dairy products contributed significantly to overall caloric intake, with noticeable variations based on household types. Farming households consumed more dairy, likely due to self-production, while unemployed households showed lower consumption levels, reflecting economic constraints [23], [16].

Household Influence: Demographics, such as employment status and household composition, emerged as key determinants of consumption patterns. Farming households displayed higher consumption of milk and traditional cheeses, consistent with agricultural traditions.

3. Regional and Urban-Rural Disparities

Urban Preferences: Urban areas exhibited a stronger preference for processed and premium dairy products, such as cheese and cream.

Rural Consumption: Rural regions leaned towards unprocessed milk and traditional cheeses, influenced by cultural practices and local production.

Regional Differences: Regions with established agricultural traditions reported higher dairy consumption, emphasizing the role of local production in shaping dietary habits.

4. Expenditure Patterns

Household expenditure on milk and dairy products represented a significant portion of food budgets, with incremental increases observed during the study period. This trend aligns with rising consumption levels and suggests a growing preference for dairy products, particularly higher-value options.

5. Societal and Historical Context
Romania's agricultural heritage and traditional diet continue to influence contemporary consumption patterns. Dairy products, particularly cheeses like telemea (cottage cheese), hold a prominent place in traditional cuisine. However, urbanization and economic changes are gradually encouraging a shift towards processed and diversified dairy products.

6. Insights from the Consumer Survey
A survey of 74 respondents provided additional insights into dairy consumption trends:

Demographics:

-*Gender Distribution*: Women comprised 83.87% of respondents, while men accounted for 16.2%.

-*Income Levels*: Most participants (97.3%) reported monthly incomes exceeding 1,650 lei, indicating a relatively stable socio-economic demographic.

-*Consumption Habits*:

A substantial majority (95.9%) reported regular consumption of dairy products, underscoring their integral role in Romanian diets.

-*Health concerns* emerged as the primary driver of food choices, with 61.6% of respondents prioritizing family health and well-being, followed by nutritional quality (31.5%).

-*Economic factors* (5.5%) and preferences for natural, preservative-free food (1.4%) played secondary roles.

Urban-Rural Dynamics:

Urban respondents accounted for 81.1% of the sample, with 18.9% from rural areas. Interestingly, place of residence had minimal influence on overall dairy consumption, although urban households favored processed products, while rural households leaned towards traditional options.

7. Consumer Interest in Functional Foods
Respondents demonstrated an increasing interest in functional foods, with notable findings:

Popular Choices:

-23.3% consumed foods fortified with vitamins and minerals.

-20.5% preferred products with dietary fiber.

-Other choices included alcohol-free (17.8%), caffeine-free (15.1%), sugar-free (12.3%), and low-fat (8.2%) foods.

Spirulina-Enriched Cow's Cheese:

-Perceived Benefits: 68.9% believed this product offered health benefits, recognizing the nutritional potential of Spirulina, known for its protein, vitamins, and antioxidants.

-Skepticism and Knowledge Gaps: 24.3% doubted its benefits, and 4.1% were uncertain, reflecting a need for better consumer education about functional foods.

-Awareness and Acceptance:

73% of respondents associated functional foods with nutritional benefits.

Only 1.4% were unfamiliar with the concept of functional foods or Spirulina-enriched products.

31.1% indicated a willingness to recommend Spirulina-enriched cow's cheese, suggesting potential for growth if taste, benefits, and accessibility are effectively communicated.

CONCLUSIONS

The study underscores the pivotal role of health and nutrition in shaping food choices among Romanian consumers. While dairy products remain dietary staples, shifting preferences point to a growing interest in functional foods such as Spirulina-enriched dairy products. However, skepticism and limited awareness among some consumers highlight the importance of targeted education and strategic marketing efforts.

By addressing taste preferences, informing the public about health benefits, and emphasizing product quality, the functional dairy market in Romania holds substantial growth potential. These efforts can contribute to healthier dietary patterns and improved public health outcomes.

This research provides an in-depth analysis of current milk and dairy product consumption trends in Romania, highlighting key factors influencing consumer behavior. The primary findings include:

-Rising Demand for Value-Added Dairy Products

The consistent growth in the consumption of cheese, cream, and other processed dairy items indicates a shift in consumer preferences toward more diverse and premium dairy products. This trend suggests that Romanian consumers are increasingly prioritizing products with perceived nutritional and health benefits, reflecting greater awareness and interest in higher-value dairy options.

-Persistence of Traditional Consumption in Rural Areas

Despite the growing interest in processed and functional dairy products, rural and farming households continue to favor traditional consumption patterns, such as fresh milk and homemade cheeses. These preferences reflect Romania's strong agricultural heritage and the cultural significance of dairy in daily diets. Preserving these traditions while encouraging innovation presents a unique challenge and opportunity for policymakers.

-Impact of Economic and Demographic Factors

Consumption patterns vary significantly across demographic and economic groups. Farming households consume more dairy products due to self-production, while urban and unemployed households exhibit more diverse consumption behaviors influenced by factors such as income levels and product accessibility. Addressing these disparities requires tailored interventions that account for the socio-economic realities of different population segments.

Implications and Recommendations

1. Policy Interventions

To improve dietary quality, there is a need for policies that promote nutritional education about the benefits of balanced diets, including a variety of dairy products. Awareness campaigns should focus on urban areas, where processed dairy products are in higher demand, while simultaneously ensuring access to high-quality dairy in rural regions. Such initiatives can help reduce urban-rural disparities and support informed consumer choices.

2. Support for Local Economic Development

Investments in the dairy industry, particularly in modernizing production and processing facilities, are crucial for sustaining growth. Supporting small- and medium-sized dairy producers, especially in economically disadvantaged regions, can promote sustainable dairy consumption and strengthen local economies. These efforts can also help reduce regional disparities in consumption patterns by ensuring locally sourced, high-quality dairy products are widely available.

3. Research and Innovation

Further studies are needed to assess the long-term impacts of urbanization and economic transitions on dietary habits in Romania. Research focusing on the interplay between modern dietary trends and traditional food systems will provide valuable insights for policymakers and industry stakeholders. Additionally, exploring opportunities to integrate functional foods, such as Spirulina-enriched dairy products, into mainstream diets could unlock new avenues for health improvements and product innovation.

This study sheds light on the evolving landscape of dairy consumption in Romania, offering critical insights into consumer preferences, economic influences, and the persistence of traditional dietary practices. By leveraging these insights, stakeholders can develop targeted strategies to enhance nutrition and improve the overall quality of life.

A collaborative, holistic approach involving policymakers, producers, and consumers is essential to promote sustainable growth in the dairy sector. These efforts will ensure that the benefits of dairy consumption, including better health and nutrition, are accessible to all Romanians, regardless of geographic location or socio-economic status.

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DETERMINANTS OF CLIMATE CHANGE ADAPTATION: WHEAT PRODUCERS IN YALVAÇ DISTRICT, TURKEY

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Abstract

The objective of this study is to analyze the factors determining wheat producers' adaptation to climate change in the Yalvaç district. Using a stratified random sampling method, 116 farmers were interviewed face-to-face. Binary logistic regression was applied to identify the factors influencing farmers' choices of adaptation measures. The results show that several factors significantly affect producers' adaptation decisions, including access to agricultural credit, the use of non-family labor, receipt of climate alerts, interaction with agricultural authorities, and soil analysis. These factors play a crucial role in the adoption of adaptive practices such as increasing fertilizer doses, crop rotation, and changing wheat varieties. This research provides critical insights for shaping agricultural policies aimed at improving the resilience of producers to climate change and enhancing their adaptive capacity.

Key words: *determinants, adaptation, wheat, producers, Turkey*

INTRODUCTION

In the global context, wheat stands out as one of the most widely produced and consumed cereals across the world [39]. It serves as a critical source of employment and wealth creation for numerous communities involved in its cultivation. However, its productivity and supply are severely threatened by climatic factors such as drought, temperature fluctuations, and irregular precipitation patterns [22]. According to [24], the growth and development of wheat are compromised by increased evapotranspiration caused by rising temperatures and drought conditions. Over the past decades, several wheat-producing countries have faced challenges related to climatic conditions.

Scientists tried to find solutions to mitigate the negative impact of climate change. [17] assessed and compared the drought tolerance of some wheat varieties in Romania, in order to chose the most resistant ones and recommend them to be cultivated by farmers. [8] used NDVI in monitoring the wheat crop vegetation, the carbon storage and the yield level on the chernozemic soils from South Romania. [28] adapted the technology of winter wheat in the conditions of climate change in Dobrogea region, the most droughty area of the South Romania in order to sustain yield and economic efficiency.

Turkey, one of the major producers, has also been impacted by these climatic variations, which have negatively affected wheat yields. In particular, rising temperatures (>30°C) and water stress (<40 mm) have posed significant threats to wheat production [22]. Additionally, cold winter temperatures and high spring temperatures have reduced yields [39]. In Turkey's Mediterranean region, climate change has led to decreased precipitation, soil erosion, and declining wheat yields [11]. The Yalvaç district, located in this region, has experienced an increase of over 15 days of hot days and nights over the past century. Projections for 2070 predict a 6°C rise in summer temperatures and a 20% reduction in winter precipitation [29, 11]. As a result, producers are compelled to implement adaptive measures to combat the effects of climate change and sustain wheat production.

According to [25], climate change adaptation is a continuous and evolving process aimed at mitigating the negative impacts of climate conditions. It involves a socio-economic and behavioral transformation by farmers to reduce the intensity of climate change effects

[38]. Adaptation can be either planned or spontaneous: planned adaptation is implemented before the impacts become apparent, while spontaneous adaptation is a reactive response to an unexpected climate crisis [36, 20]. The choice of adaptation measures is often influenced by the expected utility or satisfaction for the producer [37]. This choice can also be shaped by various factors, including socio-economic, human, natural, and institutional conditions, as well as the availability of production and marketing infrastructure. Although numerous studies have examined the determinants of climate change adaptation, including those in Turkey and other regions [1, 16, 27, 21, 32, 4], very little research has focused on the Yalvaç district.

This study fills that gap by investigating the determinants of wheat producers' adaptation in this region. It will serve as a decision-making tool for agricultural policymakers during the formulation of strategies to support farmers in overcoming adaptation barriers.

MATERIALS AND METHODS

The data used in this research were collected through face-to-face interviews with wheat producers in the Yalvaç district. Both closed and open-ended questions addressing socioeconomic, institutional, and other relevant aspects were asked of the farmers. To determine the sample size, an anonymous list of wheat production areas, drawn from the provincial producer registration system, was utilized. The stratified random sampling method was employed to establish the sample size [40].

$$n = \frac{\sum(N_h * S_h)^2}{N^2 D^2 + \sum N_h {S_h}^2} \quad ....(1)$$

In this context: n represents the sample size; N is the total number of units (after excluding producers with less than one decare from the total of 2,308, the new N becomes 2,247); N_h is the number of units in stratum h; S_h is the standard deviation of stratum h; D is calculated as d/Z, where d is the deviation from the mean, and Z represents the number of degrees of freedom in the t-distribution diagram (N-1).

The z-value corresponds to a certain confidence level 95% confidence with a margin of error of 5%.

$$n = \frac{(19{,}352)^2}{(2{,}247)^2\left(\frac{1.50}{1.96}\right)^2 + (256{,}933.7)} \text{ ; n=116}$$

A binary logistic regression model was used to identify the various factors likely to influence the adaptation measures adopted by farmers to cope with the effects of climate change.

The dependent variable (Yi), representing the climate change adaptation measure, is binary: it takes the value 1 if the farmer adopts the measure and 0 otherwise [1, 41, 21].

The adaptation measures implemented by farmers include changing wheat varieties, adjusting fertilizer and pesticide doses, crop rotation, and monitoring weather information. Wheat producers adopt one or more of these adaptation measures only if they perceive a reduction in climate risk and/or an improvement in their agricultural income.

The empirical form of the logistic regression model is as follows:

$$Yi = bo + bi \sum_{i=1}^{n} Xi + ei \quad ....(2)$$

where: b_0 represents the constant term; b_i: represents the set of coefficients, X_i denotes the set of independent variables, and e_i is the error term.

The independent variables (X) include variables related to natural, economic, human, and institutional resources, as well as the availability of production and marketing infrastructure and social capital (Table 1).

The analysis of tolerance (TOL) and variance inflation factor (VIF) was used to eliminate multicollinear independent variables.

Table 1. Description of explanatory variables

	Variable	Description	Mean	S.D
Economic resources	Income diversification	1-Yes, 2-No	0.63	0.49
	Use of agricultural credit or financial tools	1-Yes, 2-No	0.61	0.49
	Use of agricultural subsidies	1-Yes, 2-No	0.97	0.18
	Monthly earnings	TL	10,743.53	4,187.90
	Age	Years	45.63	9.68
Human Resources	Years of experience	Years	22.28	9.94
	Take part in seminars or training courses on climate change	1-Yes, 2-No	0.03	0.16
	Farm visits by agricultural engineers to provide information	1-Yes, 2-No	0.62	0.49
	Use of labor other than family labor	1-Yes, 2-No	0.46	0.50
Resources for production and marketing infrastructure	Use of certified seeds	1-Yes, 2-No	0.81	0.40
	Receive warnings about climate change	1-Yes, 2-No	0.84	0.36
Institutions resources	Se rendre à la direction départemental/provinciale de l'agriculture	1-Yes, 2-No	0.95	0.22
Social capital resources	Be a member of agriculture-related social networks	1-Yes, 2-No	0.47	0.50
	Membership of agricultural groups	1-Yes, 2-No	0.28	0.45
	Discuss climate change challenges within cooperatives	1-Yes, 2-No	0.22	0.45
Natural resources	Farm fertility	1-Yes, 2-No	0.86	0.35
	Soil analysis	1-Yes, 2-No	0.33	0.47
	Use of renewable energy sources	1-Yes, 2-No	0.09	0.28
	Violent winds in the village in the last 10 years	1-Yes, 2-No	0.47	0.50
	Hurricane in the village in the last 10 years	1-Yes, 2-No	0.03	0.18
	Flooding in the last 10 years	1-Yes, 2-No	0.27	0.44

Source: Results of the survey.

RESULTS AND DISCUSSIONS

Analysis of determinant characteristics

Economic resources

Diversifying income sources is an effective adaptation strategy in response to the impacts of climate change, as it allows producers to mitigate the risks associated with relying on a single activity. Among the respondents, 63% engage in various forms of diversification. Some achieve this through livestock farming (36%), while others pursue commerce (21%). According to [35], crop rotation also enables farmers to diversify their income sources. However, due to the small size of farms and low productivity in certain regions, [9] recommend that non-agricultural activities serve as a supplementary source of income diversification. Diversifying income sources, whether through expanding agricultural activities or exploring non-agricultural opportunities, helps enhance the economic resilience of producers against climate disruptions and other risks. It also provides a pathway to greater financial security for farming households, thereby supporting their long-term economic stability.

In the survey, 61% of the interviewed producers utilized agricultural credit for wheat production, and 52% of them were indebted as a result. This high percentage of agricultural credit usage highlights the need for financing wheat production in the Yalvaç district. Similar results have been observed in the Uşak province, where 49% of producers also used agricultural credit for wheat cultivation [30]. In the Chinese province of Sichuan, farmers use agricultural credit to increase their cereal production by investing in agricultural technologies that mitigate the effects of climate change [19]. Regarding Turkish state agricultural subsidies, a large majority of the surveyed producers (96.6%) believe these supports are beneficial. The most advantageous subsidies pertain to diesel and fertilizers. This positive perception of public subsidies, particularly those related to fuels and fertilizers, underscores their importance to producers and their favorable impact on farm profitability and productivity.

Human resources

Over the past five years, only 2.6% of the surveyed producers have attended courses, seminars, or training sessions related to climate change. These sessions mainly focused on water resource management and drought mitigation. These results highlight an increasing need for specialized climate change training programs for producers. The low participation rate in current training suggests that there is a need to strengthen and expand these initiatives, with a particular emphasis on crucial topics such as the use of drought-resistant seeds. Enhanced awareness and better access to such training will strengthen producers' capacity to cope with the effects of climate change. [10] take a similar approach, revealing that in Tokat province, only 1.5% of participants attended climate change training. Research conducted in Burundi also found that a lack of training and information on climate and adaptation strategies are major barriers to farmers' adaptation to climate change [7]. Furthermore, according to a survey by the Ministry of Agriculture and Forests, 94% of producers believe it would be beneficial for the ministry to organize specific training on managing climate change impacts to improve farmers' adaptation capacity [38]. Agricultural technicians' visits to farms play a crucial role in sharing information and providing technical advice to producers. According to the survey, 62% of the farmers interviewed reported having received visits from agricultural technicians of the provincial agriculture directorate during the 2021-2022 growing season. These visits mainly focus on technical aspects of production, such as fertilization, spraying, and pest control. However, topics related to climate change are rarely addressed during these visits. This lack of discussion on climate issues indicates a gap in integrating climate change concerns into the advisory services offered to farmers, despite their increasing importance.

[15] support this view by revealing that farmers visited by extension agents are very unlikely to implement climate change adaptation measures. Additionally, a survey by [10] in Tokat province reveals that information provided by the Provincial Directorate of Agriculture and Forests is considered insufficient by producers. They also criticize the overly bureaucratic nature of the institution and the absence of agents in the field. These criticisms underscore the need for provincial agricultural services to enhance their presence with farmers and improve the quality of assistance provided, to better meet the needs of operators and tailor recommendations to local realities.

The migration of young people from rural areas to cities in search of better living conditions directly impacts the availability of labor on farms [2]. Indeed, only 46% of the surveyed farmers reported using non-family labor for wheat production. The reliance on external labor indicates a difficulty in maintaining a sufficient local workforce. This decline in labor availability makes it more challenging to implement robust measures to address the effects of climate change. Adaptation strategies often require additional efforts in management and implementation, which are difficult to achieve without an adequate labor force. Thus, rural depopulation not only weakens farm operations but also reduces their capacity to adapt to climate-related challenges.

Production and marketing infrastructure resources

In Turkey, subsidies for the use of certified seeds, established since 2004 [12], have had a significant impact on agricultural practices. Indeed, 81% of the surveyed producers used certified wheat seeds during the 2021-2022 growing season. This high adoption rate reflects the success of the support policy, which has encouraged farmers to choose certified seeds. These seeds offer several benefits, including better resistance to drought, insects, and diseases, which contributes to reduced production costs while improving wheat yield and quality. This result highlights the importance of public policies in enhancing agricultural practices and farm resilience to climate challenges. The importance of staying informed about climate variations is underscored by the fact that 95% of farmers regularly monitor weather forecasts. Among them, 48% receive alerts from the meteorological office, while 46% obtain information through the provincial agricultural directorate. This underscores the crucial role of these institutions in providing accurate and accessible climate information. It is essential for them to provide producers with updated data that enables them to plan and adapt their agricultural practices effectively based on changing weather conditions.

Institutional resources and social capital

Among the surveyed producers, 39% use the internet to search for information on climate change. This use allows them to access a variety of resources, including real-time weather data, scientific reports, and practical advice. Meanwhile, 26% of the producers obtain information through television, indicating that traditional media continue to play a significant role in disseminating information, particularly for certain segments of producers. Additionally, 95% of the producers report turning to the provincial agricultural directorate for advice on managing their farms, with 57% of them consulting this institution more than three times a year. Other sources, such as fellow producers, neighbors, and extension centers, are also utilized. These findings align with the work of [13, 14, 31], which demonstrate that farmers receive climate change information through radio programs, cooperatives, and agricultural extension centers.

Nearly half of the producers (47.4%) are members of agricultural-related social networks, with a predominance of Facebook and WhatsApp groups. Additionally, a large majority (81%) of producers are affiliated with an agricultural cooperative in their village, primarily with the village development cooperative (67%). However, only 28% of producers report that climate change issues are addressed within their cooperative. This suggests that agricultural cooperatives are not perceived as central venues for obtaining information or participating in discussions on this crucial topic. Therefore, it is necessary to enhance engagement with climate change issues within these organizations. Nevertheless, as highlighted by [18, 34], farmers who are members of a cooperative are generally more likely to share their knowledge, innovative ideas, and problems, and to adopt agricultural practices that are adapted to the impacts of climate change, underscoring the importance of these organizations in disseminating best practices.

Natural resources

To continue farming despite the effects of climate change, 42.2% of the producers surveyed reported renting agricultural land, while 13.8% purchased land and 12.9% sold land over the past decade. Additionally, 31% of producers neither bought, sold, nor rented land. Although the majority of producers (86.2%) perceive their soil as fertile, only 33% have conducted soil analyses. This low rate of soil testing highlights an increased need for awareness about the benefits of this practice, particularly regarding more efficient resource management and optimal fertilizer use. In fact, 16% of farmers reported reducing their fertilizer purchase costs through soil testing, illustrating a willingness to improve their agricultural practices based on soil characteristics. Better soil management can also contribute to climate change adaptation by strengthening farm resilience. Furthermore, 25% of producers indicated they use wood for domestic purposes. If this practice continues, it may exacerbate pressure on natural resources and contribute to forest degradation, worsening the effects of climate change. Less than 10% of surveyed producers use renewable energy on their farms, indicating a low commitment to more sustainable practices. However, renewable energy is crucial for reducing greenhouse gas emissions and mitigating climate change impacts. Additionally, 45% of producers reported experiencing strong winds in their villages over the past decade, and 27% mentioned flooding. Extreme weather events are perceived by 27% of producers as linked to climate change, indicating growing awareness of the interactions between human activities and extreme weather conditions. Similar findings were observed in Tokat province, where farmers reported strong winds, floods, hailstorms, and frost events [10]. Studies, such as the one conducted by [23] in Elazığ province, reveal that 100% of respondents have observed changes such as increased plant diseases, seasonal anomalies and water shortages over the past 20 years, reinforcing the idea that climate change has become a tangible reality for many agricultural communities.

Analysis of the determinants of adaptability to climate change

The multicollinearity assessment was conducted using the tolerance index (TOL) and the variance inflation factor (VIF) to eliminate multicollinear variables (Table 2).

Collinearity between explanatory variables is detected when the TOL is less than 0.1 or the VIF exceeds 10 [6, 41]. Consequently, variables that did not meet these criteria were excluded. Table 2 presents the TOL and VIF results. The findings indicate that all TOL values are greater than 0.1, and all VIF values are below 10, suggesting no collinearity issues.

The results of the logistic regression, detailed in Table 3, reveal that in each model, at least one independent variable significantly influences the producers' decision to implement adaptation measures against the impacts of climate change, with a significance level of 5%.

The R^2 indicator, which ranges from 0 to 1, is used to assess how well the model fits the data. The higher the value, the better the model matches the observed data.

However, in the social sciences, a Nagelkerke R^2 value greater than 0.2 (20%) is considered indicative of a good fit [41].

Table 2. TOL and VIF results

	Variable	TOL	VIF
Economic resources	Income diversification	0.64	1.58
	Use of agricultural credit or financial tools	0.73	1.37
	Use of agricultural subsidies	0.63	1.59
	Monthly earnings	0.80	1.25
Human Resources	Age	0.26	3.78
	Years of experience	0.30	3.36
	Take part in seminars or training courses on climate change	0.86	1.16
	Farm visits by agricultural engineers to provide information	0.68	1.47
	Use of labor other than family labor	0.58	1.71
Resources for production and marketing infrastructure	Use of certified seeds	0.63	1.59
	Receive warnings about climate change	0.56	1.78
Institutions resources	Se rendre à la direction départemental/provinciale de l'agriculture	0.68	1.46
Social capital resources	Be a member of agriculture-related social networks	0.49	2.05
	Membership of agricultural groups	0.62	1.61
	Discuss climate change challenges within cooperatives	0.69	1.50
Natural resources	Farm fertility	0.77	1.3
	Soil analysis	0.70	1.44
	Use of renewable energy sources	0.83	1.20
	Violent winds in the village in the last 10 years	0.53	1.88
	Hurricane in the village in the last 10 years	0.73	1.36
	Flooding in the last 10 years	0.38	2.62

Source: Own calculation based on the survey data.

For the various models presented, the R^2 exceeds this threshold, suggesting a satisfactory fit. For instance, the Y4 model has a Nagelkerke R^2 of 0.64, meaning that the independent variables included in this model explain 64% of the variance in the producers' decisions, indicating a relatively high predictive capability. This underscores the relevance of the identified factors in influencing climate change adaptation practices.

Economic factors

The results of the binary logistic regression (Table 3) indicate that the use of agricultural credit ($p=0.02$) has a significant negative effect on farmers' decisions to practice crop rotation. This means that an increase in access to agricultural credit would lead to a 2% decrease in the likelihood of adopting this practice. This negative effect could be explained by the obligation to repay the credit, which might reduce producers' flexibility in adopting longer-term practices such as crop rotation. Similar findings were reported by [32], where access to agricultural credit also showed a negative effect on producers' climate change adaptation strategies. However, other previous studies [3, 15, 4] demonstrated that access to agricultural credit significantly and positively influences climate change adaptation measures. These studies highlight that access to financial resources enables farmers to fund the purchase of inputs and agricultural technologies, thereby promoting their adaptation to the effects of climate change. Furthermore, [1] reveal that access to agricultural credit has no notable influence on adaptation measures. This divergence in results underscores the importance of local contextual and economic factors that may differently affect how farmers utilize agricultural credit to adapt to climate change.

The use of agricultural subsidies (p=0.05) has a positive effect on farmers' decisions to increase the application of fertilizers and pesticides (Table 3). Specifically, a one-unit increase in the use of agricultural subsidies raises the probability of increasing the use of these inputs by 5%. This suggests that subsidies encourage farmers to intensify their use of fertilizers and pesticides, likely in an effort to optimize production and maximize yields. This intensification may also be seen as a response to increasingly unpredictable climate conditions, with farmers aiming to enhance the resilience of their crops against disruptions such as droughts, diseases, or pest infestations.

However, this trend of increased chemical input use may raise concerns regarding environmental sustainability, particularly in terms of impacts on soil quality and local ecosystems.

Human factors

The use of non-family labor significantly influences producers' decisions regarding climate change adaptation strategies. It has a positive effect on the decision to increase fertilizer and pesticide application (p = 0.00), with a one-unit increase in the use of non-family labor raising the likelihood of increasing these inputs by 1%. This suggests a connection between access to external labor and the intensification of agricultural practices, likely due to the increased availability of workers to manage more complex and labor-intensive farming tasks. Conversely, the use of non-family labor has a negative effect (p = 0.02) on farmers' decisions to rely on weather information for climate change adaptation. This may imply that while access to external labor supports production intensification, it may also reduce attention to proactive planning and management based on weather forecasts. Producers seem more focused on maximizing immediate yields rather than anticipating climate-related risks.

Production and marketing infrastructure factors

Receiving climate warning messages (e.g., temperature and rainfall alerts) has a significant but negative effect on producers' decisions to increase fertilizer use (p = 0.04) and practice crop rotation (p = 0.02). This outcome may be explained by the fact that upon receiving such warnings, producers might adopt a more cautious or conservative approach, reducing their confidence in increasing inputs like fertilizers or changing agricultural practices such as crop rotation. Rather than taking reactive measures by intensifying input use, they might prefer making more moderate adjustments or waiting for more stable climatic conditions before committing to major changes. These findings align with several previous studies. [1] demonstrated that access to weather information enhances farmers' adaptive capacity to climate change by making them more aware of potential risks and encouraging them to diversify their agricultural practices. Similarly, research by [33, 26, 4], confirms that knowledge of and access to climate information positively influence farmers' adaptation decisions. Farmers who receive early climate warnings are more likely to adjust their practices in a timely manner, whereas those receiving such information later may be forced to react more unpredictably or take riskier actions.

Institutional factors and social capital

Relying on the provincial/district agricultural office (p = 0.01) has a significant and negative impact on farmers' decisions to follow weather information for climate change adaptation. The negative coefficient for this variable may be explained by farmers perceiving the information provided by local authorities as insufficiently relevant or outdated to meet their immediate adaptation needs. This could discourage them from actively following weather information from other sources or relying entirely on such information to guide their agricultural practices. Similarly, [1] suggest that the negative significance of farmers' access to extension services may be linked to the perception that the information provided is often outdated or misaligned with the current realities of climate change. This perceived lack of relevance can lead to mistrust or reduced dependence on these services when making climate adaptation decisions.

However, other studies, such as those by [3, 15, 33, 5, 4], show that farmers who maintain regular contact with extension agents are generally better able to adopt practices that mitigate the effects of climate change. These regular interactions facilitate access to technical information, innovations, and practical advice that can improve farmers' resilience and adaptive capacity.

Natural factors

The regression results reveal that several factors influence producers' decision-making regarding agricultural practices in response to climate change. Conducting a soil analysis (p = 0.02) significantly affects the decision to change wheat varieties. The negative coefficient associated with this variable suggests that after performing a soil analysis, farmers are less likely to switch wheat types. This may be because soil analysis helps them better understand the characteristics of their land, allowing them to optimize the wheat varieties they already use, thereby reducing the need to change.

Table 3. Results of binary logistic regression

	Y1		Y2		Y3		Y4	
	β	P	β	P	β	P	β	P
Economic factors								
Income diversification	-0.30	0.65	-0.23	0.68	0.21	0.79	1.11	0.35
Use of agricultural credit or financial tools	-0.67	0.34	-0.91	0.09	-1.63	**0.02****	3.91	0.07
Use of agricultural subsidies	2.02	0.30	5.04	**0.05****	0.25	0.91	-14.40	1.00
Monthly earnings	0.00	0.88	0.00	0.54	0.00	0.06	0.00	0.11
Human factors								
Age	0.01	0.86	0.04	0.42	-0.06	0.28	-0.03	0.76
Years of experience	-0.01	0.51	-0.03	0.52	0.04	0.37	0.22	0.10
Take part in seminars or training courses on climate change	1.79	0.36	-0.13	0.93	2.14	0.13	-11.73	1.00
Farm visits by agricultural engineers to provide information	-0.85	0.22	0.32	0.58	-0.04	0.95	-0.93	0.38
Use of labor other than family labor	-0.63	0.44	1.99	**0.00*****	-0.74	0.39	-4.68	**0.02****
Factors for production and marketing infrastructure								
Use of certified seeds	-0.85	0.27	-1.13	0.11	0.57	0.50	-2.66	0.13
Receive warnings about climate change	-0.60	0.48	-1.76	**0.04****	-2.31	**0.02****	1.50	0.44
Institutions factors								
Go to the departmental/provincial directorate of agriculture	-0.63	0.63	-2.73	0.20	-20.31	1.00	-13.56	**0.01*****
Social capital factors								
Be a member of agriculture-related social networks	-1.68	0.06	-0.53	0.41	-0.91	0.26	-0.97	0.50
Membership of agricultural groups	1.67	0.10	-0.52	0.43	1.42	0.08	-5.10	0.06
Discuss climate change challenges within cooperatives	0.13	0.87	-0.02	0.98	0.38	0.63	-21.93	1.00
Natural factors								
Farm fertility	-0.42	0.64	1.04	0.23	-0.24	0.79	-0.22	0.90
Soil analysis	-2.62	**0.02****	0.92	0.11	-1.48	0.06	-3.95	0.11
Use of renewable energy sources	-1.68	0.21	0.26	0.78	0.57	0.62	4.30	**0.04****
Violent winds in the village in the last 10 years	1.93	**0.02****	-0.13	0.84	-0.86	0.29	1.88	0.27
Hurricane in the village in the last 10 years	-1.62	0.39	-0.25	0.88	-38.20	1.00	-31.18	1.00
Flooding in the last 10 years	-0.65	0.49	-0.41	0.61	-0.36	0.73	-2.77	0.28
Farm fertility	5.89	0.11	-0.25	0.92	42.27	1	75.59	1
N	116							
Nagelkerke R Square	0.41		0.35		0.53		0.64	

β: Coefficient, P : P-value, Y1 : Change of wheat type, Y2 : Increasing fertilizer and pesticide rates, Y3 : Crop rotation, Y4 : follow weather information, ** 5%, *** 1%

Source: Own calculation based on the survey data.

Experiencing strong winds in the village over the past ten years (p = 0.02) significantly influences the decision to switch wheat varieties. Extreme weather events, such as strong winds, may prompt farmers to adapt their crops by selecting wheat varieties that are more resilient to harsh climate conditions, thereby protecting their yield.

The adoption of renewable energy sources (p = 0.04) also significantly impacts producers' decisions to follow weather information to adapt to climate change. Integrating renewable energy sources reflects a heightened awareness of sustainability and resource management, encouraging farmers to stay attentive to weather conditions to better manage their farms in the context of climate change. These findings highlight the importance of climate-related experiences, sustainable agricultural practices, and modern technologies (such as soil analysis and renewable energy) in shaping farmers' adaptation decisions in the face of climate challenges.

CONCLUSIONS

In this study, the factors influencing climate change adaptation among wheat producers were analyzed. Using a binary logistic regression model, variables that could affect farmers' decision-making were examined. The results revealed that the adaptation measures implemented by farmers include changing wheat varieties, adjusting fertilizer and pesticide doses, crop rotation, and monitoring weather information. Factors such as access to agricultural credit, conducting soil analyses, the use of agricultural subsidies, reliance on non-family labor, and receiving climate change warning messages significantly influenced the adoption of various adaptation strategies.

Based on these findings, it is recommended to implement targeted training and awareness programs to enhance farmers' knowledge of climate change adaptation techniques. These initiatives should include practical workshops on sustainable resource management, optimizing agricultural inputs, and the effective use of technological tools such as weather alert systems. Additionally, policymakers must improve access to agricultural credit and subsidies while facilitating the development of agricultural infrastructure suited to the changing climate conditions. Increased institutional support, in collaboration with climatology and agronomy experts, would help promote farmers' resilience. Furthermore, encouraging crop diversification and alternative economic activities could reduce dependency on wheat and mitigate risks associated with climate fluctuations, thus contributing to long-term food security. These recommendations should be integrated into a national agricultural resilience strategy to address the ongoing climate challenges.

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INTEGRATING INDIGENOUS KNOWLEDGE SYSTEMS (IKS) IN CLIMATE CHANGE POLICIES IN AFRICA: BARRIERS, STRATEGIES AND FUTURE DIRECTIONS. EMPHASIS ON AGRICULTURE

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Abstract

This article examines the crucial role of indigenous knowledge systems (IKS) in climate change adaptation and mitigation from an African perspective. Despite recognition in the Intergovernmental Panel on Climate Change (IPCC)'s Fifth and Sixth Assessment Reports (AR5 and AR6) as vital contributors to climate solutions, the inclusion of indigenous communities in climate research and policy remains limited. We review peer-reviewed literature to evaluate the extent and effectiveness of IKS in addressing climate equity and community resilience across Africa, highlighting disparities in its deployment. The urgency is underscored by projections indicating a temperature rise exceeding 3°C, even with compliance to Intended Nationally Determined Contributions. We discuss how traditional localized knowledge can address climate change, as acknowledged by the IPCC, and the decline of IKS due to modernization. The review aims to assess the significance of IKS in climate strategies, identify barriers to their incorporation into science-based guidelines, and suggest pathways for integrating indigenous insights into Africa's climate policies. By shedding light on these critical themes, we advocate for a collaborative approach that values indigenous voices in tackling the pressing challenges presented by climate change.

Key words*: *adaptation, climate change policy, indigenous knowledge systems, mitigation

INTRODUCTION

Climate change adaptation and mitigation stand among some of the most pressing challenges facing society today. They are complicated further by the unpredictable nature of future climate change impacts and the necessity for fair and equitable resource allocation [63]. Amidst these global struggles, vital contributions of indigenous communities have started to gain recognition, particularly in the Intergovernmental Panel on Climate Change (IPCC) Fifth and Sixth Annual Reports (AR5 and AR6), which underscore their potential to contribute towards innovative solutions to our warming planet [2, 6]. The IPCC's AR6 reiterated the effectiveness of IKS in addressing environmental challenges and recognized these systems as equal contributors to climate science and policy [6, 18]. IKS embodies knowledge and practices shaped by generations of cultural heritage, evolving through harmonious interactions with the environment [60]. Yet, the advance of technology and modernization has led to a decline in the application of IKS to global issues [27].

Scholars increasingly acknowledge the significant role and critical relevance of IKS across various disciplines including combating the consequences of climate change [29, 30]; traditional medicine; agroforestry and biodiversity [19, 24]. However, the documentation of IKS benefits in tackling climate challenges remains inadequate leading to their underrepresentation in climate change research and policy discussions [2, 50]. This article aims to fill that gap through a comprehensive review of peer-reviewed literature, providing robust evidence for the role of IKS in climate mitigation and adaptation efforts from an African perspective. It addresses key questions about the significance of IKS in combating climate change and explores the potential for its integration into Africa's climate policies.

Moreover, it seeks to identify barriers to incorporating IKS into science-based guidelines, with the ultimate goal of enhancing engagement with indigenous communities whose knowledge is essential for fostering healthy ecosystems across Africa.

MATERIALS AND METHODS

The study employed the systematic literature review methodology [13, 50, 64] for its comprehensiveness and adaptability in examining peer-reviewed knowledge. This approach facilitates an in-depth exploration of evidence regarding the validity of IKS in climate change mitigation and adaptation. It allows for the analysis of existing evidence, evaluation of current understanding, and identification of promising avenues for future research. This review aimed to provide a holistic overview of accumulated knowledge while highlighting patterns, trends, knowledge clusters, and research gaps. Information was gathered from peer-reviewed academic publications, working papers, and reports dating back to the year 2000, a pivotal year following the recognition of IKS at the 1992 Rio Earth Summit.

An initial search across four databases: Web of Science, ScienceDirect, Scopus, and Google Scholar using key terms: 'climate change' OR 'global warming' OR 'climate variability', combined with 'adaptation' OR 'mitigation' OR 'response', and 'indigenous knowledge systems (IKS)' OR 'traditional ecological knowledge (TEK)' OR 'local knowledge (LK)', yielded 2,380 results, prompting further refinement of filters (Fig. 1).

Screening was performed using Reporting Standards for systematic review analysis (Fig. 1) across four databases: Web of Science, ScienceDirect, Scopus, and Google Scholar. We also reviewed the IPCC WGII and WGIII AR6 reference list for pertinent publications related to indigenous issues. To refine our selection to relevant works on "climate change mitigation" and "climate change adaptation," we applied a combination of filters. For mitigation, we included terms such as "mitigation," "GHGs," "carbon dioxide (CO2)," and "decarbonization." For adaptation, we utilized terms like "resilience," "adaptation," "risk management," and "disaster reduction," while also considering synonyms. We screened document titles, abstracts, and keywords to ensure comprehensive data retrieval. Our search covered publications from 2000 to 2023.

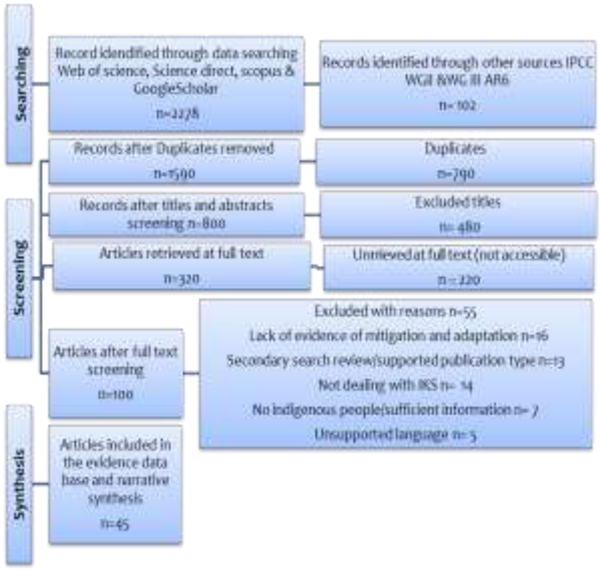

Fig. 1. The inclusion/exclusion criterion of publications used in the study
Source: Adapted from [15].

Inclusion and exclusion criteria were adapted from [15, 50, 64], focusing on prominent themes such as 'indigenous knowledge systems (IKS),' 'traditional knowledge,' and 'native science'.

Data extraction involved coding each publication according to specific subcategories related to metadata, as well as spatial and temporal distribution across Africa. This coding process was informed by concepts derived from literature focused on climate change and indigenous communities.

To ensure a robust review of the literature and assess the likelihood of disciplinary bias, we analyzed the journal disciplines of all papers cited in the Working Group II (WGII) and Working Group III (WGIII) submissions for the Sixth Assessment Report (AR6) [57]. This analysis, populated in the Web of Science (WoS), provided a comprehensive understanding of the conceptual framework underpinning the AR6 assessment report.

While this descriptive reporting review offered a broad overview of the evidence base, it had several limitations.

Studies focused solely on climate change without adequately addressing adaptation and mitigation were excluded.

Retrospectively, incorporating broader search terms such as "indigenous science", "ethnoscience" or "folk knowledge" could have expanded study findings. Additionally, resource constraints, including time limitations and manual processes, restricted our focus to key indicators of interest regarding temporal and spatial scales during the coding process.

Moreover, the mapping of the evidence base was constrained by the lack of consideration for other relevant databases that might not align with our predefined format.

During the coding and data extraction phase, we did not conduct separate validity and consistency checks typical of full systematic reviews, which are crucial for validating findings.

Nonetheless, we acknowledge that this step is essential for comprehensive evaluations that include critical appraisals of study results.

RESULTS AND DISCUSSIONS

This section presents findings and discussions under four broad themes.

These are: IKS publication typology and their distribution in Africa; IKS used in climate change adaptation; IKS used in climate change mitigation; and IKS integration in climate change policies (barriers, integration approaches, and strategies to overcome them).

IKS publication typology and their distribution in Africa

This review highlighted the growing recognition of IKS in addressing climate change in Africa, particularly since 2014 (Fig. 2).

There was a clear regional disparity in research output, with Southern Africa leading significantly, as illustrated in Fig. 3.

The 33 articles from Southern Africa (73% of total IKS articles in Africa) could reflect the robust research infrastructure and collaborative networks in countries like South Africa and Zimbabwe. These nations not only have diverse ecosystems but also a rich tapestry of indigenous practices that have been documented and studied extensively. These studies showcase that IKS can enhance biodiversity conservation and resilience to climate change. In contrast, the scarcity of IKS publications in Central and North Africa raises important questions. For instance, the lack of research in Central Africa might be linked to challenges like limited academic funding or geopolitical instability, which can hamper research initiatives. This situation underscores the need for targeted efforts to bolster research output in these regions, perhaps by fostering partnerships with international institutions or enhancing local academic capacity.

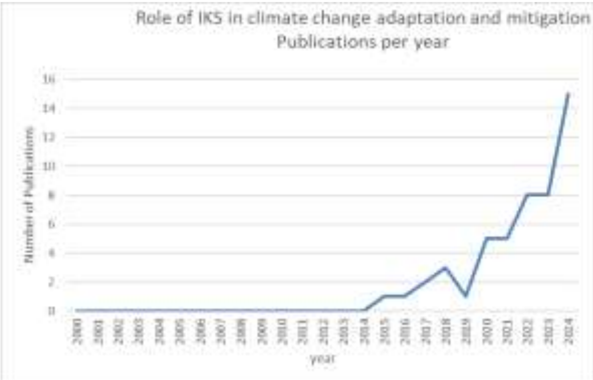

Fig. 2. The trend of IKS articles in Africa from 2000-2024

Source: Graph generated by authors from literature that met the inclusion/exclusion criteria for this review.

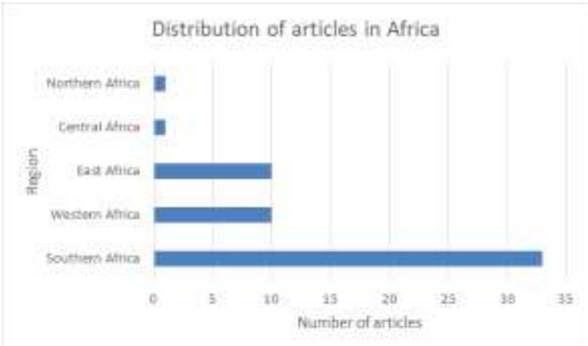

Fig. 3. Distribution of IKS articles across geographical regions of Africa

Source: Graph generated by authors from literature that met the inclusion/exclusion criteria for this review.

These findings resonate with the broader trend acknowledged in the IPCC reports, emphasizing that integrating IKS with scientific approaches can yield more effective climate adaptation strategies. For future research, it would be beneficial to explore case studies from the underrepresented regions to uncover unique indigenous practices that could contribute to holistic climate solutions. This could pave the way for a more inclusive understanding of climate resilience across the continent.

IKS used in climate change adaptation

IKS has been used by communities in Africa to adapt their farming systems to climate change in a plethora of ways. Table 1 shows the adaptation options where IKS has been utilized.

Table 1. IKS climate change adaptation options

Adaptation option	Examples	References
Cultivar improvements	Breeding of locally adapted traditional seed varieties. Climate-proof varieties, pest and disease resistance. Animal breeding.	[1, 44, 48]
Farm-level water management and storage	Rainwater harvesting.	[3, 27, 36]
Soil moisture retention	Conservation farming (*pfumvudza*), mulching, zai pits.	[20, 49, 55]
Irrigation	Canal Stone bands	[8]
Community-based adaptation	Traditional norms, taboos, sacred groves, selective logging, traditional rituals, ceremonies	[37, 38]
Farm-level land management	Terracing Use of contours	[41, 42]
Sustainable land management approaches	Control of land degradation Manuring Rotational grazing Agroforestry	[39, 47, 58]
Agro-ecological principles and practices	Intercropping, crop rotation, mixed farming	[10, 45]
Disaster risk management	Early warning systems, safety nets	[20, 27, 35]
Ecosystem-based adaptation	Wetland restoration, upstream forest ecosystem management Maintain biodiversity	[7, 40, 53]

Source: A synthesis made by authors based on literature mentioned in the table.

The IKS adaptation options and where they have been utilised in Africa are discussed in greater details as follows:

Cultivar improvements

Indigenous communities have been cultivating and preserving a diverse range of climate-resistant crop varieties that are adapted to local ecosystem conditions [1]. These traditional crop varieties often demonstrate resilience to climate challenges, such as temperature tolerance, resistance to pests and diseases [41, 44]. These practices have been observed in dry to semi-arid regions of Uganda, Sudan, Congo, Tanzania and Zimbabwe [36].

Farm level water management

Traditional methods for collecting water include the construction of ponds, tanks, and other water-harvesting structures [27]. IKS-based strategies help to mitigate the effects of climate change-induced water scarcity resulting from unpredictable rainfall patterns. Rainwater harvesting is widely practiced in various regions such as the Sahel region, East Africa, Southern Africa, West Africa and notably in the Horn of Africa.

Soil moisture retention

Indigenous communities utilize IKS-based techniques such as *zai pits* and *pfumvudza* to effectively manage climate variability. *Zai pits* have been traditionally employed for many centuries in the northern and central regions of Burkina Faso, Niger, Mali, Chad, and Nigeria [49, 55]. This age-old technique is a successful IKS-based method for addressing climate change and degradation. It is a technology which consists in planting each plant in a small pit of about 20-30 cm in width, 10-20 cm in deep and filled with manure. In this way, the rainfall water could be collected in the zai pits helping the crop to grow. The technology could be applied in ten regions where precipitations vary between 300- 800 mm per year.

Pfumvudza is a climate-smart IKS-based approach that focuses on enhancing soil moisture retention, improving soil fertility, controlling erosion, and diversifying crops. It has been widely adopted in Zimbabwe, Malawi, Zambia, and parts of East Africa [27].

This technology helps the small farmers to create planting basins, where seeds from high production potentials varieties and mulching are incorporated.

Community-based adaptation

Indigenous communities have effective methods for passing down knowledge between generations and have social institutions in place to govern resource use and adapt to climate change [29]. These methods help to maintain and strengthen traditional knowledge systems [37]. People with traditional knowledge share their expertise with younger generations through oral traditions, rituals, ceremonies, and community-based education systems [38].

Sustainable land management practices

Indigenous pastoralist communities have developed extensive knowledge and practices for managing rangelands including rotational grazing, mobility patterns, and the use of traditional indicators to determine grazing periods and areas [39, 58]. Additionally, pastoralists in Kenya, Ethiopia, and Uganda use ecological and anthropogenic indicators such as soils, vegetation, and livestock production to understand land degradation trends [47, 51]. These adaptive strategies promote sustainable livestock production, mitigate climate risks, and help maintain the health and productivity of rangeland environments [7].

Agroecological principles

Agroecological farming practices often include principles that promote sustainable and resilient agricultural systems. These principles include intercropping, crop rotation, mixed farming, and the use of traditional seed cultivars that are well-suited to local conditions [10, 45]. This type of farming enhances soil fertility, biodiversity, and water conservation, which in turn contributes to climate change resilience [49, 55].

Disaster management

Scholars have also documented the utilization of certain bird sounds in Tanzania for weather and seasonal forecasting and linked increased breeding of wild animals with a better seasonal outlook across Africa [30, 48]. The shedding and sprouting of new flashes of leaves, flowering, and profuse fruit are also indicators of predicting the onset of seasonal widely used in Burkina Faso and Tanzania [20]. In addition, rainmaking ceremonies are common in Zimbabwe, Uganda, and Burkina Faso [40 48, 52]. Aboriginal people have devised erudite systems for observing and predicting weather patterns based on symbolic moral relationships between animal behaviour, cloud formations, wind patterns, and celestial observations [27, 35]. This is extensively used across Southern Africa in traditional weather forecasting systems, agricultural planning and resource management, and disaster preparedness [32].

Ecosystem-based adaptation

IKS encompass a range of strategies that have been developed and refined over generations to help maintain biodiversity, carbon sequestration, and ecosystem services [53]. These strategies draw from traditional knowledge, practices, and innovations for instance, agroecological farming practices such as vibrant organic knowledge of forest ecosystem management and conservation [7, 40]. These practices include selective logging, sacred groves, community-based forest management, and traditional norms and taboos that regulate resource use [38].

IKS used in climate change mitigation

Climate change mitigation refers to the efforts made to minimize greenhouse gas (GHG) emissions or remove them from the atmosphere. In Africa, IKS provides a variety of options for sustainable land management practices such as agroforestry, terracing, contour ploughing, and organic fertilizers to mitigate climate change [31, 55].

Table 2 shows some of the options for sustainable land management. These methods help in conserving the soil, enhancing its fertility, and preventing erosion, thereby improving soil health and preventing land degradation [42]. By promoting carbon sequestration, these strategies contribute to mitigating climate change.

Table 2. IKS climate change mitigation strategies

Climate mitigation option	**Examples**	**References**
Solar energy	Sun drying of vegetables, fish	[54]
Wind energy	Using wind in winnowing, pumping water	[54]
Energy efficiency	Cookstoves, biogas from organic waste	[62]
Improved forests	Sacred groves, traditional norms, taboos	[47, 51]
Crop/ grassland management	Agroforestry, terracing, contour ploughing, fertility enhancement, soil erosion control, mosaic burning	[12, 42, 55]

Source: A synthesis made by authors based on literature mentioned in the table.

Indigenous communities across the African continent possess a wealth of knowledge regarding forest ecosystems, which they have cultivated over generations to foster sustainable forest management and conservation [28, 40]. Their practices encompass various strategies such as the establishment of sacred groves, implementation of community-based forest management, and adherence to traditional norms and taboos that govern resource utilization. For instance, sacred groves serve as vital biodiversity hotspots while also contributing to the preservation of local flora and fauna.

In addition to forest management, indigenous communities play an instrumental role in reforestation efforts. By actively engaging in tree planting and restoring degraded landscapes, these communities help sequester carbon from the atmosphere—an essential process in mitigating climate change [47, 51]. For example, the Maasai in Kenya have been involved in initiatives to restore indigenous tree species, thereby enhancing carbon sequestration while reviving local ecosystems.

As mentioned in discussions on ecosystem-based climate change adaptation, indigenous pastoralist communities employ traditional knowledge to promote sustainable livestock management. Practices such as rotational grazing, strategic mobility patterns, and the use of indigenous indicators for determining optimal grazing periods and areas help mitigate overgrazing and land degradation [40, 47]. For instance, the Borana pastoralists in Ethiopia utilize traditional knowledge to manage their herds effectively, which has shown to enhance resilience against climate variability.

Moreover, many indigenous communities rely on traditional energy systems that incorporate energy recycling methods, including biomass, solar energy, and wind power [54]. These systems involve practices such as using improved cookstoves, producing biogas from organic waste, and harnessing solar and wind energy for various applications [62]. By reducing dependence on fossil fuels, these practices significantly contribute to greenhouse gas emissions reduction.

Indigenous communities also make substantial contributions to climate change mitigation through the protection of natural resources and biodiversity. Techniques such as no or minimised selective burning are integral to maintaining ecosystem health and reducing carbon dioxide emissions [55]. Lastly, the ecological knowledge held by indigenous knowledge holders encompasses critical insights into local ecosystems, including species interactions, habitat functions, and environmental processes. This knowledge can guide ecosystem-based solutions for protecting and restoring wetlands, mangroves, and other natural habitats that sequester carbon and provide essential ecosystem services [9, 12]. For example, the restoration of mangrove forests by coastal communities in Senegal not only enhances carbon storage but also protects against coastal erosion and supports biodiversity.

IKS integration in climate change policies: barriers and strategies to overcome them

Integrating IKS with modern scientific approaches presents a promising pathway for sustainable development, particularly in the face of climate change [11, 56]. However, several barriers impede this integration. Strategic approaches can help overcome these challenges. This section discusses barriers to the IKS-modern science integration, integration approaches and strategies for overcoming barriers:

Barriers to IKS integration in climate change policies

There are several barriers to integrating IKS in climate change policies ranging from lack of resources and support systems for farmers to the fragmented nature of the IKS itself among others (Table 3). These barriers are described briefly in Table 3.

Approaches for integrating IKS with scientific knowledge

The study identified three primary approaches for integrating IKS with scientific knowledge and hence potentially into climate change policies and these are:

Incorporationist Approach: This method seeks to effectively integrate selected indigenous knowledge into scientific frameworks, ensuring that valuable local insights enhance scientific practices [34, 43]. For instance, incorporating traditional weather forecasting methods can complement scientific meteorological data for better agricultural planning.

Table 3. Barriers to integrating IKS in climate change policies

Challenge	Description	References
Lack of resources and support systems for indigenous people	Indigenous communities often lack the financial and technical resources to engage effectively in climate research and policy initiatives.	[33, 65]
Misalignment of IKS with modern science	IKS may not always align with modern scientific standards	[23]
Cultural misunderstandings	The pervasive cultural misunderstandings often lead to the dismissal of IKS as irrelevant or unscientific, undermining its inclusion in policy discussions.	[9]
Systemic institutional barriers	Existing institutional frameworks primarily reflect Western scientific paradigms, which can marginalize indigenous perspectives in climate governance.	[4]
Lack of representation	There is a general underrepresentation of indigenous communities in climate policy discussions leading to the exclusion of their valuable insights and experiences.	[61]
Intellectual property rights issues	Concerns over the appropriation of indigenous knowledge can create barriers to collaboration, which is essential for integrating IKS into climate policies.	[16]
Fragmented knowledge system	The diversity of IKS across different indigenous groups, complicate efforts to synthesize and apply this knowledge cohesively in climate policies.	[59]
Insufficient Collaboration Mechanisms	A lack of established frameworks for effective collaboration between indigenous knowledge holders and scientists, which limits the integration of IKS into climate policies.	[22]
Short-term focus of climate policies	The tendency of climate policies to prioritize immediate results often overlooks the long-term, holistic approaches characterized by IKS.	[46]

Source: A synthesis made by authors based on literature mentioned in the table.

Separatist Approach: This approach maintains IKS and scientific knowledge side-by-side without direct integration, allowing both systems to co-exist while acknowledging their distinct values [26]. This is often seen in policies that recognize indigenous rights while conducting separate scientific assessments.

Integrationist Approach: This aims to establish connections between IKS and scientific knowledge, creating a synthesis that respects and utilizes both systems [26]. For example, collaborative projects that incorporate community-led research alongside scientific study can yield richer, more applicable results.

The foregoing shows that to effectively integrate IKS into climate change policies and practices, several strategies should be employed. Policymakers must actively explore avenues to weave indigenous ecological knowledge, traditional land management practices, and medicinal plant knowledge into scientific frameworks [25].

Strategies for enhancing the integration of IKS into climate change policies

To counter the barriers to integrating IKS in climate change policies, there is need for coming up with a concoction of sure-proof strategies that have to be applied holistically and to be supported by all concerned. Through the implementation of these strategies, a more inclusive and effective approach to climate change adaptation policies which respect and harnesses the wisdom of indigenous communities, can be created. Table 4 discusses some of these strategies briefly.

Table 4. Strategies for enhancing the integration of IKS in climate change policies

Strategy	Description	References
Community engagement	This participatory approach empowers communities and ensures that policies are culturally relevant.	[5]
Holistic Approaches	Indigenous cultures often understand the interconnectedness of ecosystems better than most.	[5]
Data Integration	Combining scientific data with IKS can lead to more effective climate management strategies	[43]
Capacity Building	It is essential to provide resources and training for indigenous communities to participate in climate monitoring and adaptation strategies.	[17]
Policy Frameworks	Developing policies that explicitly recognize and protect Indigenous rights and knowledge systems is critical, for example the Community-Based Natural Resource Management (CBNRM) policy in Namibia	[21]
Funding and Investment	Allocating funding for projects that utilize IKS in climate resilience and adaptation is vital, for example the Green Climate Fund	[14]

Source: A synthesis made by authors based on literature mentioned in the table.

Future Directions

After examining IKS articles included in this study, and the findings discussed above, we are of the view that future research direction should prioritize the following:

-Appraising current climate change policies of African countries to identify gaps in the integration of IKS. This can be achieved through conducting comparative analyses of regions or countries where IKS is utilized against those where it is not, assessing outcomes and resilience. Successful case studies where IKS has been effectively integrated into climate adaptation strategies should be documented.

-Developing culturally sensitive research methodologies that integrate IKS with scientific approaches through creating guidelines for participatory research that not only respect IKS but place it at the same level of scientific knowledge, including community engagement techniques and validation processes.

-Development of educational programs that enhance understanding of IKS among policymakers and scientists. This can be done by holding workshops and training sessions that focus on the value of IKS in climate science, promoting interdisciplinary education.

-Unification or standardization of IKS and what they mean or represent. This will make IKS easy to validate, understand and therefore to integrate in climate change policy formulation.

-The combination of big data analytics and AI has the potential to revolutionize IKS. By analyzing large amounts of information, it can recognize patterns, forecast future climate scenarios, and facilitate evidence-based decision-making.

CONCLUSIONS

IKS represent a profound reservoir of local heritage wisdom, offering context-specific, nature-based solutions essential for addressing contemporary challenges. Research underscores that climate change is inherently complex, necessitating holistic, integrative, and participatory approaches. To effectively adapt and mitigate against climate change effects and imparts, it is imperative to align policy and legal frameworks across all levels. This alignment must incorporate both adaptation and climate mitigation strategies that actively integrate IKS. In order for this to take place there is need to research on the barriers hampering the process and to develop strategic methodologies to overcome the barriers leading to inclusive frameworks that incorporate IKS in climate change policies. These systems hold significant potential to provide innovative solutions to the ecological and socio-economic crises confronting our world today.

While some studies have explored the role of modern technologies in supporting IKS, there remains a substantial gap in research focused on the integration of IKS with scientific knowledge.

This integration is vital for fostering resilient communities and promoting sustainable ecological development.

By prioritizing this research, we can better harness the transformative power of IKS in our collective response to climate change.

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COMPREHENSIVE ANALYSIS OF ASSETS IN AGRICULTURAL HOLDINGS: STRUCTURE, IMPACT ON FINANCIAL CONDITION AND SUBSIDY EFFECTS

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Abstract

The present study analyses the relationship between asset structure and financial sustainability of agricultural holdings in Bulgaria, using data from the Farm Accountancy Data Network (FADN) for the period 2014-2020. Through a combined approach of structural and correlation analysis, the study examines the connections between fixed and current assets, liquidity, and indebtedness in farms of different economic categories (from below 8 to above 500 thousand euros standard output). The results reveal a significant predominance of fixed over current assets across all categories, with a negative correlation observed between fixed assets and liquidity, particularly in small holdings. The study establishes that large farms demonstrate better ability to balance between long-term investments and maintaining liquidity, whilst small and medium-sized holdings show greater dependence on external financing for fixed asset acquisition. The analysis of subsidies reveals a differentiated role according to farm size - for small and medium-sized holdings, they are a primary source for financing fixed assets, whereas large farms use subsidies more flexibly, both for capital investments and maintaining short-term liquidity. The research identifies the need for differentiated asset management strategies according to the economic size of holdings, with small farms needing to focus on improving liquidity through more effective management of current assets. These findings provide valuable guidance for improving financial sustainability in the agricultural sector.

Key words: *agricultural holdings, asset structure, financial sustainability, liquidity, indebtedness, subsidies*

INTRODUCTION

The financial stability and sustainability of agricultural holdings are of paramount importance for their effective functioning and development in the dynamic and often unpredictable economic environment of modern agriculture. To achieve long-term sustainability and competitiveness, agricultural holdings must implement strategic and optimal management of their fixed and current assets, whilst maintaining a balanced and flexible structure of their liabilities.

Fixed assets play a key role in the production process, forming the foundation of farms' production capacity. They are a source of long-term stability and growth potential. On the other hand, current assets provide the vital liquidity necessary for covering current liabilities, financing operational activities, and maintaining financial flexibility in the short term.

Liquidity and indebtedness emerge as critical indicators for assessing the financial health of agricultural holdings. They not only reflect the farms' current ability to meet their short-term obligations but also provide insight into their long-term financial sustainability and ability to withstand economic shocks. The optimal ratio between fixed and current assets, combined with effective liability management, has a significant impact on the financial stability and adaptability of farms. This is particularly important in the context of growing economic uncertainty, variable market conditions, and increasingly unpredictable climate changes that can seriously impact agricultural production.

In this context, understanding the role of subsidies becomes particularly important. They can serve as a valuable tool for supporting asset management and reducing financial risk, providing additional liquidity and opportunities for reducing indebtedness. The effective integration of subsidies into the overall financial strategy of farms can significantly improve their sustainability and competitiveness.

The present study focuses on the complex interaction between asset structure, liquidity, indebtedness, and overall financial sustainability of agricultural holdings across different economic categories. Through in-depth analysis of key financial indicators such as the current ratio, debt ratio, and the relationship between fixed and current assets, the study aims to reveal important patterns and dependencies. These findings could serve as a solid foundation for making informed management decisions in the dynamic and challenging agricultural sector.

Literature Review

Fixed assets in agricultural holdings typically include land, buildings, machinery, and equipment that are used over a long period and are not consumed in the short term. They are characterised by lower liquidity and usually require significant capital investments. Although these assets cannot be easily converted into cash, they play an essential role in the long-term sustainability and productivity of farms [23]. Current assets, on the other hand, include inventory, short-term receivables, and cash. They have high liquidity and can be easily converted into cash, making them important for covering current financial needs and maintaining the liquidity of agricultural holdings [1]. The balance between the two types of assets is key to the financial stability of farms. Optimal management of both types of assets is essential for maintaining the financial sustainability of agricultural holdings, as an imbalance between them can lead to liquidity problems or excessive investment in fixed assets, which reduces farm flexibility [3, 10].

Recent research on the relationship between assets and liabilities shows that the management of fixed and current assets in agricultural holdings cannot be viewed in isolation from liabilities and debt structure. This relationship is critical for financial stability and liquidity. According to studies on the ratio of fixed assets to long-term liabilities, farms with high levels of indebtedness tend to experience difficulties in meeting their short-term obligations, which can lead to financial distress. For example, studies on agricultural enterprises show that high levels of debt, especially if financed through long-term loans, can create challenges for farm liquidity [4]. This problem is exacerbated under adverse macroeconomic conditions, such as economic downturns or high interest rates.

Research on agricultural holdings in the European Union shows that high levels of fixed assets can lead to weaker liquidity. According to an analysis examining the relationship between liquidity and capital structure of Croatian firms, higher liquidity leads to reduced debt burden and improves the financial stability of holdings. Firms with more liquid assets tend to use fewer loans, which strengthens their ability to maintain liquidity [20]. Analysis of EU agricultural holdings' liquidity shows that fixed assets play an important role in long-term stability, but their excessive accumulation can limit flexibility. Research on EU farm investments finds that maintaining an optimal ratio between fixed assets and current liabilities is key to maintaining farm liquidity and profitability [12].

Despite the risks associated with excessive investment in fixed assets, they remain essential for the long-term profitability of agricultural holdings. Farms in Central Europe that rely on large investments in fixed assets often encounter difficulties in managing liquidity, especially during agricultural sector crises [17]. Balanced investments in fixed assets improve farm productivity and lead to better financial results in the long term. The impact of these assets on liquidity can be mitigated through prudent financing and capital management [21].

Current assets, such as inventory, short-term receivables, and cash, play a key role in ensuring liquidity in agricultural holdings. They have high liquidity, making them an important resource for covering current liabilities and maintaining financial flexibility. According to research on agricultural holdings in Bulgaria, current assets are sufficient to cover short-term liabilities, with the ratio between current assets and liabilities improving over the years [5]. Current asset management is a key factor in maintaining agricultural holdings' liquidity. Research in Serbia shows that farms with better current asset management achieve greater flexibility in covering short-term liabilities and have lower indebtedness [19]. Researchers conclude that agricultural firms with well-managed current assets are more capable of maintaining stable liquidity, even under economic fluctuations [15, 16]. At the same time, research shows that if current assets are not managed effectively, they can lead to financial difficulties, especially during seasonal fluctuations in agricultural sector cash flows [8].

Research indicates that good management of the ratio between current assets and current liabilities can significantly improve the financial flexibility of agricultural holdings. The optimal ratio between these elements leads to better management of short-term liquidity needs, thus reducing dependence on external financing. Studies on agricultural holdings in Turkey show that managing the ratio between long-term assets and current liabilities can improve farm liquidity [1].

Macroeconomic conditions have a significant impact on the asset structure of agricultural holdings. Factors such as inflation, economic growth, and government spending directly affect enterprises' ability to invest in fixed or current assets. Research in this context shows that macroeconomic factors play a crucial role in forming the capital structure in agriculture and consequently influence asset allocation [22]. Access to credits and subsidies is another key external factor affecting asset structure. Research in Hungary shows that the size of subsidies can reduce the need for using loans to finance current and fixed assets. This, in turn, increases farmers' ability to maintain liquidity and stability by reducing their dependence on external financing sources [14]. Market conditions also play an important role in decision-making regarding investments in fixed and current assets. A study of agricultural enterprises in the Czech Republic and Slovakia shows that market dynamics, such as raw material prices and market competition, influence these enterprises' financial structure and their asset allocation decisions [13].

Subsidies play a key role in maintaining the financial sustainability and profitability of agricultural holdings. The capitalisation of subsidies – a process where subsidies influence rental rates, land prices, and farm asset values – can have significant economic consequences for farmers. According to research conducted in the European Union, subsidies lead to increased rents and land prices, which in turn reduces farm competitiveness [11]. The impact of direct subsidies on farm budgets and fixed asset investments is well documented. Research shows that direct subsidies represent a significant portion of farm income and have a positive impact on the level of fixed asset investments. For example, in a study conducted in Poland, subsidies constitute about one-third of farm profits, supporting their fixed asset investments and improving long-term farm sustainability [24]. Dynamic analysis of the relationship between subsidies and farm efficiency shows that subsidies often have complex effects on farms' technical efficiency. A study in France finds that while subsidies are associated with decreased technical efficiency, the relationship is weak and highly dependent on the specifics of farming activities and management models used [18].

Contemporary trends in agricultural asset management are strongly influenced by technological innovations and global climate challenges. Technologies such as Agriculture 4.0 and the use of IoT, robotics, and artificial intelligence significantly change how assets are managed, with a focus on sustainability and efficiency of agricultural holdings. This is seen as a critical step towards addressing growing global food needs and reducing the environmental footprint of production systems [2]. Liquidity management and optimisation of asset ratios in agricultural holdings remains a challenge. Unpredictable climate changes and market instability create additional difficulties in maintaining an adequate balance between current and fixed assets. Financing opportunities through innovative financial instruments such as investment funds and sustainability bonds remain underutilised in the agricultural sector, limiting farmers' access to liquidity [6]. Innovations related to sustainable asset management include the integration of digital technologies and smart management systems, leading to better resource utilisation. For example, the use of AgTech solutions and innovations in mechanisation, micro-irrigation, and logistics are important for improving farm productivity and minimising costs and losses in the production process [7].

The present study contributes to existing literature by providing an in-depth analysis of asset structure and dynamics in Bulgarian agricultural holdings, as well as their influence on key financial indicators such as liquidity and indebtedness. Unlike previous studies, which often focus on individual aspects of financial management in agriculture, this research offers an integrated approach, combining asset analysis with an assessment of their impact on financial stability. A particularly important aspect of this study is that the analysis is conducted by economic size of agricultural holdings, allowing for the identification of specific challenges and strategies characteristic of different-scale farms. Furthermore, the study examines the impact of subsidies on asset structure, which is particularly relevant in the context of the EU's Common Agricultural Policy.

MATERIALS AND METHODS

The study uses data from the Farm Accountancy Data Network (FADN) [9] of the Ministry of Agriculture, Food and Forestry of Bulgaria for the period 2014-2020 to analyse the asset structure of agricultural holdings and their influence on financial indicators. The data covers financial statements of farms from six different economic categories, classified according to their total standard output – from below 8 thousand euros to above 500 thousand euros.

The analysis focuses on the structure and dynamics of fixed and current assets of agricultural holdings. Through comparison of these assets across different economic categories and through different years, understanding is sought for the investment strategies and capital structure of the farms. This way, it is examined how farms of different economic sizes allocate their assets and what trends are observed over time.

Following the analysis of asset structure, a correlation analysis is conducted to examine the relationships between fixed and current assets and the following financial indicators: current ratio and debt ratio. The current ratio is used to measure farms' ability to cover their short-term liabilities through current assets. The debt ratio assesses the share of borrowed funds in the overall financing structure, which allows evaluation of the financial risk for each farm. The correlation analysis aims to establish how assets affect the financial condition of farms. At the same time, the role of subsidies as a potential source of asset financing in different farm categories is analysed.

This combination of structural asset analysis and correlation analysis provides a comprehensive understanding of how assets influence the financial stability of farms, as well as the role of subsidies in their development.

RESULTS AND DISCUSSIONS

Structure and Dynamics of Agricultural Holdings' Assets

The analysis of fixed and current assets structure across different categories of farm holdings over the years reveals key trends related to their investment decisions and capital structure (Figure 1). Firstly, it is evident that holdings with larger economic size, especially those in the "over 500 thousand euros" category, have significantly higher both fixed and current assets compared to smaller holdings. This is expected, as large farms have more resources, allowing them to make large-scale investments in equipment, buildings, and land. These fixed assets play a key role in the sustainability and long-term productivity of agricultural holdings.

One of the main findings from the analysis is that fixed assets significantly dominate over current assets across all farm categories and throughout all years considered. This shows that agricultural holdings primarily orient themselves towards long-term investments that guarantee production sustainability in the long term. Fixed assets such as machinery and agricultural infrastructure are essential for their operation, which is reflected in the stable ratio of these assets to current assets over time.

Furthermore, there are no significant fluctuations in fixed asset values across different years. This suggests that farm holdings maintain relatively stable levels of fixed assets, and no drastic changes in their investment strategies are observed over the years. On the other hand, current assets remain at significantly lower levels, especially in smaller holdings. This may be due to limited financial resources of small farms, which force them to rely on lower liquidity and current assets for operational needs.

In smaller holdings, such as those with turnover up to 8 thousand euros, the lowest values of both fixed and current assets are observed. This is a clear indicator of their limited capitalisation and the fact that they rely on minimal resources for their operation. At the same time, holdings from higher-income categories, such as those in the range between 50 and 500 thousand euros, show balanced distribution of current and fixed assets, which allows them to maintain greater liquidity and operational flexibility.

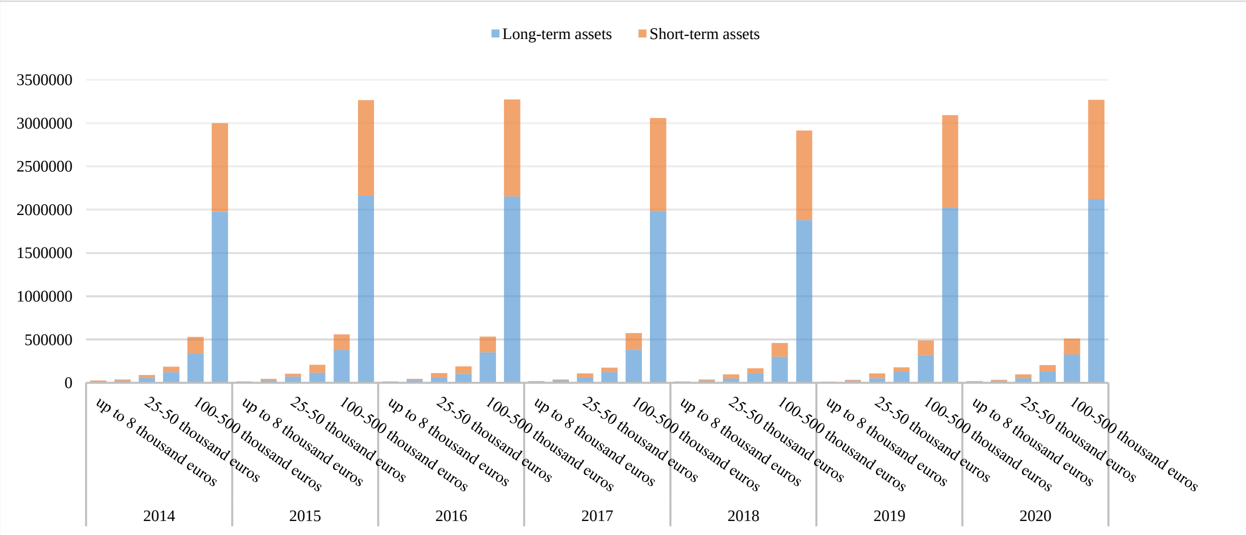

Fig. 1. Distribution of Long-term and Short-term Assets by Farm Categories from 2014 to 2020
Source: Own calculations based on FADN [9].

Analysis of Asset Influence on Liquidity

The results of the correlation analysis between assets and the total liquidity of agricultural holdings reveal significant differences depending on the economic size of the holdings, which suggests a more in-depth examination of financial strategies and asset management in each category (Table 1).

For the smallest holdings ("up to 8 thousand euros"), the negative correlation (-0.6037) between long-term assets and liquidity indicates that investments in long-term assets significantly worsen the liquidity of these holdings. This may be due to the fact that smaller holdings often have limited capital directed towards assets with a longer return period, such as agricultural machinery and equipment, which reduces their ability to maintain liquid funds to cover current liabilities. Interestingly, current assets show an almost neutral relationship with liquidity (0.0688), which means that current assets, although present, do not substantially impact these holdings' ability to cover their short-term obligations.

In the next category, "8-25 thousand euros", a negative correlation between long-term assets and liquidity (-0.3877) is also observed, but it is weaker compared to the smallest holdings. This suggests that larger holdings in this category can manage their long-term assets slightly better, but still face challenges in

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maintaining high liquidity. The stronger positive relationship between current assets and liquidity (0.1477) indicates that these assets begin to play a more significant role in liquidity, but are still not a decisive factor.

The "25-50 thousand euros" category shows the strongest negative correlation between long-term assets and liquidity (-0.6842). Here, it is evident that the increase in long-term assets significantly undermines the liquidity of the holdings. This can be explained by the fact that these holdings are likely increasing investments in long-term assets such as machinery, buildings, and land, which ties up significant capital in illiquid resources. At the same time, current assets show a stronger positive correlation (0.538), which means that these holdings depend more on current assets to maintain their short-term financial stability.

For holdings in the "50-100 thousand euros" category, a significantly weaker negative correlation between long-term assets and liquidity (-0.2792) is observed, which suggests that these holdings are able to maintain better financial flexibility despite the increase in long-term assets. This may be due to the fact that these holdings have reached a point of balance where increasing long-term assets does not lead to a sharp deterioration in liquidity. The extremely strong positive correlation between current assets and liquidity (0.929) shows that these holdings rely primarily on current assets to maintain their liquidity. This result highlights the importance of current assets as the primary mechanism for managing liquidity in this category of holdings.

For larger holdings in the "100-500 thousand euros" category, the negative correlation between long-term assets and liquidity is almost non-existent (-0.0128), which shows that these holdings manage to maintain good liquidity, regardless of increasing long-term assets. This suggests that these holdings have more stable financial structures that allow them to invest in long-term assets without compromising their short-term solvency. At the same time, the moderate positive correlation between current assets and liquidity (0.5878) indicates that current assets continue to play an important role in maintaining the financial stability of these holdings.

For the largest holdings, in the "over 500 thousand euros" category, both long-term (-0.3364) and current assets (-0.3757) show a negative correlation with liquidity. This is surprising, as larger holdings were expected to maintain more stable liquidity. This is likely due to the fact that large holdings tend to use more long-term liabilities and credits to finance their operations and investments, which creates pressure on liquidity. Additionally, despite having larger current assets, these holdings probably have significant current liabilities that affect their liquidity.

In summary, the results highlight that small holdings are more dependent on current assets to maintain liquidity, while larger holdings require a better balance between long-term and current assets. Although large holdings have a more stable financial foundation, their complex financial structures associated with long-term liabilities can create pressure on liquidity. These differences underscore the need for differentiated asset management strategies depending on the economic size of the holding.

Table 1. Correlation between Long-Term and Short-Term Assets and Liquidity in Farms by Economic Size

Farmers by economic size	Correlation between long-term assets and liquidity	Correlation between short-term assets and liquidity
up to 8 thousand euros	-0.6037	0.0688
8-25 thousand euros	-0.3877	0.1477
25-50 thousand euros	-0.6842	0.5380
50-100 thousand euros	-0.2792	0.9290
100-500 thousand euros	-0.0128	0.5878
over 500 thousand euros	-0.3364	-0.3757

Source: Own calculations based on FADN [9].

Analysis of Asset Influence on Indebtedness

The analysis of the correlation between long-term and current assets and the debt ratio across different economic farm categories reveals important dependencies in financing structure (Table 2).

Table 2. Correlation between Long-Term and Short-Term Assets and Debt Ratio in Farms by Economic Size

Farmers by economic size	Correlation between long-term assets and debt ratio	Correlation between short-term assets and debt ratio
up to 8 thousand euros	0.8919	0.5550
8-25 thousand euros	0.6804	0.2625
25-50 thousand euros	0.8474	-0.2811
50-100 thousand euros	0.4503	-0.4925
100-500 thousand euros	-0.3214	-0.0421
over 500 thousand euros	0.3949	0.7000

Source: Own calculations based on FADN [9].

For the smallest farms (with an economic size up to 8 thousand euros), the correlation between long-term assets and indebtedness is strongly positive (0.8919), which shows that these farms rely significantly on external financing for acquiring long-term assets. The high correlation between current assets and indebtedness (0.555) also indicates that these farms likely use external funds not only for long-term but also for current assets, such as working capital and inventories.

Farms with an economic size between 50 and 100 thousand euros demonstrate a decreasing dependency between long-term assets and indebtedness (0.4503), while the correlation between current assets and indebtedness becomes strongly negative (-0.4925). This suggests better management of current assets and possibly reducing dependence on external financing for short-term needs.

For farms with an economic size between 100 and 500 thousand euros, an interesting trend is observed – the correlation between long-term assets and indebtedness is negative (-0.3214), which suggests that these farms manage to finance their long-term assets with internal resources or use other financial mechanisms that reduce their indebtedness. The correlation between current assets and indebtedness is almost zero (-0.0421), which suggests that current assets do not significantly impact the indebtedness of these farms.

The largest farms, with an economic size over 500 thousand euros, demonstrate a moderate positive correlation both between long-term assets and indebtedness (0.3949) and between current assets and indebtedness (0.7). This may mean that these farms use a balanced approach to financing their assets, relying on both internal and external funds to cover their needs for long-term and current assets.

In conclusion, the analysis reveals that small and medium farms are more dependent on external financing for acquiring long-term assets, while larger farms show a better ability for self-financing. These results highlight the importance of access to financial resources for small and medium farmers, while simultaneously emphasising the more sustainable financial structure of large holdings.

Analysis of Subsidy Influence on Assets

The correlation coefficients in the table reflect the relationship between long-term and current assets and subsidies for farmers with different economic sizes (Table 3). The findings from this correlation emphasise the varying role of subsidies as a financing source for different types of assets depending on the holding size.

For farmers with small holdings, with assets up to 8 thousand euros, we observe a moderate positive correlation between long-term assets and subsidies (0.3738) and a weak negative correlation between current assets and subsidies (-0.0509). This result suggests that subsidies in small holdings are likely used primarily for financing long-term assets, such as machinery, facilities, and infrastructure. At the same time, current assets have no significant connection with subsidies, which implies that liquidity and working assets in these holdings are less dependent on government and European financial programmes.

Table 3. Correlation between Long-Term and Short-Term Assets and Subsidies in Farms by Economic Size

Farmers by economic size	Correlation between long-term assets and subsidies	Correlation between short-term assets and subsidies
up to 8 thousand euros	0.3738	-0.0509
8-25 thousand euros	0.3679	-0.486
25-50 thousand euros	0.0727	0.504
50-100 thousand euros	0.2302	0.498
100-500 thousand euros	0.7554	0.5938
over 500 thousand euros	0.0688	-0.3905

Source: Own calculations based on FADN [9].

For farmers with assets between 8 and 25 thousand euros, we again observe a positive correlation between long-term assets and subsidies (0.3679), which means that subsidies continue to be an important source of financing for capital investments in these holdings. However, the strongly negative correlation with current assets (-0.486) suggests that subsidies are not actively used for financing liquid assets such as inventories and cash. This may be due to the limited application of subsidies for working needs and the fact that smaller holdings are more inclined to invest in long-term assets.

An interesting pattern is observed for farmers with assets between 25 and 50 thousand euros, where there is a very weak positive correlation between long-term assets and subsidies (0.0727), but a significantly positive correlation between current assets and subsidies (0.504). This result shows that in these holdings, subsidies are directed towards supporting short-term liquidity and working capital. In this way, subsidies support current assets such as inventories and working funds, which can be crucial for the sustainable functioning of the holdings.

Farmers in the 50-100 thousand euros category also show positive correlations for both asset types: a moderate positive correlation for long-term assets (0.2302) and a significant positive correlation for current assets (0.498). This pattern confirms that subsidies in this category of holdings play a balanced role for both capital investments and farmers' operational needs. Thus, these subsidies provide support both for farm modernisation through long-term assets and for maintaining the necessary working capital for daily operations.

For farmers with assets from 100 to 500 thousand euros, we observe the strongest positive correlation between long-term assets and subsidies (0.7554), as well as a significant correlation with current assets (0.5938). This result clearly shows that in larger holdings, subsidies play a critical role in financing assets, supporting both investments in long-term assets and the liquidity of the holdings. This corresponds to the larger-scale investments that big holdings typically make in machinery, facilities, and modernisation, which are a primary source of competitiveness.

For the largest farmers with assets over 500 thousand euros, the correlation between long-term assets and subsidies is weak (0.0688), while the correlation with current assets is negative (-0.3905). This means that these farms likely rely less on subsidies for financing their current assets, such as inventories, short-term receivables, and cash. Instead, they can rely on internal financial resources or other forms of financing to cover their short-term needs. In these cases, subsidies are likely directed towards specific capital investments, while the holdings themselves rely on internal financing for working assets and operational expenses.

Based on the analysis of the correlation between assets and subsidies, it can be concluded that subsidies play different roles depending on the size of the holdings. Small and medium farmers use subsidies primarily for financing long-term assets, while for larger holdings, subsidies support both capital investments and short-term liquidity. However, for the largest holdings, subsidies are less connected with current assets, which suggests that these holdings have stronger alternative sources for financing liquidity.

CONCLUSIONS

Based on the conducted analysis, the following main conclusions can be drawn:
-*Predominance of long-term assets:* Long-term assets significantly dominate current assets across all farm categories, showing a focus on long-term investments and sustainable development. Farms with a larger economic size have more resources for investing in machinery, equipment, and infrastructure.
-*Role of economic size:* Large holdings ("over 500 thousand euros") show significantly larger assets compared to smaller ones, which provides advantages in investment decisions and the ability to maintain better liquidity.
-*Negative correlation between long-term assets and liquidity*: For small holdings, long-term assets worsen liquidity, demonstrating difficulties in managing short-term obligations. The strongest negative correlation is observed in holdings in the "25-50 thousand euros" category, indicating that as long-term assets increase, they become increasingly illiquid.
-*Role of current assets in liquidity*: Current assets play a crucial role in the liquidity of holdings, especially for those of medium and large size. The strongest positive correlation between current assets and liquidity is observed in holdings in the "50-100 thousand euros" category, highlighting their dependence on current assets for maintaining financial stability.
-*Differences in external financing dependency*: Small and medium holdings rely significantly on external financing for acquiring long-term assets, with a strongly positive correlation between long-term assets and indebtedness. Large holdings show greater financial independence and self-financing ability.
-*Varied role of subsidies:* Subsidies play an important role in asset financing, but their role differs depending on the holding's size. Small and medium holdings rely on subsidies primarily for financing long-term assets, while for larger holdings, subsidies support both capital investments and short-term liquidity.
-*Greater financial flexibility of large holdings:* Large holdings demonstrate an ability to maintain good liquidity despite increasing long-term assets. They rely on a balanced approach between long-term and short-term assets for liquidity management.
-*Need for differentiated strategies:* The findings underscore the need for differentiated asset management strategies depending on the economic size of holdings. Small holdings must focus on improving liquidity through efficient management of current assets and limiting external financing for long-term assets.
These conclusions show the different financial strategies and challenges faced by agricultural holdings, depending on their size and asset structure. They also highlight the significance of well-balanced asset management for maintaining liquidity and sustainability of agricultural holdings.

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COMPARISON OF FOOD WASTE MANAGEMENT POLICES BETWEEN GREECE AND ARMENIA: POSSIBLE RECOMMENDATIONS FOR ARMENIA

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Abstract

The topic of food waste management has become a global discussion in recent years, but it is still not widely addressed in Greek and Armenian societies. This can be attributed to the common cultural and historical backgrounds of these countries. This study explores waste management practices in both countries, with a specific focus on their respective national frameworks and initiatives. The study critically discusses Greece's National Waste Prevention Programme (NWPP) and extrapolates key policies and strategies pertinent to the Armenian context. Moreover, the current geopolitical changes and their potential influence on the food waste management system of Armenia have been discussed. Cultural and historical backgrounds necessitate a comparative examination between these two nations' policies. Employing a comprehensive document analysis using a deductive, concept-driven approach facilitated by docAnalyzer.ai, this study identifies substantial deficiencies within existing policy documents. It underscores the need for enhanced education, increased investments, and strengthened collaborative efforts as significant factors crucial for effecting systemic transformation. Addressing these gaps through informed policy interventions can enable both governments to implement successful models of food waste management and foster circular economies adjusted with respective socio-economic landscapes.

Key words: *comparative policy analysis, food waste management, Greece, Armenia, policy gaps*

INTRODUCTION

Food waste and loss has deeply affected economy, environment quality and consumers' savings during the last decades. The amount of wastes food varies from a country to another depending in the specific circumstances [24].
Many researchers are focused on the analysis of waste situation looking for various solutions to diminish the amount of food losses [1, 24, 20, 21, 27, 30].
A variety of policies have been proposed to tackle food waste, emphasizing national strategic frameworks, legislative measures, food donation initiatives, waste recycling, public awareness and education, and systematic data collection (Abusin et al, 2020; Shen et al., 2023) [1, 26].
However, effective food waste management policies remain necessary in Greece and Armenia, where low recycling rates and the lack of a cohesive national food waste recycling system indicate significant gaps. Some European countries, such as France, already implemented an anti-waste law in 2016, which forbids large supermarkets from discarding or destroying unsold food. Instead, these retailers are mandated to donate the excess to charities and food banks. Noncompliance with this legislation can result in fines and imprisonment. This law is widely acknowledged as a crucial advancement in combating food waste (The Republic of France, 2016) [15].
Another successful example is Italy's law implemented in 2016, which encourages food donation and the use of the doggie bag at retail and restaurant levels through fiscal incentives and bureaucratic simplification. This law has proven to be effective in facilitating the redistribution of food waste, leading to Italy's improved ranking in the Food Sustainability Index from 9th position in 2016 to 4th position in 2017 (Food Sustainability Index, 2017) [14], (Italian

Republic, 2016) [18]. In this context, examining the food waste management policies of different countries can provide valuable insights. Greece and Armenia, two countries with a lot of common cultural, historical, and geopolitical backgrounds, present a unique opportunity for comparative analysis. A significant factor in my decision to undertake this research was my academic experience at the University of West Attica in Greece, where exposure to the country's cultural and socio-economic environment had a profound impact on my research interests. While Greece has made notable strides in developing comprehensive food waste management policies, Armenia continues to face significant challenges in this area. Understanding the similarities and differences between these countries' approaches can inform more effective policymaking in Armenia.

This research aims to answer following research questions.

RQ1: How do current Greek policies regulate food waste management, and how well it goes so far?

RQ2: What recommendations can be made for Armenia regarding food waste management policies to formulate a comprehensive and efficient national strategy?

MATERIALS AND METHODS

This study employs a comprehensive document analysis to investigate food waste management policies in Greece and the Republic of Armenia given their socio economic, political, cultural and historical familiarities. The analysis utilizes docAnalyzer.ai [5], a sophisticated tool designed to facilitate the extraction of relevant concepts from extensive policy documents. The primary data sources for this research include national policy documents, legislative texts, and official reports related to waste management from both Greece and Armenia. These documents were accessed through governmental websites, academic databases, and international environmental organizations. A deductive, concept-driven approach was adopted for the document analysis. The key concepts "food," "waste," and "management" were used as search terms within the docAnalyzer.ai platform to identify and extract pertinent information. This approach ensured a focused examination of the policies relevant to food waste management. Process of analysing included: Identification of key documents, data input into docAnalyzer.ai, Concept extraction and Thematic Analysis.

To ensure the reliability and validity of the findings, cross-referencing was conducted with secondary literature, including academic papers and expert reports on waste management. Additionally, expert consultations were held to validate the interpretations derived from the document analysis. While docAnalyzer.ai provided a robust framework for identifying key concepts, the analysis was limited to the quality and comprehensiveness of the input documents. Furthermore, the deductive approach may have overlooked emerging themes not captured by the predefined key concepts.

RESULTS AND DISCUSSIONS

Food waste is gaining increasing attention in Western politics, with countries in the European Union, including Greece, becoming more proactive in measuring and regulating it. On May 3, 2019, the Commission Delegated Decision (EU) 2019/1597 [6] was adopted, supplementing Directive 2008/98/EC of the European Parliament and of the Council. This decision establishes a common methodology and minimum quality requirements for the uniform measurement of food waste levels. (European Commission, 2019) [6].

In 2022, the EU food waste amount accounted for 59 million tons, of which 54%, meaning 32 million tons, was produced by households.

In average, each European carries out 132 kg food waste per year, of which 72 kg are produced at home.

The top 10 EU member states with the highest amount of food wastes are presented in Table 1.

Table 1. Top 10 EU countries producing food wastes at home

	Food waste (Thousand tons)	Market share (%)
EU-27	32,000	100.0
1. Germany	6,289	19.6
2.Italy	5,905	18.5
3.France	3,944	12.3
4.Poland	2,528	7.9
5.Spain	1,434	4.5
6.Portugal	1,284	4.0
7.Greece	**914**	**2.8**
8.Netherlands	848	2.6
9.Belgium	751	2.3
10.Czechia	652	2.0
All 10	24.549	76.7

Source: Own calculations based on the data from Eurostat, 2022 [13, 3].

Germany is the top producer of wastes having a share of 19.6% in the EU waste amount. On the 2nd position comes Italy with 18.5%, then France with 12.3%, Poland with 7.9%, Spain with 4.5, Portugal with 4%.

Greece is situated on the 7th position producing over 914 thousand tons wastes from households, meaning 2.8%.

The country is followed by Netherlands with 2.6%, Belgium with 2.3% and Czechia with 2%.

However, if we consider the waste produced at home per inhabitant in the EU-27, the countries which occupy the top positions are: Portugal 123 kg/capita, Italy 100 kg and Malta 88 kg.

If we take into account the whole amount of wastes, Eurostat data reveals that Greece's annual per capita food waste is 191 kilograms, surpassing the EU average and ranking as the fourth highest in the European Union (Figure 1).

In 2016, Greece's circular use of materials was 2.4%, which increased to 5.4% by 2020. Despite this growth, the country still lags the EU average of 12.8% for this metric. (Eurostat, 2020) [12].

Greece has taken a positive step by streamlining environmental assessments under various EU directives. However, weak administrative capacity remains a significant challenge. EU funding supports bridging this gap, with Greece receiving over EUR 30 billion from its RRP (2021-2026) and EUR 20 billion from cohesion policy (2021-2027).

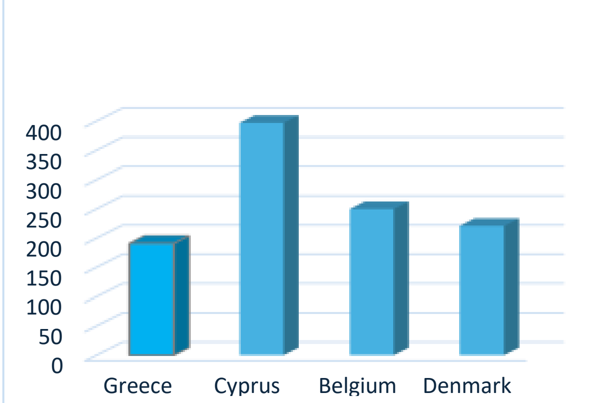

Fig. 1. Average annual food waste amounts per capita in Greece compared to other EU countries (kg)
Source: Eurostat, 2020 [12].

The Greek RRP aims to establish new regulatory authorities in the waste and water sectors, which should positively impact these areas. From 2014-2020, Greece's environmental investments were 0.72% of GDP, relying on EU and national funds. The estimated need for 2021-2027 is over 1.12% of GDP, indicating a financing gap of at least 0.4%. Issues persist with absorbing EU funds, especially in waste management and nature protection. Since 2014, Greece has paid over EUR 184 million in fines for EU waste and urban wastewater violations (European Commission, 2022) [7].

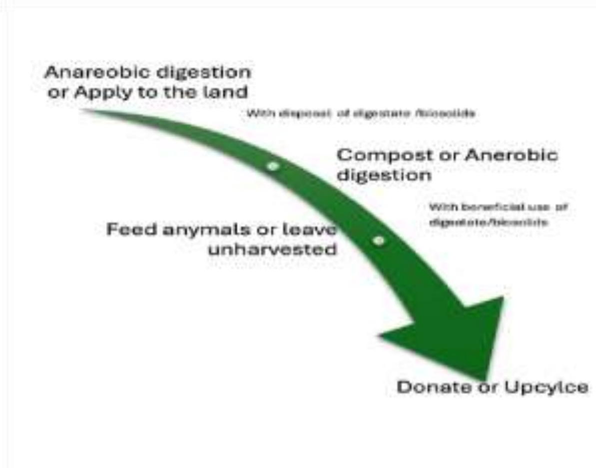

Fig. 2. Strategy for minimizing the environmental impact of food waste
Source: [29].

Figure 2, a custom illustration based on the US Environmental Protection Agency report, demonstrates strategies for minimizing the environmental impact of food waste by identifying preferred and less preferred activities.

The Greek National Waste Prevention Programme (NWPP) spanning 2021-2030 [10] targets a 30% reduction in per capita food waste by 2030 compared to 2022 levels. The initiative encompasses strategies to minimize food losses across the production and supply chain. Key stakeholders participating in the NWPP include households, businesses, producers, economic operators, and citizens/consumers. The programme outlines sector-specific measures for primary production, processing and manufacturing, retail and distribution, catering and restaurants, and households within the food supply chain (European Environment Agency 2023, p.7) [9].

The National Waste Prevention Programme (NWPP) is developing a targeted food waste prevention programme aligned with the national circular economy action plan and roadmap spanning 2021–2025 [10]. This initiative includes specific measures to achieve a 30% reduction target, and involves formulating, implementing, and monitoring the programme. The NWPP also mandates the creation of an electronic platform where obligated entities must annually submit relevant data starting in 2022, aimed at monitoring food waste and donated food surpluses.

Furthermore, the NWPP supports the 'Alliance for the Reduction of Food Waste', a national initiative launched in 2020 by Boroume and AB Vassilopoulos [4]. This alliance engages key stakeholders across the food supply chain in collaborative efforts toward food waste prevention (European Environment Agency, 2023) [9].

The European Environmental Agency published an early warning assessment regarding the 2025 targets for municipal and packaging waste. This report included a thorough evaluation of Greece's progress in achieving its 2025 recycling goals for these waste categories. It highlights both success factors and risks related to achieving these targets. Key points include:

1.Separate collection system: Greece's existing system for separate bio-waste collection is quite limited, primarily collecting only garden waste in urban and suburban areas. In rural regions, there is no provision for separate biowaste collection. (European Environment Agency, 2022, p. 21) [9].

As of mid-2024, the universal collection of bio-waste has not yet been implemented, despite plans for municipalities to establish it by the end of 2022. This initiative also aimed to extend the obligation for separate collection to non-household waste. (European Environment Agency 2022, p. 23, p. 47) [9].

2. Extended producer responsibility (EPR): As of mid-2024, the regulations mandating separate biowaste collection by catering companies, initially set for implementation by the end of 2022, have not been enacted. These regulations, part of the Extended Producer Responsibility (EPR) framework, require food producers to manage their waste. Additionally, starting in 2023, food processing and manufacturing companies, vegetable markets, supermarkets, and hotels with over 100 beds were also supposed to comply with these requirements. (European Environment Agency 2022, p. 23) [9].

3.Economic Instruments: The landfill fee, set at 20 EUR per ton starting from 2022, is an economic tool designed to discourage landfilling by making it more costly, thus promoting alternative waste management practices such as composting. (European Environment Agency 2022, p. 34) [9].

While the current biowaste treatment capacity is inadequate, there are plans to expand it. This expansion likely involves investing in composting and other bio-waste treatment facilities to divert waste from landfills and enhance resource recovery (European Environment Agency 2022, p. 47) [9].

The report highlights Greece's challenges in meeting recycling targets for packaging and municipal solid waste (MSW). Greece risks not achieving the 65% recycling target for packaging waste by 2025, with the current recycling rate at 52.9%, 12.1 percentage points below the target. Similarly, the country faces difficulties in meeting the 55% MSW recycling target by 2025, as the recycling rate was only 21% in 2019, significantly below the goal. The report notes a modest increase of 5.3 percentage points since 2015. For landfilling of municipal waste, a preliminary assessment indicates potential issues, with the official early warning assessment due in 2032 (European Environment Agency, 2022) [9].

The legislative framework for waste management in Greece is not only crucial for national and European Union compliance but also attracts attention from international investors, including the United States. Recent and upcoming legislative changes create a favourable environment for future investments in the country. Significant projects funded by the Operational Program 'Transport Infrastructures - Environment and Sustainable Development 2014-2020' involve the establishment and operation of Solid Waste Treatment units. These projects receive funding from Greek Solid Waste Management Agencies, local municipalities, European funds, and other sources. Key Greek companies such as GEK Terna, Helektor, AVAX, Intrakat, Mytilineos, Messogeios, Thalis, and Watt are actively involved. These initiatives represent a total investment of approximately €1,345 million, aimed at enhancing solid waste treatment infrastructure and capacity across Greece. (International Trade Administration U.S. Department of Commerce, 2023) [17].

Analysing the current Greek National Waste Prevention Programme (NWPP)

This paper describes the National Waste Prevention Programme (NWPP) for the period 2021-2030 of Greece, which seeks to foster a reduction in raw material consumption and transform consumer behaviour to gradually decrease waste generation. It outlines ambitious objectives, including a targeted 30% reduction in per capita food waste by 2030 compared to 2022 levels, alongside substantial cuts in single-use plastic consumption over the coming years. Encompassing a wide array of sectors such as primary food production, manufacturing, retail, catering, and construction, the NWPP prioritizes managing various waste types, including food, paper, packaging, plastics, electronics, textiles, and industrial and construction waste. The programme aims to engage diverse stakeholders ranging from households to businesses, economic operators, and consumers in a concerted effort to promote sustainable practices. Measures include incentivizing food donation and redistribution, advocating for building renovation over demolition, fostering innovation in waste-reducing technologies, promoting circular consumption patterns, and enhancing public awareness. To monitor progress and effectiveness, the Ministry of Environment and Energy will oversee the evaluation of programme outcomes. Implementation will involve establishing monitoring systems for food waste production, defining criteria for food donation suitability, promoting the establishment of nationwide repair canters for electronic equipment, and facilitating networks for the exchange and sale of used electronics. These initiatives underscore Greece's commitment to advancing sustainability goals and improving waste management practices across the nation.

The Greek National Waste Prevention Programme focuses primarily on the environmental and social advantages of food waste reduction, while also addressing its economic dimensions.

Economic aspects:

-<u>Financial incentives for food donation:</u> Tax incentives for food donation have been introduced to incentivize businesses to donate excess food, thereby potentially lowering their operational costs. Specifically, the document outlines a provision (article 21 of law 4819/2021 (Hellenic Parliament, 2021) [16]) that proposes a 20% reduction in taxes for food donations, highlighting a deliberate effort to stimulate food donation through financial incentives. It also highlights the importance of leveraging funding for food waste reduction, mentioning the National Strategic Reference Framework and LIFE+ as examples. Moreover, it proposes establishing economic incentives for food donation, indicating the potential for investment in Greece.

-<u>Increased business competitiveness:</u> by maximizing waste valorisation and reducing waste exports can contribute to increasing business competitiveness.

-Boosting repair services and purchase second hand products: highlights that providing financial incentives, such as reduced VAT and tax exemptions, can boost repair services and the purchase of second-hand products.

Social aspects:

-NGO initiatives: The "Alliance for the Reduction of Food Waste," initiated by the Boroume organization and AB Vassilopoulos [24], unites a diverse range of stakeholders, encompassing professional and industry associations, companies spanning the food supply chain, civil society organizations, and the academic and research sectors (European Environment Agency, 2023, p. 28) [9]. The document underscores the voluntary nature of this collaboration, highlighting the commitment of approximately 35 stakeholders who have signed onto the cooperative agreement within the alliance.

-Food donations: "Social Grocery" stores in Athens, donate a variety of products, including groceries, food, water, and household items, to families facing serious financial problems. In addition to environmental benefits, these initiatives contribute to supporting vulnerable social groups.

-**Environmental aspect:**

-Climate change: Food waste contributes significantly to achieving the United Nations Sustainable Development Goal of reducing global food waste by 50% per capita at the retail and consumer levels, as well as minimizing food losses throughout production and supply chains by 2030.

This reduction targets the environmental impact of food waste, focusing on its detrimental effects on climate change and resource depletion. Thus, addressing food waste not only aligns with global sustainability goals but also mitigates its adverse environmental consequences, particularly its role in exacerbating climate change and depleting vital resources

The document, while outlining the National Waste Prevention Programme's ambitious targets, does not explicitly address potential barriers or challenges that may hinder their full achievement. However, it does underscore the necessity of further examining constraints related to food donation, which could potentially impede progress. Moreover, the document discusses the introduction of economic incentives for food donation, hinting at possible funding gaps or implementation difficulties that might present obstacles to effective execution. Additionally, the document emphasizes the critical role of public awareness and behavioural change in achieving programme objectives. It stresses the importance of informing and educating households and the catering sector about altering food consumption and management practices, indicating that insufficient public engagement could pose a significant challenge.

Current Legislative Framework Addressing Food Waste in the Republic of Armenia

The Law of the Republic of Armenia, adopted on June 23, 2011 "On Garbage Removal and Sanitation" [23] defines the subject of the regulation of the law, which is the relationship with garbage collection and sanitation, defines the principles of organization of the garbage collection and sanitation process, the fee for garbage collection, its rates, the range of payers, their rights and responsibilities, payment procedure, responsibility for non-payment, non-fulfillment of obligations or improper fulfillment, the procedure for exercising the powers of local self-government bodies, the organization of garbage collection and sanitation (National Assembly of the Republic of Armenia, 2011)[23]. The current law does not mandate waste sorting at the household, enterprise, or food facility levels. Moreover, the Republic of Armenia has yet to establish a unified central system for processing biodegradable waste. The Republic of Armenia Law on Wastes governs the legal and economic aspects of waste collection, transportation, storage, processing, utilization, disposal, and volume reduction. It also addresses related activities and aims to prevent negative impacts on human health and the environment (National Assembly of the Republic of Armenia, 2004) [22]. A report on waste governance in Armenia made in 2020 identifies several gaps in the current "Waste" law and calls for significant transformations. Notably, the concept of waste hierarchy is absent, despite the law promoting its components. The law lacks a clear sequence of priorities essential for the waste hierarchy approach. It also omits definitions for key terms such as biological waste including Food waste, waste manager, separate collection, high-quality recycling, low-quality recycling, intermediary, and reseller. Additionally, the circular economy and types of materials subject to processing are not defined. To comply with the CEPA (‘Comprehensive and Extended Partnership Agreement between Republic of Armenia and EU’, 2021) [28] on preparing waste management plans according to the five-step waste hierarchy and waste prevention programs, the term waste hierarchy needs to be included in the law While the law promotes "zero waste," "less waste," and resource-efficient technologies, it fails to emphasize the importance of promoting zero waste and less waste-generating consumption. Waste sorting, crucial for efficient material use, is also not sufficiently promoted. Furthermore, although Article 23 of the Law on Waste (National Assembly of the Republic of Armenia, 2004) [22] offers incentives for organizations to implement waste reduction technologies, there is no legal act outlining the application and receipt process for these benefits. (Alpetyan Harutyun et al. 2020, p. 56) [2] .

Unlike Greece, the Republic of Armenia currently lacks a comprehensive National Vision on Food Waste Management and the Implementation of a Circular Economy. Should Armenia pursue membership in the European Union, it will be crucial for Yerevan to initiate reforms in sustainable development and effective waste management. During a speech at the European Parliament on October 17, 2023, the Prime Minister of Armenia emphasized the country's readiness to align closely with the European Union to the extent that the EU deems possible. (*RFE/RL’s Armenian service*, 2023) [25]. This declaration was followed by a special resolution from the European Council on EU-Armenia relations, which suggested considering Armenia's candidacy for EU membership. These developments indicate that food waste management in Armenia could gain significantly more attention. (European Parliament, 2024) [11]. Another indication of potential changes in food waste management and circular economy models over the next four years stems from a press statement by European Commission President von der Leyen. The statement outlined a Resilience and Growth Plan for Armenia, which includes an investment of 270 million EUR aimed at enhancing the robustness and resilience of the Armenian economy and society (European Commission, 2024) [8].

Analyzing the implementation report of Yerevan city development for 2023, published in spring 2024, reveals that collaboration with several European partner capitals has facilitated an increase in waste collection sites. However, a notable omission in the report is the lack of emphasis on the collection of food waste, its volumes, or its integration into circular economy models. The report indicates that approximately 28 tons of plastic, 30 tons of glass, and 580 tons of cardboard were collected through recyclable waste sorting. Under the "Cooperation of Yerevan, Warsaw, Tirana Capitals on the Common Challenges of Hazardous Waste Management" program, around 1,000 waste bins were donated. In 2024, 2,024 additional waste bins will be placed throughout Yerevan, doubling the number of existing addresses and enhancing waste collection efforts. (Yerevan Municipality, 2024) [31]. The fall of 2019 saw the Yerevan Municipality initiate a small-scale composting pilot program. This program aims to manage and process organic waste from gardens, street trees, and parks. There are also plans to include organic kitchen waste, which will be separately collected from public institutions such as kindergartens, schools, and universities. However, the main action plan of Yerevan Municipality still lacks a comprehensive model for food waste or bio-waste collection and management (Alpetyan Harutyun et al. 2020, p. 103) [2]. A recent research paper has called on the Armenian government to introduce green and circular public procurement processes, particularly in the food industry and catering sectors within public institutions such as kindergartens, hospitals, and elderly homes. It also advocates for the establishment of a dedicated fund for circular economy projects, in close collaboration with financial institutions, NGOs, and public authorities (Markosyan and Aleksanyan, 2023) [19].

CONCLUSIONS

Analyzing Greece's National Waste Prevention Plan for 2021-2030 [10] reveals that waste control mechanisms and their implementation are prioritized at the state level. However, numerous challenges remain, and more time is needed to achieve specific targets. Non-governmental organizations, particularly Boroume, play a crucial role in managing food waste through close collaboration with the government, leading to the development and implementation of effective waste reduction laws. Nevertheless, Greece cannot solely depend on public structures, it requires mechanisms for leveraging successful experiences, investments, and scientific research to achieve rapid and effective progress in this field. As a member of the European Union, Greece has the necessary prerequisites to undertake these actions.

For the Republic of Armenia, following recommendations were made, exercising best practices of Greece, and opportunities as a whole.

Adopting Greek and International Practices:

1.Establish a National Vision on Food Waste Management: Armenia should develop a comprehensive national strategy similar to Greece's NWPP, focusing on the environmental, social, and economic aspects of food waste reduction. This strategy should include clear targets, such as reducing food waste by 30% by 2030.

2.Implement Economic Incentives for Food Donation: Following Greece's example, Armenia could introduce tax incentives to encourage businesses to donate excess food. This could be modelled after Greece's provision for a 20% tax reduction for food donations. Additionally, leveraging international funding sources such as the National Strategic Reference Framework and LIFE+ could support these initiatives.

3.Promote Public Awareness and Behavioral Change: Like Greece, Armenia should prioritize public awareness campaigns to educate households and the catering sector on sustainable food consumption and waste management practices. Collaboration with NGOs and civil society organizations can enhance these efforts. It could also involve promoting the activities of local companies that already utilize circular business models, such as the ORVAKO vermicomposting plant and the ISSD - Innovative Solutions for Sustainable Development of Communities NGO. These organizations should be integrated into public life, including school and university programs. Additionally, the government should establish decentralized training camps focused on food waste prevention and management, and ensure the participation of these organizations in such initiatives.

4.Develop Circular Economy Models: Armenia should adopt circular economy principles, particularly in public procurement processes related to the food industry and catering in institutions such as restaurants, kindergartens, hospitals, and elderly homes. Establishing a separate fund for circular economy projects, in collaboration with financial institutions and NGOs, can drive innovation and sustainability. Incorporating circular business concepts into start-up projects and mandating that existing food industry companies adopt efficient food management practices in accordance with the law should also be key priorities for the government.

Addressing Legislative Gaps:

1.Incorporate Waste Hierarchy and Circular Economy Definitions: The Armenian waste management legislation should include clear definitions and prioritize the waste hierarchy approach, addressing terms like biological waste, separate collection, high-quality recycling, and circular economy materials.

2.Mandate Waste Sorting: To improve waste management efficiency, Armenia should mandate waste sorting at the household, enterprise, and food facility levels. This will ensure better resource utilization and align with international best practices.

3.Enhance Legal Framework for Waste Reduction Technologies: Armenia's existing incentives for waste reduction technologies need a clear legal framework outlining application and receipt processes.

This can help streamline the adoption of innovative waste management solutions.

Leveraging International Support:

1.Utilize European Union Support: In light of Armenia's potential EU membership and the European Commission's Resilience and Growth Plan, which includes a 270 million EUR investment, Armenia should prioritize reforms in sustainable development and optimal waste management.

2.Collaborate with European Partner Capitals: Building on the successful cooperation with European partner capitals, Armenia should expand its waste collection infrastructure, focusing on integrating food waste collection into circular economy models.

3.Implement Composting Programs: Expanding on the Yerevan

Municipality's composting pilot program, Armenia should develop a comprehensive bio-waste collection and composting model, involving public institutions and promoting organic waste processing.

Currently, the Republic of Armenia does not conduct research on food waste collection, its volume, causes, or the associated environmental and economic impacts.

Waste management, as defined in previous laws and the current government's vision, remains generalized and lacks specific segmentation for different types of waste and sanitation categories.

The issue of waste collection in both Yerevan and the provinces persists, with a significant portion of waste still being burned in open spaces, leading to environmental problems and inconveniencing nearby residents. International experience demonstrates that waste can be an economic resource or raw material.

Both legislative and educational efforts should prioritize the implementation of circular economy models.

At least a few organizations need to advocate for these models and encourage the government to make sustainable and circular decisions.

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MARKET STUDY ON ROMANIAN AGRICULTURAL PRODUCTS IN THE CONTEXT OF ENSURING FOOD SECURITY AT THE NATIONAL LEVEL

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Abstract

Food security has gained special attention from political representatives around the world, mainly due to the important role it plays in achieving the Sustainable Development Goals (SDGs). Considering that agricultural production contributes directly to ensuring food security, this study aimed to present an overview of the agricultural products market in Romania, in the context of ensuring food security. The study started from the analysis of statistical indicators regarding the average annual consumption per inhabitant, production per inhabitant and current prices for the main categories of agricultural products, provided by the National Institute of Statistics for the period 2018-2022. The presented indicators were processed by statistical methods, calculating: the average, the standard deviation, the coefficient of variation and the annual growth rate, and then analyzed for each category of agricultural products separately. The results showed that, an average annual consumption per inhabitant with a relatively constant dynamic for the categories of agricultural products analyzed. The category of agricultural products that recorded the highest consumption was milk and milk products in milk equivalent 3.5% fat (excluding butter). In terms of the production of the main agricultural products per capita, cereals for grains stood out by achieving the highest production per capita, followed by milk. Cereals value at producer price (including seeds) register the highest level.

Key words*: *food security, agricultural products, production, consumption, prices.

INTRODUCTION

One of the main objectives of the agricultural policy is the sustainable development of the regional food supply system and contributes to the systemic development of the agrifood sector. To achieve this objective, food security must be ensured, which represents one of the most important problems of the agri-food sector [4].

FAO defines food security as *„the direct access of all people to the food they need to fulfill their vital functions and lead a healthy and active life''* [8]. The basic principles of food security are self-sufficiency with the main agricultural products, availability, accessibility, balance and sustainability [12].

To ensure food security, it is necessary to understand the mechanism of the market for agricultural products, the relationships between production, trade and food consumption. However, the social and environmental impact of food systems and dietary health requirements remain the biggest challenges. Responding to these challenges requires transformative changes to address the crisis in the food system. To this end, it is necessary to strengthen the links in the food chain and establish solid alliances between production and consumption with the objective of designing alternative food systems [10].

Studies show that price volatility of grain products affects factors of production and affects national food security. Under the influence of complex factors such as spatio-temporal influencing factors, price correlation and market diversity, it is increasingly important to improve the accuracy of cereal product price prediction for sustainable agricultural development [7].

The need to adopt current food systems has prioritized the issue of food and nutritional security at the center of the agro-food policies of states and governments, imposing a commitment to health and social change, through public policies that can provide effective responses to respond to these requirements [6].

Food security, characterized by the availability, accessibility, use and stability of agri-food products, represents an essential concern in the context of the sustainable development of the agri-food sector and human well-being. The pandemic generated by the COVID-19 virus has further exacerbated existing challenges, putting even greater pressure on agri-food systems and exacerbating their vulnerabilities [3]. Food security issues have been amplified during the pandemic caused by the COVID-19 virus, intensifying significantly under the influence of the full-scale war between Russia and Ukraine, threatening global famine [2, 9].

Currently, the issue of food security is endangered by climate change which is seriously affecting agricultural production. A solution to this problem could be to encourage the adaptation of farmers to climate change, this solution can contribute to promoting sustainable agricultural production and ensuring food security [13].

In the climate change scenario, growing adequate food is a major challenge for food security. In order to provide food for the population, the introduction of new vegetable crops and the expansion of new varieties are important tasks of breeding programs [1]. Soil conservation and prevention of soil degradation have become imperative in efforts to ensure food security, protect biodiversity and maintain healthy ecosystems [5].

In this context, the purpose of the research is to present the current situation of the agricultural products market in Romania, based on the statistical indicators published by the National Institute of Statistics, the research is relevant considering the objective of ensuring food security.

MATERIALS AND METHODS

The research is based on the representative indicators of the agricultural market in Romania (demand and supply), the data series being provided by the National Institute of Statistics (INS).

To carry out the study, the following indicators were analyzed: average annual consumption for the main agri-food products - demand, production per inhabitant for the main agri-food products - supply and current prices (value at the producer's price) in the time frame 2018-2022.

During the research, the following statistical indicators were calculated and analyzed:

Arithmetic mean (m) which is the ratio between the sum of the values in the data series (x_1, x_2 .... x_n) and the number of years considered (n):

$$m= \frac{x_1+x_2+\cdots+x_n}{n}$$

The standard deviation that indicates how much the values are dispersed from the mean:

$$\partial = \sqrt{\frac{\sum(xi-\overline{x})^2}{n-1}}$$

where:

∂ = standard deviation;

xi = values of the data series over a number of years;

n = number of years considered.

Coefficient of variation (C):

$$C = \frac{\partial}{\overline{X}} * 100$$

whose value could be interpreted as follows:

-Between 0-10% - greater degree of homogeneity of the series;

-Between 10-20% - medium variation;

-Over 20% - high variation.

The annual growth rate indicates the annual growth of the analyzed phenomenon:

$$r = \sqrt[n-1]{\prod\left(\frac{p\,n}{p\,n-1}\right)} - 1$$

r = average annual growth rate;

∏ pn/pn-1 = indicators of chain growth.

The research methods used were quantitative analysis and comparative analysis.
The statistical research process involved the following stages: data collection and recording, data processing, analysis and interpretation of results.

RESULTS AND DISCUSSIONS

In the analyzed period, the average annual consumption for the main agricultural products registered a slight upward trend, with the exception of cereals and cereal products in grain equivalent and vegetables and vegetable products in fresh vegetable equivalent, which registered a decrease at the level of the analyzed period of 0.033%, respectively 0.100%.
The highest increase (+0.034%) was recorded for eggs, from 236 pieces in 2018 to 244 pieces in 2022 (Table 1).

Table 1. Dynamics of average annual consumption per inhabitant in the period 2018-2022

Categories of agricultural products	**MU**	**2018**	**2019**	**2020**	**2021**	**2022**	**2022/2018**
Cereals and cereal products in grain equivalent	kg	205.3	204.2	199.9	200.6	198.6	-0.033
Potatoes	kg	95.4	92.2	93.4	98.1	97.7	0.024
Vegetables and vegetable products in fresh vegetable equivalent	kg	173.4	170.2	175	180.2	156	-0.100
Fruits and fruit products in fresh fruit equivalent	kg	110.8	111.3	107.6	115.3	112.2	0.013
Meat and meat products in fresh meat equivalent	kg	73.3	74.4	74.1	74.7	74	0.010
Milk and milk products in milk equivalent 3.5% fat (excluding butter)	liter	250.6	252.2	252.5	255.6	256.1	0.022
Egg	pieces	236	241	236	243	244	0.034

Source: data processing provided by INS-TEMPO ONLINE, CODE: CLV104A [11], Accessed on 06.09.2024.

From the analysis of the statistical indicators calculated for the average annual consumption per inhabitant, the following were highlighted:
- ***For cereals and cereal products*** in grain equivalent, it varied between 199 and 205 kg/inhabitant, registering an average of the period of 202 kg/inhabitant and a standard deviation of 3 kg/inhabitant. The 1.43% value of the coefficient of variation indicates the homogeneity of the analyzed data series, and the negative value (-0.83%) of the annual growth rate indicates the negative dynamics of consumption during the analyzed period.
- For potatoes, the average annual consumption oscillated between 92 and 98 kg/inhabitant, recording an average of 95 kg/inhabitant and a standard deviation of 3 kg/inhabitant. The value of the coefficient of variation (2.71%) shows the existence of a series of homogeneous data, and the value of the annual growth rate indicates the positive dynamics of the average consumption in the analyzed time interval.
- ***For vegetables and vegetable products*** in fresh vegetable equivalent, the average annual consumption recorded values between 156 and 180 kg/inhabitant, the average of the period was equal to 171 kg/inhabitant with a standard deviation of 9 kg/inhabitant. The low value of the coefficient of variation (5.33%) signifies the presence of a series of homogeneous data, and the annual negative growth rate (-2.61%) indicates the downward trend of the average annual consumption per inhabitant for the product category - vegetables.
- ***For fruits and fruit products*** in fresh fruit equivalent, the average annual consumption oscillated between 108 and 115 kg/inhabitant, registering an average of the period of 111 kg/inhabitant with a standard deviation of 3 kg/inhabitant. The coefficient of variation of 2.48% indicates the homogeneity of the data series, and the value of the annual growth rate (0.31%) indicates the positive dynamics of the

average annual consumption per inhabitant in the product category. - fruits.

- ***For meat and meat products*** in fresh meat equivalent, the average annual consumption was between 73 and 75 kg/inhabitant, registering an average of the period equal to 74 kg/inhabitant with a standard deviation of 1 kg/inhabitant. The value of the coefficient of variation (0.71%) indicated a homogeneous series of data, and the value of the annual growth rate (0.24%) indicated the positive dynamics of the average annual consumption per inhabitant in the product category - meat.

- ***For milk and milk products*** in milk equivalent 3.5% fat (excluding butter), the average annual consumption recorded values between 251 and 256 kg/inhabitant, recording an average of 253 kg/inhabitant with a standard deviation of 2 kg/ inhabitant The value of the coefficient of variation (0.93%) indicates a series of homogeneous data, and the value of the annual growth rate (0.54%) indicates the positive dynamics of the average annual consumption for the product category - milk.

- ***For eggs***, the average annual consumption oscillated between 236 and 244 pieces/inhabitant, the average of the analyzed period being equal to 240 pieces/inhabitant with a standard deviation of 4 pieces per inhabitant.

The coefficient of variation of 1.59% indicates the existence of a homogeneous data series, and the value of the annual growth rate of 0.84% indicates the positive dynamics of egg consumption in the analyzed time interval (Table 2).

Table 2. Statistical indicators calculated for the average annual consumption per inhabitant in the period 2018-2022

Product	**MU**	**Minimum**	**Maximum**	**Mean**	**Average Standard Deviation**	***Coefficient of Variation (%)**	**Annual Growth Rate (%)**
Cereals and cereal products in grain equivalent	kg	199	205	202	3	1.43	-0.83
Potatoes	kg	92	98	95	3	2.71	0.60
Vegetables and vegetable products in fresh vegetable equivalent	kg	156	180	171	9	5.33	-2.61
Fruits and fruit products in fresh fruit equivalent	kg	108	115	111	3	2.48	0.31
Meat and meat products in fresh meat equivalent	kg	73	75	74	1	0.71	0.24
Milk and milk products in milk equivalent 3.5% fat (excluding butter)	liter	251	256	253	2	0.93	0.54
Egg	pieces	236	244	240	4	1.59	0.84

*Coefficient of variation: <10 - small; 10-20 - medium; >20 - high.
Source: data processing provided by INS-TEMPO ONLINE, CODE: CLV104A [11], Accessed on 06.09.2024.

In Figure 1, the quantities of agri-food products purchased by a household were graphically represented by product categories and social categories of household members, thus the following were highlighted: cereals and eggs were the most purchased product categories in households.

If we refer to the social categories, a greater buying tendency was observed among pensioners and employees (Figure 1).

Regarding production per inhabitant, the following trends were observed for the main agricultural products in the analyzed period:

- The highest production was registered in the category - cereals for grains, and the lowest production in the category - wool.
- At the level of the 2018-2022 period, decreasing trends in production per inhabitant were observed for the following product categories: sugar beet (-70.52%), potatoes (-54.48%), grains for grains (-38 .86%), vegetables (-34.63%), fruit (-16.33%), milk (-1.04%) and meat (-0.39%). For wool (+8.33%) and eggs (+7.51%), production growth trends per inhabitant were observed in the analyzed time frame (Table 3).

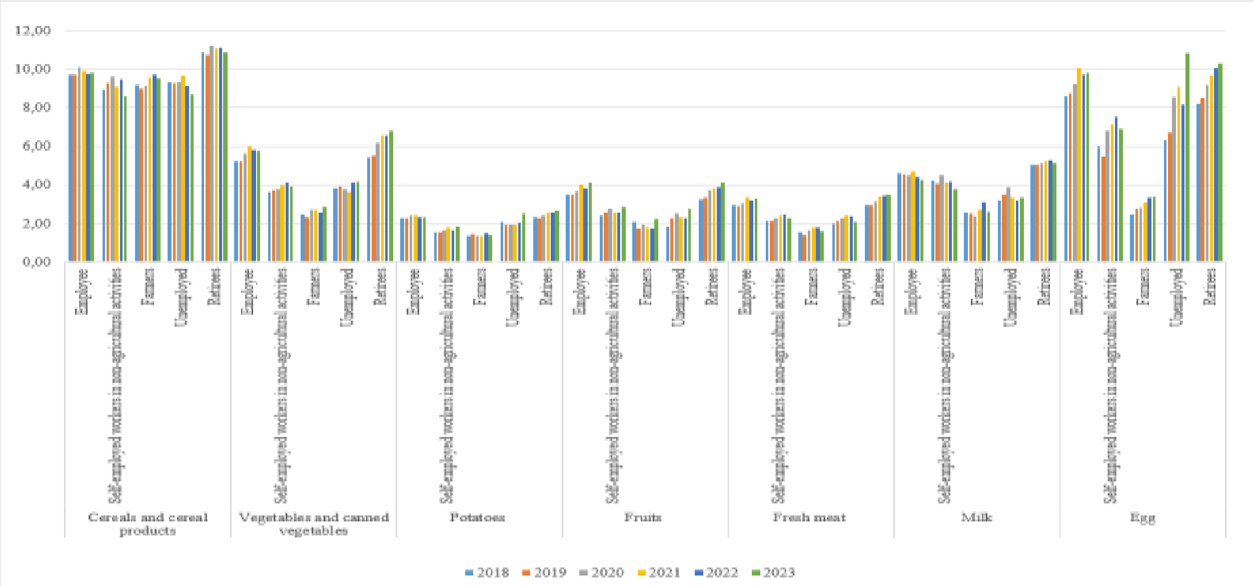

Fig. 1. The dynamics of the quantities of agri-food products purchased by a household by product category and the main social categories in the period 2018-2023
Source: data processing provided by INS TEMPO ONLINE, BUF113J [11], Accessed on 22.10.2024.

Table 3. Production dynamics of the main agricultural products, per inhabitant in the period 2018-2022

Products	MU	2018	2019	2020	2021	2022	2022/2018
Cereals for grains	kg	1,619.5	1,569.6	940.8	1453	990.1	-38.86%
Sugar beet	kg	50.2	47.3	37.2	41	14.8	-70.52%
Potatoes	kg	155.1	135.6	83	73.1	70.6	-54.48%
Vegetables	kg	194.9	182.2	180.5	182.7	127.4	-34.63%
Fruits	kg	93.1	76.8	82.4	89.1	77.9	-16.33%
Meat	kg	76.2	77.2	75.8	76.1	75.9	-0.39%
Milk	liter	239.9	238.2	240.2	237.8	237.4	-1.04%
Wool	kg	1.2	1.2	1.2	1.2	1.3	8.33%
Eggs	pieces	293	287	282	310	315	7.51%

Source: data processing provided by INS-TEMPO ONLINE, CODE: AGR200A [11], Accessed on 06.09.2024.

From the analysis of the statistical indicators calculated for **the production of the main agricultural products per inhabitant**, the following were highlighted:
- *For cereals for grains*, production varied between 940.8 and 1,619.5 kg/inhabitant recording a period average of 1,315 kg/inhabitant with a standard deviation of 325%. The high value of the coefficient of variation of 24.71% suggests the existence of an inhomogeneous data series, and the value of the annual growth rate indicates the negative dynamics of grain production per inhabitant (Table 4).
- *For sugar beet*, production varied between 14.8 and 50.2 kg/capita, the average of the period being 38kg/capita with a standard deviation of 14 kg/capita. The coefficient of variation of 36.73% indicated an inhomogeneous series of data, while the annual negative growth rate (-26.31%)

indicated the downward trend of sugar beet production per inhabitant (Table 4).

- *For potatoes*, production oscillated between 70.6 and 155.1 kg/inhabitant recording an average of the period of 103 kg/inhabitant with a standard deviation of 39 kg/inhabitant. The high value of the coefficient of variation of 37.80% indicates an inhomogeneous data series, and the negative annual growth rate (-17.86%) indicates the downward trend of potato production per inhabitant (Table 4).

- *For vegetables,* production ranged between 127.4 and 240.2 kg/capita, with a mean of 174 kg/capita and a standard deviation of 26 kg/capita. The coefficient of variation showed an average value (15.23%), which suggests a slightly homogeneous data series, and the negative annual growth rate (-10.08%) indicates+ a downward trend in vegetable production per inhabitant (Table 4).

- *For fruits*, production varied between 76.6 and 77.2 kg/capita recording a period average of 84 kg/capita and a standard deviation of 7 kg/capita. The coefficient of variation value (8.44%) indicates a homogeneous data series, and the annual growth rate (-4.36%) indicates the negative dynamics of fruit production per inhabitant (Table 4).

- *For meat*, production was between 75.8 and 77.2 kg/inhabitant, the average of the period being 76 kg/inhabitant with a standard deviation of 1 kg/inhabitant. The value of the coefficient of variation of 0.73% indicates the existence of a homogeneous data series, and the annual growth rate of -0.10% indicates the negative dynamics of meat production per inhabitant (Table 4).

Table 4. Statistical indicators calculated for the production of the main agricultural products, per inhabitant in the period 2018-2022

Product	**MU**	**Minimum**	**Maximum**	**Mean**	**Average Standard Deviation**	***Coefficient of Variation (%)**	**Annual Growth Rate (%)**
Cereals for grains	kg	940.8	1,619.5	1,315	325	24.71	-11.58
Sugar beet	kg	14.8	50.2	38	14	36.73	-26.31
Potatoes	kg	70.6	155.1	103	39	37.80	-17.86
Vegetables	kg	127.4	194.9	174	26	15.23	-10.08
Fruits	kg	76.8	93.1	84	7	8.44	-4.36
Meat	kg	75.8	77.2	76	1	0.73	-0.10
Milk	liter	237.4	240.2	239	1	0.53	-0.26
Wool	kg	1.2	1.3	1	0	3.67	2.02
Eggs	pieces	282	315	297	14	4.85	1.83

*Coefficient of variation: <10 - small; 10-20 - medium; >20 - high.
Source: data processing provided by INS-TEMPO ONLINE, CODE: AGR200A [11], Accessed on 06.09.2024.

- *For milk*, production showed values between 237.4 and 240.2 kg/inhabitant, the average of the period being 239 kg/inhabitant with a standard deviation of 1 kg/inhabitant. The coefficient of variation was 0.53% indicating the existence of a homogeneous data series, while the negative annual growth rate (0.26%) indicated the decreasing trend of milk production per inhabitant (Table 4).

- *For wool*, production varied between 1.2 and 1.3 kg/inhabitant recording a period average of 1 kg/inhabitant with a standard deviation of 0 kg/inhabitant. The value of the coefficient of variation of 3.67% characterizes the data series as a homogeneous one, and the positive annual growth rate (2.02%) indicates the increasing trend of wool production per inhabitant.

-*For eggs*, production recorded limits between 282 and 315 kg/inhabitant, the average of the period being 297 kg/inhabitant with a standard deviation of 14 kg/inhabitant. The coefficient of variation of 4.85% indicates the homogeneity of the data series, and the annual growth rate of 1.83% indicates the positive dynamics of egg production during the analyzed period (Table 4).

In the period 2018-2022, the trends in the value of the main categories of agricultural products at the producer price have increased for all analyzed products, less for potatoes for which the trend was one of decrease (-22.39%), from 4.107 million lei in 2018 to 3.187 million lei in 2022. The most significant increases in the value of producer prices were observed for eggs and milk. For eggs, at the level of the period, an increase of 53.46% was recorded, from 3,274 million lei in 2018 to 5,025 million lei in 2022, and for milk the increase was 50.25%, from 4,320 million lei in 2018 to 6,490 million lei in 2022 (Table 5).

Table 5. The value of agricultural products at the producer price in the period 2018-2022 (millions LEI)

Products	2018	2019	2020	2021	2022	2022/2018
Cereal (including seeds)	22.700	22.610	14.927	27.708	27.149	19.60%
Vegetables and horticultural products	11.344	12.560	12.683	15.864	14.578	28.51%
Potatoes (including seed)	4.107	5.390	5.086	2.297	3.187	-22.39%
Fruits	6.686	5.971	6.927	7.853	7.362	10.11%
Animal products	9.338	9.592	10.041	10.824	13.708	46.80%
Milk	4.320	4.562	4.949	5.247	6.490	50.25%
Egg	3.274	3.294	3.163	3.712	5.025	53.46%

Source: data processing provided by INS TEMPO ONLINE, CODE: AGR208A [11], Accessed on 12.09.2024.

From the analysis of the statistical indicators calculated for **the average value** of the agricultural products at the producer price in the time frame 2018-2022, the following aspects were highlighted:

-For cereals, the average value at the producer price varied between 14,927 and 27,708 million lei, registering an average of the period equal to 23,019 million lei and a standard deviation of 5,119 million lei. The high value of the coefficient of variation of 22.24% indicates the existence of a non-homogeneous data series, and the positive annual growth rate of 4.58% indicates the increasing trend of the value at the producer price for this category of agricultural products.

- For vegetables and horticultural products, the average value at the producer price was between 11,344 and 15,864 million lei, the average of the period being 13,406 million lei with a standard deviation of 1,796 million lei. The value of the coefficient of variation (13.40%) indicates an inhomogeneous series of data, and the value of the annual growth rate (6.47%) indicates the positive dynamics of the value at the producer price for this category of agricultural products (Table 6).

- For potatoes, the average value at the producer price oscillated between 2,297 million lei and 5,390 million lei, registering an average of 4,013 million lei for the period with a standard deviation of 1,292 million lei. The coefficient of variation presented a value of 32.20%, indicating the inhomogeneity of the analyzed data series, and the negative annual growth rate (-6.14%) suggests the downward trend of the producer price value for this category of agricultural products.

- For fruits, the value at the producer price varied between 5,971 and 7,853 million lei, recording an average of the period of 6,960 million lei and a standard deviation of 710 million lei. The value of the coefficient of variation (10.20%) characterizes the data series as inhomogeneous, and the value of the annual growth rate (2.44%) indicates the positive dynamics of the value at the producer price for this category of agricultural products (Table 6).

Table 6. Statistical indicators; mean, minimum, maximum, standard deviation, coefficient of variation and annual growth rate calculated for the value at the producer's price in the period 2018-2022 (millions of LEI)

Product	Minimum	Maximum	Mean	Average Standard Deviation	*Coefficient of Variation (%)	Annual Growth Rate (%)
Cereal (including seeds)	14.927	27.708	23.019	5.119	22.24	4.58
Vegetables and horticultural products	11.344	15.864	13.406	1.796	13.40	6.47
Potatoes (including seed)	2.297	5.390	4.013	1.292	32.20	-6.14
Fruits	5.971	7.853	6.960	710	10.20	2.44
Animal products	9.338	13.708	10.700	1.773	16.57	10.07
Milk	4.320	6.490	5.114	848	16.58	10.71
Egg	3.163	5.025	3.694	773	20.92	11.30

*Coefficient of variation: <10 - small; 10-20 - medium; >20 - high.

Source: data processing provided by INS-TEMPO ONLINE, CODE: AGR208A [13], Accessed on 12.09.2024

- For products of animal origin, the value of the producer price oscillates between 9,338 and 13,708 million lei, recording an average of 10,700 million lei for the period with a standard deviation of 1,773 million lei. The value of the coefficient of variation (16.57%) indicates the existence of an inhomogeneous data series, and the annual growth rate (10.07%) indicates the positive dynamics of the producer price value for this category of agri-food products.
- For milk, the value at the producer price oscillated between 4,320 and 6,490 million lei, the average of the period being 5,114 million lei with a standard deviation of 848 million lei. The coefficient of variation of 16.58% highlights a less homogenous series of data, and the positive value of the annual growth rate indicates the tendency to increase the value at the producer price for this category of agri-food products.
- For eggs, the value at the producer's price recorded limits between 3,163 and 5,025 million lei, the average of the period being 3,694 million lei with a standard deviation of 773 million lei. The high value of the coefficient of variation was 20.92% indicates the presence of an inhomogeneous data series, and the positive annual growth rate of 11.30% indicates the tendency of the increase in the value at the producer's price for this category of agri-food products (Table 6).

CONCLUSIONS

The average consumption per inhabitant of the main categories of agro-food products analyzed in this study showed a relatively constant dynamic. The category of agri-food products that recorded the highest consumption was milk and milk products in milk equivalent 3.5% fat (excluding butter).
In terms of the production of the main agricultural products per capita, cereals for grains stood out by achieving the highest production per capita, followed by milk.
Regarding the current prices – value at the producer price, cereals (including seeds) register the highest price, followed by vegetables and horticultural products.
Regarding the current prices – value at the producer price, cereals (including seeds) register the highest price, followed by vegetables and horticultural products.
The results of the study showed the following:
- For cereals for grains, the demand was lower than the supply, at the level of 2022 the average annual consumption was 198.6 kg/inhabitant while the production was 990.1 kg/inhabitant.
- For potatoes, the demand is higher than the supply, in 2022 the average annual potato consumption was 97.7 kg/inhabitant, while the production recorded 70.6 kg/inhabitant.
- For vegetables and products in fresh produce equivalent, the demand was higher than the supply in 2022 when the average annual consumption was 156 kg/inhabitant, while the production was 127.4 kg/inhabitant.

- For fruits and fruit products in fresh fruit equivalent, the demand was also higher than the supply, the average annual consumption was 112.2 kg/inhabitant, and the production was 77.9 kg/inhabitant.
- For meat and meat products in fresh meat equivalent, in 2022, the demand was approximately equal to the supply. Average annual consumption was 74 kg/capita, while production was 75.9 kg/capita.
- For milk and milk products in milk equivalent 3.5% fat (excluding butter), the demand is higher than the supply. In 2022, the average annual consumption was 256.1 liters/capita, while the production recorded 237.4 liters/capita.
- For eggs, demand is lower than supply. The average annual consumption recorded in 2022 244 pieces/inhabitant, while the production was 315 pieces/inhabitant.

The increase in agricultural production can represent a solution for ensuring national food security, but it cannot completely solve this problem, as the supply needs to be supplemented with imported products.

Currently, Romania exports significant amounts of raw materials and imports finished products, one of the negative effects generated by this situation is the lack of factories for processing agricultural products at the national level. in this context, in order for Romania to be able to ensure the food security of the country, it is imperative to make some investments to develop the food industry. Also, introducing artificial intelligence to improve quality and ensure food safety while delivering significant capital savings and optimizing resources can be a sustainable solution.

At the same time, ensuring agricultural prices is an important tool for maintaining food security, it has been observed that the elasticity of supply is higher than the elasticity of demand for most agricultural products. In this context, price insurance of agricultural products changes the supply curve of these types of products by reducing the elasticity of supply, having a positive impact by reducing price fluctuations and stabilizing production.

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THE MATRIX OF INDICATORS FOR RECOGNIZING THE AGRIBUSINESSES ECOSYSTEM ASSETS: CONVERGENCE OF SYSTEM OF ENVIRONMENTAL-ECONOMIC ACCOUNTING (SEEA) AND INTERNATIONAL FINANCIAL REPORTING STANDARDS (IFRS)

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Abstract

The main objective of this research is to develop an accounting matrix for the agribusiness sector, based on current trends such as SEEA and IFRS, to support sustainable accounting and reporting. The study emphasizes the importance of developing a system of indicators that reflect the impact of the interaction between agribusiness and environmental ecosystems, particularly in the context of climate change. The research highlights the need for non-financial reports based on Global Reporting Initiative (GRI) and Environmental, Social and Governance (ESG) standards, which provide a comprehensive picture of agricultural enterprises' environmental, social, and governance performance. In this regard, it was developed a convergence matrix between SEEA and IFRS methodologies, emphasizing the importance of including ecosystem resources in agricultural accounting. The study also analyzes the existing obstacles in the Republic of Moldova for implementing SEEA in local accounting, particularly due to the lack of prerequisites for evaluating ecosystem assets in financial reporting. The research results include the development of a method for assessing agribusiness's contribution to maintaining ecosystem resources and formulating statistical indicators to monitor the state of these resources. In conclusion, the research proposes the integration of modern accounting approaches that allow investors and other stakeholders to better assess risks and opportunities related to agribusiness sustainability, thus helping prevent the ecological crisis and ensuring sustainable development.

Key words: *agribusiness, methodology of accounting, SEEA concept, natural capital, ecosystem assets, convergence matrix*

INTRODUCTION

In the current context of transforming economic relations, aspects of sustainable development are becoming increasingly relevant due to the worsening of global environmental and social problems. Economic activity directly impacts both climate change and societal processes. The ecological crisis characteristic of today's economy is a consequence of capitalism’s inherent goal of profit maximization. One way this goal is achieved is by undervaluing environmental resources (such as arable land, forests, water, mineral, and biological resources) used in the production of goods. These resources are often regarded by businesses as gifts from the environment, while the resulting environmental costs are passed on to society, often with the support of government policies [38].

There is no doubt that businesses rarely bear the cost of their negative environmental impacts, despite their heavy reliance on natural resources provided by ecosystems—such as fresh water, clean air, fertile soil, and biodiversity. With finite environmental reserves, this trend has inevitably contributed to the ecological crisis.

In response to the ecological crisis, the Sustainable Development Concept (SDC) was established, with environmental protection at its core. However, the SDC also aims to promote economic growth and social justice, as reflected in its 17 Sustainable Development Goals (SDGs). Notably, the SDGs highlight Goal 13, "Climate Action," and Goal 15, "Life on Land," both of which can be achieved through responsible consumption and production (Goal 12). This goal envisions a transition to a low-carbon, green economy. Additionally, Goal 17 "Partnerships for the Goals" emphasizes the creation of inclusive partnerships to stimulate social finance and drive progress towards sustainable development [35].

In the context of the SDC, agribusiness, which has long been a source of national income growth and a form of social relations, is now endowed with an additional attribute—sustainability. Agribusiness is considered sustainable when it fulfills its social responsibility by contributing to both food security and the resolution of the environmental crisis. It is well known that a broad group of agricultural products (such as dairy, cattle hides, soybeans, coffee, etc.) are considered "direct drivers" of land degradation, and they are increasingly drawing the attention of stakeholders. An analysis by the Food and Land Use Coalition found that between 2005 and 2017, G7 members (including the EU) were responsible for approximately 30% of tropical deforestation and over 2.7 billion tons of CO_2 emissions, driven by imports of these agro-products [22].

Sustainable agribusiness is a key driver of development in developing countries, including the Republic of Moldova (RM). An analysis of the current national economy reveals that a significant portion of the workforce is employed in agriculture (20.9% of total jobs in 2023), yet its contribution to the Gross Domestic Product (GDP) remains disproportionately small, accounting for only around 10% between 2020 and 2022. These indicators highlight low productivity and competitiveness, making RM's agribusiness sector vulnerable [19].

One possible solution to the current situation is a significant increase in investment in agribusiness, utilizing both internal and external financing sources. Achieving this would help facilitate the transition to a sustainable agribusiness model. In the initial phase, a system of statistical indicators could serve as a tool to support this process. However, the effectiveness of these indicators will depend on their ability to adequately measure agribusiness' contribution to sustainable development and, ultimately, to resolving the environmental crisis. Additionally, addressing the environmental crisis will require assessing the actions of not only agribusiness but also other actors in the supply chain, including providers of non-financial and financial resources, consumers, and policymakers [22].

This assessment can be achieved through the integration of a specialized system of indicators into agribusiness reporting.

Society, businesses, and institutional structures require indicators that reflect the interconnections between the economy, human beings, and the environment. The development of a specific system of indicators to measure the implementation of the SDC will inevitably expand the scope of available information and, consequently, lead to changes in the format of business reporting used to convey this information to stakeholders.

The recognition of the critical role of environmental resources in promoting societal well-being within the Sustainable Development Concept led to the development of the specialized System of Environmental-Economic Accounting (SEEA). Its core principle is that to ensure the rational use and preservation of natural resources, it is essential to account for them. This system helps measure the impact of economic activities on natural resources and identify priority areas for "green" investments. The SEEA was further extended to cover agriculture, forestry, and fisheries through the System of Environmental-Economic Accounting for Agriculture, Forestry, and Fisheries [36].

The Strategy "European Moldova 2030" (hereinafter, Strategy 2030) outlines a number of priority directions for the transition to the paradigm of sustainable development and provides for a number of protective measures to neutralize the current national problems, including the environmental crisis, based on the homocentric vision of society development. At the same time, the Strategy-2030 highlights that, due to low income levels, the people of the Republic of Moldova prioritize economic challenges over environmental concerns and fail to recognize the importance of natural resources for their well-being and sustainable development. The foundation of the society's "environmental philosophy" is a tendency to view ecosystem resources—such as land, water, minerals, and biological resources—as nature's gifts, which are perceived as free and unlimited [19].

This raises an important question: *What are the prospects for implementing SEEA provisions in the Republic of Moldova, a developing country, to mitigate the environmental crisis and ensure the sustainable development of agribusiness?*

At the same time, it is known that the Natural Capital Coalition [21] as a modern accounting practice recognizes IFRS [17]. This raises the question: *How do the SEEA provisions relate to the IFRS methodology for agribusiness accounting in the context of the Sustainable Development Goals*? The answers to these questions will support the hypotheses *(H)*:

H1: The accounting and reporting system of the Republic of Moldova, which is oriented towards the continental accounting model, does not yet have the prerequisites to implement SEEA and provide useful information on the state of ecosystem assets in financial reporting, including agribusiness.

H2**:** The convergence of IFRS methodology and the SEEA concept contributes to the development of a sustainable agribusiness accounting system.

Justification of the hypothesis is carried out according to the following scheme:

Stage 1 – Characterization of the model for achieving sustainability and development of agribusiness in line with the European Moldova-2030 Strategy;

Stage 2 – Conceptualization of the agribusiness accounting matrix in the context of the development of its sustainable accounting and reporting model;

Stage 3 – Development of key indicators related to climate change as a result of the interaction between agribusiness and environmental ecosystems.

Numerous studies address the challenge of agribusinesses achieving a sustainable model, with a key focus on assessing resource efficiency. To illustrate the relationship between resource consumption and production volume, GDP per unit of resources used remains a prevalent metric at the macroeconomic level. However, the economic development model primarily centered on GDP growth raises concerns among academic economists [30].

The connection between economic growth and environmental degradation is currently one of the most debated topics in both scientific and public discourse worldwide. It is frequently suggested that the pursuit of economic prosperity often comes at the expense of environmental health and resource depletion [27].

In this context, assessing the condition of ecosystem assets and the services they provide is crucial for agribusinesses striving for sustainable development. According to Skika et al., a system of statistical indicators secves as one of the tools to achieve this goal. This system includes assessments of: 1) agricultural land as an investment; 2) agricultural land subject to changes in use policy; and 3) uncertainties related to current and future agricultural land use, among others [28].

However, this set of indicators fails to capture the impact of agribusiness on the condition of ecosystem assets.

Erbas (2024) [12] notes that agribusiness requires external investment, typically provided by the government through subsidies. The reluctance of real sector enterprises to invest in agribusiness is largely due to the absence of an effective valuation system for agricultural land and other ecosystem assets, which hinders the assessment of financial and social risks and the potential for increasing equity capital [12]. Such an opinion is also supported by other researchers [9, 5].

Furthermore, the lack of reliable information on ecosystem asset values distorts macroeconomic indicators such as GDP, Gross Value Added (GVA), and the Value of Industrial Product (VIP) [14].

The sustainable development of agribusiness directly depends on the state of the environment, making the use of modern information tools in agribusiness management imperative. This underscores the importance of generating qualitative information about the results of this interaction [11].

Ofurum's assertion is noteworthy: the function of management, with accounting as a “language of business” includes identifying stakeholders who contribute to the increase in business capital and ensuring their interests are represented. Due to the absence of natural capital valuation in financial statements, the information provided often does not meet stakeholders' needs, leading to a financial report that falls short of its intended purpose [23].

In this regard, two ways of preparing non-financial reporting have been developed. *The first approach* is based on GRI standards and ESG-indicators and aims to present information about environmental, social, governance activities, and corporate social responsibility, but which cannot be explained in terms of currency [10].

Today, it is known as a systematization of ESG-indicators to assess the extent to which a business is committed to non-profit goals beyond maximizing the value created for its owners [7].

According to this approach, within the environmental aspect of activities, businesses focus on issues that are significant for both them and other stakeholders: compliance with environmental legislation, environmental characteristics of products, energy efficiency, energy conservation and innovation, as well as the protection of land resources and vegetation. The importance of this type of information is beyond doubt. However, it does not provide a comprehensive account of the business unit's activities and does not reflect all the factors that contribute to wealth creation and well-being [4], as it is primarily quantitative in nature.

The *second approach* is based on the "Integrated Reporting" standard. Its development was driven by the introduction of a combination of short-term and long-term indicators into practice, designed to reflect a business's ability to mobilize its intellectual (intangible) assets along with its physical (tangible) assets [16].

This approach is now known as the systematization of information through Key Performance Indicators (KPI), which characterize the quality, sustainability, and variability of a business's cash flows and revenues [10].

Each of these non-financial reporting formats serves as a complement to financial reporting, and the use of different measurement units for their indicators indicates a lack of interconnection between them, as well as between each of them and the financial reporting [15].

Meanwhile, the issue of valuation is fundamental. After all, shareholders and investors evaluate business performance in the “language” of numbers, showing information about the impact of non-financial resources on the state of the business and vice versa, about the contribution of the business to their maintenance, which is useful to them when making responsible investment decisions. At the same time, the statistical nature of ecosystem asset valuation does not contradict the IFRS methodology, since its object is reporting as a whole, the indicators of which are represented by average estimated values calculated on the basis of statistical methods [29].

The recognition by the concept of sustainable development of the crucial role of environmental resources in ensuring the well-being of society led to the development of a specialized SEEA. At the beginning, System of Environmental-Economic Accounting was presented with two documented assets: SEEA Central Framework 2012 (SEEA-CF) [40]; SEEA Ecosystem Accounting 2021 (SEEA-EA) [41]. It was further developed in relation to activities related to agriculture, forestry and fisheries [36].

The SEEA-AFF applies the ecological-economic structures and principles described in the Central Framework [34] and its aim is to integrate the data needed to describe how biophysical and management information related to production in agriculture, forestry and fisheries can be integrated into the statistical system established under the SEEA-EA [37].

At the same time, the Task Force of the Conference of European Statisticians proposed a set of core indicators and statistics related to climate change calculated using SEEA-EA. This set consists of 44 indicators, which include: total land area in general and by category; area of disturbed land and area of restoration; area of reclaimed land; amount of waste generated (emissions); amount of waste used or neutralized [33].

In addition, the Economic Commission for Europe Paper states that environmental accounting can be used to monitor and analyze a wide range of environmental issues, including climate change, although there is no specific accounting for climate change in SEEA-EA [37].

In addition, the GHG Agricultural Protocol Guidance interprets the Corporate Accounting and Reporting Standard for the Agricultural Sector [13].

The need for its development is justified by the fact that agribusiness accounts for about a quarter of anthropogenic emissions into the environment. It is noted that the most acceptable options for reducing these emissions in agribusiness are improving crop and pasture management, restoring organic soils, and rehabilitating degraded lands. This guidance aims to achieve the following objectives: to improve the consistency and transparency of accounting and reporting of emissions to the environment, to assist in the cost-effective preparation of inventories that provide accurate and objective information on their climate impact.

Such a systematic approach is expected to help inform management decisions regarding effective environmental control and the promotion of responsible agribusiness investments. The European Parliament has also adopted a similar decision [8].

Given this point, the GNG Protocol emphasizes that accounting and reporting of wastes (emissions) affecting ecosystem assets should be based on basic principles that are adequate to the principles of modern accounting methodology: relevance, completeness, consistency, transparency, reliability [13].

It is obvious that the establishment of a comprehensive system for accounting for ecosystem assets and the contribution of sustainable agribusiness to their maintenance is impossible without institutional solutions that promote the implementation of environmental-economic accounting in agribusiness and its integration with national accounting and reporting systems, including those of the Republic of Moldova.

The above studies demonstrate the importance of this issue and undoubtedly contribute to the understanding of the urgency of developing an effective SEEA-based mechanism for accounting for ecosystem assets and integrating it into accounting methodology.

In this context, the purpose of the paper is to develop an accounting matrix for the agribusiness sector, based on current trends such as SEEA and IFRS, to support sustainable accounting and reporting.

MATERIALS AND METHODS

This research employs a combination of general scientific and specialized methods, including a systems approach, content analysis, synthesis, graphic and mathematical modeling, and a review of specialized literature. The application of the systems approach is evident in the strategic integration of specific scientific methods to develop the research methodology, which encompasses problem definition, hypothesis formulation, and justification.

The primary methods of this methodology are content analysis and matrix modeling. The content analysis method, which compares the provisions of National Accounting Standards (NAS, 2013), International Financial Reporting Standards (IFRS), and the System of Environmental-Economic Accounting (SEEA), has facilitated the development of an environmental-economic accounting algorithm for agribusiness (Table 1). This method also led to the creation of a convergence matrix between these standards (Table 2). Matrix modeling is utilized to visualize the algorithm for constructing an agribusiness accounting system based on SEEA provisions. Additionally, it aids in developing the SEEA convergence matrix with accounting methodology (Table 2) and establishing a system of indicators for assessing the state of the ecosystem and agribusiness's contributions to its maintenance (Table 3).

The aim of the research is to explore the possibilities of developing a sustainable accounting model for agribusiness based on current trends (SEEA and IFRS) in the context of the Sustainable Development Goals.

In this regard, the following sources were used to form the evidential basis:

(i)Official documents and reports from the UN, the United Nations Economic Commission for Europe, the European Parliament, and other international organizations in the field of ecosystem asset and capital accounting systems;

(ii)The legislative and regulatory framework of the Republic of Moldova regarding accounting and reporting;

(iii)International standards related to both financial reporting and sustainable development, including integrated and non-financial reporting;

(iv)Works by renowned scholars published in scientific journals, including those indexed in the Scopus and Web of Science databases, as well as in the form of monographs.

RESULTS AND DISCUSSIONS

1. Model for achieving agribusiness sustainability aligned with the National Development Strategy „European Moldova 2030"

The problem of ecological crisis has arisen as a result of human activities, especially those that qualify as businesses. Agribusiness (agricultural enterprises), as an integral part of the economic sector, is faced with a dilemma: either to gain more income from increased yields or to degrade soils, water scarcity and loss of biodiversity, in other words, to degrade the environment on whose resources it depends. The resolution of this dilemma is a challenge for the current scientific and institutional environment, the overcoming of which will lead to a balance between environment and society, the "capitulation" to which has far-reaching consequences for both agribusiness and the "health" of the entire planet.

The developments of the scientific environment contributed to the transition to the SDC and formed the methodological platform of environmental-economic accounting [1]. Environmental and economic accounting is designed to neutralize the ingrained tradition of perceiving environmental resources as a "gift" of nature and excluding their value from the cost of production. The ecological consequence of this tradition is the degradation of natural capital. In the context of the current agribusiness dilemma, consideration of ecological consequences is of particular importance. J. Richard (2009 a and b) note the lack of specific accounting standards for accounting for environmental factors and natural capital elements. The lack of a clear position on the demand for this type of information and demonstration of the benefits of such information slows down the motivation of business, including agribusiness, to keep environmental accounting and publish relevant information [24, 25].

Environmental-economic accounting is the first step in resolving this problem.

However, for the implementation of the SDC, an institutional environment must be established and clearly defined, one that promotes the reformatting of the economy by mitigating the absolutization of economic growth and encouraging environmentally-oriented businesses aimed at achieving sustainable development goals.

It is known that the core of the institutional platform, which establishes directions for the development of a particular state, region or association, is the development strategy. In RM today, the Strategy 2030 serves as such a strategy. It identifies priority areas for transition to the SDC, and establishes actions and policies to address the environmental crisis and support agribusiness in its transition to a sustainable development model. Therefore, according to the Strategy-2030, environmental components have a direct impact on a person throughout his life, determining the state of health, labor productivity, economic growth potential, etc. At the same time, the neglect of environmental problems caused by climate change over the past years, manifested mainly in the deviation from environmental goals in favor of economic goals or the interests of narrow groups, has made society even more vulnerable. Land resources in RM are very intensively exploited and soils with a high level of quality and productivity are subject to degradation processes, the most serious of which is erosion. To maintain their productivity, agribusinesses use significant amounts of organic fertilizers and products, which are another source of soil degradation risks. The state of the land fund in agribusiness has been negatively affected by the reform regarding the form of land ownership and the process of degradation has only intensified (annually 6,400 ha of agricultural land is degraded). At the same time, the Republic of Moldova remains far behind European countries in terms of public and private investments in environmental protection [19].

Currently existing environmental economic instruments (e.g., taxes and environmental permits) are not able to change the situation. It should be noted that a similar situation occurs in other countries, for example, in Ukraine and Belarus, where the process of implementation of modern environmental policy is predominantly focused on the elimination of environmental impacts rather than on prevention [3, 20].

At the same time, the most common tools are recovery of payments for environmental pollution, waste generation, water pollution, air pollution [3, 20].

In the absence of decisive action, the impacts of climate change on agribusiness, the environment and public finance will become even more severe [19].

The key aspects of the outlined strategy that aid in identifying the issues for agribusiness transition to a sustainable development model are presented in Fig. 1.

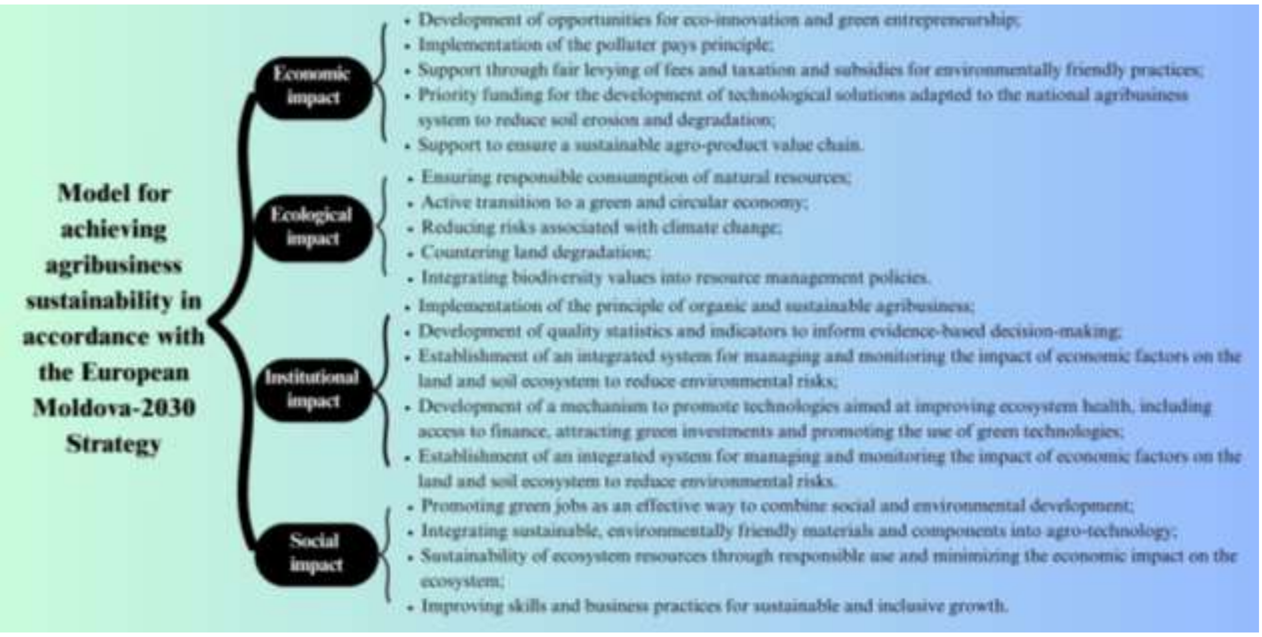

Fig. 1. Model for achieving agribusiness sustainability aligned with the European Moldova 2030 Strategy
Source: developed by the authors.

The model of achieving sustainability by agribusiness presented in Figure 1 provides for the need to develop and implement a comprehensive approach to consistently reduce external and increase internal environmental costs in agribusiness. This involves the introduction of environmental technologies, reduction of waste generation and deepening of waste recycling, and support of environmental activity of agribusiness under the modern technological mode. In this process, the environmental responsibility of agribusiness is strengthened through the implementation of measures to prevent and eliminate negative environmental impacts during the life cycle of products (environmental aspect).

The model of formation of sustainable agribusiness provides for institutional solutions, including improvement of environmental statistical accounting and implementation of the system of national accounts on the basis of statistical data to manage and monitor the impact of agribusiness on its ecosystems (institutional aspect). This implies the development of a unified methodology for building the system of accounts. Moreover, understanding and applying the principles of environmental-economic accounting will contribute to the development of agribusiness reporting with respect to the disclosure of the ESG-contribution of agribusiness to its sustainable development model (economic aspect). In doing so, the social responsibility of agribusiness (social aspect) promotes fair labor practices, sustaining the national economy and contributing to the overall well-being of society [18].

2. Conceptualization of the Accounting Matrix in Agribusiness in the Context of Developing its Sustainable Accounting and Reporting Model.

However, the strategy looks to the future, so to assess the feasibility of implementing its model for creating sustainable agribusiness, it is necessary to compare the principles of SEEA with the current procedures for evaluating and presenting information on the condition of ecosystem assets used by agribusiness, as prescribed by the National Accounting Standards (hereinafter - NAS). As already noted, SEEA-AFF applies the eco-economic principles of SEEA-CF and the accounting rules described in SEEA-EA to activities related to agriculture, forestry, and fisheries. The preparation of a separate documentary act within the framework of SEEA for these types of activities is predetermined by the fact that they directly depend on the environment and its resources and, in turn, exert influence on them. SEEA-AFF emphasizes that it is, in general, a statistical system for organizing data. This means that it allows for the description and analysis of the relationship between the environment and economic activities related to agriculture, forestry, and fisheries. We briefly summarize the key points of the SEEA concept regarding the application of its provisions for organizing eco-economic accounting for agribusiness (Table 1), which the authors believe will contribute to mitigating the ecological crisis.

As stated in SEEA-AFF, the basic accounting organization aimed at establishing sustainable agribusiness can be expanded in various ways, as SEEA-AFF serves as a platform for an accounting structure designed to facilitate the integration and use of data related to activities in agriculture, forestry, and fisheries within the economic and environmental spheres.

Since the IFRS concept is recognized as a modern methodology for constructing reporting and accounting, alongside a comparison with NAS, we will conduct a critical analysis of the similarities and differences between IFRS and SEEA, and then establish the degree of convergence between them.

The developed convergence matrix will serve as a basis for creating a corresponding conceptual accounting platform in the agribusiness sector aimed at sustainable development.

It is important to note that the IFRS methodology is based on the application of economic valuation in the preparation of financial statements, for which the IFRS system includes the standard IFRS 13 “Fair Value Measurement”.

The provisions of this standard within the framework of the fair value concept recommend applying one of three approaches to valuing accounting objects: the cost approach, the income approach, and the market approach.

Table 1. Key elements of SEEA defining the framework for ecological accounting in agribusiness

Stage	Content
I	The **conceptual framework** establishes an understanding of: ecosystems (dynamic territorial complexes consisting of biotic and abiotic components interacting as a functional whole while ensuring the existence of ecological structures, processes, and functions, CF p. 2.21), ecosystem assets (a set of ecosystem services reflecting various characteristics, processes, and types of ecosystems, CF p. 2.2.3), the triad of ecosystem services (benefits provided by ecosystem functions to humanity, CF p. 2.22), the institutional sector as an economic unit (CF p. 2.6), and its products and waste (CF p. 2.5).
II	The **system of account** for ecosystem assets is designed to reflect their condition at the beginning and end of the period, in both physical and monetary terms. The monetary accounts for the condition of assets provide significant information on the interaction between business and ecosystems. An account titled 'Capital' is provided to reflect the acquisition and disposal of ecosystem assets (particularly for land and biological resource transactions in agribusiness). It is recommended to group accounts by types of activities: primary, agricultural production, environmental protection, and ecological management (CF p. 2.51, 2.60, 2.67, 2.71-2.74).
III	The **system of indicators**, based on which the condition of ecosystem assets is assessed and the ecosystem as a whole is characterized (p. 5.5.4 CA). The indicators are classified as variables since they are used to characterize biodiversity. The basis for their selection is compliance with the aspects of the concept of qualitative characteristics of information: semantic (relevance, reliability, and materiality), pragmatic (reliability, accessibility, simplicity, and comparability), and specific in the context of socio-ecological impact (completeness and cost-effectiveness).
IV	**The concept of monetary valuation**, which is central. The motivation for monetary valuation is the ability to compare different ecosystem assets and ecosystem services (p. 8.3 CA); moreover, it allows for the analysis of changes in the condition of ecosystem assets and their flows, for example, in agribusiness — analyzing changes in soil (fertility, erosion, degradation from toxic pollutants). The concept of exchange value assessment is applied in ecosystem accounting (p. 8.13 EA), which includes two approaches: market and NPV. The NPV approach is recommended for evaluating ecosystem assets and their services (p. 8.37 EA). Based on monetary valuation, an analysis is conducted of five broad types of changes: improvement, degradation, transformation, reassessment, and other changes. The NPV approach implies assessing the future ability of ecosystem assets to provide ecosystem services, which requires consideration of the prices and quantities of ecosystem services, institutional mechanisms, and the lifespan of ecosystem assets (EA p. 8.37). Exchange value is necessary to justify entries in the accounts of ecosystem assets.
V	**The concept of the triad of ecosystem services**: provisioning, regulating, supporting, and cultural services. In agribusiness, its economic aspect is directly linked to the use of ecosystem resources, often including both ecosystem assets and their ecosystem services, which are interpreted as contributions to the production of agricultural products. Quantitative measurement of ecosystem services (provisioning, regulating, and supporting) is provided, which depends on the type of ecosystem and its characteristics. Their valuation is based on exchange value, which facilitates comparison with changes in the condition of ecosystem assets (p. 7.70). For agribusiness, a coherent valuation of ecosystem assets and services is a key element (p. 2.71 A).
VI	**The object of ecosystem accounting** is ecosystems, and in this context, it is aimed at the systematic registration of data on ecosystem assets: their used stocks, services, and changes in condition due to the impact of agribusiness. The ecosystem accounting approach includes documenting the relationships between ecosystems and units of the institutional sector based on a developed chart of accounts and the selected valuation method. In corporate accounting, the focus is on the entities of agribusiness. It is recommended to establish an accounting procedure for ecosystem services, which serves as a linking concept between ecosystem assets and agribusiness (p. 6.1). Its importance is justified by the extensive use of provisioning and regulating ecosystem services by agribusiness, which are not explicitly recorded in the system of national accounts. Ecosystem services are classified as final and intermediate.
VII	**Documentation involves** the development of management forms. Systematized data on the condition of ecosystem assets are reflected in the Balance Sheet, while the flow of changes in condition (increase and decrease) is shown in the Profit and Loss Statement.

Source: developed by the authors.

Each of these approaches includes specific valuation methods, the choice of which depends on the specific use of each accounting object. As mentioned above (Table

2), SEEA recommends using the concept of exchange value, which is based on the income and market approaches to valuing ecosystem assets and their services.

The NAS methodology is oriented towards a continental accounting model, and in this regard, its basic principle is the 'cost principle,' while reporting is prepared according to the rules of the legal approach [31]. Adhering to the cost principle excludes the application of income or market approaches to the valuation of ecosystem assets. However, their value, as is well known, is influenced by the time factor, which is determined on one hand by societal demand, and on the other hand by the value of the ecosystem, such as land, its ecosystem assets and services, which are determined by its limited productivity.

Now we will move on to the development of a convergence matrix for the IFRS methodology, the SEEA concept, and the NAS methodology regarding the formation of accounting in agribusiness aimed at sustainable development.

The development of the designated matrix is carried out according to a three-step algorithm proposed by [15]. In the first stage of the algorithm, the key points of each of the studied concepts were examined in relation to the specific characteristics of agribusiness.

The objective of the second stage was to address the following questions:

- the identification of criteria for comparing the IFRS methodology, the SEEA concept, and the NAS methodology concerning accounting in agribusiness;
- and the formulation of explanations to clarify the indicator that corresponds to the IFRS methodology, is characteristic of the SEEA concept, and complies with the provisions of the NAS.

The third stage involves the actual construction of the matrix to address the questions: *What are the prospects for the implementation of the SEEA provisions in the developing country of the Republic of Moldova to neutralize the ecological crisis and ensure the sustainable development of agribusiness?*

How do the provisions of SEEA relate to the IFRS methodology for accounting in agribusiness in the context of sustainable development goals?

The convergence matrix of the IFRS methodology and the SEEA is presented in Table 2.

Table 2. Convergence Matrix of Accounting Indicators of the Republic of Moldova and International Practices for Disclosing Information on the State of Ecosystems

Criteria	Notes	NAS	IFRS	SEEA (CF, EA, AFF)
The role in ensuring sustainability	The degree of alignment with the principles of the SDC?	Low degree of alignment with the SDC	It responds flexibly to the requirements of the SDC and ensures the transition to a socio-economic model of financial reporting.	It is part of the SDC and contributes to the transition to a socio-economic model of financial reporting.
Information users	Who are the users of infor-mation about the state of ecosystems and natural capital, the source of their origin?	Owners (associates, shareholders, founders, members), creditors, clients, customers, emp-loyees, government authorities, and the public.	Existing and potential investors, lenders, and other creditors expecting a return on investment, which depends on the responsible management of all resources.	Owners (investors and shareholders), business policy developers, government, ecological economists, the public, and others.
Methodolo-gical approach.	What methodology is provided for solving the problem?	Based on traditional accounting methodology.	Based on the theory of normative accounting and reporting, the concept of financial capital, and the concept of economic valuation.	SEEA-AFF applies the principles and accounting structures contained in the System of National Accounts and SEEA and has an interdisciplinary nature: ecological economics, statistics, and economic valuation in management accounting.

Classifica-tions for accounting ecosystem assets:	What classification groupings are proposed to address this issue?	They are absent. Only ecosystem resources are considered: 1. biological asset - a living animal or plant; 2. agricultural products derived from the biological assets of agriculture	They are absent. Only ecosystem resources are considered: 1. biological asset – a living animal or plant; 2. agricultural products harvested from the biological assets of agriculture; 3. consumed and productive biological assets.	1. accounts (in monetary and physical terms); 2. types of ecosystem assets based on their boundaries; 3. types of ecosystem services; 4. products of ecosystem assets; 5. biotransformations and cultivated (abiotic) processes.
Methods for quantitative measurement of ecosystem assets.	Are quantitative measurement methods provided?	Not provided. It is noted that there is a need to assess quantitative changes.	Not provided. It is the prerogative of management accounting.	A system for accounting for the supply and use of ecosystem assets and their services is described.
Measu-rement concept	What valuation concept is accepted as the basic method-logy of the research?	The principle of cost.	The concept of fair value.	The concept of exchange value.
Method for measuring ecosystem assets and their changes.	What methods for measuring value are recommended?	Actual cost. The application of net realizable value is provided for in accounting under IFRS (IAS 41).	Fair value or based on income (net present value method - NPV) or market approaches. It is accepted as a priori. It is noted that it can be challenged, but only at the initial recognition of a biological asset for which there are no market quotations.	NPV method. The complexity of assessing ecosystem assets in agriculture is noted, as they are used to generate income. This requires a balanced accounting of ecological factors and economic factors (consumer demand) that influence economic decision-making regarding ecosystems.
A method for measuring ecosystem services and their changes	What methods are recom-mended for measuring the value of ecosystem services?	Not provided.	Not provided.	Based on the concept of exchange value, the priority method is NPV
Change in the quantitative state of ecosystems	Are changes in the quantitati-ve status of ecosystems taken into account?	Not taken into account. Only the modification of biological assets under the influence of biological transformation (growth, degenera-tion, reproduction, production of agri-cultural products) is considered.	Not taken into account. It is provided that managing changes in agriculture contributes to the process of biotransformation. The accounting for changes is conducted concerning the modification of biological assets under the influence of biological transformation (IAS 41) and within the framework of calculating the depletion of mineral reserves (IFRS 6).	It is an important element for integrating data on the state of ecosystems.
Change in the value status of ecosystems	What are the reasons for changes in value?	Information is absent. It is provided that biological transformation leads to the devaluation of long-term biological assets.	It is usually caused by their devaluation and depletion. It is provided that biological transformation leads to the devaluation of long-term environmental assets, the restoration of which is regulated by IAS 37 and IFRIC 1.	Caused by degradation, transformation, and revaluation.
Recognition of natural capital	Should natural capital be recognized as part of the elements of financial reporting as a component of business capital?	Not provided.	The capital method is applied regarding the contributions of non-financial participants in agriculture (IAS 20). For ecosystem resources, this method is excluded (IAS 41).	Not considered separately. However, it is a tool of the SEEA for implementing the SDC, which requires the opening of an account and recognition of natural capital as a driving force for ecological business activity.
Disclosure of information	What is the purpose of the information disclosure process?	It is defined by the need for economic decision-making by a wide range of users.	It is determined by reporting requirements aimed at assessing the value of the business and its economic impact on society.	The information goes beyond standard economic production functions. The goal is to improve the quality of data for analyzing the state of ecosystems and to ensure a structured connection between them and the economic aspect of agriculture.

Source: developed by the authors.

In this regard, it is appropriate to emphasize the particularity of SEEA, which focuses on developing a special accounting system for ecosystem assets and their services used by agribusiness, as well as preparing managerial and statistical information and presenting it in the relevant reporting. At the same time, the role of financial accounting and reporting is recognized in the context of decision-making. Furthermore, the emphasis on statistical information does not contradict the IFRS methodology [29]. Sokolov asserts that IFRS are not focused on accounting but rather on the formation of microstatistics or statistics of individual businesses, whose reporting is statistical reporting built through the processing of accounting data [29]. The statistical nature of the data in IFRS reporting is indicated by the requirement for comparability and the use of the retrospective method for correcting errors. It should be noted that this viewpoint does not represent an innovation in accounting methodology or a criticism of IFRS. The well-known scholar and developer of the static balance concept, Sher, interpreted accounting as a branch of mathematics, and the balance sheet as a collection of statistical data characterizing the assets and liabilities of a business. The above substantiates the validity of Hypothesis *H2*.

It is evident that to the extent there is convergence between IFRS and SEEA, there is divergence between the National Accounting Standards and SEEA. Based on the above, it can be concluded that the National Accounting Standards system is based on classical accounting methodology, oriented towards the continental accounting model. Currently, there are no prerequisites for the implementation of SEEA and the presentation of useful information regarding the state of ecosystem assets in financial reporting, including in agribusiness (*Hypothesis H1*).

In this regard, it is hard not to agree with the position of the Natural Capital Coalition, which states that the integration of IFRS and SEEA, while challenging, is possible [6]. Limitations are associated with the provision of truthful information in the preparation of financial statements due to objective difficulties in obtaining data, particularly regarding the value of ecosystem services, which are influenced by market factors such as consumer demand, as well as non-market factors such as scarcity and natural disasters. At the same time, these difficulties should not hinder the search for solutions to the problem of accurately assessing ecosystem assets and their services.

3.Development of key indicators related to climate change resulting from the interaction of agribusiness and environmental ecosystems.

The Strategy 2030 defines the long-term goal of ensuring the fundamental right to a healthy and safe environment. Its achievement is aimed at neutralizing the environmental crisis and should be implemented by integrating the following policies into the production processes of national industries, including agribusiness:

- Monitoring and evaluation of environmental factors' quality in accordance with international requirements;
- Management of the quality of ecosystem services;
- Accounting for and managing the impact of the economic sector on ecosystem assets that contribute to reducing environmental risks [19].

To implement these policies, specific indicators are required, but despite the growing need for climate change-related information, users still face challenges in obtaining relevant data [32].

It is clear that the formation of value indicators characterizing natural phenomena and the economic factors influencing them, as well as the contribution of environmental resources to the production of consumer goods, is a rather complex process that requires the application of modernized measurement methods [2; 26].

Meanwhile, SEEA provides a description and recommends the use of some of these methods for both ecosystem assets and ecosystem services.

However, a set of indicators based on statistical data can serve as a starting point for obtaining the necessary information on changes in the state of ecosystem assets, and more broadly, on climate change. This approach is outlined in the Guidance on the role of national statistical offices in achieving national climate goals [33], which states that the process should begin with the statistics and data already available, followed by creating a community of users and starting a discussion on the relevance and use of the data. There is already a practice of forming such indicators — a set of key indicators and statistical data related to climate change. Moreover, the document of the United Nations Economic Commission for Europe [13] states that environmental accounting can be used to monitor and analyze a wide range of environmental issues, including climate change, although there is no specific climate change accounting within SEEA-CF. The set of key climate change-related indicators, calculated based on SEEA, serves several purposes:

a) providing a clear picture of the most pressing climate change issues;
b) addressing the most relevant current policy questions;
c) assisting in meeting future information needs.

The most characteristic indicators of an ecosystem such as land, on the basis of which the impact of agribusiness on its condition and vice versa is to be assessed, include:

- total area of land use overall and by category;
- area of degraded land and area of restoration;
- area of reclaimed land; amount of waste (emissions) generated; amount of waste (emissions) used or treated.

Table 3. Set of Statistical Indicators for Assessing the Condition of the Ecosystem and the Contribution of Agribusiness to its Maintenance

n/n	Indicator	Qualification of ecosystem condition indicators					Base of calculation
		factors	emissions	impacts	consequences	adaptation	
1	Loss of land covered by natural vegetation	V					SEEA: Earth as an ecosystem
2	Total greenhouse gas emissions (CO2) resulting from agribusiness	V	V				SEEA: Emissions into the atmosphere
3	Greenhouse gas (CO2) emission intensity resulting from production: ▪ from fuel combustion ▪ from land use changes	V	V				SEEA: Emissions into the atmosphere (monetary valuation is difficult)
4	Carbon stocks in soil			V			SEEA: Complexity of carbon accounting (monetary valuation is difficult)
5	The ratio of degraded land area to total land area			V			SEEA: Earth as an ecosystem
6	Direct losses in agribusiness caused by ecosystem degradation (natural climate disasters)			V			SEEA: Secondary ecosystem resources
7	Share of expenditures on disaster risk reduction				V		Accounting data
8	Share of expenditures on resource and transportation taxes in the total volume of taxes and social security contributions				V		Accounting data
9	Total volume of subsidies and similar transfers related to ecosystem degradation				V		Accounting data
10	Net emissions (absorption of dioxide by soil)				V		SEEA: Complexity of carbon accounting (monetary valuation is difficult)
11	Share of agricultural land area where productive and sustainable farming methods are used					V	SEEA: Earth as an ecosystem

Source: developed by the authors based on Conference of European Statisticians' Set of Core Climate Change-related Indicators and Statistics Using the System of Environmental-Economic Accounting (2020) [39].

Important indicators of agribusiness's contribution to overcoming the environmental crisis include payments for the use of natural resources. It is important to note that all the listed indicators are regularly presented in the official materials of the National Bureau of Statistics of the Republic of Moldova.

Using the core set of climate change-related indicators and the characteristic indicators of the primary ecosystem interacting with agribusiness, we will propose a set of statistical indicators for which a monetary valuation is possible (Table 3).

CONCLUSIONS

A feature of agribusiness is the extensive use of non-financial resources – ecosystem resources of the environment, which on one hand contribute to societal well-being and income generation, while on the other hand degrade in the absence of a mechanism to maintain their condition. For the sustainability of agribusiness on a continuous basis, it is necessary to assess the condition of ecosystems and make investments to maintain their size. Meanwhile, the ecological crisis, including resource management issues, suggests that this condition is not being met.

The result of the research is the justification of the proposed hypotheses and the synthesis of general and specific conclusions. However, the key results of the research are:

1) the development of a matrix for aligning accounting methodology and the SEEA concept in order to build an accounting system for a sustainable agribusiness model;

2) the identification of indicators for assessing changes in the condition of ecosystem assets in the context of their interaction with agribusiness and measuring the contribution of agribusiness to their maintenance in order to overcome the ecological crisis.

The matrix was developed using a three-stage algorithm: analysis of the provisions of each of the researched concepts; identification of criteria for comparison; formulation of explanatory questions to clarify the comparison indicator

As a result, the authors formulated the following conclusions:

-The model for achieving sustainability in agribusiness involves the need to develop and implement a comprehensive approach that includes four aspects: economic, ecological, institutional, and social.

-Based on the assessment of current trends, the authors consider the application of IFRS methodology to be a promising direction, which does not contradict the use of statistical information characterizing agribusiness;

-To the extent that there is convergence between IFRS and SEEA, there is divergence between national accounting standards and SEEA. It is clear that since the national accounting system is oriented towards the continental model of accounting, there are currently no prerequisites for the implementation of SEEA and the provision of useful information on the condition of ecosystem assets in financial reporting, including that of agribusiness;

-A starting point for obtaining the necessary information on changes in the condition of ecosystem assets, as well as on climate change in general, could be a set of indicators based on statistical data.

It is anticipated that the results obtained will provide businesses with a better understanding of the modern approach to shaping the informational framework of reporting, particularly regarding the recognition of mineral resources and natural capital, enabling investors to assess risks when making environmental decisions.

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ECONOMIC AND ENERGY EFFICIENCY OF FUNGICIDES AND HERBICIDES IN SOYBEAN CROPS

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Abstract

The article presents calculations of the economic and energy efficiency of herbicide and fungicide application in soybean crops in the Ukrainian Forest Steppe. In the first experiment the soybean varieties Aurelina, EC Commander and EC Navigator and five variants of herbicide protection were studied. In the second experiment, the soybean varieties Amadea and Aurelina and ten fungicide protection variants were tested. It was found that the highest indicators of conditional net income, profitability and coefficient energy efficiency in the soybean varieties Aurelina, EC Commander and EC Navigator were obtained by using post-emergence herbicides with the active ingredient Bentazon, Imazamox (2 l/ha) + Chisalofop-P-Ethyl (2 l/ha) – 525.1, 437.6 and 558.9 EUR/ha; 87.1, 73.6 and 92.0 %; 1.83, 1.70 and 1.90. The maximum conditional net profit, profitability level and coefficient energy efficiency of the soybean varieties Amadea and Aurelina were in the variant with pre-sowing seed treatment with fungicide with the active ingredient Fipronil, Thiophanate-methyl, Pyraclostrobin (2 l/t) and the use of the active ingredient Pyraclostrobin, Epoxiconazole during the growing season – 509.0 and 421.3 EUR/ha; 76.4 and 63.1%; 2.14 and 2.02.

Key words: *soybean, variety, herbicide, fungicide, grain yield, conditional net income, profitability, coefficient energy efficiency*

INTRODUCTION

Analysis of global experience shows that high economic efficiency of soybean cultivation technology is achieved through a rational combination of production and placement factors, specialization, concentration, intensification and high marketability [6, 26]. The feasibility of a technology for growing crops, in particular soybeans, is determined by the possibility of effectively reducing the unit cost of production. Production costs are formed on the basis of all material and labour resources required to organize the production process and perform all operational elements of the technology [16]. Determining economic efficiency is an indicator that will allow a full assessment of whether the recommended measures to minimize soybean stress will be in demand under production conditions, as they will be able to ensure a sustainable high level of profit [7, 18].

The most promising are the technological components of the cultivation of any crop, where the economic and energy costs of production are low and the payback of costs, profitability and energy evaluation coefficients are high [28].

Among the factors that determine the level of economic efficiency of soybean cultivation, an important role is played not only by new, highly productive varieties, but also by specific technological methods that allow their genetic potential to be fully exploited [3].

The integrated use of optimal technology elements should not only ensure high soybean productivity, but also reduce the cost of cultivation. Often, the use of unjustified technological operations leads to expensive products and, as a result, significant losses [2, 13]. The systematic application of climate-smart measures, such as the selection of new varieties, crop protection products, complex chemical and biological products, and the evaluation of fertilizer and soil management systems, ensures a high economic and energy return from soybean production [8, 17, 19].

The use of herbicides to protect soybean crops from the economic point of view ensures the level of costs of cultivation technology of 19.5-20.9 thousand UAH/ha and keeps the cost of soybean seeds at 6.4-7.3 thousand UAH/ha. Thus, when using a separate method of herbicide protection of crops with an additional need for application, the main differences in costs were formed [15].

The results of the economic analysis showed that against the background of the use of the biological fertilizer phosphate gel and the introduction of a chemical plant protection system, the total cost of gross production of the soya bean variety Oleshshya was the highest (59.4 thousand UAH/ha). The lowest indicators (25.0 thousand UAH/ha) were found in the variant of the variety Ideal without plant protection and without the use of fertilizers, which caused significant yield losses of the studied crop.Profitability reached its maximum value in the variety Oleshshya, ranging from 249 to 254%, against the background of biological and chemical plant protection, as well as seed treatment with the biological product phosphate gel. The highest rates of profitability of soybean seed production were obtained in the variant with the introduction of the biological fertilizer phosphate gel, which exceeded the control by 21.2-59.5% [29].

The most cost-effective way to grow soybeans is to bacterize the seeds with Phosphonitragin and apply $N_{30}P_{60}K_{60}$ + N_{15} in the budding phase. At the same time, the cost of production increased by 6,687 UAH/ha, but the net profit increased by 10,462 UAH/ha and the cost price decreased by 661 UAH/t, and the level of profitability was 124% [30].

In the conditions of Western Polissya of Ukraine, the most economically profitable is the cultivation of soybean varieties Cassidy and ES Mentor, with a conditional net profit of 36,743 and 35,993 UAH/ha, respectively. This was made possible by inoculating the seeds with Legum Fix and applying the chelated microfertilizer Wuksal Oilseed (2.0 l/ha) twice (BBCH 60-66) [24].

In the Ukrainian Forest Steppe, the highest soybean production costs were achieved with a seeding rate of 900 thousand/ha and chemical crop care. The same technology was used to produce products with the highest costs and the Romantika variety with a seeding rate of 800 thousand/ha and mechanical crop management had the lowest cost per tons of soybean grain [25].

The lowest cost of grain was provided by the soybean variety Svyatogor under the biological plant protection system (8.99 thousand UAH/t), while the variety Danaya under the chemical one – 9.04 thousand UAH/t. The best energy and economic indicators were also obtained in these variants: conditional net profit, profitability and energy coefficient – 25.86 and 27.39 thousand UAH/ha; 90 and 89%; 1.31 and 1.34, respectively [31].

Energy analysis is the determination of the ratio between the amount of energy accumulated in the crop yield during photosynthesis and the energy used in production. Its purpose is to measure all technological operations in terms of individual energy units. This helps us to take a balanced approach to the selection of varieties, the choice of an optimized crop management system and the use of a range of agronomic practices in the technological process. The scientific substantiation of the technological process of crop cultivation will help to optimize the energy flow through agrotechnical measures for the purpose of targeted formation of highly productive agrocenoses [11, 12, 28].

Conducting an energy assessment of technological measures for growing crops helps to compare their effectiveness and determine the feasibility of using [21]. The relevance of this approach is driven by modern production and the need to save energy per unit of crop production [24].

Determining energy input and output allows quantification of the energy efficiency of crop production [10]. Energy analysis can help to compare different technologies for growing a particular crop. One of the ways to improve the efficiency of energy use in crop production is to optimize technological methods and increase the output per unit area. Energy analysis, which is a concentrated expression of the law of energy conservation and transformation, allows us to compare energy consumption and energy content (supply) in the harvest [4, 5].

The aim was to determine the economic and energy efficiency of herbicides and fungicides in soybean.

MATERIALS AND METHODS

The research was carried out in 2021-2023 at Limited Liability Company «Savarske»Obukhiv district of Kyiv region, which is located in the soil and climatic zone of the Forest-Steppe of Ukraine. Experiment 1 'Efficiency of herbicide application in soybean crops' was conducted according to the following scheme: Factor A. Soybean varieties. 1. Aurelina 2. EC Commander 3. EC Navigator Factor B. Herbicides (active ingredient). 1. Control (water treatment) 2. S-metholachlor and Terbutylazine (4.5 l/ha), before emergence of the crop 3. Dimethanamide-P (1.2 l/ha) + Pendimethalin (5 l/ha), before emergence of the crop 4. Bentazone (3 l/ha) + Fluazifop-P-butyl (1 l/ha) in the phase of 4-5 leaves of the crop 5. Bentazone and Imazamox (2 l/ha) + Chisalofop-P-Ethyl (2 l/ha), in the phase of 2-4 leaves of the crop.In experiment 2 'Efficiency of fungicide protection of soybean crops' the following variants were studied: Factor A. Varieties. 1. Amadea 2. Aurelina. Factor B. Fungicides (active ingredient). 1. Control (water treatment of seeds and plants)2. Thiabendazole, Metalaxyl-M, Fludioxonil (1.25 l/t) (seed treatment before sowing) 3. Fludioxonil, Metalaxyl-M, Sedaxane (1 l/t) (seed treatment before sowing) 4. Fludioxonil, Difenoconazole, Thiamethoxam (1 litre/t) (pre-sowing seed treatment) 5. Fipronil, Thiophanate-methyl, Pyraclostrobin (2 litres/t) (seed treatment before sowing)6. Pyraclostrobin, Epoxiconazole (2 l/ha) (during the growing season) 7. Thiabendazole, Metalaxyl-M, Fludioxonil (1.25 l/t) + Pyraclostrobin, Epoxiconazole (2 l/ha) (during the growing season) 8. Fludioxonil, Metalaxyl-M, Sedaxane (1 l/t) (seed treatment before sowing) + Pyraclostrobin, Epoxiconazole (2 l/ha) (during the growing season) 9. Fludioxonil, Difenoconazole, Thiamethoxam (1 l/t) (seed treatment before sowing) + Pyraclostrobin, Epoxiconazole (2 l/ha) (during the growing season) 10. Fipronil, Thiophanate-methyl, Pyraclostrobin (2 l/t) (seed treatment before sowing) + Pyraclostrobin, Epoxiconazole (2 l/ha) (during the growing season).

Soybean crops were treated before emergence and during the growing season (2-5 leaves) with a working solution of herbicides (250 l/ha) in the experimental plots. Seed treatment with fungicides was carried out before sowing and during the growing season (before emergence) with a working solution (250 l/ha) in the experimental plots. In the control treatments, seed and crop were treated with water at a rate of 250 l/ha.

The area of the sowing plot in both experiments is 144 m^2, the accounting plot is 120 m^2 and there are three replications. The treatments were systematically arranged. The soil of the experimental plots is a typical medium loamy chernozem.

The economic assessment of soybean cultivation technology was carried out at prices as of the end of 2023 according to the following guidelines [20]. The calculation of the energy efficiency of soybean cultivation was carried out according to the method of O. K. Medvedovsky and P. I. Ivanenko [21].

RESULTS AND DISCUSSIONS

Economic indicators of soybean production efficiency include grain yield, cost of production, gross production value, price per ton of grain, notional net profit per hectare sown and profitability [9].

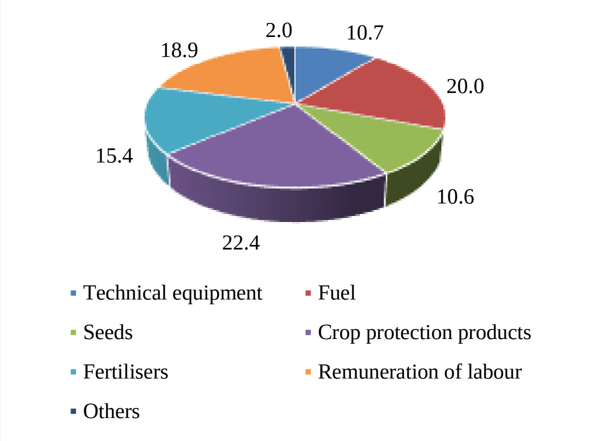

Fig. 1. Structure of economic costs in soybean cultivation
Source: Authors' own results.

In the structure of economic costs of soybean cultivation, the largest share belongs to fuel (20.0%), plant protection products (22.4%), labour (18.9%) and fertilizers (15.4%) (Fig. 1).

The share of technical inputs and seed material is 10.7% and 10.6% respectively.

When using herbicides, a balanced assessment should be made of the economic thresholds for their use, the risk of competition between weeds and crops, and the appropriateness of using protective products.

After all, a small number of weeds and the use of expensive products may not be recouped by the increase in yield [6, 23, 27].

It was found that the cultivation technology costs of the soybean varieties Aurelina, EC Commander and EC Navigator were minimal in the variants without herbicide use – 503.0, 494.8 and 507.7 EUR/ha, while the level of profitability was also the lowest - 4.8, 2.6 and 11.7% (Table 1).

Table 1. Economic efficiency of herbicide application on soybean crops (average for 2021-2023)

Variants of herbicide application	Grain yield, t/ha	Production value, EUR/ha	Costs of growing soybeans, EUR/ha	Production cost, EUR/t	Conditional net income, EUR/ha	Profitability level, %
Aurelina						
1	1.51	527.3	503.0	333.9	24.3	4.8
2	2.69	942.7	583.4	216.6	359.3	61.6
3	2.84	992.8	600.9	211.8	392.0	65.2
4	3.12	1092.0	589.5	188.9	502.5	85.2
5	3.22	1,128.2	603.0	187.1	525.1	87.1
EC Commander						
1	1.45	507.5	494.8	341.3	12.7	2.6
2	2.45	856.3	575.2	235.1	281.1	48.9
3	2.69	941.5	592.7	220.3	348.8	58.9
4	2.86	999.8	581.3	203.5	418.5	72.0
5	2.95	1,032.5	594.9	201.7	437.6	73.6
EC Navigator						
1	1.62	567.0	507.7	313.4	59.3	11.7
2	2.76	967.2	588.1	212.8	379.1	64.5
3	2.93	1,024.3	605.6	206.9	418.8	69.2
4	3.19	1,117.7	594.2	186.1	523.5	88.1
5	3.33	1,166.7	607.8	182.3	558.9	92.0

Source: Authors' own results.

In the second variant of herbicide protection (S-metolachlor and Terbutylazine (4.5 l/ha)) the costs of soybean cultivation technology were 583.4, 575.2 and 588.1 EUR/ha and the level of profitability was 61.6, 48.9 and 64.5%.

In the third variant of herbicide application (Dimethenamide-P (1.2 l/ha) + Pendimethalin (5 l/ha)) production costs increased by 5.6-9.8% compared to the control, but the conditional net profit and profitability of the studied varieties were in the range of 348.8-418.8 EUR/ha; 58.9-69.2%.

The post-emergence application of the fourth variant (Bentazon (3 l/ha) + Fluazifop-P-butyl (1 l/ha)) increased the conditional net profit and profitability to 418.5-523.5 EUR/ha; 72.0-88.1%. In the fifth herbicide application variant (Bentazon and Imazamox (2 l/ha) + Chisalofop-P-Ethyl (2 l/ha)) the highest conditional net profit and profitability indicators were obtained in the investigation – 437.6-558.9 EUR/ha; 73.6-92.0%.

Due to lower grain yields variety EC Commander had the lowest conditional net profit and profitability, ranging from 12.7 to

437.6 EUR/ha and from 2.6 to 73.6%. The highest values for these indicators were recorded for variety EC Navigator – 59.3-558.9 EUR/ha and 11.7-92.0%.

According to Y. R. Kandel et al. [14] and C. A. Bradley [1] fungicides can be used preventively to increase soybean yields, but their use was profitable in about 14% of cases based on the average market price of soybeans in 2008-2014. According to J. M. Orlowski et al. [22] fungicide use is profitable even in the absence of disease.

For the cultivation of the studied soybean varieties on the control without the use of fungicides the cost of production in the variety Amadea was 557.8 EUR/ha and Aurelina – 559.2 euro/ha the cost of one ton of seed was 225.8 and 239.8 EUR/t, respectively (Table 2). The level of profitability was the lowest in the experiment – 55.0 and 45.9%.

It should be noted that even at the lowest level of soybean yield, the control plots in the experiment showed high net income and profitability. This was made possible by the high price of soybeans, which was 350 Euro per tonne at the end of 2023. Due to lower grain yields, the Aurelina variety soybean was inferior to Amadea in terms of economic efficiency.

Table 2. Economic efficiency of fungicide application on soybean crops (average for 2021-2023)

Variants of fungicide application	Grain yield, t/ha	Production value, EUR/ha	Costs of growing soybeans, EUR/ha	Production cost, EUR/t	Conditional net income, EUR/ha	Profitability level, %
Amadea						
1	2.47	864.5	557.8	225.8	306.7	55.0
2	2.90	1,015.0	612.2	211.1	402.8	65.8
3	2.92	1,023.2	609.6	208.5	413.5	67.8
4	3.11	1,087.9	633.1	203.7	454.9	71.9
5	3.17	1,110.1	644.5	203.2	465.6	72.2
6	2.83	990.5	579.7	204.9	410.8	70.9
7	3.07	1,074.5	634.1	206.6	440.4	69.4
8	3.09	1,082.7	631.5	204.2	451.1	71.4
9	3.30	1,154.4	655.0	198.6	499.4	76.3
10	3.36	1,175.4	666.4	198.4	509.0	76.4
Aurelina						
1	2.33	816.1	559.2	239.8	256.9	45.9
2	2.70	945.6	613.6	227.1	332.0	54.1
3	2.73	954.9	611.0	224.0	343.9	56.3
4	2.91	1,018.5	634.5	218.0	384.0	60.5
5	2.94	1,029.0	645.9	219.7	383.1	59.3
6	2.66	929.8	581.1	218.7	348.7	60.0
7	2.88	1,006.3	635.5	221.1	370.7	58.3
8	2.90	1,015.0	633.0	218.3	382.0	60.4
9	3.05	1,065.8	656.4	215.6	409.4	62.4
10	3.11	1,089.1	667.8	214.6	421.3	63.1

Source: Authors' own results.

With fungicide protection, grain yield increased by 0.43-0.89 and 0.37-0.78 t/ha in the varieties Amadea and Aurelina, compared with the control. When fungicides were used both as a pre-sowing treatment of soybean seed and during the growing season there was a change in the direction of growth in the indicators that determine economic efficiency. For example, in the variety Amadea, the conditional net income and profitability increased by 96.1-158.9 EUR/ha and 10.8-17.3% compared to the control in the second to fifth variants of pre-sowing soybean seed treatment with fungicides. For the variety Aurelina this increase was 75.1-126.2 EUR/ha and 8.2-13.4%. The level of profitability of the studied varieties in the seventh to tenth fungicide application variants increased by 12.4-21.4%, compared to the control.

The highest conditional net profit and level of profitability in the second experiment was obtained in soybean varieties Amadea and Aurelina in the variant with pre-sowing seed treatment with fungicides Fipronil, Thiophanate-methyl, Pyraclostrobin (2 l/t) and the use a fungicide with the active ingredient Pyraclostrobin, Epoxiconazole during the growing season – 509.0 and 421.3 EUR/ha; 76.4 and 63.1%, respectively.

An analysis of the energy costs of soybean cultivation shows that the largest share in its structure is accounted for by fuel (30.2%), followed by fertilisers (25.7%) and technical inputs (23.1%) (Fig. 2). Plant protection products accounted for 10.3%, labour for 5.5% and seeds for 3.4%.

On average, in 2021-2023, the lowest total energy yield with harvest was in the control variants (without herbicides) in the variety Aurelina – 15.37 GJ/ha in the ECvariety Commander – 14.79 GJ/ha and in the EC variety Navigator – 16.52 GJ/ha (Table 3).

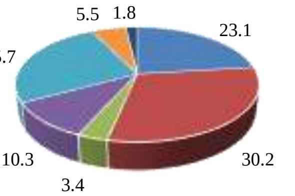

Fig. 2. Structure of energy costs in soybean cultivation
Source: Authors' own results.

Table 3. Energy efficiency of herbicide application on soybean crops (average for 2021-2023)

Variety	Variants of herbicide application	Total energy yield with harvest, GJ/ha	Total energy consumption for soybean cultivation, GJ/ha	Coefficient energy efficiency
Aurelina	1	15.37	17.64	0.87
	2	30.97	19.68	1.57
	3	32.34	19.92	1.62
	4	35.57	20.15	1.77
	5	37.07	20.21	1.83
EC Commander	1	14.79	17.23	0.86
	2	27.89	19.34	1.44
	3	30.67	19.87	1.54
	4	32.57	20.01	1.63
	5	34.22	20.08	1.70
EC Navigator	1	16.52	17.89	0.92
	2	31.78	19.90	1.60
	3	33.95	20.31	1.67
	4	37.04	20.42	1.81
	5	39.00	20.47	1.91

Source: Authors' own results.

At the same time the total energy consumption for soybean cultivation of these varieties ranged from 17.23 to 17.89 GJ/ha and the coefficient energy efficiency had minimum values of 0.87, 0.86 and 0.92, respectively. In the second and third herbicide application variants (S-metolachlor, Terbutylazine (4.5 l/ha) and Dimethanamide-P (1.2 l/ha) + Pendimethalin (5 l/ha)) the total energy yield with harvest increased by 13.10-22.48 GJ/ha, compared to the control. Taking into account the slight increase of 2.01-2.85 GJ/ha in total energy consumption for soybean cultivation compared to the control varieties, the coefficients energy efficiency of Aurelina, EC Commander and EC Navigator increased to 1.57 and 1.62, 1.44 and 1.54 and 1.60 and 1.67, respectively.

When the post-emergence herbicides Bentazon (3 l/ha) + Fluazifop-P-butyl (1 l/ha) were included in the soybean cultivation technology the coefficient energy efficiency increased and amounted to 1.77 GJ/ha for Aurelina, 1.63 GJ/ha for EC Commander and 1.81 GJ/ha for EC Navigator.

The maximum increase in the energy efficiency of soybean varieties cultivation was noted in the variants where post-emergence herbicides Bentazon and Imazamox (2 l/ha) + Chisalofop-P-ethyl (2 l/ha) were used. In the varieties Aurelina, EC Commander and EC Navigator the total energy yield with harvest was 37.07, 34.22 and 39.00 GJ/ha and the coefficient energy efficiency was 1.83, 1.70 and 1.91.

The use of fungicides also affected the energy efficiency of the soybean cultivation technology. The soybean varieties Amadea and Aurelina had the lowest total energy yields with with harvest and coefficient energy efficiency in the control –25.69 and 24.02 GJ/ha; 1.33 and 1.29 (Table 4).

The use of fungicides for pre-sowing seed treatment (third to fifth variants) helped to increase the coefficient energy efficiency to 1.87-2.04 for the variety Amadea and 1.79-

1.98 for the variety Aurelina. The use of a preparation containing the active ingredient Pyraclostrobin, Epoxiconazole (2 l/ha) on vegetative soybean plants ensured that this indicator was 1.79 and 1.73. In the seventh to tenth fungicide application variants the coefficient energy efficiency of the varieties Amadea and Aurelina was in the range of 1.95-2.14 and 1.87-2.02, respectively.

Table 4. Energy efficiency of fungicide application on soybean crops (average for 2021-2023)

Variety	Variants of fungicide application	Total energy yield with harvest, GJ/ha	Total energy consumption for soybean cultivation, GJ/ha	Coefficient energy efficiency
Amadea	1	25.69	19.34	1.33
	2	36.83	19.74	1.87
	3	37.42	19.86	1.88
	4	39.48	19.89	1.98
	5	40.28	19.78	2.04
	6	35.66	19.96	1.79
	7	39.30	20.15	1.95
	8	39.90	20.11	1.98
	9	42.55	20.22	2.10
	10	43.32	20.25	2.14
Aurelina	1	24.02	18.68	1.29
	2	34.04	19.07	1.79
	3	34.92	19.11	1.83
	4	36.96	19.10	1.93
	5	37.93	19.14	1.98
	6	33.47	19.38	1.73
	7	36.51	19.57	1.87
	8	36.83	19.60	1.88
	9	39.28	19.65	2.00
	10	39.83	19.67	2.02

Source: Authors' own results.

The highest values of total energy yield with harvest and energy coefficient efficiency were obtained during pre-sowing seed treatment with fungicides Fludioxonil, Difenoconazole, Thiamethoxam (1 l/t) and during vegetation with Pyraclostrobin, Epoxiconazole (2 l/ha) – 43.32 and 39.83 GJ/ha; 2.14 and 2.02.

CONCLUSIONS

The highest indicators of conditional net profit and profitability for soybean varieties Aurelina, EC Commander and EC Navigator were obtained using post-emergence herbicides with the active ingredients Bentazon and Imazamox (2 l/ha) + Chisalofop-P-ethyl (2 l/ha) – 525.1, 437.6, 558.9 EURs/ha; 87.1, 73.6, 92.0%.

The maximum conditional net profit and profitability were obtained in soybean varieties Amadea and Aurelina in the variant with pre-sowing treatment with the fungicide Fipronil, Thiophanate-methyl, Pyraclostrobin (2 l/t) and the use of the fungicide Pyraclostrobin, Epoxiconazole during the growing season – 509.0 and 421.3 EUR/ha; 76.4 and 63.1%.

Based on the analysis of the energy efficiency of soybean cultivation, it was determined that the most appropriate technology option is the use of post-emergence herbicides Bentazon and Imazamox (2 l/ha) + Chisalofop-P-Ethyl (2 l/ha), which ensures ancoefficient energy efficiency of 1.70-1.91.

The use of fungicides contributes to a better energy use and increases the energy intensity of the crop and the coefficient energy efficiency by 39.3-68.5 and 38.5-58.4%, respectively compared to the controls. The highest values of total energy yield with harvest and coefficient energy efficiency were obtained when the seeds were treated with Fipronil, Thiophanate-methyl, Pyraclostrobin (2 l/t) before sowing and with Pyraclostrobin, Epoxiconazole (2 l/ha) during the growing season – 43.32 and 39.83 GJ/ha; 2.14 and 2.02, respectively.

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WINE TOURISM EXPERIENCES – THE KEY ENABLERS FOR ATTRACTING VISITORS IN RURAL AREAS AS A STRATEGY FOR SUSTAINABLE DEVELOPMENT OF AGRITOURISM IN ROMANIA

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Abstract

The current research sets out to examine what type of experiences are attracting tourists to the wineries. Wine tourism is a part of agritourism and it represents an opportunity to attract tourists in rural regions where the wineries are usually concentrated. In general, tourism experiences that are found at a winery are related to experiencing the wine, expanding wine knowledge, or leisure and entertainment activities. In the last years, the wine makers from Romania, besides grape growing and wine production, they have been involved in expanding their business and investing in tasting rooms, restaurants, accommodation and leisure activities - all these facilities to serve as attraction for the tourists. Firstly, for the wine tourism services to be developed, it should be defined which are tourists' expectations in terms of wine tourism experiences, while secondly the focus should be on the effort needed from the wineries, meaning investment costs, extra staff and trainings, infrastructure, engagement in marketing activities etc. Considering the increasing interest for this type of tourism, the research is based on a self-administrated survey that refers to the motivations of tourists, the key factors that influence the decision to visit a wine region and the main activities and services from the wineries that engage visitors. Based on the received responses, the data will be analyzed using descriptive statistics, correlation and regression in order to show the influence between the wine tourism experiences and tourists' expectations. Wine tourism experiences in the rural areas contribute to the development of agritourism and the economy of the region.

Key words**:** *wine experiences, sustainable agritourism development, winescape, wine tourists, experience tourism*

INTRODUCTION

Experience tourism is the new niche type of tourism that might represent an opportunity for hospitality and tourism companies to expand [3]. When it comes to wine tourism the memories of the experiences lived during the visit at the winery are one of the most important influence factors for tourists. Thus, [19] stated that winery experience is fundamental for engaging tourists and for the development of wine tourism. The synergy between wine and tourism is seen as beneficial for both parties, and in order to achieve strong results behind this, it is needed for a creative environment to develop activities that make people want to travel to the wine regions for such experiences.

On the other side, based on the definition from [8], wine tourism is considered to be a visitation to the vineyards, wineries, wine festivals and wine exhibitions, where wine tasting and experiencing the characteristics of the vine are the main reasons for visit. This definition is reinforcing the importance of experience for wine tourism, where wine tasting represents the starting point of a winery visit.

Wine tourism is considered being part of the rural tourism or agritourism, where the main reason is that geographically wineries are located in agricultural areas. Moreover, the wine tourism experiences combined with the rurality of the landscape is generally recognized by authors [14] as being attractive for visitors.

[23] categorize wine tourism experiences as follows: educational experience in wine tourism, entertainment experience in wine tourism, esthetic experience in wine tourism and escapist experience in wine tourism. Educational and escapist experiences are requiring active participation from tourists' side. The main activities for an educational

experience are wine tasting and seminars for wine knowledge expansion, as well as various type of classes where wine is associated with gastronomy or art. At the same time, escapist experiences are referring to non-usual type of activities at the winery such as vineyard tour by horse, vineyard hiking and cycling, grape harvesting or hot air ballooning over vineyards.

The passive participation is characteristic for entertainment and esthetic experiences where main activities consist of wine museums, wine blending demonstration, enjoying the ''winescape'', visits to typical restaurants, bars and cafes, or other type of events with wine theme [23].

Other researchers identified the main wine tourism experiences that visitors can get during their winery visit. Thus, [24] sustain that interaction with wine cellar staff, entertainment activities, wine educational exposure are part of the experiences related to wine. Furthermore, wine routes represent another key factor for wine tourism, that encourage business growing of wine producers and contributes to the recognition among tourist of wine region where it comes from. Hence, agritourism includes, as well, wine related experiences as cultural and nature-based activities converging in an authentic rural wine tourism participation of visitors [24].

In the perspective of consumer behaviour, the experience generated by a travel activity determines tourists to be more engaged to a specific type of tourism, and to also recommend it further to their acquaintances; this engenders word of mouth marketing. The experience of visitors needs to generate value for them [7], so that they remain with a positive memory that can influence future decisions when making travel plans related to wine tourism, mainly because tourism experience is highly subjective [24] [18]. Moreover, [25] affirms that wine tourism experience consists in more than wine tasting and visit of the wine cellar or the territory where the wine is produced. Thus, wine tourism and diversity of wine experiences requires more involvement of the wine producers in order to expand their services at the cellar, that includes and links economic, cultural or social dimensions.

Motivations and behavioural intentions of wine tourists are important to be outlined, for wine producers to understand which are visitors' expectations when it comes to the services and activities at the winery. Additionally, in order to create a competitive advantage for their wine cellar and to attract tourists, wine makers have to engender unique experiences that determine people to choose their venue against other places from the same wine region [5].

On the other hand, for the supply side of the wine tourism, that consists of wineries and wine producers, to reach customer satisfaction and engagement, they recognize the need of having a general picture of the wine tourist [17]. Customer engagement has shown grater financial performance [5], consequently the interest for designing innovative experiences represents a focal point for wine makers, as well as to understand customers perspective when it comes to wine tourism. In relation with the supply side of wine tourism, it is not generally available that all wineries to be interested in practicing wine tourism, and to benefit from the advantages that were showed to the wine industry over time [12].

[6] examine the reasons why wine producers are reluctant to wine tourism, where some of the motivations are lack of experience in tourism activities and trained employees, as well as increased costs for this type of activities. The main interest for wine producers is grape growing and wine making, while wine tourism would require additional efforts from their side and to be involved in development of touristic services. Wine tourism will serve as an extension of their primary business, even though the advantages are generally accepted such as direct selling, workplaces creation, promotion of the region [21] or gaining consumers loyalty [5].

Wine related attractions that can be performed during a winery visit include various experiences [14], that will further influence tourists' perception of wine tourism.

Thus, the current study stands to examine the types of wine tourism experiences that might influence tourists' decision to visit a wine region, what they are looking for when practicing wine tourism in Romania and their engagement in this type of tourism.

MATERIALS AND METHODS

This paper sample consists of 112 people who identified as wine tourists. The questionnaire was filled online at the respondent's convenience, where it was distributed on social media platforms (Instagram and Facebook) in targeted groups identified with wine consumers, wine professionals or travellers that enable to target people with interest in wine tourism. This method was chosen due to ease of access to the sample and low cost.

Previously, before sharing the questionnaire online, a pilot study was conducted (N=8) in order to establish the logic and clarity of the questions. The questionnaire consists of four sections, firstly the respondents were asked for consent to participate to the study, while the rest of the sections include interest in wine tourism, types of wine tourism experiences and socio-demographic characteristics. The time period for collecting the data was between February – March 2024.

In this study, the quantitative methodology was mainly used based on the survey responses received, while a short qualitative analysis of the wine producer's perspective of wine tourism is included at the end of the research.

The collected data was analysed using Descriptive Statistics from Microsoft Office package and frequency tests, correlation and regression from SPSS statistical package.

RESULTS AND DISCUSSIONS

Wine tourism in Romania has started to develop in the last couple of years. In regard to the offer side, Romania has a significant number of wine makers and wineries that are spread in seven wine regions classified as DOC (Designation of Origin) and IG (regions with geographical indication) areas by [16]. as shown in Table 1.

Romanian wine production ranks as 12th worldwide as per [13], while in terms of vineyards surface it is placed as 11th[13] from total reported countries.

Table 1. Romania's wine regions

Romania's wine regions
Wine region of Banat Hills
Wine region of Crişanei and Maramureş Hills
Wine region of Moldavian Hills
Wine region of Muntenia and Oltenia Hills
Wine region of Transylvania Highlands
Wine region of Dobrogea Hills
Wine region of Danube Terraces and other lands

Source: [16].

The current stage of development of wine tourism in Romania shows that most of the wineries have a tasting room where they can receive tourists, and that they practice wine cellar and vineyards tours [26]. Moreover, there are wineries that besides the basic services, they have a restaurant on the property, accommodation and spa facilities [15], or they are able to provide other leisure activities for their visitors, such as sports (fishing, tennis, hiking, off road etc.), vineyards walks and picnics or visits to thematic museums in the wine region etc. [22].

In the first stage of analysis all respondents (N=112) have consented to participate to the research, and the tiebreaker question was if they usually consume wine, while only 3 people have responded negatively. However, they were not excluded from the research as [10] identifies the types of wine tourists (wine lovers, wine interested and the curious tourist), where the author describes the curious tourist as a person that is not wine oriented, but they are visiting wine regions to find out what wine tourism means. Furthermore, [4] in their wine tourist types classification identify visitors as wine lovers, wine connoisseurs, wine interested, wine novices and the hanger-on, where the last typology is a segment of people that are visiting a wine region as part of a group, and at the moment of visit they are not interested in wine.

In addition, the research considers both categories of people, the ones that already visited wine regions (83%) and the ones who did not (17%) for an overall perspective of understanding which are the experiences that would influence travellers to decide to try wine tourism.

Romania has several vineyards that are split across the country, therefore in general it is easy to reach a wine region.

In regard to the frequency of visits to wine regions and wineries, most of the respondents said that they are vising once a year (32.1%) or once every few years (31.3%) (Figure 1).

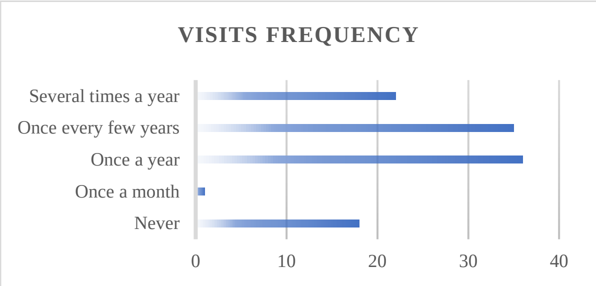

Fig. 1. Frequency of visits to wine regions
Source: Result of survey, 2024.

The category of people that visit wine regions and wine cellars more often are usually wine professionals that are working in the industry - several times a year – 19.6% and once a month - 0.9%, while 16.1% have never visited a wine region until now.

Resulting from the research, the most visited wine region is Muntenia and Oltenia Hills with a majority of 56.3% from the total, while the second visited wine region is Moldova Hills – 36.6%.

Muntenia and Oltenia Hills are located in the south of Romania, and the location is close to the capital of Romania, Bucharest, this could be considered as a strength of the location because the areas are easy to be reached.

On the other side, Moldova Hills is the region with the most wineries with a vast history in wine making, thus it is considered a region with high potential for visits.

Dobrogea Hills (26.8%) and Danube Terraces (13.4%) are also located as well in a strategic area of Romania, being easy to reach when people are transiting the area mostly in the summer in their way to the Black Sea.

The central and west located wine regions sums up less visits compared with the other wine regions, where Banat Hills has the lowest rate, 8.9% in this current study (Fig. 2).

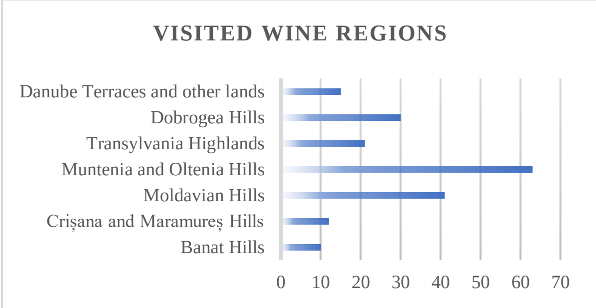

Fig. 2. Visited wine regions from Romania
Source: Result of survey, 2024.

Provided that the respondents were asked about which are the main resources used for planning a wine tourism trip, a frequency test was performed.

Frequency test was used to provide an overview of the distribution of values within a variable, and to understand the tendency of the received responses.

However, social media platforms such as Instagram or Facebook are generally used to find out information about wine tourism. In total 85 respondents choose social media as primary resource, where 25.9% are using only social media, while 14.3% also check out reservation platforms or wineries official websites.

The people who look for information from multiple sources are 12.5% or less as it can be noticed in the below Table 2, alternatively only 1.8% are planning their trip to wine region based on recommendations, and 0.9% are using other sources.

It is generally available that nowadays, the majority of people are looking for information about everything on internet, thus considering that wine tourism is relatively a new product for the Romanian market the details advertised on various websites should be enough for people in order to be able to plan a trip to wine regions.

Moreover, the main channel for advertising is social media, because it is the easiest way to reach the consumers, where this type of marketing is also preferred by wine and tourism industries.

The main reasons for visiting a wine region and the wine cellars are mainly to taste wine 74.1%, mentioned by 83 people, as well as to enjoy the vineyards landscapes (67% of the respondents), to learn about wine (52.7% of the respondents) or to buy wine (43.8% of the respondents), these results are similar with the studies of [20] or [2].

Table 2. Frequency test – Resources used for planning a wine tourism trip

Resources for planning a wine tourism trip		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Other	1	.9	.9	.9
	Recommendations	2	1.8	1.8	2.7
	Reservation platforms (Booking, Airbnb etc.)	9	8.0	8.0	10.7
	Reservation platforms (Booking, Airbnb etc.); Travel agencies	1	.9	.9	11.6
	Reservation platforms (Booking, Airbnb etc.); Wine related websites (winetourism.com, winetoursromania.com, viator.com etc.)	1	.9	.9	12.5
	Reservation platforms (Booking, Airbnb etc.); Winery website	3	2.7	2.7	15.2
	Reservation platforms (Booking, Airbnb etc.); Winery website; Wine related websites (winetourism.com, winetoursromania.com, viator.com etc.)	1	.9	.9	16.1
	Social media (Instagram, Facebook, TikTok etc.)	29	25.9	25.9	42.0
	Social media (Instagram, Facebook, TikTok etc.); Reservation platforms (Booking, Airbnb etc.)	7	6.3	6.3	48.2
	Social media (Instagram, Facebook, TikTok etc.); Reservation platforms (Booking, Airbnb etc.); Wine related websites (winetourism.com, winetoursromania.com, viator.com etc.)	3	2.7	2.7	50.9
	Social media (Instagram, Facebook, TikTok etc.); Reservation platforms (Booking, Airbnb etc.); Winery website	16	14.3	14.3	65.2
	Social media (Instagram, Facebook, TikTok etc.); Reservation platforms (Booking, Airbnb etc.); Winery website;Travel agencies	1	.9	.9	66.1
	Social media (Instagram, Facebook, TikTok etc.); Reservation platforms (Booking, Airbnb etc.); Winery website;Wine related websites (winetourism.com, winetoursromania.com, viator.com etc.)	14	12.5	12.5	78.6
	Social media (Instagram, Facebook, TikTok etc.); Reservation platforms (Booking, Airbnb etc.); Winery website;Wine related websites (winetourism.com, winetoursromania.com, viator.com etc.);Travel agencies	3	2.7	2.7	81.3
	Social media (Instagram, Facebook, TikTok etc.); Travel agencies	1	.9	.9	82.1
	Social media (Instagram, Facebook, TikTok etc.); Winery website	9	8.0	8.0	90.2
	Social media (Instagram, Facebook, TikTok etc.); Winery website; Wine related websites (winetourism.com, winetoursromania.com, viator.com etc.)	2	1.8	1.8	92.0
	Wine related websites (winetourism.com, winetoursromania.com, viator.com etc.)	2	1.8	1.8	93.8
	Winery website	7	6.3	6.3	100.0
	Total	112	100.0	100.0	

Source: Result of survey, 2024.

The question regarding the reasons for visiting, the respondents had the option to choose multiple answers, therefore they mentioned that they wanted to see where the wine is produced and to understand the wine making process (34.8%), while 37 respondents stated that they wanted to try a new type of tourism for them - wine tourism mainly chosen by the people who have not visited yet a wine region. In regard to what, [4] mentioned in their wine tourism classification, 29.5% might be considered hanger-on because they are visiting wineries as part of a group. However, the lowest statements were for answers like to meet the wine producers (16.1% of the respondents) or out of curiosity (based on recommendations) for 9.8% from the total answers.

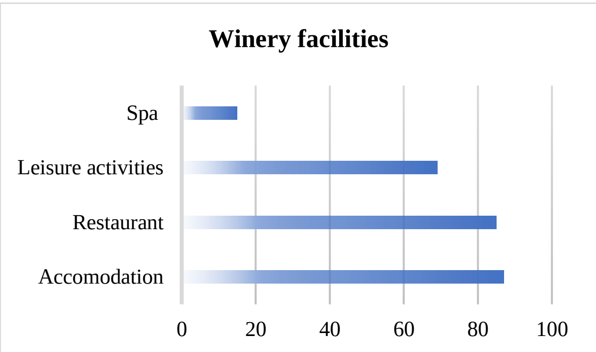

Fig. 3. Winery facilities
Source: Result of survey, 2024.

In the above Figure 3, it can be seen which are the facilities that respondents are looking for when travelling to a wine region. Soare et. al. (2010) points out in their study that wineries started to invest in tasting rooms, but even more in accommodation facilities or restaurants [22]. Consequently, nowadays there are many wineries that offer various services at their property and are very well developed. Hence, tourists' preferences showed that most of them want to have accommodation (77.7%) and restaurant (75.9%), as well as other leisure activities (61.6%), if we consider all these facilities, it can be said that the winery offer meets all the needs of visitors, and that tourists can have a full experience at the winery.

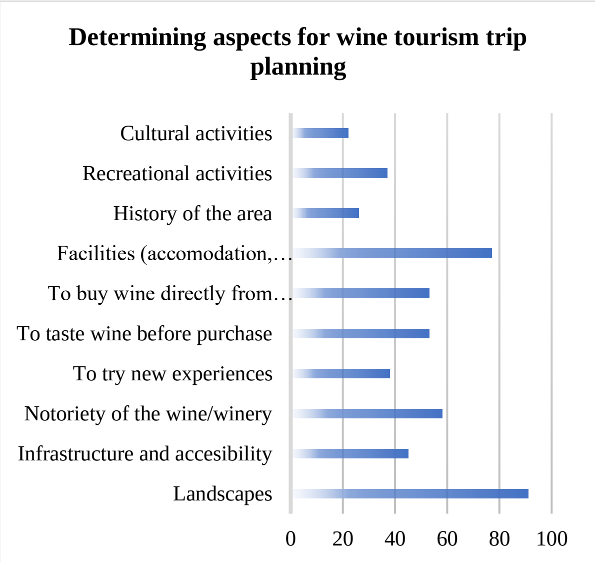

Fig. 4 Determining aspects for wine tourism trip planning
Source: Result of survey, 2024.

In the following section, the study was focused on determining which are the main aspects that travellers are taking into consideration for a wine tourism trip planning, which are the type of experiences that attract them in a wine region and which are the activities that they really intent to do during their visit. Thus, Fig. 4 shows that most of the respondents are considering the rural landscapes (81.3% - 91 people) of vineyards and the facilities from the area (68.8% - 77 people), the results reinforcing the idea that people are looking for full experiences when travelling to a wine region. The rest of the aspects mentioned are related to subjective motivations depending on each person preferences, ensuing notoriety of the winery or infrastructure and accessibility, considering that in general wineries are located in rural areas where the roads are not in a very good condition; these aspects are found in other scholar's research regarding tourist motivations [2]. In regard to the activities that tourists prefer, the respondents mentioned mostly to taste wine (47.3%), recreational activities (33%) and cultural activities (19.6%) that are specific to the area, these being identified as pull motives by [5]. On the other side, only 33.9% from the respondents will plan such a trip as part of the new experience that they want to try.

The experiences that attract tourists can be seen in Fig. 5, in the questionnaire respondents had to choose from an open list with wine tourism experiences that are usually available for this type of activity. In general, even small wineries have the proper facilities to organise wine tastings or winery tours, these being the most representative activities for wine tourism [10].

In this research 90 people mention that they want to do a wine tasting during their visit together with other activities, out of which 7 people are only going for wine tasting.

82 respondents said that they wanted to do a winery visit, while vineyard walks were mentioned by 58 people.

For the not usual activities that can be done at the winery identified as escapist experiences by [23], 37.5% are attracted to come for biking through vineyards or horseback riding through the vineyard – 33.9%, while 25% from the respondents would try the experience of hot air balloon rides over the vineyards. The experiences that involve food are vineyard picnics and wine pairing, that were chosen by 51 people meaning 45.5% out of total responses received.

Furthermore, experiences that engage with learning about wine were wine blending demonstrations, wine making demonstrations and museums visits were summaries less than 24% for each activity.

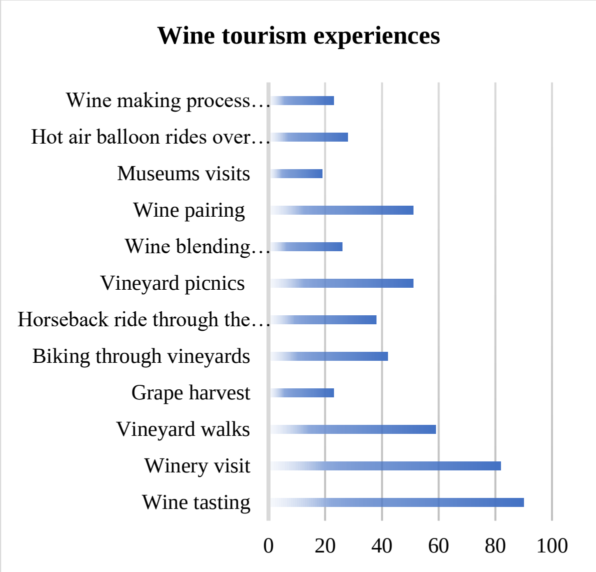

Fig. 5. Wine tourism experiences that attract visitors
Source: Result of survey, 2024.

Additionally, to better understand tourist preferences regarding wine tourism experiences, the respondents were asked which are the activities that they really intend to do during their visits in a wine region. Therefore, a frequency test was performed for the purpose of data exploration based on the received responses. In the below table 3, data distribution shows that 14 people (12.5%) are aiming for a more complex experience combining many activities such as representative activities (wine tasting, winery visit, vineyard walks), together with leisure activities and activities where wine and gastronomy are combined (wine pairing). Few of the respondents stick with the main wine tourism activities, only one or more (e.g. wine tasting, winery visit and vineyard walks), identified also by other authors like [1].

Entertainment experiences are distributed across the received answers, where we include mainly leisure activities (fishing, biking, hiking etc.) mentioned by 51 people and cultural activities as per 35 people. On the other side, the activities classified as educational experiences by [23] had an extensive distribution in the frequency test as this activity has been mentioned by 71 people from the total respondents.

In addition, the participants of the study were asked to choose one of the wine tourism experiences identified by [23], in order to understand what travellers' direction are in regard to this. Entertainment experience was chosen by 51.8% from total respondents, showing that vineyards walks, biking through vineyards or participation to wine blending demonstration are attractive to them. Escapist experiences have been chosen by 21.4% of the participants displaying the intentions for not usual activities, like hot air balloon ride over the vineyard or horseback riding through vineyards. Educational experience sums 15.2% from the responses, while esthetic experiences only 11.6%.

In order to deepen the understanding of the wine tourism experiences that attract visitors in rural areas, linear scale questions were asked so that the respondents note from 1(Totally disagree) to 5 (Totally agree) some statements related to wine tourism development and agritourism.

For this analysis were used regression and correlation tools, in order to identify the relationship between the variables and the strength between them.

Firstly, a correlation test has been performed in order to determine the relationship between wine tourism offer perspectives and the available activities at the winery. As Table 4 shows the mean is around 3 meaning that the respondents are not really aware of how varied the wine tourism offer is in Romania, but they tend to know more which are the available activities that they can do at the winery.

Standard deviation below 1 shows that indeed, the general opinion of the respondents is mostly neutral.

Table 3. Frequency test – Planned activities for a wine tourism trip

Planned activities						
		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Events (festivals, workshops etc.)	1	.9	.9	.9
	Vineyard walks	2	1.8	1.8	2.7

	Vineyard walks;Leisure activities (e.g. biking, fishing, hiking etc.)	4	3.6	3.6	6.3
	Vineyard walks;Wine pairing activities	1	.9	.9	7.1
	Vineyard walks;Wine pairing activities;Leisure activities (e.g. biking, fishing, hiking etc.)	1	.9	.9	8.0
	Wine pairing activities	2	1.8	1.8	9.8
	Wine tasting	3	2.7	2.7	12.5
	Wine tasting;Events (festivals, workshops etc.)	2	1.8	1.8	14.3
	Wine tasting;Leisure activities (e.g. biking, fishing, hiking etc.)	1	.9	.9	15.2
	Wine tasting;Vineyard walks	2	1.8	1.8	17.0
	Wine tasting;Vineyard walks;Cultural activities;Wine pairing activities;Leisure activities (e.g. biking, fishing, hiking etc.);Events (festivals, workshops etc.)	1	.9	.9	17.9
	Wine tasting;Vineyard walks;Leisure activities (e.g. biking, fishing, hiking etc.)	1	.9	.9	18.8
	Wine tasting;Vineyard walks;Wine pairing activities	5	4.5	4.5	23.2
	Wine tasting;Vineyard walks;Wine pairing activities;Leisure activities (e.g. biking, fishing, hiking etc.);Events (festivals, workshops etc.)	1	.9	.9	24.1
	Wine tasting;Wine pairing activities;Leisure activities (e.g. biking, fishing, hiking etc.)	1	.9	.9	25.0
	Wine tasting;Winery visit	4	3.6	3.6	28.6
	Wine tasting;Winery visit;Cultural activities;Wine pairing activities	2	1.8	1.8	30.4
	Wine tasting;Winery visit;Cultural activities;Wine pairing activities;Events (festivals, workshops etc.)	1	.9	.9	31.3
	Wine tasting;Winery visit;Leisure activities (e.g. biking, fishing, hiking etc.);Events (festivals, workshops etc.)	1	.9	.9	32.1
	Wine tasting;Winery visit;Vineyard walks	9	8.0	8.0	40.2
	Wine tasting;Winery visit;Vineyard walks;Cultural activities	1	.9	.9	41.1
	Wine tasting;Winery visit;Vineyard walks;Cultural activities;Wine pairing activities	5	4.5	4.5	45.5
	Wine tasting;Winery visit;Vineyard walks;Cultural activities;Wine pairing activities;Events (festivals, workshops etc.)	1	.9	.9	46.4
	Wine tasting;Winery visit;Vineyard walks;Cultural activities;Wine pairing activities;Leisure activities (e.g. biking, fishing, hiking etc.)	6	5.4	5.4	51.8
	Wine tasting;Winery visit;Vineyard walks;Cultural activities;Wine pairing activities;Leisure activities (e.g. biking, fishing, hiking etc.);Events (festivals, workshops etc.)	14	12.5	12.5	64.3
	Wine tasting;Winery visit;Vineyard walks;Events (festivals, workshops etc.)	1	.9	.9	65.2
	Wine tasting;Winery visit;Vineyard walks;Leisure activities (e.g. biking, fishing, hiking etc.)	2	1.8	1.8	67.0
	Wine tasting;Winery visit;Vineyard walks;Leisure activities (e.g. biking, fishing, hiking etc.);Events (festivals, workshops etc.)	1	.9	.9	67.9
	Wine tasting;Winery visit;Vineyard walks;Wine pairing activities	9	8.0	8.0	75.9
	Wine tasting;Winery visit;Vineyard walks;Wine pairing activities;Events (festivals, workshops etc.)	1	.9	.9	76.8
	Wine tasting;Winery visit;Vineyard walks;Wine pairing activities;Leisure activities (e.g. biking, fishing, hiking etc.)	3	2.7	2.7	79.5
	Wine tasting;Winery visit;Vineyard walks;Wine pairing activities;Leisure activities (e.g. biking, fishing, hiking etc.);Events (festivals, workshops etc.)	5	4.5	4.5	83.9
	Wine tasting;Winery visit;Wine pairing activities	6	5.4	5.4	89.3
	Wine tasting;Winery visit;Wine pairing activities;Events (festivals, workshops etc.)	1	.9	.9	90.2
	Wine tasting;Winery visit;Wine pairing activities;Leisure activities (e.g. biking, fishing, hiking etc.)	2	1.8	1.8	92.0
	Winery visit;Cultural activities;Leisure activities (e.g. biking, fishing, hiking etc.)	2	1.8	1.8	93.8
	Winery visit;Cultural activities;Leisure activities (e.g. biking, fishing, hiking etc.);Events (festivals, workshops etc.)	1	.9	.9	94.6
	Winery visit;Vineyard walks;Cultural activities	1	.9	.9	95.5
	Winery visit;Vineyard walks;Leisure activities (e.g. biking, fishing, hiking etc.)	1	.9	.9	96.4
	Winery visit;Vineyard walks;Leisure activities (e.g. biking, fishing, hiking etc.);Events (festivals, workshops etc.)	1	.9	.9	97.3
	Winery visit;Vineyard walks;Wine pairing activities;Leisure activities (e.g. biking, fishing, hiking etc.)	2	1.8	1.8	99.1
	Winery visit;Wine pairing activities	1	.9	.9	100.0
	Total	112	100.0	100.0	

Source: Result of survey, 2024.

Table 4. Descriptive statistics for wineries offer and available activities

Descriptive Statistics			
	Mean	Std. Dev.	N
Romanian wineries have a varied offer for wine tourism	3.02	.949	112
When I plan a wine tourism trip, I know what activities are available	3.27	.995	112

Source: Result of survey, 2024.

The results displayed for the correlation of wine tourism offer and available activities show a moderate to high relationship between the variables, meaning that the visitors have an idea of which are the available activities at the winery, however they are not confident to consider that the offer for wine tourism services is varied enough.

Table 5. Correlation between wineries offer and available activities

Correlations			
		Romanian wineries have a varied offer for wine tourism	When I plan a wine tourism trip, I know what activities are available
Romanian wineries have a varied offer for wine tourism	Pearson Correlation	1	.729
	Sig. (2-tailed)		.000
	N	112	112
When I plan a wine tourism trip, I know what activities are available	Pearson Correlation	.729	1
	Sig. (2-tailed)	.000	
	N	112	112

Correlation is significant at the 0.01 level (2-tailed)
Source: Result of survey, 2024.

For a better understanding of the relationship of wineries offer and available activities, the linear regression test was performed where "available activities" was considered the independent variable as this is general information that tourists can find without visiting a winery, while "wineries offer" was considered dependent variable as this is subjective based on visitor's perception, and the opinion can be formed only after the visitation of the winery. Hence, the value of Adjusted R Square = 0.528 shows that available activities are determined in about 52.8% cases by the variety of wineries offer, concluding that the influence between the variables is moderate to strong.

Table 6. Regression between wineries offer and available activities

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.729	.532	.528	.652

Source: Result of survey, 2024.

Additionally, in order to see the relationship between wineries infrastructure and wine tourism impact for agritourism and if this is a good practice to attract people in rural areas by different means, a correlation test was performed. Thus, considering that means for ''Wine tourism has a positive impact for agritourism'' and ''Wine tourism is a good practice to attract people in rural areas'' are close to 4 (Agree), this result that people consider wine tourism as being favourable for agritourism development, and that wine tourism is indeed a good opportunity to bring visitors to rural areas where wineries are located.

Table 7. Descriptive statistics of wineries infrastructure and wine tourism impact for agritourism

Descriptive Statistics			
	Mean	Std. Deviation	N
Romanian wineries have proper infrastructure for wine tourism activities	3.14	.919	112
Wine tourism has a positive impact for agritourism	3.96	.914	112
Wine tourism is a good practice to attract people in rural areas	3.93	.956	112

Source: Result of survey, 2024.

Evidence from above Table 7 illustrates that there is a positive relationship between all the variables, overall, the correlation shows a moderate (0.522) to high (0.666) relation. To summarize if wineries infrastructure would be more developed in the future, the impact of wine tourism for agritourism will increase and will result in more people visiting rural areas.

Table 8. Correlation between wineries infrastructure and wine tourism impact for agritourism

Correlations				
		Romanian wineries have proper infrastructure for wine tourism activities	Wine tourism has a positive impact for agritourism	Wine tourism is a good practice to attract people in rural areas
Romanian wineries have proper infrastructure for wine tourism activities	Pearson Correlation	1	.522	.391
	Sig. (2-tailed)		.000	.000
	N	112	112	112
Wine tourism has a positive impact for agritourism	Pearson Correlation	.522	1	.666
	Sig. (2-tailed)	.000		.000
	N	112	112	112
Wine tourism is a good practice to attract people in rural areas	Pearson Correlation	.391	.666	1
	Sig. (2-tailed)	.000	.000	
	N	112	112	112

Correlation is significant at the 0.01 level (2-tailed)
Source: Result of survey, 2024.

In the last phase of the survey, the demographic profile of the respondents was designed, where the profile is similar to participants of other studies related to wine tourism experiences such [2] or [18] in regard to age, gender, residence, education and occupation, while monthly income is adapted to each country economic specific.

However, in reference to the supply side of wine tourism the study conducted by Gurgu and Fîntîneru (2023 and 2024) [8, 9] was used, where wine producers were interviewed to explore their perspectives on the advantages and disadvantages of wine tourism activities for their businesses. The sample consisted of only 19 Romanian wineries from total of 63 wineries that were invited to participate. Firstly, the wine producers stated that wine tourism contributes to their brand image and it is favourable for advertising, it helps to increase wine sales and that engage customers loyalty for their wines. Secondly, another benefit would be that during their visit to wineries, the consumers have the chance to learn about wine and to expand their knowledge.

Table 9. Demographic profile of respondents

	% tourists
Age	
18 - 25 years old	17.00%
26 - 35 years old	34.80%
36 - 50 years old	33.00%
51 - 65 years old	13.40%
above 65 years old	1.80%
Gender	
Female	67.90%
Male	32.10%
Residence	
Urban	83.00%
Rural	17.00%
Education	
Middle school	1.80%
High school	15.20%
University degree	83.00%
Occupation	
Employed	67%
Freelance	2.70%
Unemployed	0%
Student	15.20%
Retired	1.80%
Monthly income	
<1,900 lei	9.80%
1,901 - 2,500 lei	3.60%
2,501 - 5,000 lei	25.90%
5,001 -7,500 lei	18.70%
7,501 - 10,000 lei	24.10%
>10,000 lei	17.90%

Source: Result of survey, 2024.

On the other side, wine makers point out the main challenges that they have when practicing wine tourism, for instance that wine tourism requires high investments and increases the cost of winery maintenance, and that they do not have proper governmental support in order to expand their business to such type of activity. Moreover, wine industry declares that there is not enough trained labour for wine tourism, and that currently the demand is quite low. Therefore, it can be concluded that wineries are still looking for the value that wine tourism could bring for their wine business.

CONCLUSIONS

The current research highlights wine tourism experiences, showing the current stage of wine tourist preferences and which are the main experiences that engage travellers to visit a wine region.

Wine tourism experiences are happening in rural areas due to the location of the wineries, thus agritourism embraces wine tourism as being a significative part of it. As illustrated in the study there is a positive relationship between wineries infrastructure for wine tourism and agritourism development; if wineries expand more their business to wine tourism, rural tourism will benefit from it as more people will come to visit the areas. Hence, the economy of the region will also increase based on the new created working places, opportunity for expansion of the other touristic attractions from the area etc.

The study showed which are the main experiences that might be considered as motivation drivers when tourists plan their wine tourism trip. As classified by [23] there are four types of wine tourism experiences: educational, entertainment, esthetic and escapist. Based on the received responses, overall, the travellers tend for an entertainment experience grounded on complex leisure activities such as wine tastings, vineyard walks and picnics, biking through vineyards, wineries tours etc. From this, it can be concluded that wine producers should focus on expanding and on adding more activities that can be done at the winery with the purpose of attracting visitors.

In the same way, other determining factors for tourists are winery facilities or proper infrastructure of the wine region. On this has been established that visitors are looking for accommodation, restaurants and a strong offer of leisure activities that they can do during their visits. Moreover, other services like spas would be considered as an asset for the property.

Furthermore, the sources used when planning a wine tourism trip highlight the power of social media nowadays, as 75.9% from total respondents are looking for information there. Even more, social media can really influence the decisions for visiting a location instead of another place, as people are reviewing their experiences on the internet more and more. The presence of the accommodation facility of the winery on booking platforms such as Booking.com or Airbnb brings confidence to the tourists when choosing to come to visit, while it is equally important that the official website to provide clear and concise information about everything that a prospect visitor might want to know previous to the trip, for instance property facilities, available activities and services, how they can make a reservation, costs etc.

Following this research, it can be concluded that between wine tourism and agritourism exists a strong relationship. Considering the interdependence between the two, the development of both types of tourism can happen at the same time, while wine tourism experiences might be the driver that bring people to visit the rural areas, agritourism might use this as a strategy to engage the visitors and to sustain the expansion of the overall tourism of the area.

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TREND ANALYSIS AND FORECASTING OF COWPEA (*Vigna unguiculata* L) PRICES IN YOBE STATE, NIGERIA

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Abstract

In order to aid players in the cowpea industry in making timely decisions in the face of unclear future prices of cowpea, this study's primary goal was to determine the trend and predict future cowpea prices in Nigeria's Yobe State. The National Bureau of Statistics (NBS) database provided secondary data on the monthly price of cowpea in the study area between January 2016 and May 2023. The analysis was conducted using the Box-Jenkins methodology's ARIMA model and descriptive statistics. The outcome showed that cowpea price trend in January 2016 was at ₦229.05/kg and fluctuated upwards and downwards until December 2020. However, the trend continue rising in January 2021 at ₦243.01/kg and continuously increasing without typically declining up to May 2023. And with respect to the Forecasting, the data' stationarity was tested using graphical and formal tests, and found out that the data was not stationary at level but series remained stationary after applying first order difference. Model selection criteria proved that ARIMA (1.1.0) was the best model for the process. Diagnostic test confirm ARIMA (1.1.0)'s suitability for the forecasting. Seven months projected cowpea market prices were done. The trend and projected cowpea price were in continues increase. In view of these government should implement appropriate measures such as restricting cowpea export and eliminating import taxes of cowpea product in order to stabiles the price.

Key words: *cowpea, forecasting, trend, price, Yobe State, Nigeria*

INTRODUCTION

Most of cowpea production occurred in Africa especially in Niger, Nigeria, Burkina Faso, Mali, and Senegal [16]. [24] asserted that cowpeas are produced in all nations in sub-Saharan Africa, Asia, South America, Central America, the United States, and the region surrounding the Mediterranean Sea in tropical and subtropical zones. However, marketing is a process of satisfying human needs by bringing products to people in the proper form and at a proper time and place [3]. They added that marketing has economic value because it gives form, time, place, utility to products and services. [1] affirmed that cowpea storage methods are very important on the product chain in Nigeria. [20] evaluated the cowpea productivity when tillage practices are implemented aiming to assure soil conservation and increase product quality.

[26] pointed out that understanding agricultural commodity price trends is essential for producers, marketers, consumers, and policymakers to prevent inefficiency in agricultural markets due to poor market knowledge and structural imperfections [17], [9]. [8] stated that farmers' 40% share in food crop retail pricing is low, with price swings due to harvest gluts and offseason shortages. Moreover, production of agricultural goods is largely influenced by price changes and directly depends on natural environment, therefore market conditions must be continuously analysed always to be ready, and future situation evaluations must be done in order for producers and marketers to survive and adapt to the price changing conditions for

their respective decision marking [7]. However, farmers face a significant difficulty in developing effective production and marketing strategies to reduce risks due to the price instability and uncertainty. [10] mentioned that price forecasting is essential for facilitating effective decisions and will be crucial in coordinating the supply and demand of agricultural products. Therefore, anticipating agricultural prices will be helpful to producers, consumers, processors, planners for rural development, and other market participants. [7] highlighted that Producers and marketers rely on historical market pricing for their respective choice. Nonetheless, time series analysis is a stochastic modelling technique that aids in forecasting future occurrences by utilizing data from past periods. It finds application in a number of domains, including geophysics, meteorology, finance, business, statistics, and agriculture [4]. Time series analysis, according to [12], is widely utilized by marketers to look at the long-term trends in their entire sales.

[6] sustains that one of the most effective methods for forecasting is ARIMA, which is typically used in financial time series. The ARIMA model just requires historical time series data for the variables which are forecasted [22].

In Turkey, [18] has successfully used ARIMA methods for predicting sugar price.

Sales analysis is important for businesses to predict sales trends, forecast personnel and goods needs, and predict seasonal and annual sales [12]. Hence understanding cowpea price trend and forecasting will help consumers, government organizations, producers, marketers, and non-governmental organizations make well-informed decisions about cowpea prices in the study area. Therefore, the main objectives of this study were to ascertain the cowpea price trend and forecast future prices in the study area.

MATERIALS AND METHODS

The Study Area

Yobe State was carved out of Borno State on 27 August 1991. It borders Bauchi, Borno, Gombe, and Jigawa, while to the north it borders the Republic of Niger. The state is primarily a rural state, majority of the population lives in rural settlements, and its economy is agricultural-based, comprised mostly of livestock, crops, horticultural production and fisheries, gum arabic and palm trees [25]. The state is located in the North-eastern geopolitical zone of Nigeria between latitudes 10º and 14º North and longitude 11º 30´ to 14°45´East [23]. The state experiences hot, dry weather for the majority of the year, with temperatures between 300 and 420 degrees Celsius. The north typically receives more rainfall than the south, with 400 to 500 millimetres falling in the north and 600 to 1,000 millimetres in the south. [11] and major crops grown in the state include: millet, sorghum, cowpea, rice, maize, sesame, wheat and groundnuts while livestock kept include sheep, cattle and goat [11].

Source and Method of Data Collection

National Bureau of Statistics (NBS) database was used to access monthly cowpea prices in the study area from January 2016 to May 2023.

Methods of data analysis

The trend of cowpea prices in the study area was ascertained using descriptive statistics (graph), as employed by [5] The future price of cowpea in the study area was estimated using the ARIMA model (Box-Jenkins methodology). The Box-Jenkins approach forecasted the price of cowpea and identified the appropriate ARIMA (p, d, and q) model parameters [21].

Test of stationarity

Graphical and format test Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root test were employed to test the stationarity of the data at 0.05 level of significant. Adopted from [6].

Type of ARIMA Model for the Study

The study considered three type of ARIMA models, each capable of forecasting future cowpea price values in the study area, based on adequacy tests.

(1)**AR (p) Model**

AR (p) model is concerned with the actual data.

$Y_t = \varphi_0 + \varphi_1 Y_{t-1} + \varphi_2 Y_{t-2} + \varphi_3 Y_{t-3} + \ldots \varphi_p Y_{t-p} + \varepsilon_t$ ------------------------------------equation (1)

where:

Y_t= Response variable (price of cowpea) at time t

Y_{t-1} Y_{t-2}, Y_{t-3} ……… Y_{t-p} is the respective variables (price of cowpea) at different time lags

φ_0, = constant, φ_1, φ_2, φ_3 ……..φ_p are the coefficients

ε_t is the error term

(2) **MA(q) Model**

MA (q) model is concerned with the error term.

$Y_t = \mu_0 + \partial_1\epsilon_{t-1} + \partial_2 \epsilon_{t-2} + \partial_3 \epsilon_{t-3} + \partial_q \epsilon_{t-q} + \epsilon_t$ --equation (2)

where:

μ_0 = constant mean of the series

∂_1, ∂_2, ∂_3 ………∂_q = coefficients of estimated error term, ϵ_t = error term

(3) **ARMA (p, q) model**

The combination of equation (1) and (2) give ARMA (p, q) model with general form:

$Y_t = \varphi_0 + \varphi_1 Y_{t-1} + \varphi_2 Y_{t-2} + \varphi_3 Y_{t-3} + \varphi_p Y_{t-p} + \varepsilon_t + \mu_0 + \partial_1\epsilon_{t-1} + \partial_2\epsilon_{t-2} + \partial_3\epsilon_{t-3} + \partial_q\epsilon_{t-q} + \epsilon_t$ ---equation (3)

Adopted from [2].

ARIMA Model Building

The Flow Diagram in Figure 1 illustrates how the ARIMA model using Box–Jenkins method was built for the study.

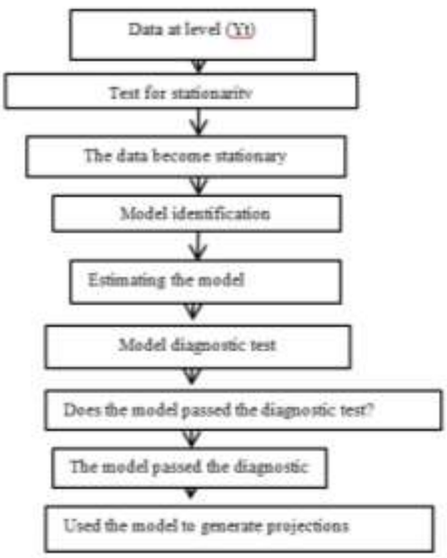

Fig. 1. Building ARIMA model using box-jenkins methodology
Source: Adapted from [14]

Forecasting accuracy

Mean Absolute Percentage Error (MAPE) was used to test the accuracy power of the ARIMA model selected for the forecasting.

$MAPE = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{\hat{Y}t - Yt}{Yt}\right| x100$ ----------------- -------------------------------------equation (4)

where:

Yt = Actual price of cowpea,

$\hat{Y}t$ = Forecasted price of cowpea,

n = Total number of observations

Adopted from [10], [21].

Forecasting

ARIMA model, which offers the highest estimated accuracy, was used to estimate cowpea prices in the study area on a monthly basis for seven months, from June 2023 to December 2023.

RESULTS AND DISCUSSIONS

Price trends for cowpea in the study area from January 2016 to May 2023

A monthly trend of cowpea prices in Nigeria's Yobe state, expressed in naira per kilogram (kg), from January 2016 to May 2023 is depicted in Figure 2. The cowpea price trend was at ₦229.05 per kilogram in January 2016. From the January 2016, the price trend continued to fluctuate upward and downward until June, when it was at ₦220.56/kg. In July of 2016, the price trend increased to ₦267.26/kg. And in August, the price trend goes down to ₦233.06/kg. After that, the trend fluctuated downward and upward until December of 2016 where price was at ₦258.58/kg. The price trend of cowpeas was at ₦244.92 in January 2017 but it continued to fluctuate, reached its peak at ₦324.32 in September and goes down to ₦292.26 in December. In January 2018 the price was ₦311.13/kg it later drops down to ₦297.19, ₦294.88, ₦226.25, ₦274.73 and ₦262.25 in February, March, April, May and June 2018 respectively. In July 2018 the cowpea price trend was at ₦301.84/kg and decrease to ₦288.14 in August and keeps up increasing in September, October and November the same year and later declined to ₦279.31/kg in December 2018.Similar pattern of fluctuations in cowpea prices trend was observed in the study area in 2019. In January 2019 the price was at₦259.71/kg; it increased to ₦270.57 in February and decreased to ₦261.87 in March. The price trend move upwards to ₦271.92, ₦274.22 and ₦299.89 in April, May and June 2019 respectively and later fluctuated downwards to ₦255.00, ₦220.00, ₦246.43, ₦210.00, ₦215.71 and ₦213.17 in July, August, September, October, November and December 2019 respectively. The cowpea price trend was at ₦198.31/kg in January 2020, but it was quickly drop to the lowest value in the study's period to ₦148.69, ₦149.49 and ₦150.84 in March, April and May, 2020 respectively. And then the price trend jump up to ₦208.68 in June, then it kept going upward until December 2020, when it was at ₦ 239.66/kg. Then cowpea prices trend began to move upward in January 2021 when it was at ₦243.01/kg and remained rising until the end of the year without customarily falling. The price trend of cowpea in the study area was at ₦485.87/kg in May 2023, having risen steadily since January 2022 until the end of the investigation. This may be explained by the general increases in the cost of food commodities in Nigeria as a result of the country's rising fuel pump prices brought on by the Nigerian government's elimination of the fuel subsidy.

At first, the study's findings were comparable, but from January 2021 to May 2023, they diverged from those of [5]. Who looked at cowpea integration and price trends in the Biu and Miringa markets in Borno State, Nigeria's Biu Local Government area, using a graphical representation of the price data, they described the trend of cowpea price variation from 2016 to 2018 and discovered both upward and downward trends in cowpea prices in the Biu and Miringa markets during that time.

Estimated Cowpea Prices in the Study Area from June 2023 to December 2023

The steps involved in projecting cowpea using the Box-Jenkins's Methodology are model identification, model estimation, diagnostics checking and forecasting.

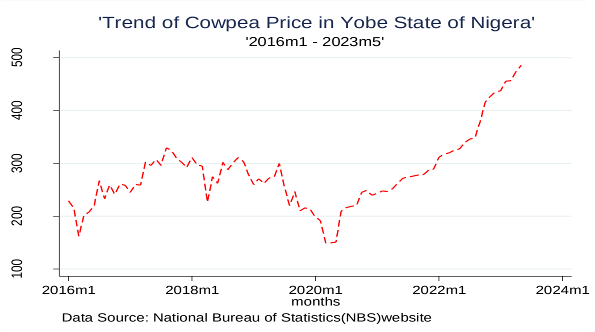

Fig. 2. Cowpea price trend in Yobe state, Nigeria, 2016 m1 - 2024 m1.
Source: Own design based on the data from National Bureau of Statistics, NBS [15].

Model identification

Stationarity and determining the order of p, d, and q in an ARIMA model are two aspects of model identification.

Stationarity

The stationarity of the Cowpea price series was tested using the graphical and formal tests, the Augmented Dickey-Fuller (ADF) and the Phillips-Perron test for unit root, in this analysis.

Graph of cowpea price

The series' up-and-down trend on the graph in Figure 3 indicates that it is not stationary.

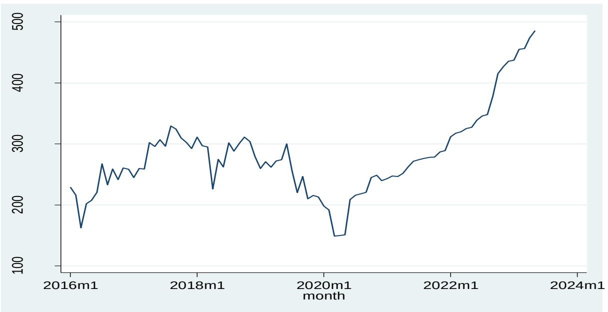

Fig. 3. Cowpea price in Yobe state, Nigeria, 2016 m1 - 2024 m1.
Source: Own design based on the data from National Bureau of Statistics, NBS [15].

The preliminary understating of time series data indicates that there is no consistency in the variables over a specified period of time. Figure 3 shows that cowpea price is a non-stationary variable, requiring for the use of differencing.

Graph of cowpea price at first difference

Figure 4 graph revealed that series become stationary after applying the first difference. The plot indicates non-seasonality, the time series has a constant mean, and the observations fluctuate horizontally as indicated by the pattern of fluctuation.

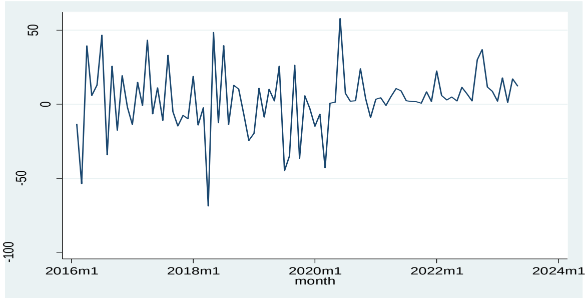

Fig. 4. Graph of cowpea price at first difference
Source: Own design.

Correlogram of autocorrelation of cowpea price

Correlogram Figure 5 also shows that the series is non-stationary at level; there is slow decay in ACF which was die down quickly, which suggested that, the series was non-stationary.

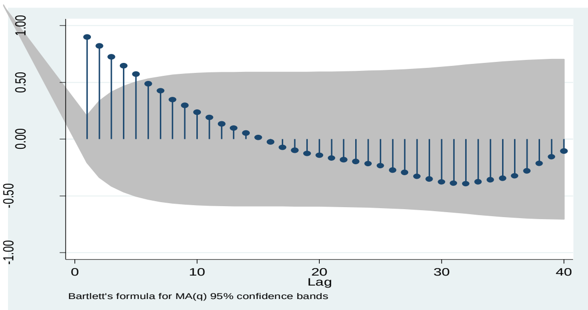

Fig. 5. Correlogram of autocorrelation of cowpea price
Source: Own design.

Correlogram of partial autocorrelation

Correlogram of partial autocorrelation in Figure 6 shows spike suggested that the series was not stationary at level.

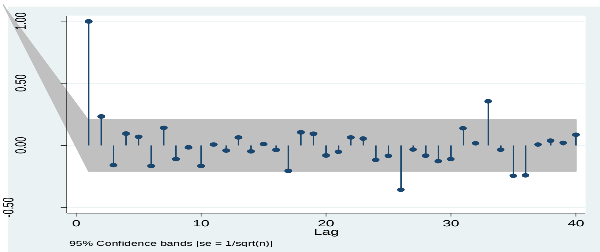

Fig. 6. Correlogram of partial autocorrelation of cowpea price
Source: Own design.

Formal test

Two formal tests were used to determine whether the series was stationarity: the Phillips-Perron test (PP) and the Augmented Dicky Fuller test (ADF). The Augmented Dicky fuller test at level revealed a p-value of 0.9697 which is greater 0.05, this means that the series has a unit root, therefore it is non-stationary. Likewise the Phillips-Perron test at level revealed a p-value of 0.9835 this shows that the series has a unit root, therefore it is non-stationary. In addition the trend and the constant are also not significant. Since the series has a unit roots and is it non-stationary, then the series was transformed by taking the first order difference.

First order differences

Dickey-Fuller test for unit root revealed a p value of 0.000, which is less than 0.05; this showed that after applying the first difference, the series is now stationary. The null hypothesis that the series has a unit root is now rejected because the Phillips-Perron test for the unit root also showed that the series is stationary with a p-value of 0.0000. Since the series become stationary after the first order difference, ARIMA (p.d.q) model was used for the study. This is in conformity with [6] who used the Box Jenkins Methodology for Estimation and Forecasting Models in Higher Education in Athens to model the proportion of 18-19 year olds enrolled in higher education. An Autoregressive Integrated Moving Average (ARIMA) model was created to fit the previous time series. The study found the process was not stationary and needed differentiation. The ADF test and PP tests confirm that the higher education enrolment series was not stationary (ADF p-value of 0.3745, PP test p-value of 0.3753) as indicated by the p-value greater than 0.05%. He further stated that the series was not stationary, according to both Autocorrelation Function (ACF) and Partial Auto Correlation Function (PACF). However, he further reported that data transformation confirms the ARIMA model's stationary assumption, and the time series on higher education enrolment was stationary after the first order difference with a p-value for the ADF test of 0.0000.

Determining the order of p.d.q in ARIMA models

The order of p.d.q. in the ARIMA models was ascertained by using the Autocorrelation function (ACF) and the Partial Autocorrelation function (PACF) in order to identify possible ARIMA candidates for further process.

Autocorrelation function (ACF)

The Autocorrelation function plot presented in Figure 7 indicates that lag number one is the best value of q (q = 1), as ACF shows exponential decay at lag 1.

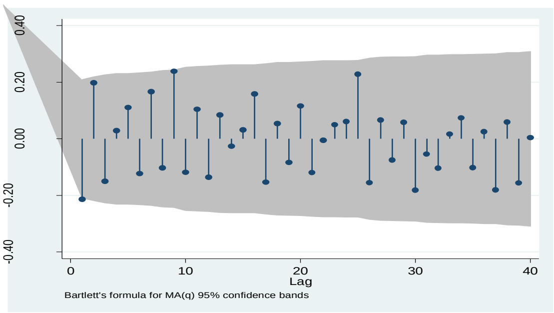

Fig. 7. Autocorrelation function (ACF) plot
Source: Own design.

Function of partial autocorrelation (PACF)

One lag from Figure 8's Partial Autocorrelation Function stood out as being just above the cut off. Since the PACF exhibits exponential decay at lag1, this lag was selected as the optimal value of p, i.e., p = 1.

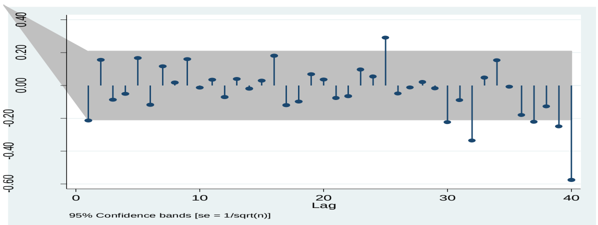

Fig. 8. Partial autocorrelation function (PACF) plot
Source: Own design.

From the use of the partial autocorrelation and autocorrelation functions there were three potential models found: ARIMA (1.1.1), ARIMA (0.1.1), and ARIMA (1.1.0). According to [20], the models' auto-regression and moving average orders are actually determined using the ACF and PACF.

Models estimation

The following estimates were made for the three identified ARIMA candidates: ARIMA (1.1.1), ARIMA (0.1.1), and ARIMA (1.1.0):

ARIMA (1.1.1) model

The estimate for the ARIMA (1.1.1) model was shown in Table 1.

Table 1. Estimated ARIMA (1.1.1) Model

D.cp	Coefficient	Std. Err	Z	P>|z|
Constants	2.896541	2.070816	1.40	0.162
AR L1	-.6225263	.3344268	-1.86	0.063
MA L1	.4174488	.3698285	1.13	0.259
SigmaSQ	20.72324	1.241937	16.69	0.000

Log Likelihood = -391.657
p-value =0.0040

AIC = 791.3141

BIC = 801.2234

Source: National Bureau of Statistics (NBS) [15].

Model: ARIMA (0.1.1)

Table 2 displayed the estimate for the ARIMA (0.1.1) model.

Table 2: ARIMA (0.1.1) Model Estimate

D.cp	Coefficient	Std. Err	Z	P>|z|
Constants	2.942809	2.017398	1.46	0.145
MA L1	-.16696	.0978899	-1.71	0.088
SigmaSQ	21.06451	1.226133	17.18	0.000

Log Likelihood = -393.0686
p-value = 0.0881

AIC = 792.1373

BIC = 799.5693

Source: National Bureau of Statistics (NBS) [15].

Model: ARIMA (1.1.0)

Table 3 displayed the ARIMA (1.1.0) model's estimated values.

Table 3: ARIMA Model Estimate (1.1.0)

D.cp	Coefficient	Std. Err	Z	P>|z|
Constants	2.932958	1.975713	1.48	0.138
AR L1	-.212745	.0977985	-2.18	0.030
SigmaSQ	20.94895	1.212561	17.28	0.000

Log Likelihood = -392.5836
p-value = 0.0296

AIC = 791.1672

BIC = 798.5992

Source: National Bureau of Statistics (NBS) [15].

Model selection criteria

According to Table 4, model C was the best model based on the number of significant variables, while model A is the best based on the smallest sigma square. Additionally, because model A had a larger log likelihood, it is also the best based on log likelihood. Model C is the best model based on Akaike's (AIC) value because it was the lowest. Similarly, due to its lowest BIC value, model C remains the best model based on the Bayeseian (BIC) algorithm. In summary, model C is the recommended model for residual checking (diagnostics).

Table 4. Model selection criteria

Criteria	Model			Best model
	Model A ARIMA (1.1.1)	Model B ARIMA (0.1.1)	Model C ARIMA (1.1.0)	
No. of sig. variables	0/3	0/2	½	C
Sigma sq	20.72324	21.06451	20.94895	A
Log likelihood	-391.657	-393.0686	-392.5836	A
Akaike (aic)	791.3141	792.1373	791.1672	C
Bayesian (bic)	801.2234	799.5693	798.5992	C
Best model				C

Source: National Bureau of Statistics (NBS) [15].

Diagnostic

Diagnostic checking is required to make sure the identified model is suitable for analysis or not. In reality, it involves carrying out diagnostic testing on the residual term that was derived from the ARIMA model, to verify whether the model's residuals are stable (white noise). The residual plot, portmanteau test and Inevitability test AR root graph were used to confirm this.

Residual plot

The residual plot presented in figure 9 confirmed that the residuals estimated from the chosen model (ARIMA (1.1.0)) are white noise, meaning that the error revolves around the mean. This suggested that there was no evidence of error autocorrelation in the model. Therefore the model is fit for forecasting the future values of cowpea prices in the study area.

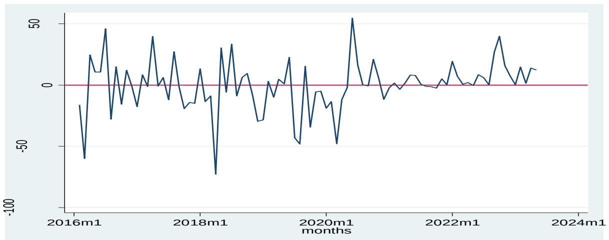

Fig. 9. Residuals plot
Source: Own design.

Portmanteau test

The portmanteau test revealed a p-value of 0.1091 which was greater than 0.05, therefore the null hypothesis that the residual are white noise cannot be rejected. In this case the residuals are stable. Hence the ARIMA (1.1.0) model chosen is fit for forecasting the future price of cowpea in the study area.

Inevitability test (AR Roots graph)

From figure 10 AR root had lie inside the unit circle, this confirmed that the residuals are white noise and the process was stable. And this suggests that the selected ARIMA model was capable of predicting the future cowpea prices in Nigeria's Yobe state.

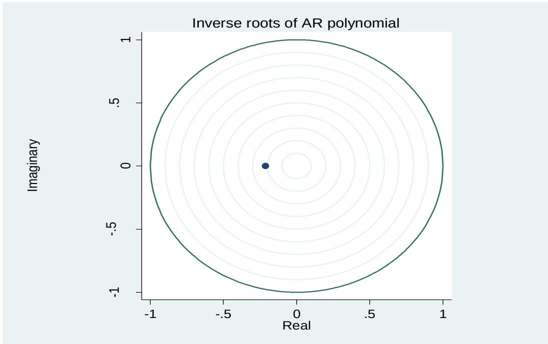

Fig. 10. AR Root
Source: Own design.

The future value of cowpea prices in the study area could be accurately predicted by the ARIMA (1.1.0) model, since the residual plot, portmanteau test and AR root graph both demonstrated that the residuals are white noise (stationary).

Forecasting

Seven Month of forecasted cowpea price was presented in Table 5 provided the predicted value of cowpea price. However, this forecast was based on the past values of the cowpea price in Yobe state. The anticipated cowpea price indicated that the price of cowpeas in the study area would continue to rise in the upcoming months. The findings of the study were consistent with those of [13], who carried out research on the forecasting of cowpea prices in Adamawa state, Nigeria, and discovered that there will be upward trend of cowpea prices in Adamawa State in February and October - November in the year 2018. However, the finding of this study was contrary to the findings of [19] who study Agricultural Production Forecasting the Box-Jenkins (ARIMA) model was used to forecast paddy production in southern India. Their research showed that future years will see both an increase and a decrease in rice production.

*Table 5. Forecasted Cowpea Price from June, 2023 to December, 2023 in Yobe State

Month	Forecasted cowpea price (FCP) in Naira/kg
June	486.83
July	490.18
August	493.03
September	495.98
October	498.91
November	501.84
December	504.77

Source: National Bureau of Statistics (NBS) [15].
*The forecasted prices could fluctuate within ± 5% due to lack of price control system in place.

Forecasting Accuracy

Graph and Mean Absolute Percentage Error (MAPE) were employed to assess the model's forecasting accuracy.

Graphical presentation of actual and forecasted cowpea price

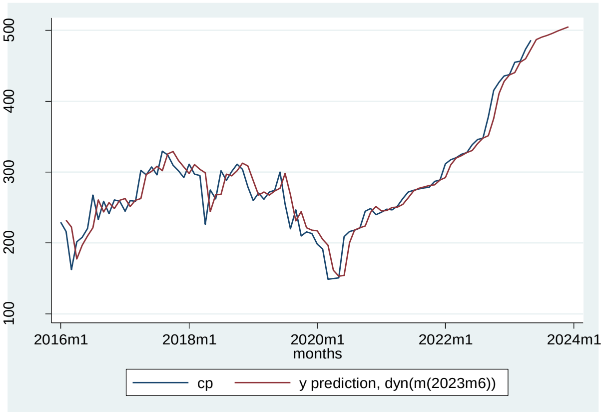

Fig. 11. Graph of actual and forecasted cowpea price
Source: Own design.

The red line on the graph in Figure 11 represents the forecasted cowpea price, while the blue line represents the actual cowpea price. The graph showed that there is a positive correlation between the actual cowpea price and forecasted price.

Mean absolute percentage error (MAPE)

5.86% was the mean absolute percentage error (MAPE) of the forecasted cowpea price in the study area. This demonstrates how well the ARIMA (1.1.0) model predicted the future value of cowpea prices in the study area. This was based on [21] scale of judgment for forecasting accuracy, which indicated that a forecast is highly accurate if the MAPE is less than 10%.The study's findings were in consistent with that of [21], who examined the Box-Jenkins ARIMA model for S&P BSE stock index trend detection and stock price forecasting. Due to random stock price behaviour, they discovered a positive correlation coefficient between the predicted and actual stock prices as well as a MAPE of 8.65, which indicates the model's accuracy and suitability for future forecasting.

CONCLUSIONS

Up until the conclusion of the investigation in May 2023, the price of cowpea in the study area fluctuated between up and down trends before finally rising. This demonstrates that the cowpea price trend in the research area was unstable. A seven-month cowpea price projection was made using the Box-Jenkins's Methodology and the cowpea price proved non stationary at level but it remained stationary at first difference. ARIMA (1.1.0) model was identified for the forecasting process and the projected cowpea prices were estimated from June – December 2023 with highly accurate forecast.

In order to stabilize cowpea price instability and allow stability in trend movement of cowpea prices in the study area, to help cowpea producers, marketers, consumers and policymakers in making their respective decisions, government should implement appropriate measures such as restricting cowpea produce exports and eliminating import taxes on cowpea product. In addition more research should be done to forecast the price of other crops using Box-Jenkins's Methodology, as this will assist government organizations, farmers, traders, and consumers in making their appropriate decisions.

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AGRICULTURAL ACTIVITIES AS AN ADDITIONAL WORK FOR SHEEP FARMERS IN BULGARIA

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Abstract

The aim of the present study is to analyze the agricultural activities (tillage applied and the types of crops grown) as an additional work for sheep farmers in Bulgaria. The information from the survey was gathered from 14 Bulgarian sheep farmers. Out of 14 farmers, 4 of them (29%) alternate autumn crops (maize, wheat, rye, triticale) with spring crops (oats, peas) or with alfalfa, and one farmer leaves cultivated areas fallow every two years due to the increased acidity of the soil. Farmers who do not practice crop rotation mostly grow alfalfa. Two of the farmers (14%) stated that they grow alfalfa as a monoculture. The majority of farmers (87%) grow leguminous fodder for feeding sheep, and half (53%) of farmers grow cereals. Of the tillage methods used for soil preparation among the surveyed sheep farmers, it is the most applied deep ploughing (57.2%), followed by disking (42.8%), shallow ploughing (35.7%) and lastly harrowing (21.5%) and other tillage methods (21.5%). More than half of farmers (64.3%) do not use plant protection products, 28.6% apply conventional products, and 7.1% - products compatible with organic farming. The prevailing part of farmers (42.9%) applied both mechanical and chemical means of control of weeding. Half of the farmers answered that they only fertilize with animal manure.

Key words: *sheep farmers, tillage applied, crops, control of weeds, fertilizers*

INTRODUCTION

Fodder production is needed for feeding farm animals, including sheep. Although sheep in Bulgaria can be raised, in the majority of cases, entirely on pasture during the summer season, during the winter season it is necessary to feed them with concentrated, juicy and coarse fodder. For this reason, the prevailing part of sheep farmers produce fodder and, accordingly, cultivate own and/or rented lands. To produce profitable sheep production, it is necessary to keep production costs under control, and farmers strive to reduce the cost of production of milk and animals for sale. For this reason, a large number of sheep farmers prefer to produce at least part, if not all, of the necessary fodder for the animals, with the idea being that the cost of the produced fodder is lower than the purchase price on the market. For this reason, the production of fodder is an inseparable part of the production activity of many sheep farms in Bulgaria. The sale of fodder is also an additional income for sheep farmers, important for the financial efficiency of the farms, and more precisely: surplus amounts of fodder produced by the farmers are sold [6].

Tillage, fertilization of soil, plant protection methods, irrigation systems, crop rotation, weed control and the condition of agricultural machinery are an integral part of forage production, which has a direct impact on the farm efficiency. Fertilizers and soil improvers are plowed into the soil during tillage.

Tillage of the soil is needed for the aeration of the soil, weed, temperature, water and moisture control [11]. Different tillage methods affect weed density and thus generate different levels of production costs for farmers [9]. It was found that conventional tillage is connected with higher production costs, time and energy, compared to conservation tillage [2]. Conservation tillage is important for the keeping of productivity of crops and for restoration of degraded lands [12], as well as this method is effective for the water management, prevention of the erosion process [3]. Also conservation tillage can foster fertility of land and yields [7]. Proper tillage management improves yields and contributes to the reduction of atmospheric carbon dioxide by sequestration of soil organic carbon [8].

The aim is to analyze the tillage methods applied and the types of crops grown by Bulgarian sheep farmers.

MATERIALS AND METHODS

The information was gathered from 14 Bulgarian sheep farmers by the survey interview method. The farmers were asked the following questions:

- What crop rotation do you practice?
- Do you grow monocultures?
- What irrigation system do you use?
- What crops do you grow on the arable land?
- What tillage methods do you apply?
- What plant protection products do you apply?
- How do you control weeds?
- What do you fertilize the land with?
- Which of the statements describes the best used agricultural machinery on the farm?

The possibilities for answer are: I do not have agricultural machinery and I do not use it; I rent someone else's equipment / services; most of my equipment is old, but with low to medium fuel consumption; my equipment is old and has a high fuel consumption; most of my equipment is new and with low fuel consumption; most of my equipment is new, but with medium fuel consumption.

RESULTS AND DISCUSSIONS

Out of 14 farmers, 4 of them (29%) alternate autumn crops (maize, wheat, rye, triticale) with spring crops (oats, peas) or with alfalfa, and one farmer leaves cultivated areas fallow every two years due to the increased acidity of the soil. Farmers who do not practice crop rotation mostly grow alfalfa. Two of the farmers (14%) stated that they grow alfalfa as a monoculture. Only 1 farmer irrigates about 80% of the alfalfa arable land with sprinkler irrigation. The remaining farmers practice non-irrigated agriculture.

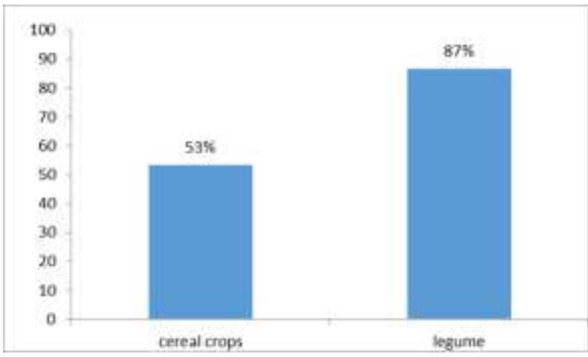

Fig. 1. What crops do you grow on the arable land?* n=14

* The sum of the percentages is over 100, because most farmers grow more than one crop.

Source: Own calculations.

It was found that the majority of farmers (87%) grow leguminous fodder for feeding sheep, and half (53%) of farmers grow cereals (Fig.1). Studies have shown that adding alfalfa to lamb diets increases profit compared to straw or hay [10].

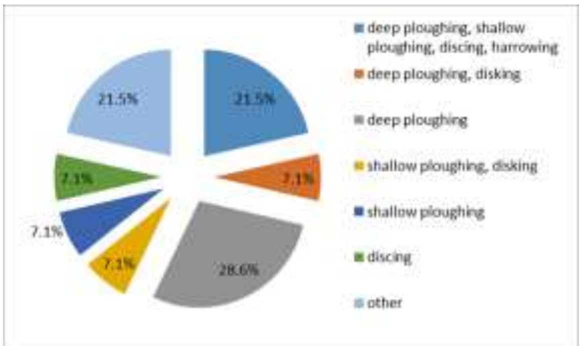

Fig. 2. Tillage methods applied (n=14)

Source: Own calculations.

Of the tillage methods used for soil preparation among the surveyed sheep farmers, it is the most applied deep ploughing (57.2%), followed by disking (42.8%), shallow ploughing (35.7%) and lastly harrowing (21.5%) and other tillage methods (21.5%) (Fig.2). About 1/3 of farmers apply more than 1 tillage method (35.7%). 21.5% of farmers practice: deep ploughing, shallow ploughing, discing and harrowing; 7.1% - deep ploughing and disking; 28.6% - only deep ploughing; 7.1% - shallow ploughing and disking; 7.1% - disking only.

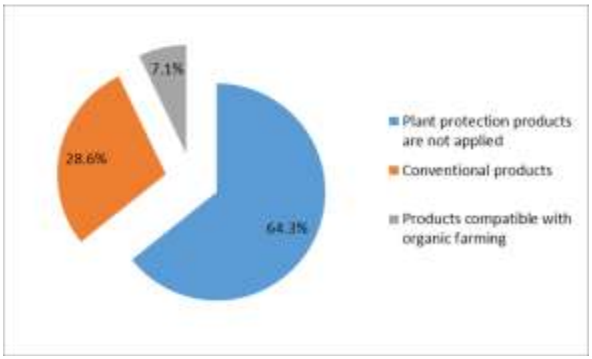

Fig. 3. Plant protection products applied (n=14)
Source: Own calculations.

Plant protection products applied from the the surveyed sheep farmers are presented on Fig. 3. More than half (64.3%) do not use plant protection products. 28.6% apply conventional products, and only 7.1% - products compatible with organic farming. It has been found that consumers are attracted to organic food, which they perceive to be healthier when compared to that produced by conventional agriculture [5].

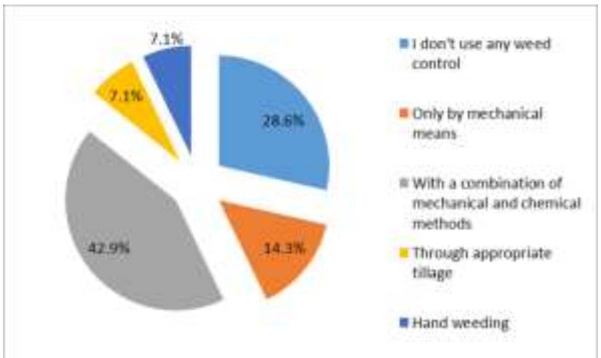

Fig. 4. How do you control weeds?
Source: Own calculations.

When asked how you control weeding (Fig. 4), 28.6% of farmers answered that they do not apply any weeding control method; 14.3% control weeds with the help of mechanical means; the majority of farmers (42.9%) applied both mechanical and chemical means of control; 7.1% - through appropriate tillage and 7.1% - through hand weeding. Losses from weeds have been found to exceed losses from any other agricultural pest and can reduce yields with 50% or more through competition for water [1].

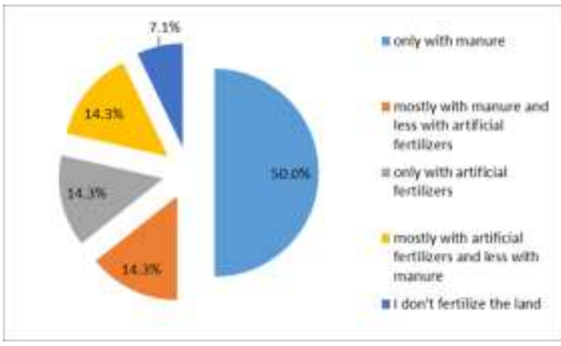

Fig. 5. What do you fertilize the land with (n=14)?
Source: own calculations.

To the question "What do you fertilize the land with?" (Fig. 5), half of the farmers answered that they only fertilize with animal manure. An equal percentage of farmers (14.3%) mainly use manure and less artificial fertilizers; fertilize only with artificial fertilizers; fertilize mainly with artificial fertilizer and less with manure. 7.1% of sheep farmers do not fertilize the land. Application of sheep manure to contaminated soils has been found to improve plant growth [4].

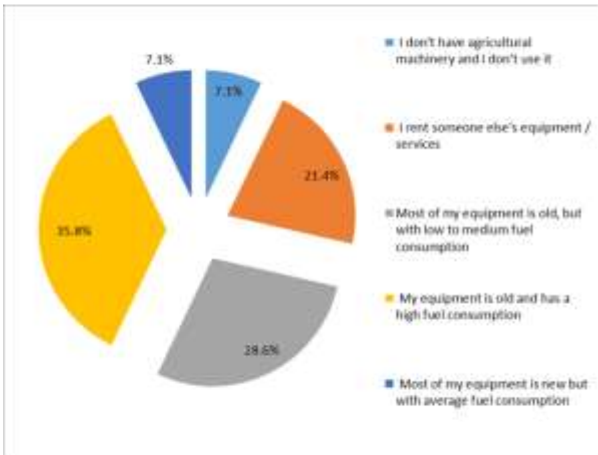

Fig. 6. Which of the statements describes the best used agricultural machinery on the farm ? (n=14)
Source: own calculations.

Fig. 6 shows the distribution of sheep farms in terms of the agricultural machinery used. Only 7.1% of farmers do not have and use agricultural machinery. 21.4% of sheep farms rent someone else's equipment / services; in 28.6% of farms, the equipment owned is mostly old, but with low to medium fuel consumption. In 35.8% of the farms, the equipment owned is old and with high fuel consumption. It is noteworthy that none of the farmers indicated the option "most of my equipment is new and with low fuel consumption". 7.1% of the respondents indicated that most of the equipment is new, but with average fuel consumption.

CONCLUSIONS

We can conclude that a large part of the interviewed farmers cultivated land and harvested fodder crops in order to support the activity of the farm, provide quality forages and reduce the cost of feeding the animals. It was found that the majority of farmers (87%) grow leguminous fodder for feeding sheep, and half (53%) of farmers grow cereals. Out of 14 farmers, 4 of them (29%) alternate autumn crops (maize, wheat, rye, triticale) with spring crops (oats, peas) or with alfalfa, and one farmer leaves cultivated areas fallow every two years due to the increased acidity of the soil. Farmers who do not practice crop rotation mostly grow alfalfa. Of the tillage methods used for soil preparation among the surveyed sheep farmers, it is the most applied deep ploughing (57.2%), followed by disking (42.8%), shallow ploughing (35.7%) and lastly harrowing (21.5%) and other tillage methods (21.5%). More than half of farmers (64.3%) do not use plant protection products, 28.6% apply conventional products, and 7.1% - products compatible with organic farming. The prevailing part of farmers (42.9%) applied both mechanical and chemical means of control of weeding. Half of the farmers answered that they only fertilize with animal manure.

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ANALYSIS OF THE INFLUENCE OF CLIMATIC PHENOMENA ON VEGETABLE PRODUCTION

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Abstract

Vegetables are one of the basic products in human nutrition, as they provide nutrients, vitamins and minerals. Also, in addition to their nutritional role, they also have an important economic value, given the high productivity on small areas of land. However, vegetable crops, especially those that are grown in the field, are very vulnerable to certain climatic factors such as extreme temperatures, pedological drought and precipitation. This research was focused on the impact of climate change on vegetable production, with emphasis on the negative effects of temperatures and precipitation on them. At the same time, the analysis carried out in this study underlines the importance of understanding the relationship between climate variability and changes in vegetable production. To carry out the analysis in this paper, the WoS database was queried, from where the scientific works relevant to the studied topic were extracted. For the analysis of the influence of climate change on vegetable production, statistical data provided by the National Institute of Statistics were used, namely the average annual temperature and the amount of precipitation. The research method used to carry out the study was quantitative data analysis, using statistical methods. The results of the study show a moderate correlation between the climatic phenomena analyzed and vegetable production, but emphasize the complexity of the factors influencing production. In addition to climatic factors, other agronomic, economic and technological factors are equally important. In this respect, the adaptation of the vegetable sector to climate change becomes essential to ensure a sustainable agricultural system and food security.

Key words: *vegetable production, correlation, temperatures, rainfall*

INTRODUCTION

Climate change affects the entire planet, with economic, social and ecological repercussions [31]. Extreme weather events (e.g., soil drought and high temperatures) have become more frequent, directly and negatively affecting water resources and endangering ecosystems and the agricultural sector [31, 23]. All these phenomena require agriculture to adapt as quickly as possible to increasingly unpredictable weather conditions (e.g., temperature fluctuations, changes in precipitation amounts and the frequency of extreme events) [13, 2, 15, 16, 17].

With the increase in the global population, the role of agriculture becomes essential in society, the agricultural sector being responsible for providing food resources [9]. However, the agricultural sector is one of the most vulnerable sectors of the economy. Given this context, the agricultural sector is intensively studied in scientific research to assess the impact of climate change on it [20]. Research shows that food production will be strongly affected by increasing temperatures as well as the negative effects of greenhouse gases [19]. Vegetable crops have a particularly important role in the global economy due to their high yields per hectare and profitability, in addition to all this, vegetable crops also offer benefits for human health [3]. At the Romanian level, studies show that agriculture is dependent on climatic conditions, food security and the well-being of the population, these conditions being influenced by the ability of farmers to adapt to new environmental requirements. Farmers, especially subsistence farmers, face challenges related to limited access to resources, price volatility and perishability of produce. Managing these challenges requires an integrated strategy that combines modern technologies with sustainable practices and effective public policies. At the same time, reducing the risks of global warming involves both adaptation measures and climate change mitigation actions. Given this context, farmers need to adopt solutions such as the use of resistant hybrids, the implementation of efficient irrigation systems and the adoption and use of digital technologies for permanent crop monitoring. Sustainable practices such as crop rotation and soil conservation also contribute to maintaining productivity and conserving water resources [22].

Scientific research has made progress in developing horticultural varieties that are resistant to abiotic stresses (e.g. drought, high temperatures, soil salinity and heavy rainfall) [18]. Climate change negatively impacts crop yields, livestock productivity, and farmers' incomes [18, 27, 7], and farmers' adaptation to new climatic conditions must be supported by technological progress and access to information [5, 32]. Vegetable production, carried out throughout the year in the open field or protected spaces, is influenced by factors such as water, light and nutrients.

Farmers can use these resources to change the timing of crop establishment, implement modern irrigation technologies, such as drip or sensor-controlled, and weather event warning, to identify the optimal times for sowing, harvesting or applying phytosanitary treatments [5].

Despite these efforts, farmers continue to face challenges related to limited access to market resources and information, price fluctuations and crop perishability. More effective management and appropriate public policies can support the development of this vital sector [10, 26].

Given the present context, the purpose of the paper is to qualitatively and quantitatively analyze the influence of meteorological factors on vegetable production, in the context of climate change, so as to present the relationship between climate variability and the dynamics of this agricultural sector. In the study, we aimed to highlight the way in which climatic factors are affected by vegetable production.

MATERIALS AND METHODS

In order to achieve the proposed objectives, the research had an organized approach in two stages using the quantitative research method. In the first part, the bibliometric analysis involved a review of the studies found in the Web of Science database. Bibliometric analysis is a quantitative research method, which centralizes publications according to several criteria (subject, title, keywords, authors, years, countries, etc.). This stage aimed to identify the current trends and directions of research in the field studied. Bibliometric analysis has appeared in scientific research since 1969, when Alan Pritchard used it for the first time in a scientific paper [8]. At this stage, the analysis was performed by configuring the "Topic" field in the WoS database [35], which filters the search for scientific articles by title, keywords, author, and abstract. The keywords used in the search were "vegetables" and "climate change". The search results showed a sample of 375 publications, and through the VOSviewer 1.6.19 software [34], the publication's data were presented graphically, through maps and then interpreted.

The work continues with the collection and analysis of meteorological data (precipitation, temperatures) and vegetable production, creating the possibility of making statistical correlations. The data were taken from National Institute of Statistics-NIS [21] and National Meteorological Administration (ANM) [22]. By using statistical analysis methods, such as correlation and regression, it was possible to determine the existence/non-existence of a significant relationship between environmental variables and vegetable production.

RESULTS AND DISCUSSIONS

A bibliometric study on the topic based on WoS information

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Following the keyword query, a number of 375 publications were identified in WoS, most of which were published in journals such as: Acta Horticulturae, Sustainability, Frontiers in Plant Science, Science of the Total Environment and Agriculture Basel.

WoS Publishing Dynamics

Analyzing the number of publications per year, it was observed that the first publication on the researched topic was recorded in 1979. Since 2000 (3 publications), the number of publications began to increase, reaching a maximum number of 43 publications in 2021. In 2024, 15 publications were recorded. It is important to know that the research was conducted in the middle of this year (Fig. 1).

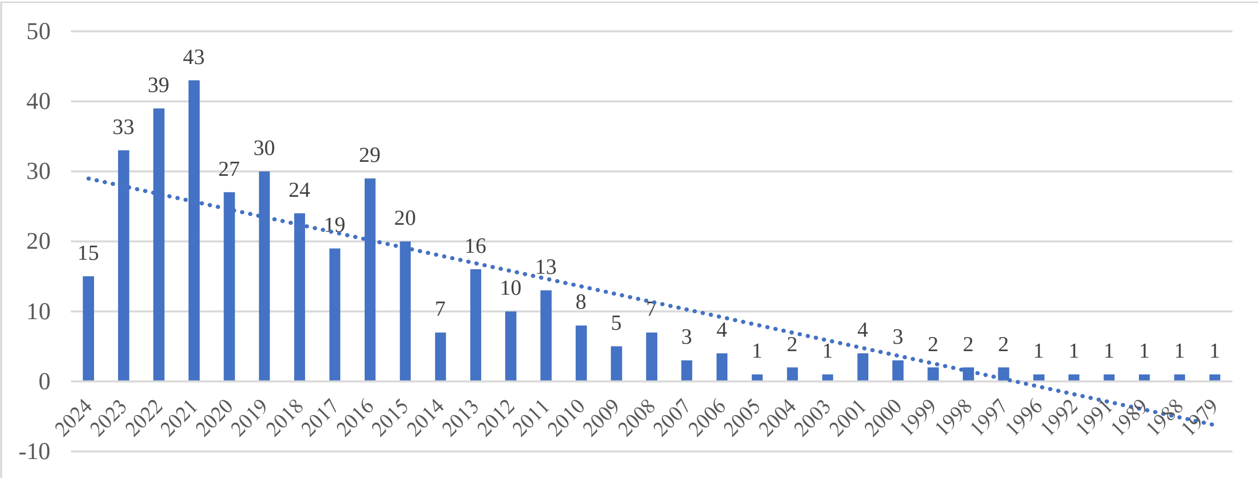

Fig. 1. Dynamics of WoS publications by keywords "vegetable" & "climatic changes" in the period 1979-2024 (number of documents/year)

Source: Own processing based on WoS results using VOSviewer [34, 35].

VOSviewer Terms Map

The main areas of research on the concepts of "vegetable" and "climate change" were extracted using the VOSviewer program and represented in the figure below. This provides an easy-to-follow summary of the most debated sub-themes and shows the correlations between them. Only the main terms are highlighted, while most remain in the background.

The term map illustrates several clusters created based on the power of word association.

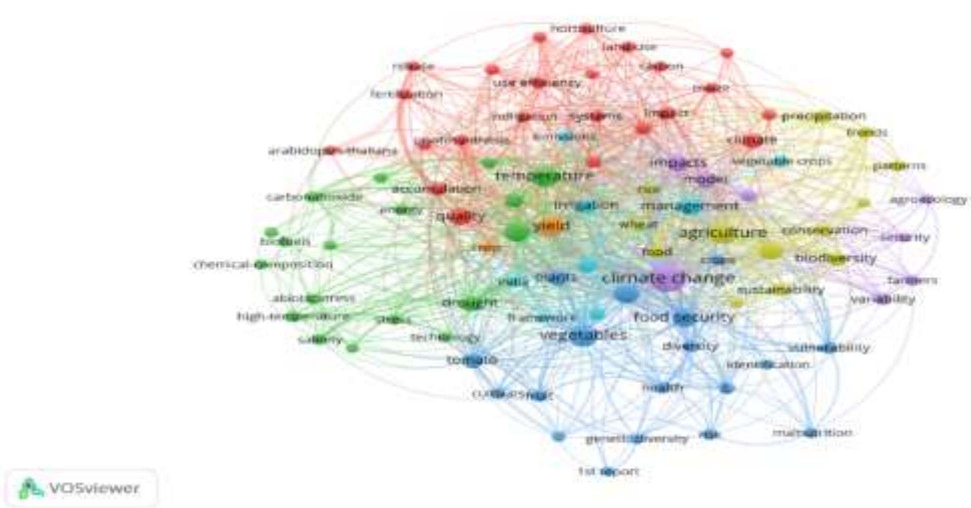

Fig. 1. Map of the correlation of the terms *"vegetable" & "climatic changes"*

Source: Own processing based on WoS results using VOSviewer [34, 35].

The term correlation map, illustrated in the graph below, indicates seven different clusters of terms, based on their frequent use in the literature published in WoS. Some clusters are larger, such as red, green, and blue clusters, while others are smaller, such as yellow, light blue, and orange clusters.

The first cluster (red) is the one that has the highest representation and refers to the culture system. It includes 23 terms, including: horticulture, system, climate, fertilization, impact, etc.

The second cluster (green) is made up of 18 terms that belong to the field of climate change, among which we mention: temperature, carbon dioxide, energy, drought, biofuels, etc.

The third (blue) dark cluster also includes 18 terms and is located in the area of food security, among the main words found are: vegetables, fruits, vulnerability, main nutrition, diversity, etc.

The fourth cluster (yellow) is made up of 13 terms that focus around the concept of sustainable agriculture, among which we mention: agriculture, sustainability, biodiversity, food, conservation, etc.

The fifth cluster (purple) comprises 8 terms: agroecology, climate change, farmers, impact, model, productivity, security and variability. Also, the sixth cluster (light blue) also includes 8 terms: emissions, framework, greenhouse, India, irrigation, management, performance, vegetable crops. The terms in the two clusters come from the authors' various research carried out to measure the impact of climate change on the horticultural sector (Figure 1).

The graphical representation of the density generated by VOSviewer indicates the terms or keywords that have been most frequently used in the bibliographic analysis or in the research in the analyzed field. Due to the frequency of these keywords, the density map indicates areas of interest or research topics that are more important or relevant in that field. Thus, for the researched subject, the following representative words are identified: climate change, agriculture, yield, food security, management, adaptation, sustainability, sustainable agriculture and impact (Figure 2).

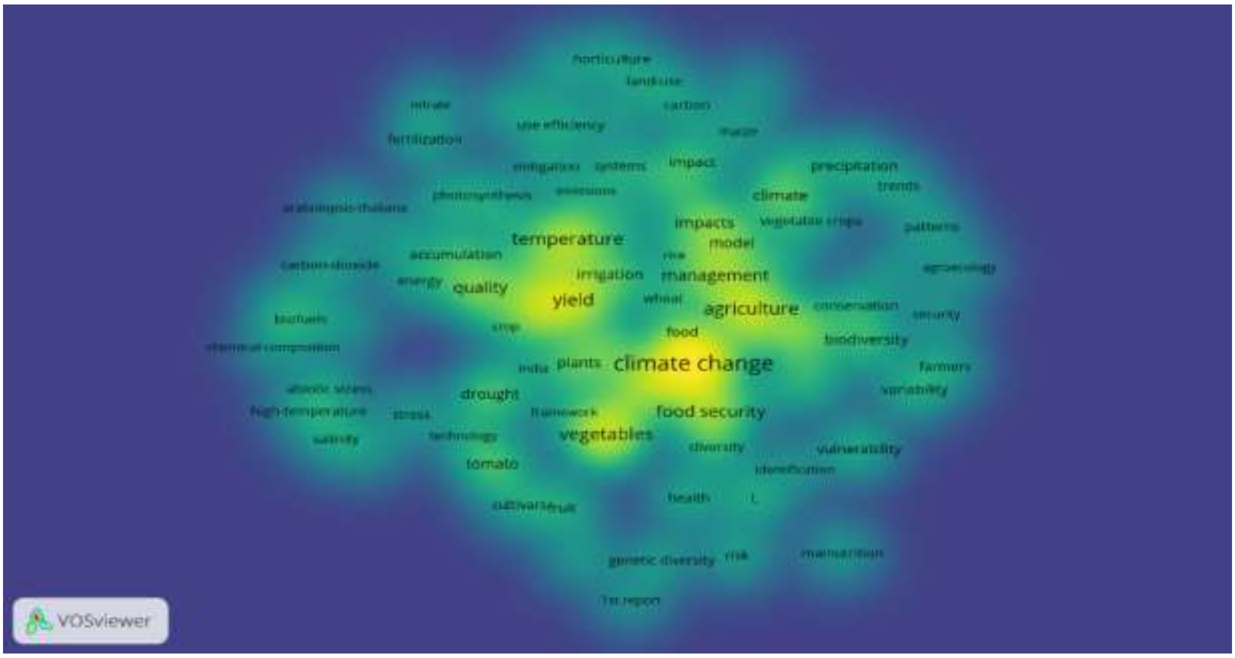

Fig. 2. Graphical representation of the density of the keywords *"vegetable" & "climatic changes"*
Source: Own processing based on WoS results using VOSviewer [34, 35].

In terms of the distribution of Web of Science publications on *"the topics of "vegetable" & "climatic changes"* by country, India is the country that registered the largest number of publications, respectively 68 publications, followed by China (41 publications), Germany (38 publications), USA (29 publications), France (18 publications) and Italy (16 publications). In In Romania, 3 publications were indexed on the analyzed topics, ranking it 45th in the top countries (Fig. 3).

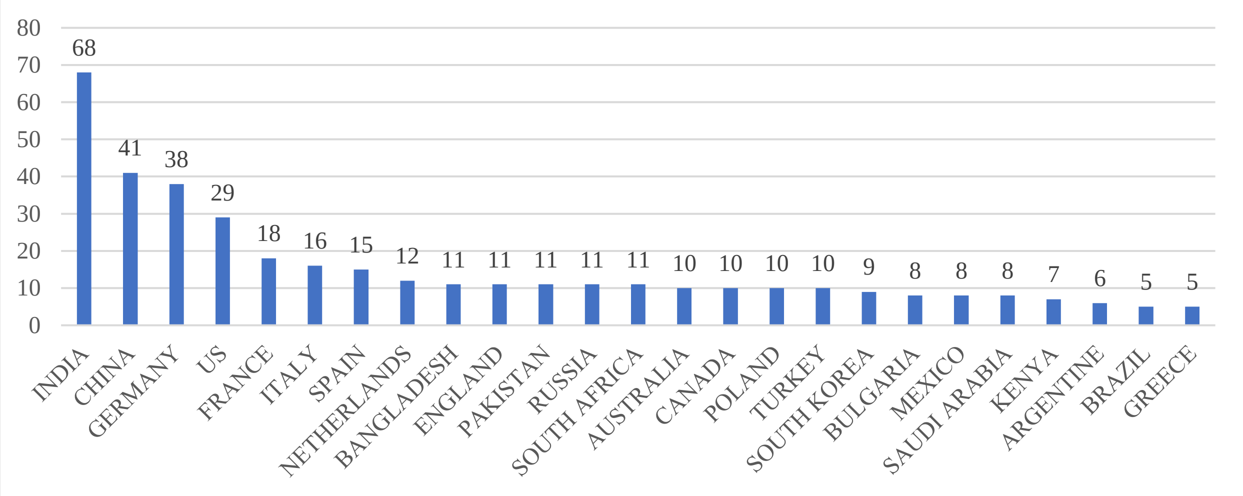

Fig. 3. Top 25 countries by number of publications in WoS by keywords
Source: own processing using excel based on WoS results [35].

The influence of climate change on vegetable cultivation

More and more research has shown that factors such as environmental pollution, increased atmospheric CO2 levels and the greenhouse effect are closely associated with climate change. Drought, high temperature and salinity are among the main environmental stressors affecting crop yields, causing a global food security crisis. These effects are even more profound when it comes to horticultural crops, which are generally more sensitive to climate change than field or tree crops [11].

According to Acikgoz (2011) [1], climate sets the limits and provides guidance on the cultivation methods of field vegetable crops as well as their cultivation time and varieties. At the same time, the author believes that field vegetables are much more vulnerable to climate change than arable crops. They are negatively influenced by temperature changes and extreme weather phenomena (e.g. drought, floods and severe storms, etc.) [12].

Considering these opinions of the author, we can state that vegetable production is directly threatened by climate change and the resistance of pathogens to phytosanitary treatments.

Influence of temperatures

Temperature fluctuations are one of the major challenges facing agriculture worldwide.

Romania has a diversified vegetable sector with a long tradition in vegetable cultivation.

The average annual temperature in Romania has increased significantly in recent decades, and seasonal fluctuations bring with them capital consequences for agricultural production. These changes influence not only the volume and quality of crops, but also consumer behavior and marketing methods.

For Romanian farmers, temperature variations affect planting and harvesting periods, increase risks related to pests and diseases, and increase uncertainty in the market.

Vegetable crops are affected by global warming, climate change, and biotic and abiotic factors [3]. According to studies, increasing temperatures directly affect photosynthesis [18] which causes changes in the content of sugars, organic acids, and vitamins [4, 19]. These changes influence the firmness and antioxidant activity of vegetables, influencing the quantity and quality of production [20, 29].

Climate change increases the frequency of disease and pest problems, leading to a decrease in production and quality. Under these conditions, vegetable cultivation becomes unprofitable. High temperatures also intensify problems related to drought and soil salinity, making vegetable cultivation difficult [3]. The most affected are vegetable crops grown in the field and only to a lesser extent those grown in protected areas [4].

Higher and higher temperatures will change agricultural production patterns. The vegetation period of the crops can influence the crops differently: for some it can be beneficial, but for others it will lead to the deterioration of production. In addition, high temperatures affect water resources, expand diseases, pests and weeds [5, 19].

The increase in temperatures causes the intensification of evapotranspiration, which causes water stress to plants, especially in dry periods. Experiments in different regions of the world have shown that increased temperatures reduce crop yields and increase production costs. Vegetables whose edible part is fruit (peppers, cucumbers, pumpkin, tomatoes, eggplant, etc.) They are particularly sensitive to heat stress, which leads to a decrease in production and a deterioration in its quality [4].

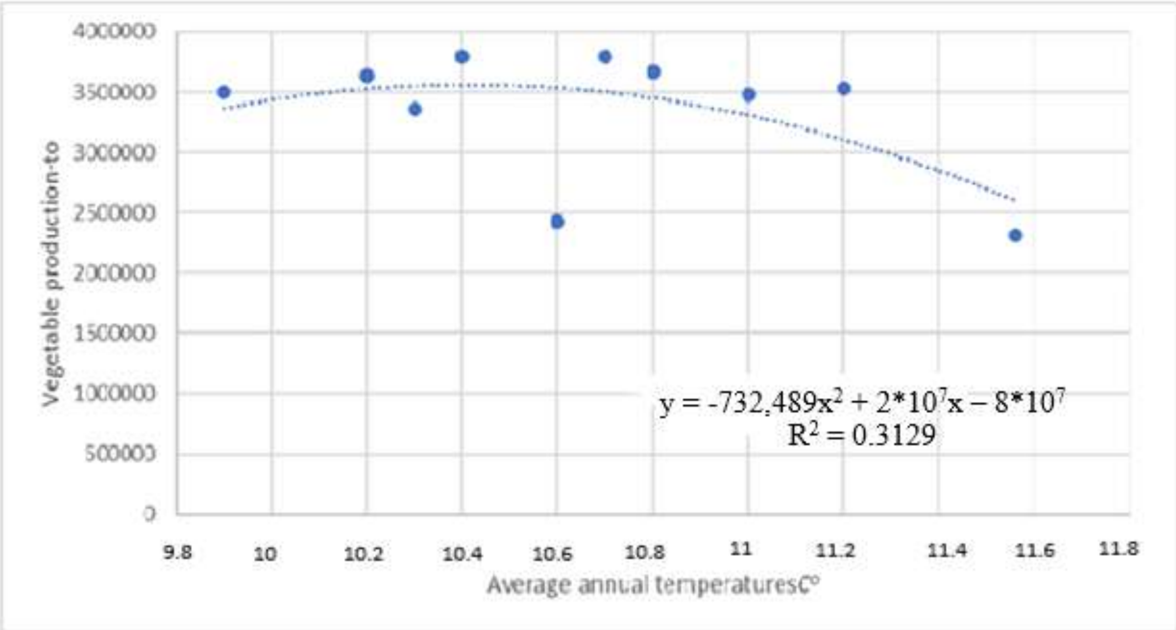

Fig. 4. Influence of average annual temperatures on vegetable production in 2015-2023
Source: own processing based on the data from [21, 22].

In order to analyze the influence of temperatures on vegetable production, NIS statistical data were used for these indicators in the period 2015-2023. The average annual air temperature had a general trend of increasing by about 1.18% annually, so that in 2023 it reached 11.56°C, 0.76°C more than in 2015.

Figure 4 illustrates the relationship between variations in average annual temperatures and vegetable production over the last 9 years, highlighting trends and the impact of climate change on vegetable growing. The trend line described by the equation $y = -732,489x^2 + 2*10^7x – 8*10^7$, shows that temperatures have a positive effect on production until an optimal point is reached. After this threshold, the excessive increase in temperatures causes a decrease in vegetable production.

The value of the coefficient of determination $R^2 = 0.3129$ indicates that approximately 31.29% of the variation in production is explained by temperature. This value suggests a moderate influence of temperature on production, and there are other important factors that contribute to its variations and are not included in the model, such as soil characteristics, irrigation methods, rainfall level and other technological and agricultural management factors.

Influence of precipitation

As global warming progresses, soil moisture and precipitation patterns will undergo significant changes. Climate projections indicate changes in precipitation patterns, both in intensity and frequency, leading to increased evaporation. While some areas will become wetter, others will experience soil moisture loss, increased erosion, and prolonged drought [5]. These changes will directly affect agriculture, a sector that uses approximately 72% of the world's freshwater extraction [6].

Water is a vital resource for agriculture, providing the soil moisture needed at different stages of plant growth. It optimizes plant metabolic processes, promotes efficient nutrient uptake, and supports root system development. Under water stress, crops undergo significant physiological changes that affect growth, leaf number, and yield [24].

Globally, water is becoming a scarce resource, disproportionately affecting regions prone to water scarcity. Many small farms, which produce over 70% of the world's food [25], are located in regions with limited access to irrigation, of which less than a third have the necessary infrastructure [33].

Studies show that climate change has an unequal impact, affecting developing countries more because resources are more limited and the capacity to adapt is lower. This amplifies the uncertainty of food supply and destabilizes markets [14, 36].

In Romania, agriculture is deeply dependent on weather conditions, and fluctuations in precipitation have a significant impact on production. In recent years, our country has experienced periods of extreme drought followed by intense floods, both of which have devastating effects on soil and crops. During periods of drought, plants suffer from water stress, and in years with excessive precipitation, floods degrade soil quality and destroy crops.

After 2000, farmers in various regions have observed a decrease in the number of rainy days and an increase in daily temperatures. Research indicates that the main barriers to adaptation to climate change are limited access to financial resources and infrastructure [28, 30]. In this context, adaptation to new climatic conditions has become a priority for farmers and policymakers [14].

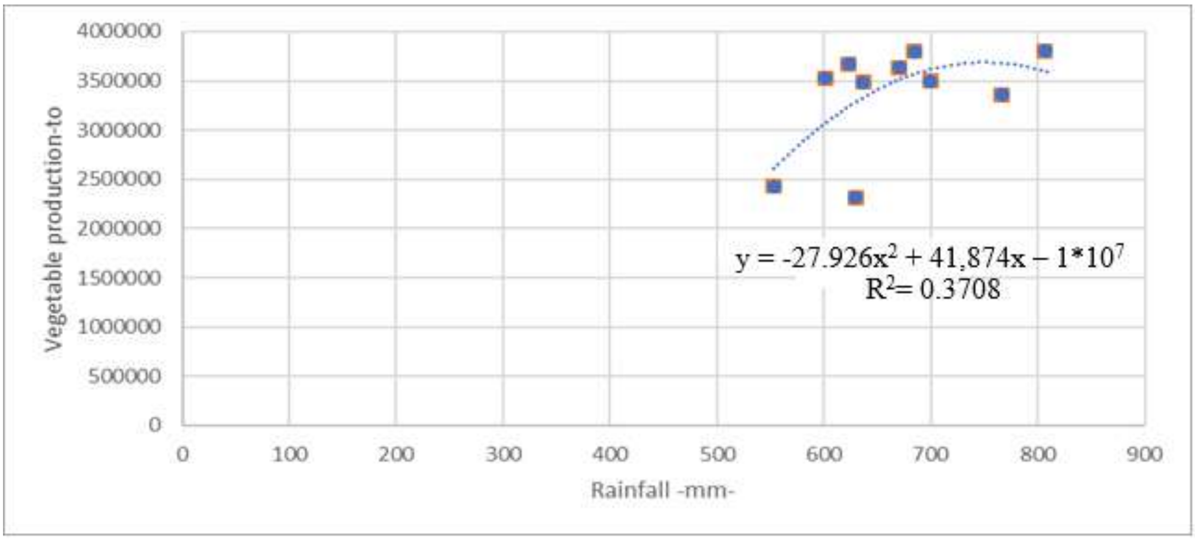

Fig. 5. Influence of rainfall on vegetable production in 2015-2023
Source: own processing based on the data from [21, 22].

In order to analyze the influence of the amount of precipitation on vegetable production, the statistical data of the NIS for these indicators in the period 2015-2023 were used. The average annual amount of precipitation has been on a downward trend in recent years, with a reduction of about 2.71% per year. In 2022, the amount of precipitation reached a minimum of 553.2 mm, a year marked by difficult climatic conditions for agriculture. Even though there was a slight increase in precipitation in 2023 (629.76), its level remains significantly lower than in 2016, when the maximum of 766.1mm was recorded.

As in the case of temperatures, Figure 5 described by the equation $y = -27.926x^2 + 41{,}874x - 1*10^7$ indicates the positive effect of precipitation on production up to an optimal point, after which excess precipitation begins to negatively affect production.

The value of $R^2 = 0.3708$ indicates that only 37.08% of the production variations can be explained by the rainfall regime, the rest being influenced by other factors.

CONCLUSIONS

The study highlights the importance of vegetables both as an essential source of food and as a valuable economic element, but which are also very sensitive to climate change. The analyzed data indicate a trend of rising temperatures, and rainfall is decreasing, factors that directly affect agriculture. Very high temperatures and uneven rainfall distribution have significantly influenced the yield of vegetable crops, this statement has also been confirmed by scientific research in the field of agricultural economics.

The results of this study show the existence of a direct link between climate variations and vegetable production, influenced by other factors, such as: soil quality and irrigation methods, which play a key role in the development of vegetable crops. This situation highlights the complexity of the relationship between the agricultural sector and climate change and the need to develop additional studies for an in-depth understanding of the interaction between natural and agronomic factors.

Adapting the vegetable sector to climate change is imperative to ensure sustainability and food security. It is also necessary to adopt a more efficient management of water resources, especially through sustainable irrigation and innovative technologies for crop protection.

Thus, to ensure sustainable agricultural production, measures must be adopted that include the development of varieties resistant to climate change.

In conclusion, the study highlights the importance of a deep understanding of the relationship between climate variability and crop dynamics to protect the agricultural sector and ensure sufficient food resources in the long term.

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A DECADE OF RURAL TOURISM IN ROMANIA (2013-2023) AND THE POTENTIAL OF EMERGING TECHNOLOGIES FOR SUSTAINABLE DEVELOPMENT

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Abstract

This study is examining the evolution of rural tourism in Romania from 2013 to 2023, focusing on the factors contributing to its growth. Based on data from the National Institute of Statistics, rural tourist accommodations increased by 23% for tourist guesthouses and by 118.8% for agro-tourist guesthouses over the decade. Tourist arrivals in agro-tourist guesthouses more than doubled, with Romanian tourists increasing by 168.6%. Despite the challenges posed by the COVID-19 pandemic, the sector demonstrated resilience and continued growth, with slow fluctuations over the Covid-19 period. The study also briefly touches on how emerging technologies, such as virtual reality or 360-degree videos, could enhance tourist experiences and support the sustainable development of rural areas, ensuring that Romania remains competitive on the global tourism market.

Key words: *rural tourism, agro-tourism, Romania, sustainable development, virtual reality*

INTRODUCTION

In 2023, the valuation of the global rural tourism was $102.7 billion. From 2023 to 2033, it is forecast to have 6.8% compound annual growth rate (CAGR), potentially reaching a value of around $198.3 billion by the end of that period [9].
In 2023, Romania's whole tourism sector represented 4.19% of the country's gross domestic product (GDP) and it is projected to increase to an estimated 5.71% by 2028, a rise of 1.5 percentage points [29]. This suggests that future growth may be quite gradual [29]. With this slow increase of only 1.5%, it can be concluded that there is significant room for improvement and development, especially in the current context, the era of rapid digitalization and accelerated global communication.
In Romania, in the pandemic years, 2020-2023, rural tourism sector received particular attention but as early as 2015, the Ministry of Agriculture and Rural Development recognized its importance and highlighted in the publication "România Rurală - Rețeaua Națională de Dezvoltare Rurală" (The National Network of Rural Development) that Romanian rural tourism has been steadily gaining popularity, both among domestic tourists and foreign visitors [23]. This trend indicates the need for higher focus on rural sector so that it can maximize its potential. Rural tourism is a form of tourism activity that focuses on providing visitors with experiences in non-urban areas, situated in the plains, hilly and mountain of a rare beauty of the landscapes [19], involving a variety of nature-based activities, agricultural interactions and cultural exchanges. It promotes local economic growth, contributes to job creation and encourages the dispersal of tourist demand across different times and regions, helping to reduce seasonality [33].
Rural tourism in Romania has significant potential due to its ability to attract tourists through specific motivations such as contact with nature and culture (The Carpathian Mountains, Danube Delta, Transylvania due to its picturesque landscape or Bucovina known for its painted monasteries, such as Voronet Monastery and Moldovița Monastery) or the desire for tranquillity,

making it a growing alternative to conventional tourism. This form of tourism contributes also to the preservation of local traditions, environmental sustainability and offers tourists a unique connection to the past while enjoying modern comforts. With a rural area of 208,068 km², representing approximately 87% of the territory and a population of 9.08 million in 2022, the rural space is a vital resource for tourism development, holding significant potential [24]. In the same report, it is mentioned that studies indicate that over 80% of Romanian communes have medium or high tourism potential, many of which have access to unique natural resources and important historical sites [24]. Another important aspect is related to what a strategic document developed through a collaboration between the central public authority responsible for tourism development (at that time, the Ministry of Tourism), the General Secretariat of the Government (SGG) and the World Bank (WB) says. The document identifies nature and adventure tourism, including ecotourism and rural tourism, as one of the four main segments that can attract more spending from foreign tourists and result in a longer average duration of their stays (holidays, trips, journeys etc.) [25].

Rural tourism can also contribute to job creation and incomes as it has the potential to generate significant employment in Romania, particularly in regions that have limited economic opportunities.

A key consequence of permanent emigration and rural-to-urban migration in Romania is the increasing age of the population and the isolation of rural communities, largely due to a lack of employment opportunities and widespread underemployment [10].

Promotion of local products and crafts could be an answer to support local business and preserve traditional crafts and practices. According to a study made in 2021, many tourists are drawn to experiencing local products during their travels, whether it's sampling dishes made from regional ingredients or buying packaged versions to take home as special souvenirs. Food-based attractions that highlight traditional and regional flavours have become popular, often serving as a key reason for visiting these areas [12].

The development of rural tourism in Romania is sustained by a continuous growth in the number of tourist and agri-tourist guesthouses [4, 5] and the support offered by European specific programmes [16].

To have an even more advantageous promotion of rural tourism in Romania, it is necessary to keep pace with the rapid advancements in emerging technologies. We have to swiftly adapt to and adopt the digital transition that happens all over the world in order to keep Romania competitive on the global tourism market. Among the emerging technologies, virtual reality demonstrates significant potential for introducing innovative and diverse features in the tourism industry that can bring benefits to both tourists as well as businesses [32, 20, 11, 3].

As innovative formats gain popularity, new economic models are taking shape. The travel experiences of the future will likely blend both online and offline elements [22]. Rather than choosing between virtual or physical experiences, it is highly probable to see an increase in hybrid offerings where virtual events, educational entertainment (edutainment) and sources of inspiration seamlessly integrate with visits to physical destinations [22]. Virtual reality is highly connected with metaverse, augmented reality and artificial intelligence [6] and it has gained quite a lot of attention due to Covid 19 period [18]. In a highly cited paper (with over 1,000 citations) titled Virtual Reality: Applications and Implications for Tourism, the author, Daniel A. Guttentag, defines virtual reality as a computer-generated, three-dimensional environment in which users can navigate and engage within a simulated environment, even activating our senses [14].

Virtual reality (VR) technology and tourism, translated in virtual tourism, can simulate real travel experiences or environments, offering exploration and interaction with destinations worldwide in a remote manner but in the same time, creating the sense of presence and reality. One important factor is that this combination of virtual reality and tourism can be used in different sectors that are connected with tourism industry, including marketing, logistic, education, heritage preservation and can be seen, not necessary as a replacement of real travel but rather, an alternative that can be on hand in various circumstances in which physical travel is not possible [14].

More than this, a research firm states that the global virtual tour market, valued at $0.96 billion in 2023, is projected to grow at a CAGR of 27.9%, reaching $17.88 billion by 2035 [1]. This financial forecast shows that virtual reality technology has a lot of promise in tourism market, creating more likely new patterns in terms of businesses, tourist options and technologies.

In this context, one of the main challenges that can be seen as a global issue is the fact that it is an unequal internet distribution and access, particularly in isolated areas which most of the time are rural areas. In this regard however there are a few studies [36, 30, 21,17] which showcase the ongoing bottlenecks in rural internet connectivity and the ways these gaps can be filled.

Nevertheless, in an era of digital connectivity, these gaps can actually become opportunities for further and faster development and in the same time, inclusion for technology access.

It is necessary for Romania to develop at fast pace, the infrastructure to support the integration of rural populations into the digital ecosystem, especially because half of Romania's population (9 million people) is living in rural areas [24]. Realising that, Romania can assure competitivity in sectors like tourism, agriculture, nature conservation, positioning itself as a strong competitor on European and global markets.

In this context, the paper aimed to analyze the evolution of rural tourism in Romania from 2013 to 2023, regarding accommodation capacity in tourist and agro-tourist guesthouses, its fluctuations over the Covid-19 period and also to quantify how the emerging technologies, such as virtual reality or 360-degree videos, could enhance the sustainable development of this type of tourism.

MATERIALS AND METHODS

The study employed quantitative and qualitative methods to analyse the evolution of rural tourism in Romania from 2013 to 2023. For the quantitative data, we used the National Institute of Statistics Tempo Online Datasets. [26]. A time-series analysis was conducted to observe and compare rural tourism growth trends. The collected data were processed and visualized in the form of tables and graphs to identify trends, patterns and correlations. The figures illustrate the dynamics of tourist arrivals, overnight stays, accommodation capacities, providing a clearer visualization of the rural tourism landscape in Romania.

The qualitative approach was made through examining global emerging technologies platforms, mainly virtual reality and 360-degree videos (surround video), to identify their potential for enhancing rural tourism experiences, focusing on accessibility, sustainability and cultural preservation. The integration of qualitative findings from VR technology studies was used to support the discussion on future applications in Romania's rural tourism sector.

RESULTS AND DISCUSSIONS

Dynamics of rural accommodations in Romania over a decade (2013-2023)

Table 1 shows the situation of tourist and agro-tourist accommodation classification in Romania over the period from 2013 to 2023. Tourist guesthouses increased from 1,335 in 2013 to 1,642 in 2023, representing a growth of 23%. In particular, 3-star tourist guesthouses consistently maintained the largest share, rising from 737 in 2013 to 1,007 in 2023, representing 36.6% increase with 270 more accommodations over ten years.

On the other side, agro-tourist guesthouses saw important growth, with the total number rising from 1,598 in 2013 to 3,498 in 2023, reaching 118.8% increase. Agro-tourist guesthouses saw increases at almost all categories, for example, 2 daisies, from 597 accommodations in 2013 to 832 accommodations, resulting 235 more accommodations over a decade and 5 daisies, from 15 to 90 accommodations from 2013 to

2023, resulting 75 more accommodations for the same period (Table 1).

Table 1. Rural tourist accommodation facilities categorized by types and comfort levels, Romania (2013-2023)

Type of accommodation	Comfort category	Years										
		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
		Number										
Tourist guesthouses	Total	1,335	1,323	1,527	1,530	1,666	1,709	1,669	1,729	1,745	1,696	1,642
	5-star	14	11	15	15	22	22	20	17	20	24	24
	Weight %	1.1	0.8	1.0	1.0	1.3	1.3	1.2	1.0	1.2	1.4	1.5
	4-star	131	136	161	192	205	202	199	201	247	257	207
	Weight %	9.8	10.3	10.5	12.6	12.3	11.8	11.9	11.6	14.2	15.2	12.6
	3-star	737	748	893	894	984	1,001	997	1,044	1,043	973	1,007
	Weight %	55.2	56.5	58.5	58.4	59.1	58.6	59.7	60.4	59.8	57.4	61.3
	2-star	394	368	404	377	417	443	411	427	393	404	373
	Weight %	29.5	27.8	26.5	24.6	25	25.9	24.6	24.7	22.5	23.8	22.7
	1-star	58	57	52	50	36	38	42	37	39	36	29
	Weight %	3.6	3.4	2.7	2.5	1.4	1.3	1.5	1.2	1.1	1	0.8
	Not rated by stars	1	3	2	2	2	5	:	3	2	2	2
	Weight %	0.1	0.2	0.1	0.1	0.1	0.2	:	0.1	0.1	0.1	0.1
Agro-tourist guesthouses	Total	1,598	1,665	1,918	2,028	2,556	2,821	2,800	3,022	3,460	3,484	3,498
	5-daisy	15	20	19	19	26	35	35	49	49	55	90
	Weight %	0.9	1.2	1	0.9	1	1.2	1.3	1.6	1.4	1.6	2.6
	4-daisy	159	177	214	229	261	298	293	318	368	389	428
	Weight %	9.9	10.6	11.2	11.3	10.2	10.6	10.5	10.5	10.6	11.2	12.2
	3-daisy	769	837	1,021	1,129	1,470	1,627	1,648	1,794	2,081	2,093	2,097
	Weight %	48.1	50.3	53.2	55.7	57.5	57.7	58.9	59.4	60.1	60.1	59.9
	2-daisy	597	579	607	598	743	801	767	809	902	887	832
	Weight %	37.4	34.8	31.6	29.5	29.1	28.4	27.4	26.8	26.1	25.5	23.8
	1-daisy	58	52	57	53	56	60	57	52	60	60	51
	Weight %	3.6	3.1	3	2.6	2.2	2.1	2	1.7	1.7	1.7	1.5

Source: Calculation based on data from NIS Tempo Online, TUR101B [26].

These results indicate that there are positive signs of the strengthening of rural tourism infrastructure in Romania over the last decade, despite challenging times like Covid-19 pandemic (2020-2023). The increases may also reflect growing investments in rural infrastructure and a shift in tourist preferences towards more comfortable and quality-driven rural tourism experiences.

Analysing the data on overnight stays in 2013 versus 2023 (Table 2), it can be observed that the highest percentage growth occurred in 5-star tourist guesthouses, from 13,065 tourists in 2013 to 37,429 in 2023, growth of 186.4%, although in terms of absolute numbers, 3-star guesthouses experienced the largest increase in 2023, reflecting a preference for more affordable yet comfortable accommodations. Agro-tourist guesthouses also showed substantial growth, particularly in the 5-daisy category, with an increase of 422.8%, while 4-daisies increased by 217.3% among Romanian tourists, indicating a significant rise in demand for high-comfort rural tourism. Conversely, lower comfort categories, such as 1-star tourist guesthouses and 1-daisy agro-tourist guesthouses, saw declines. For example, foreign tourists in 1-star guesthouses experienced an 81.4% decrease, suggesting a shift in preferences towards higher-quality rural accommodations over the decade (Table 2). One of the most notable components of the table is the "Not rated by stars" category for Romanian tourists in tourist guesthouses, which has seen a significant growth rate of 1,934.82%, growing from just 402 tourists in 2013 to 8,178 in 2023. This increase could suggest that a significant number of tourists are now choosing accommodations that are not formally rated, which could indicate a growing demand for more informal or unconventional accommodations, such as family-owned guesthouses or boutique rural stays that do not conform to standard star rating systems (Table 2).

Table 2. Growth rate of overnight stays (2013 vs 2023) by accommodation type, comfort level and tourist category, Romania

Type of accommodation	Comfort category	Type of tourists	Year		Growth rate 2013 vs 2023 (%)
			2013	2023	
			Number		
Tourist guesthouses	5-star	Romanian	13,068	37,429	186.40
	-	Foreign	5,937	5,745	-3.23
	4-star	Romanian	139,860	359,242	156.85
	-	Foreign	34,599	31,340	-9.41
	3-star	Romanian	636,455	1,040,883	63.54
	-	Foreign	79,298	90,345	13.93
	2-star	Romanian	233,610	227,745	-2.51
	-	Foreign	23,099	17,936	-22.35
	1-star	Romanian	29,792	16,240	-45.48
	-	Foreign	1,059	197	-81.40
	Not rated by stars	Romanian	402	8,178	1,934.32
	-	Foreign	21	1,769	8,323.80
Agro-tourist guesthouses	5-daisy	Romanian	18,368	96,033	422.82
	-	Foreign	2,524	4,280	69.57
	4-daisy	Romanian	152,392	483,490	217.26
	-	Foreign	17,886	16,953	-5.21
	3-daisy	Romanian	476,854	1,493,494	213.19
	-	Foreign	40,708	69,718	71.26
	2-daisy	Romanian	241,086	314,648	30.51
	-	Foreign	23,113	32,967	42.63
	1 daisy	Romanian	21,433	16,033	-25.19
	-	Foreign	2,111	1,436	-31.97

Source: Calculation based on data from NIS Tempo Online, TUR105B [26].

Overall number of places increased by 41.79%, from 305,707 in 2013 to 433,487 in 2023. Tourist guesthouses saw a 24.17% rise, reaching 33,930 places in 2023, up from 27,325 in 2013 (Table 3).

Table 3 Number of places in rural guesthouses, Romania (2013-2023)

Year	Total number of places in Romania	Total number of places in tourist guesthouses - Romania	Total number of places in agro-tourism guesthouses - Romania
2013	305,707	27,325	28,775
2014	311,288	27,295	30,480
2015	328,313	32,051	35,188
2016	328,888	32,602	37,394
2017	343,720	34,816	44,499
2018	353,835	35,823	48,574
2019	356,562	35,198	49,053
2020	358,119	35,312	52,389
2021	410,291	35,387	55,778
2022	422,114	34,587	56,850
2023	433,487	33,930	58,086
Growth rate 2013 vs 2023 (%)	41.79	24.17	101.86

Source: Calculation based on data from NIS Tempo Online, TUR102C [26].

From 28,775 in 2013 to 58,086 in 2023, a growth of 101.86%, is related to the number of places in agro-tourist guesthouses. This can be seen as a positive indicator that agro-tourism became more popular over the analysed ten years.
As seen in Figure 1, the portion attributed to tourist guesthouses has declined over the analysed decade; from 8.94% in 2013 to 7.83% in 2023 though in the timeframe 2015-2020 had fluctuations between 9% and 10% showing promising to develop more, once Covid-19 pandemic period started, the decrease went to under 8%. On the other hand, the share of agro-tourist guesthouses shows a clear upward trend, rising from 9.41% in 2013 to 13.4% in both 2022 and 2023, noticing though that in 2020, when Covid-19 started, there was a peak of 14.63%. While tourist guesthouses have become a slightly smaller portion of the overall accommodation options, agro-tourist guesthouses have seen increased prominence, potentially reflecting growing demand for rural tourism experiences. The steady rise in agro-tourist guesthouses, particularly after 2016, highlights the increasing preference for rural stays, thus reaching 14.63% in 2020 and going a little bit down in 2023, to 13.4% (Figure 1).

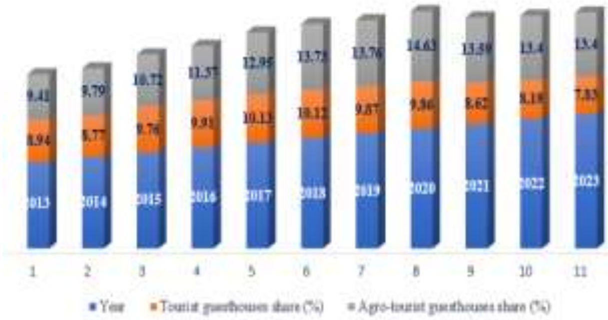

Fig. 1. Share of accommodation places in tourist and agro-tourist guesthouses as a percentage of the total accommodation capacity in Romania, 2013-2023.
Source: Author's analysis using data from the NIS, Tempo Online Database, TUR102C [26].

Table 4 highlights an uptrend in tourist arrivals in all accommodation types in Romania between 2013 and 2023.
For instance, Romanian tourist arrivals in all accommodation types rose from 6.2 million in 2013 to nearly 11.8 million in 2023, showing substantial increase.
A similar trend can be observed for foreign tourists, with arrivals climbing from 1.7 million in 2013 to 2.1 million in 2023. In tourist guesthouses specifically, the number of Romanian tourists increased from 590,069 in 2013 to 961,547 in 2023, reflecting a growth of over 60%, peaking at 1,133,674 tourist arrivals in 2019.
Agro-tourist guesthouses saw even higher growth, with Romanian tourist arrivals more than doubling from 463,563 in 2013 to 1,245,163 in 2023, the highest growth. Foreign tourists, though a smaller share, also showed significant increases in both types of rural accommodations.
This overall rise in tourist arrivals, particularly in rural guesthouses, underscores a growing interest in rural tourism over the analysed decade.
Table 5 shows that Romanian tourist arrivals in tourist guesthouses grew by 62.95%, from 590,069 in 2013 to 961,547 in 2023. In agro-tourist guesthouses, Romanian arrivals have risen by 168.6%, from 463,563 to 1,245,163. Foreign tourist arrivals in agro-tourist accommodations have grown 61.11%.

Table 4. Yearly tourist arrivals all accommodation types versus rural guesthouses, Romania (2013-2023)

Year	Type of tourists	Tourist arrivals in all accommodation types	Tourist arrivals in tourist guesthouses	Tourist arrivals in agro-tourist guesthouses
2013	Romanian	6,225,798	590,069	463,563
	Foreign	1,717,355	63,395	38,183
2014	Romanian	6,551,339	635,182	507,868
	Foreign	1,914,570	68,947	41,434
2015	Romanian	7,681,896	806,696	622,187
	Foreign	2,239,978	92,798	50,569
2016	Romanian	8,521,698	912,982	748,320
	Foreign	2,480,824	107,624	65,134
2017	Romanian	9,383,266	1,035,214	917,213
	Foreign	2,760,080	122,451	87,187
2018	Romanian	10,108,509	1,114,622	1,083,662
	Foreign	2,796,622	119,673	89,793
2019	Romanian	10,691,195	1,133,674	1,171,790
	Foreign	2,683,748	120,802	101,088
2020	Romanian	5,944,775	636,920	745,535
	Foreign	453,867	17,477	9,901
2021	Romanian	9,326,348	858,062	1,061,917
	Foreign	878,974	35,797	25,410
2022	Romanian	10,914,023	917,722	1,139,724
	Foreign	1,674,310	59,972	41,975
2023	Romanian	11,790,888	961,547	1,245,163
	Foreign	2,120,068	75,928	61,520

Source: NIS Tempo Online, TUR104B [26].

Table 5. Tourist arrivals at Romanian tourist and agro-tourist guesthouses: comparison between 2013 and 2023 (%)

Tourist arrivals	2013	2023	Growth rate 2013 vs 2023 %
Romanian - Tourist Guesthouses	590,069	961,547	62.95
Foreign - Tourist Guesthouses	63,395	75,928	19.76
Romanian - Agro-Tourist Guesthouses	463,563	1,245,163	168.60
Foreign - Agro-Tourist Guesthouses	38,183	61,520	61.11
Total - Tourist Guesthouses	653,464	1,037,475	58.76
Total - Agro-Tourist Guesthouses	501,746	1,306,683	160.42

Source: Calculation based on data from NIS Tempo Online, TUR104B [26].

There is a significant rise in tourist arrivals in all accommodation types between 2013 and 2023 (Figure 2), particularly among Romanian tourists. In 2013, there were 6,225,798 Romanian tourist arrivals, which surged by nearly 89% to reach 11,790,888 in 2023. Foreign tourist arrivals also grew, although at a slower rate, increasing by about 23%, from 1,717,355 in 2013 to 2,120,068 in 2023. When focusing on guesthouses, Romanian tourist arrivals rose by 63%, from 590,069 in 2013 to 961,547 in 2023, with a peak of 1,133,674 in 2019. An interesting aspect is that for the years 2013 and 2023, the percentage of tourist arrivals in guesthouses compared to all accommodation types shows a slight decrease, in 2013, 9.48% of tourist arrivals were in guesthouses though in 2023, this percentage went down to 8.16%. A smaller proportion of tourists in 2023 have chosen guesthouses compared to 2013, despite the overall increase in tourist arrivals. A more modest increase of around 20%, was seen in foreign tourist arrivals in guesthouses from 63,395 to 75,928 in the same period. These figures highlight a growing domestic tourism market, with Romanians showing a particularly strong preference for guesthouse stays, while foreign interest, though growing, remains smaller (Figure 2).

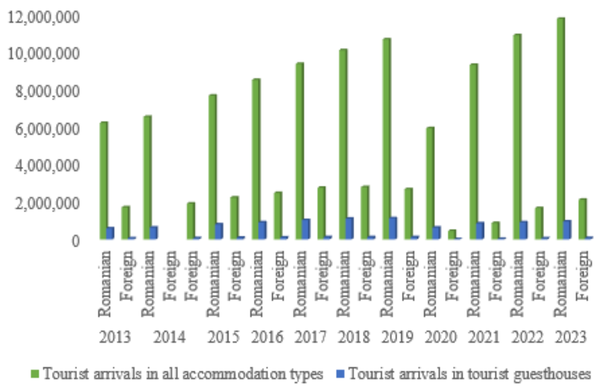

Fig. 2. Tourist arrivals in all accommodation types versus tourist guesthouses, by tourist type, Romania (2013-2023)
Source: Author's analysis using data from NIS Tempo Online, TUR104B [26].

In agro-tourist guesthouses, Romanian tourist arrivals were rising from 463,563 in 2013 to 1.2 million in 2023, an increase of 168%. Foreign tourist arrivals also grew, from 38,183 in 2013 to 61,520 in 2023, a rise of about 61%. Pre-pandemic, the peak year for agro-tourist guesthouses was 2019. There were registered 1.17 million Romanian arrivals and 101,088 foreign arrivals.
In 2021, Romanian tourists' arrivals in agro-tourist guesthouses reached 1,061,917, from 745,535 in 2020, but after 2021, the growth was moderate, 1,139,724 in 2022 and 1,245,163 in 2023 (Figure 3).

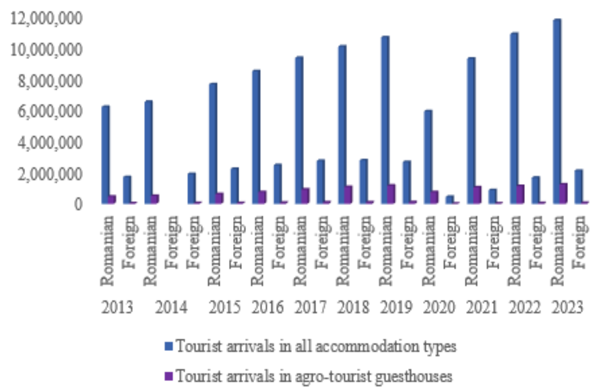

Fig. 3. Tourist arrivals in all accommodation types vs. agro-tourist guesthouses, by tourist type, Romania (2013-2023)
Source: Author's analysis using data from NIS, Tempo Online, TUR104B [26].

Table 6. Yearly overnight stays across all accommodation types versus tourist and agro-tourist guesthouses, Romania (2013-2023)

Year	Type of tourists	Overnight stays in all accommodation types	Overnight stays in tourist guesthouses	Overnight stays in agro-tourist guesthouses
2013	Romanian	15,884,817	1,053,187	910,133
	Foreign	3,477,854	144,013	86,342
2014	Romanian	16,511,937	1,128,686	990,179
	Foreign	3,768,104	144,428	91,342
2015	Romanian	19,047,701	1,454,948	1,256,092
	Foreign	4,471,639	209,585	112,900
2016	Romanian	20,609,141	1,640,386	1,457,163
	Foreign	4,831,816	241,364	140,776
2017	Romanian	21,801,487	1,855,827	1,750,354
	Foreign	5,291,036	257,693	178,131
2018	Romanian	23,315,138	1,995,894	2,068,888
	Foreign	5,329,604	233,569	186,398
2019	Romanian	24,795,253	2,087,156	2,318,252
	Foreign	5,290,838	237,061	200,353
2020	Romanian	13,581,775	1,162,688	1,494,216
	Foreign	997,365	39,009	21,089
2021	Romanian	20,823,029	1,537,893	2,041,720
	Foreign	1,924,533	67,873	48,061
2022	Romanian	23,377,839	1,638,934	2,183,949
	Foreign	3,666,533	115,454	81,684
2023	Romanian	25,186,916	1,689,717	2,403,698
	Foreign	4,504,676	147,332	125,354

Source: NIS Tempo Online, TUR105D [26].

Romanian tourists saw a steady increase in overnight stays, with numbers rising from 15,884,817 in 2013 to 25,196,116 in 2023. In tourist guesthouses, overnight stays increased from 1,053,187 in 2013 to 1,689,717 in 2023. In agro-tourist guesthouses, the same years, the numbers grew from 910,133 to 2,403,698. Foreign tourists overnight in agro-tourist guesthouses went from 86,342 to 125,354, indicating a growing preference for rural accommodation in the time frame of 2013-2023 (Table 6).

The most significant increase is seen among Romanian tourists staying in agro-tourist guesthouses, where overnight stays rose by 164.10%, from 910,133 in 2013 to 2,403,698 in 2023. Tourist guesthouses also saw substantial growth for Romanian visitors, with a 60.43% increase, reaching 1,689,717 in 2023. Although foreign tourists showed a smaller growth in tourist guesthouses, agro-tourist guesthouses had an increase of 45.18% (Table 7).

Table 7. Growth in tourist overnight stays at Romanian tourist and agro-tourist guesthouses: a comparison between 2013 and 2023 (%)

Tourist overnight stays	2013	2023	Growth rate 2013 vs 2023 %
Romanian - Tourist Guesthouses	1,053,187	1,689,717	60.43
Foreign - Tourist Guesthouses	144,013	147,332	2.30
Romanian - Agro-Tourist Guesthouses	910,133	2,403,698	164.10
Foreign - Agro-Tourist Guesthouses	86,342	125,354	45.18
Total - Tourist Guesthouses	1,197,200	1,837,049	53.44
Total - Agro-Tourist Guesthouses	996,475	2,529,052	153.79

Source: Calculation based on data from NIS Tempo Online, TUR105D [26].

There was a steady increase in overnight stays in all accommodation types for Romanian tourists, rising from 15.8 million in 2013 to 25.1 million in 2023, an increase of around 59%. In tourist guesthouses, overnight stays by Romanian tourists grew from 1.05 million in 2013 to 1.69 million in 2023, a 60% rise. Foreign tourists had a more moderate growth, with overnight stays in all accommodation types increasing by 30%, from 3.47 million in 2013 to 4.5 million in 2023. However, their stays in tourist guesthouses remained relatively stable, with only a 2.3% rise from 144,013 in 2013 to 147,332 in 2023. This suggests that while Romanian tourists increasingly opt for both types of accommodation, foreign tourists show slower growth in choosing tourist guesthouses (Figure 4).

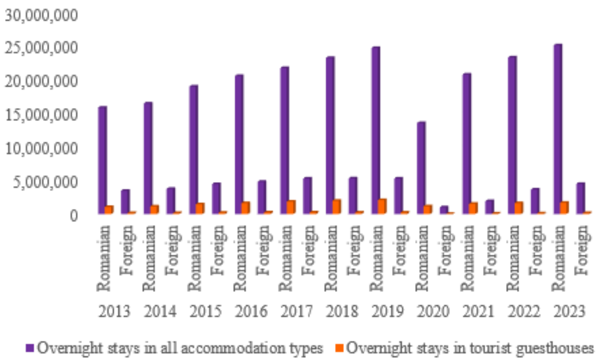

Fig. 4. Comparison of tourist overnight stays in all accommodation types versus tourist guesthouses, categorized by tourist type, Romania (2013-2023)
Source: Author's analysis using data from NIS, Tempo Online, TUR105D [26].

The examination of overnight stays from 2013 to 2023 across all accommodation types and tourist guesthouses reveals significant trends throughout the decade. In 2019, the total number of overnight stays reached its peak across all accommodations before the pandemic period (Covid-19), with 24,795,253 for Romanian tourists, showing a 6.3% increase from 2018. Similarly, tourist guesthouses also saw their peak in 2019, reaching 2,318,252 Romanian overnight stays, up from 2,068,888 in 2018. The foreign overnight stays in all accommodations saw a peak of 5,329,604 in 2018, while in tourist guesthouses, the peak was in 2019 with 200,353 foreign overnight stays, slightly higher than the 2018 figure of 186,398. However, the year 2020 reflected a sharp decline due to the pandemic, with Romanian overnight stays in all accommodations dropping to 13,581,775 and in tourist guesthouses to 1,494,216, considering that the last two previous years, 2019 and 2018, the Romanian tourist overnights spend in agro-tourist guesthouses was more than two million stays. The decrease was most probably caused by the travel restrictions imposed by Covid-19 pandemic. In 2023, the recovery started to be seen; 25,186,916 overnight stays - Romanian tourists in all accommodations and 2,403,698 in agro-tourist accommodations, suggesting that tourism demand is returning to pre-pandemic levels, in domestic rural tourism (Figure 5).

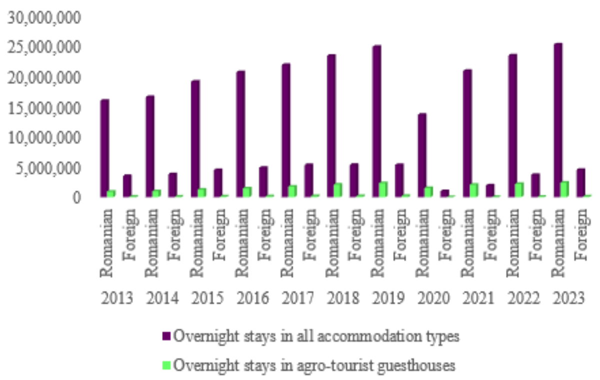

Fig. 5. Tourist overnight stays in all accommodation types vs. agro-tourist guesthouses, by tourist type, Romania (2013-2023)
Source: Author's analysis using data from NIS, Tempo Online, TUR105D [26].

Table 8. Rural tourist reception structures by ownership type and tourist numbers, Romania, 2013-2021

Types of tourist reception structures	Forms of ownership	Years								
		2013	2014	2015	2016	2017	2018	2019	2020	2021
		Number of people								
Tourist guesthouses	Total	653,464	704,129	899,494	1,020,606	1,157,665	1,234,295	1,254,476	654,397	893,859
	Integral state property	543	396	357	182	283	395	581	410	779
	Majority state property	:	:	:	:	:	:	180	104	85
	Mostly private property	801	669	475	665	287	308	538	1,148	2,669
	Entirely private property	627,577	682,318	875,761	998,892	1,134,130	1,210,116	1,230,862	641,170	873,172
	Cooperative property	1,317	1,189	1,368	3,151	2,165	2,941	1,878	547	229
	Public property	1,303	304	498	774	810	301	72	:	:
	Entirely foreign property	20,405	18,386	19,069	15,049	18,012	17,779	18,643	10,368	16,357
	Public property of national and local interest	1,518	867	1,766	2,113	1,978	2,455	1,743	650	588
Agro-tourist guesthouses	Total	501,746	549,302	672,756	813,454	1,004,400	1,175,455	1,272,878	755,436	1,087,327
	Integral state property	1,571	1,798	2,742	3,237	2,766	4,668	6,956	2,401	3,497
	Majority state property	:	361	684	794	569	648	424	366	:
	Mostly private property	562	306	94	:	:	:	:	:	:
	Entirely private property	477,991	524,711	649,167	789,385	971,939	1,137,317	1,230,497	732,821	1,053,236
	Cooperative property	6,496	9,345	5,763	5,266	4,738	5,276	5,303	1,264	860
	Public property	1,337	1,870	1,822	1,297	1,385	1,696	1,689	636	1,347
	Entirely foreign property	12,974	10,142	11,385	12,164	21,681	22,512	26,492	17,218	27,369
	Public property of national and local interest	815	769	1,099	1,311	1,322	1,338	1,517	730	1,018

Source: NIS Tempo Online, TUR104A [26].

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Table 8 presents the overall number of tourist guesthouses which increased from 653,464 in 2013 to 893,859 in 2021. Guesthouses owned entirely by private entities saw a significant increase, growing from 627,577 tourists in 2013 to 873,172 in 2021, with peaks in 2017, 2018, 2019, over 1 million people, highlighting the dominance of private ownership in the sector. Meanwhile, foreign-owned tourist guesthouses experienced fluctuations but overall stable numbers - 20,405 tourists in 2013, marking the biggest number of people for 2013-2021 timeframe. Agro-tourist guesthouses also proved growth, with total number of tourists rising from 501,746 in 2013 to 1,087,327 in 2021. The most substantial increase was seen in entirely private-owned agro-tourist guesthouses, which attracted 477,991 tourists in 2013 and surged to 1,053,236 tourists by 2021, indicating strong growth in rural tourism under private ownership. These patterns suggest a clear positive trend toward the privatization of rural tourist accommodation facilities.

Preliminary conclusions

Based on the analysis utilizing data from the National Institute of Statistics' Tempo Online Database, though in some aspects the numbers are encouraging, especially in domestic rural tourism, it can be said that there is plenty of space to become more competitive on the international rural tourism market and be even more attractive for foreign tourists.

Romania has spectacular places in all parts of the country, Maramureș, Dobrogea, Bucovina, Transilvania, that can not only bring more foreign tourists and prolong their stays but can also improve the life quality of locals and rural communities. In this sense, it is imperative to start aligning rural tourism, including here, farm tourism, eco-tourism, nature-based tourism, community tourism with the emerging and advanced technologies such as virtual reality, augmented reality, mixed reality, artificial intelligence, blockchain, for a sustainable rural tourism development and a top place on the rural tourism global arena. If Romania does not start now, it will not be able to keep pace with the fast development of technology and will lose momentum in the global tourism market.

In this context, rural tourism requires innovation and adaptation to new technologies.

Virtual reality (VR) has proven to be a transformative tool in tourism by breaking barriers and offering immersive experiences to potential travellers. While the primary function of VR is to offer immersive, borderless travel, the applications and benefits for rural tourism can be viewed through various lenses.

Below, we explore five key benefits that VR can bring to rural tourism in Romania, supported by global examples of successful VR projects.

Integrating emerging technologies in rural tourism: 5 important takeaways from active 360-Degree and virtual reality projects

Based on a simple search made on October 2, 2024, using the key words “virtual tourism” in the Web of Science database, it could have been noticed that virtual reality started to gain significant attention in the tourism industry starting with 2010, with a notable increase in research and application from around 2015 onwards. Though there are not many scientific papers at the intersection of virtual tourism and rural tourism [13, 31], this is understandable due to the fact that the infrastructure of virtual reality technology is still in early-stage of development.

Taking all these conditions, we can analyse some successful global examples that could serve as inspiration for Romania’s rural tourism. The objective is to identify five key insights that could support the sustainable growth of rural tourism in Romania, both domestically and internationally, through the integration of virtual reality and 360-degree videos to attract more tourists and enhance their experiences.

Takeaway 1: Creating immersive rural and nature-based experiences for tourists to pre-view destinations

Yosemite National Park, located in California, United States of America. Virtual Yosemite is a well-integrated virtual reality project that allows users to explore over 400 different locations within Yosemite National Park and its surrounding areas through interactive 360° tours (Photo 1). Created by virtual reality photographer Scott Highton, the project offers high-resolution panoramas that enable users to zoom in and pan around to explore details, providing an immersive experience for online visitors, offering detailed and accessible views of famous locations like Half Dome, Yosemite Falls, Mariposa Grove of Giant Sequoias, as well as less known places [34].

This infrastructure can be an important resource for people that want to see the travel destination before physically visiting it.

Photo 1. Yosemite National Park
Source: VirtualYosemite.org, https://www.virtualyosemite.org/virtual-tour/#node52 [34].

Using virtual reality technology, Romania can create digital platforms to present traditional villages, countryside, natural parks, creating a teaser for potential visitors who want to explore Romania's landscapes.

Piatra Craiului National Park, could benefit from virtual tours. Virtual reality could offer immersive 360-degree virtual tours of the Piatra Craiului Mountains, showcasing its sharp limestone ridges and unique biodiversity [27], similar to how Virtual Yosemite allows users to explore its sites. Virtual stops can be made so that remote visitors can learn and gain a comprehensive understanding of a location. This can include exploring historical background, geographical features, natural resources, cultural significance, thus offering a multifaceted perspective that encompasses past and present. Adopting virtual reality technology in this early-stage, Romania would be able to position itself as a forward-thinking destination.

Takeaway 2: Promoting education via tourism and digital accessibility

Subjects like history or geography can become more attractive to students and tourist if lessons are made virtually interactive. Through this tool, rural Romania can become even more accessible to a global audience in manners that the traditional tourism cannot.

ExpeditionsPro [7] is a UK-based platform created by Simon Fretwell, designed to continue the legacy of Google Expeditions after its discontinuation in 2021 (Photo 2). It was built with education in mind, enabling users to access the content on mobile devices or dedicated VR headsets. It has the possibility of creating personal virtual tours but also to choose from the existing library thus making it even more fast-accessible [28].

Photo 2. Create your own virtual tour
Source: https://expeditionspro.com/#!/up [7].

By combining education and virtual tours, Romania can boost rural tourism by developing 360-degree VR tours experiences for areas like Maramureș, Bucovina or Dobrogea, allowing users to explore local traditions, crafts and biodiversity. Of this instrument could also benefit the remote regions which are less accessible or less-known to global audiences. Being digitally accessible and more interactive and customisable, children or young adults can be attracted to learn, in an innovative manner, using their mobile phones, about Romania's rural landscapes and stories thus becoming more interested to explore them physically and, in the same time, to enrich their general culture.

Takeaway 3: Preserving and promoting cultural heritage through immersive virtual experiences

iHeritage, which focuses on augmented and virtual reality (AR/VR) experiences for UNESCO World Heritage sites offers immersive VR tours of famous cultural landmarks, such as Petra in Jordan (Photo 3), the Pyramids of Giza in Egypt, the Alhambra in Spain. These experiences provide a highly engaging way for users to explore cultural heritage through fully immersive, 3D virtual environments, enabling a deeper understanding of historical and cultural significance [15].

Photo 3. Petra, Jordan
Source: https://www.iheritage.eu/unesco-world-heritage/jordan-petra/ [15].

In Romania, UNESCO World Heritage Sites like Wooden Churches of Maramureș, the Painted Monasteries of Bucovina, the Dacian Fortresses of the Orăștie Mountains can be found in rural areas, thus being both geographically remote and vulnerable to time and climate effects.

Usually, UNESCO heritages are locations that must be protected due to several reasons from which can be mentioned the distinct architectural styles and historical importance. This protection involves weather impact, mass-tourism, isolation but through immersive virtual reality (VR) experiences, like those provided by iHeritage, these sites can be digitally preserved. Beyond this aspect, the virtual preservation allows global audiences to explore them without the risk of affecting them. In Romania, this virtual preservation can be made in locations such as Maramureș which is well known for its incredible wooden carvings and crafts. Similar to iHeritage platform, virtual reality platforms can be made so all these pieces of art to be digitally reconstructed, allowing visitors to see them virtually without the risk of physical deterioration. Integrating VR in rural tourism could also downsize the foot traffic in locations that are fragile thus supporting sustainable tourism and cultural access.

It would also enable the education of younger generations, teaching them about the cultural significance of these sites, ensuring that their heritage is passed down and appreciated.

Takeaway 4: Rural tourism through virtual reality for inclusion and accessibility

Wander platform offers both 360-degree immersive experiences and virtual reality (VR) functionality, allowing users to explore global locations using Oculus Quest headsets (Photo 4) thus moving it beyond just static 360-degree viewing [35].

Photo 4. Oculus Quest 2: Wander (Walk-through of How to use) and Virtually Travel with me!
Source: https://www.youtube.com/watch?v=bERzOl7TgnU, [2].

While it focuses on well-known sites, it could easily be adapted to feature rural tourism in Romania, showcasing remote villages, hiking trails, nature reserves in areas like Maramureș or Bucovina. Romania can leverage Wander-style VR to make rural destinations accessible to tourists with physical limitations or those living far away. It would offer broaden access tourism, making the country's hidden rural gems available to a broader audience.

Takeaway 5: Promoting agro-tourism through virtual reality

VR can offer immersive farm experiences, giving tourists the opportunity to explore rural farming environments, learn about agricultural practices, even participate in activities like virtual harvesting or animal care. This is particularly relevant for informing tourists on farm-to-table concepts, sustainability in agriculture or traditional farming methods. While there are not widely known VR platforms dedicated solely to agro-tourism yet, FarmVR [8] platform is an example that opens the path towards this concept. FarmVR (Photo 5) provides virtual reality services to businesses and individuals within the agriculture industry to help them promote their farms or agricultural practices. The platform offers tools such as 360-degree video production, virtual farm tours and interactive VR experiences that can be used for marketing, education or enhancing on-farm productivity [8].

Photo 5. Virtual Farm
Source: https://farmvr.com/ [8].

Using the FarmVR model, Romania can integrate VR into its agro-tourism industry, allowing farms to digitally promote their offerings, educate the public and create new revenue streams. Traditional Romanian farms could highlight wine production, shepherding, organic farming practices through virtual tours, expanding their reach to a broader global audience interested in rural and eco-friendly travel. Also, Romanian farms could participate in global agricultural events, sharing best practices and attracting tourists interested in authentic, immersive experiences of rural life.

CONCLUSIONS

As shown by the analysis in this paper, using data from the National Institute of Statistics, for the period 2013-2023, Romania's rural tourism registered growth in accommodation facilities, bookings and overnight stays, with domestic tourists leading the way. One significant growth in rural tourism accommodations is the category of agro-tourist guesthouses accommodations, which saw 118.8% increase over the decade. Despite challenges such as the COVID-19 pandemic, rural tourism infrastructure has expanded, particularly in more comfortable, higher-quality accommodations. The demand for rural destinations, driven by the desire for cultural, nature-based and tranquil experiences, were most probably the key factors contributing to this growth. Rural tourism holds the potential to strengthen the local economy, preserve cultural heritage and even promote environmental sustainability in Romania's countryside. Furthermore, the integration of emerging technologies like virtual reality (VR) presents a valuable opportunity to enhance the appeal of rural tourism. VR could enable tourists to pre-experience the rural destinations from Romania, to support education, accessibility and cultural preservation.

By adopting emerging technologies, Romania can showcase its unique rural landscapes, traditions, cultural sites, to a broader international audience. Examples like iHeritage, which digitally preserves UNESCO sites and FarmVR, which promotes agro-tourism businesses in Australia, provide practical applications for Romania to follow. Therefore, the convergence of tourism growth trends and emerging technologies indicates substantial opportunities for Romanian rural tourism to achieve sustainable development and global competitiveness.

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EVALUATION OF NGOs WITH AGRICULTURAL PROFILE FROM LEGAL AND MANAGERIAL POINT OF VIEW. CASE STUDY

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Abstract

The members of an associative structure contribute to its success, an aspect that must be taken into account from the very beginning of the establishment procedure, by co-opting the right persons, those creative, entrepreneurial persons with similar ideas, interests and needs, who see the association as an opportunity to do things better. The purpose of this paper is to analyze and interpret the perception of members of agricultural NGOs in Călărași county regarding the conduct of activities in the legal and managerial spheres, by surveying a number of 95 associated members coming from 21 agricultural associations in Călărași county, correlated with the influence of short and medium-term results and activities carried out on the members of these associative structures. In forming the research sample, the condition was established that the associative structure to be active, an aspect verified by submitting the balance sheet for the year 2023 and subsequently confirmed by telephone by representatives of these structures, when setting up a meeting to apply the questionnaire. In the analysis and interpretation of the information collected on the basis of the questionnaire, the theoretical χ2 test was used. Developing entrepreneurial culture, by facilitating access of the population in the rural communities to vocational training courses, information seminars, counseling and dissemination of information of real interest for the rural area, employment services, through viable partnerships between profile NGOs and local decision-makers can be a solution for the sustainable development of rural areas

Key words: *questionnaire, survey, legal, managerial, NGO, perspectives*

INTRODUCTION

At the European level, including in Romania, non-governmental organizations - NGOs have registered an evolution and recognition in recent years, through their involvement in rural development, through participation in the development of local strategies, through intervention with decision-makers and state institutions to defend the rights and interests of the groups of citizens they represent [14, 16].

The low participation and involvement of citizens in the socio-political life of their community is based on an old, undemocratic concept, which considers it is the obligation of the state to do everything for the development of the rural community [1,5]. That is why, emphasis must be placed on cooperation between public authorities, the private sector and NGOs, in a public-private partnership that proposes, develops and implements projects aimed at local development from an economic, social and cultural perspective [2, 6, 11].

The association expresses the relationships that are established between different entrepreneurs in the same field of activity in order to carry out a common, long-term action, to achieve a common goal, whatever it may be. This is the concrete form of manifestation of cooperation in a horizontal plane, and the relationship between cooperation and association is the relationship from part to whole. [3, 4, 18]. Beyond the advantages offered by belonging to an associative form, in Romania, it is necessary to overcome some barriers that stand in the way of the development of associative forms. These barriers relate to the existence, at the level of cooperatives, of members with their own behavioral traits, who have a certain level of education and professional training and who give up their individual beliefs with difficulty in order to think collectively and in the interest of all members [8,10,11].

Beyond these functional and social barriers, association and cooperation are modern forms of organizing the means of production and marketing, which can bring Romanian agriculture to the same level as European agriculture, and can help agricultural producers to meet the competitive demands of the market.

The members of an associative form must have common objectives and attitudes oriented towards tolerance, entrepreneurial spirit, generosity, the desire to know as much as possible and to be open to technology and the implementation of new, modern techniques for obtaining agricultural products.

Unlike other fields of activity, in the agricultural sector, the need for association is much greater, given the specifics of the activity, but also the multiple relationships that farmers establish upstream and downstream of agriculture. Their union in association forms helps them to have greater negotiating power in the relationships they establish with suppliers, buyers or authorities responsible for this field [4, 9].

In the near future, taking into account the remarkable evolution at the international level, civil society in our country will also have a much more important role than at present in rural development, but, although many organizations in this sphere actively participate in actions taken at the local, national and even international levels, their activity is not promoted properly [7, 18].

The purpose of this paper is to analyze and interpret the perception of members of agricultural NGOs in Călărași county regarding the conduct of activities in the legal and managerial spheres.

MATERIALS AND METHODS

A number of 95 associated members from 21 agricultural associations in Călărași county have been interviewed regarding the influence of short and medium-term results and activities carried out by the members of these associative structures.

The survey was based on a questionaire where the questions for members of agricultural associations were structured by two levels, respectively, 2 filter questions and 6 grid-type questions, with 3 pre-established answers, respectively: *total agreement*, *partial agreement*, *disagreement*.

The filter questions aimed at classifying the respondent in an age category and classifying his/her farm in a certain size range, taking into account the fact that the members of these structures are persons who carry out activities in the agricultural field. The age groups were structured in five stages, starting with the group up to 35 years old, up to the group over 65 years old. The size of the respondent's farm was included in five stages: starting with < 10 ha, up to > 200 ha.

The associative structures were evaluated statistically and quantitatively, through the lens of a set of specific conditions for achieving the results obtained in the short and medium term, respectively, through the lens of the activities carried out in legal, managerial terms.

In forming the research sample, the condition was established that the associative structure be active, an aspect verified by submitting the balance sheet for the year 2023 and subsequently confirmed by telephone by the representatives of these structures, when setting up a meeting to apply the questionnaire.

The study included 21 agricultural associations, of which one association also obtained a notice of recognition of the quality of producer group.

For the selection of associations, we consulted the database of the Călăraşi County Council, based on which reporting is made to the MARD regarding professional/employer/ union associative structures in agriculture, which are registered at the town halls, as well as the database of the Agricultural Directorate and the County Directorate of Statistics in Călăraşi, for the associations established under Ordinance 26/2000 [12,13]. It should be noted that the associations subject to the study have a number of members ranging between 21 and 119 associates.

In the analysis and interpretation of the information collected on the basis of the questionnaire, the theoretical Chi, Hi or χ2 test was used, theoretically, a concordance test applied to statistical distributions for which we can calculate the cumulative distribution function [15].

RESULTS AND DISCUSSIONS

The associations are legal entities without patrimonial purpose that operate in different sectors of agriculture, as follows: three of the associations have as their object of activity “Auxiliary activities for animal husbandry”, according to CAEN 0162, which includes animal husbandry activities, as well as auxiliary services related to the performance of this activity; 6 associations have as their object of activity the defense of the economic and commercial interests of cereal producers in relation to suppliers of raw materials and materials, as well as potential clients; 2 associations promote the activities of their members, who mainly deal with beekeeping, in relation to the state and the input market and the sale of bee products; 10 associations identify sales markets for agricultural products, develop and propose legislative projects, under the terms of the law; facilitate meetings between market partners, thus promoting collaboration with organizations and institutions in the territory

Following the processing of the questionnaire applied to representatives of agricultural associations in Călărași county, from the information presented in Table 1, a number of 95 people answered the questions. By age category, the share is held by the 36-45 age group, respectively, 28.4% of the total, followed by the 45-55 age group, with a percentage of 26.3%

Table 1. The structure and share of respondents according to age

Age group	No of respondents	%
< 35 years old	22	23.2
36-45 years old	27	28.4
45-55 years old	25	26.3
56-65 years old	14	14.7
>65 years old	7	7.4
Total	**95**	100.0

Source: Questionnaire regarding the evaluation of agricultural associative structures, in Călărași county [17].

An important percentage is also the respondents under 35 years of age, 23.2%, a positive aspect, which signifies the fact that young people from rural areas are involved in the activities of associative structures, in the conditions in which they demonstrate and support that the employed population from rural areas has a tendency to age. The age category over 56 years, stratified into 2 groups, records a cumulative percentage of 22.1%.

Following the processing of the questionnaire applied to the representatives of agricultural associations in Călărași county, from the information presented in Table 1, a number of 95 persons answered the questions. By age category, the share is held by the age group 36-45 years, respectively, 28.4% of the total, followed by the group 45-55 years, with a percentage of 26.3%.

From Table 2, it results that 52.6% of respondents who are part of agricultural associations own farms with sizes below 50 ha, respectively, 20% own farms smaller than 10 ha and 32.6% belong to the 10.1-50 ha category; 25.3% own farms in the 50.1-100 ha category and 17.9% farms between 100.1-200 ha; over 200 ha, they occupy a percentage of 4.25%.

Table 2.The structure of the respondents according to the size of the farm

Size of farm	MU	Total	
		No.	%
< 10 ha	No	19	*20.0*
	%	100	*X*
10.1 -50 ha	No	31	*32.6*
	%	100	*x*
50.1 ha-100 ha	No	24	*25.3*
	%	100	*x*
100.1 ha -200 ha	No	17	*17.9*
	%	100	*x*
>200 ha	No	4	*4.2*
	%	100	*x*
Total	No	95	*100.0*

Source: Questionnaire regarding the evaluation of agricultural associative structures, in Călărași county [17].

From the data presented in Table 3, there is an insignificant correlation between the age of the respondents and the size of the farm managed by them. A percentage of 23.2% are under 35 years old, and 11 of them are administrators of farms with areas between

50.1 and 200 ha, an encouraging aspect in terms of comparison with national statistics, according to which the agricultural population is aging. Among those aged between 36-45 years old, 37% own farms with an area of over 50 ha. Farms with an area between 10.1-50 ha are owned by 64% of respondents in the age group 46-55 years old. Those who have farms larger than 200 ha are distributed equally on all categories of age groups.

As it can be seen from the information presented in Table 4, of those who partially agree to the way in which the legal procedures for the functioning and development of the association are applied, most are in the age groups under 35, 46-55 and 56-55; of those who disagree to the mentioned item, over half are under 45.

The $\chi 2$ test, with a value of 32.19 for the calculated Chi, which falls between the values of 28.19 and 35.82 of the theoretical Chi, shows a distinctly significant link between age and dissatisfaction with the way in which the legal procedures for the functioning and development within the associative structure are applied, knowing that young persons have a different perception of the way in which an organization is organized and managed, compared to the elderly, who find it harder to accept change and innovation in their activity.

Regarding the condition regarding the way the activity is carried out within the association and the size of the respondents' farm, Table 5 shows that: most of the respondents express partial agreement with this item and are part of the categories of those with less than 200 ha; the majority of those with total agreement are respondents whose farms that cover an area between 10.1-50 ha, respectively, between 50.1-100 ha, namely 21 respondents out of the 33; regarding the dissatisfied ones, we can state that their distribution is weighted across all categories of farms; the connection through the $\chi 2$ test between the two variables, through the Chi value calculated at 24.23, is significant, certifying that the size of the farm has an influence on the perception of how the daily activity is carried out within the cooperative/producer group.

From Table 6, regarding the active involvement of members in the association, analyzed in terms of the respondents' age, the following is noted: the majority of respondents who express partial agreement are 45.26% of the total, followed by those who disagree with the stated item, with a percentage of 29.47%, and by those who fully appreciate the involvement of members in the association with 25.27%; of those who expressed partial agreement, most are part of the group up to 55 years old; Regarding those who express total disagreement regarding this item, the distribution has the same variations, over 50% of those who expressed disagreement being part of the categories up to 45 years old, those who truly want the life of the association to be active, to be visible in the community space and for their voice to be heard when measures are proposed to relaunch and develop the rural space: the analysis made with the chi-square test, through the calculated Chi value of 29.23, highlighted that there is a distinctly significant connection between age and the perception of the active involvement of members in the activity of the association.

Regarding the condition on the active involvement of the organization's members in its life and the correlation with the size of the respondents' farms, from Table 7. it is found that: the respondents who express partial agreement belong to the categories 10.1 to 50 ha, respectively, 14 respondents, the category under 10 ha – 10 respondents and the categories 51-100 ha, respectively, 101-200 ha, 9 respondents each, with a cumulative percentage of about 45% of the total responses; the majority of those with full agreement are the respondents who have their farms on an area between 10.1-50 ha, equal to the number of those with farms of 50.1-100 ha, 7 respondents from each category, totaling a percentage of over 50% of the total of those who expressed full agreement with this item; As for those who express total disagreement with this item, the majority are from the categories of up to 200 ha, with a weighted distribution by farm category; the connection through the $\chi 2$ test between the two variables is significant, with the calculated Chi value of 25.34, certifying that the size of the farm has an influence on the perception of how the association members are involved in its activity, respectively, those who have larger farms are also the ones who establish themselves as leaders and try to impose their point of view.

From Table 8, regarding the functional nature of conflict and communication management within the association, analyzed in terms of the respondents' age, the following is noted: the majority of respondents, who express partial agreement, are 51.58% of the total, followed by those who appreciate fully functional conflict and communication management within the organization with 26.32% of the total respondents; those who disagree with the stated item, have a percentage of 22.10%; of those who express partial agreement, most are part of the 36-45 age group, followed by the 46-55 age group and those under 35; those who express total disagreement regarding this item, the groups between 36-45 and under 35 years old stand out, representing 66.67% of the respondents who appreciated this item in this way; The analysis performed with the hi-square test revealed that there is no significant connection between age and the perception of the functionality of conflict management and communication in the association activity.

Regarding the condition on the functionality of conflict management and communication within the association and the correlation with the size of the respondents' farm, from table 9 it is found that: the respondents who express partial agreement with this item are distributed by age groups, most of them belonging to the categories 10.1 to 50 ha, respectively, 17 respondents, the category under 10 ha and 50.1-100 ha having an equal number of such appreciations and in the category 100.1-200 ha, a number of 11 respondents; the majority of those with total agreement are the respondents who have the farm on an area between 10.1-50 ha, and 50.1-100 ha, totaling a percentage of 60% of those who made appreciation in this way; Regarding those who express total disagreement with this item, the distribution is weighted by farm categories, with the highest percentage being recorded in the farm categories between 10.1-50 ha, respectively, in the 50.1-100 ha and under 10 ha category; the connection through the $\chi 2$ test between the two variables is significant, the calculated Chi value of 25.11 certifying that the size of the farm has an influence on the perception of how conflict management and communication within the association they belong to is functional.

From Table 10, it is found that most respondents are from the category of those who express partial agreement on the way in which activities are carried out that lead to group cohesion within the association; those who express total agreement with the mentioned item represent only 16.8%, in one age category, with no such appreciations being recorded; the majority of those who express disagreement are respondents from the age categories 36-55 years, to which are added the extremes, respectively, the category under 35 years old but also those from the category of pensioners, over 65 years old, the latter category exceeding half of the number of respondents in this category.

The $\chi 2$ test, through the calculated Chi value of 32.12, which falls between the theoretical Chi values of 28.19 and 35.82, shows a distinctly significant link between age and perception regarding the way in which activities are organized that lead to the cohesion of members within the associative structure.

Regarding the condition on the way in which activities leading to group cohesion are organized within the cooperative/producer group and the correlation with the size of the respondents farms, from Table 11, it is found that: most of those who express partial agreement are part of the categories of over 50.1 ha, compared to the number of respondents in these categories, noting that they have decision-making power within the organization, with a percentage of approximately 50% among respondents with this option; the majority of those with total agreement are respondents who have farms on an area between 10.1-50 ha, which leads to the conclusion that they are also those who organize and participate in such actions, totaling 50% of the appreciations with this qualification for this item; regarding those who express total disagreement with this item, we can state that the majority fall into the categories with farms of up to 10 ha, 50.1-100 ha and 101.1-200 ha; the connection through the $\chi 2$ test between the two variables is distinctly significant, the calculated Chi value of 29.71 certifying that the size of the farm has an influence on the perception regarding the organization of group cohesion activities within the association. The quantitative interpretation of the responses included reporting the activities and results on a scale of values that synthesized the responses on 3 levels: disagreement, total agreement and partial agreement.

Thus, the activities were grouped into two levels - legal and managerial, as presented in Table 12. We find that most of the responses **partially agree**, with percentages ranging between 41.05% and 51.58%. **Total agreement** is expressed in percentages ranging between 16.8% and 34.74% and **disagreement** with the mentioned items is expressed in percentages ranging between 22.10% and 40% of the respondents.

As shown in Table 13, the short-term results, correlated with the specific activities, were defined in 3 categories, which concerned the legal procedures for establishment and development, the functionality of communication and conflict management, and the cohesion of the group. We note that most of the responses fall into the scale of **partial agreement** values, with percentages ranging between 41.05 and 55.8%, while the **total agreement** responses have a very large variation, from 11.6% to 34.74%. The **disagreement** responses were given by respondents ranging between 22.10% and 40%.

Table 3. Analysis of the correlation between the respondents age who are part of the associations and the size of the managed farm

Age	MU	Size of farm (ha)					Total	
		< 10	10.1 -50	50.1 -100	100.1 - 200	>200	No.	%
< 35 years old	No.	3	8	7	3	1	22	23.2
36-45 years old	No.	8	9	6	4	X	27	28.4
46-55 years old	No.	4	12	5	3	1	25	26.3
56-65 years old	No.	2	2	2	7	1	14	14.7
>65 years old	No.	2	X	4	x	1	7	7.4
Total	No.	19	31	24	17	4	95	100
	%	20.0	32.6	25.3	17.9	4.2	100	X
Indicators	Test $\chi 2$	Significance threshold						
	≤	0.2	0.1	0.05	0.01	0.001		
Chi theoretical	≥	21.24*	22.52	25.6.3	31.10	38.19	N	
Chi calculated	21.52							

Source: Questionnaire regarding the evaluation of agricultural associative structures, in Călărași county [17].

Table 4.Analysis of the correlation between the age of the respondents and the perception of the way in which the legal procedures of operation and development are applied within the association

Age	MU	The application of legal procedures of functionality and development is made without difficulties			Total	
		Disagrement	Partial agreement	Total agreement	no	%
< 35 years old	No	7	11	4	22	23.2
36-45 years old	No	8	7	12	27	28.4
46-55 years old	No	3	10	12	25	26.3
56-65 years old	No	2	9	3	14	14.7
>65 years old	No	3	2	2	7	7.4
Total	No	23	39	33	95	100
	%	24.21	41.05	34.74	100	X
Indicators	Test $\chi 2$	Significance threshold				
	≤	0.1	0.05	0.01	0.001	
Chi theoretical	≥	15.18	23.11	28.19	35.82	**
Chi calculated	32.19					

Source: Questionnaire regarding the evaluation of agricultural associative structures, in Călărași county [17].

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Table 5. Analysis of the correlation between the size of the respondents' farm and the perception of the way in which the legal procedures for operation and development are applied within the association

Mărimea exploatației	UM	The application of legal procedures of functionality and development is made without difficulties			Total	
		Disagreement	Partial agreement	Total agreement	No	%
< 10 ha	no	6	8	5	19	20.0
10,1 -50 ha	no	4	14	13	31	32.6
50.1 ha-100 ha	no	5	11	8	24	25.3
100.1 ha -200 ha	no	5	6	6	17	17.9
>200 ha	no	3	X	1	4	4.2
Total	no	23	39	33	95	100
	%	24.21	41.05	34.74	100	X
Indicators	Test χ2	Significance threshold				
	≤	0.1	0.05	0.01	0.001	
Chi theoretical	≥	18.16	23.01	27.24	33.17	*
Chi calculated	24.23					

Source: Questionnaire regarding the evaluation of agricultural associative structures, in Călărași county [17].

Table 6. Analysis of the correlation between the respondents age and the perception of the active involvement of members in the life of the association

Age	MU	the members active imvolvment in the life of association is found out			Total	
		Disagreement	Partial agreement	Total agreement	no	%
< 35 years old	No	9	11	2	22	23.2
36-45 years old	No	8	13	6	27	28.4
46-55 years old	No	6	11	8	25	26.3
56-65 years old	No	2	6	6	14	14.7
>65 years old	No	3	2	2	7	7.4
Total	No	28	43	24	95	100
	%	29.47	45.26	25.27	100	X
Indicators	Test χ2	Significance threshold				
	≤	0.1	0.05	0.01	0.001	
Chi theoretical	≥	15.18	23.11	28.19	35.82	**
Chi calculated	29.23					

Source: Questionnaire regarding the evaluation of agricultural associative structures, in Călărași county [17].

Table 7. Analysis of the correlation between the size of the respondents' farm and the perception of how the members of the association are involved in its life

Size of farm	MU	The members active involvment in the life of association is found out			Total	
		Disagreement	Partial agreement	Total agreement	No	%
< 10 ha	no	6	10	3	19	20.0
10.1 -50 ha	no	10	14	7	31	32.6
50.1 ha-100 ha	no	8	9	7	24	25.3
100.1 ha -200 ha	no	4	9	4	17	17.9
>200 ha	no	x	1	3	4	4.2
Total	no	28	43	24	95	100
	%	29.47	45.26	25.27	100	X
Indicators	Test χ2	Significance threshold				
	≤	0.1	0.05	0.01	0.001	
Chi theoretical	≥	18.16	23.01	27.24	33.17	*
Chi calculated	25.34					

Source: Questionnaire regarding the evaluation of agricultural associative structures, in Călărași county [17].

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Table 8. Analysis of the correlation between the age of the respondents and the perception of the functionality of conflict management and communication

Age	MU	Conflict and communication management is functional			Total	
		Disagreement	Partial agreement	Total agreement	No	%
< 35 years old	No	7	12	3	22	23.2
36-45 years old	No	7	14	6	27	28.4
46-55 years old	No	4	13	8	25	26.3
56-65 years old	No	2	6	6	14	14.7
>65 years old	No	1	4	2	7	7.4
Total	No	21	49	25	95	100
	%	22.10	51.58	26.32	100	X
Indicators	Test χ2	Significance threshold				
	≤	0.1	0.05	0.01	0.001	
Chi theoretical	≥	15.18	23.11	28.19	35.82	N
Chi calculated	15.72					

Source: Questionnaire regarding the evaluation of agricultural associative structures, in Călărași county [17].

Table 9. Analysis of the correlation between the size of the respondents' farm and the perception of the functionality of conflict management and communication

Size of farm	MU	Conflict and communication management is functional			Total	
		Disagreement	Partial agreement	Total agreement	no	%
< 10 ha	no	6	10	3	19	20.0
10.1 -50 ha	No	7	17	7	31	32.6
50.1 ha-100 ha	No	6	10	8	24	25.3
100.1 ha -200 ha	No	2	11	4	17	17.9
>200 ha	No	X	1	3	4	4.2
Total	No	21	49	25	95	100
	%	22.10	51.58	26.32	100	X
Indicators	Test χ2	Significance threshold				
	≤	0.1	0.05	0.01	0.001	
Chi theoretical	≥	18.16	23.01	27.24	33.17	*
Chi calculated	25.11					

Source: Questionnaire regarding the evaluation of agricultural associative structures, in Călărași county [17].

Table 10. Analysis of the correlation between the age of the respondents and the perception of the way in which activities are organized that lead to group cohesion within the association

Age	MU	Activities that lead to group cohesion are carried out			Total	
		Disagreement	Partial agreement	Total agreement	No	%
< 35 years old	No	7	11	4	22	23.2
36-45 years old	No	14	10	3	27	28.4
46-55 years old	No	11	11	3	25	26.3
56-65 years old	No	2	6	6	14	14.7
>65 years old	No	4	3	X	7	7.4
Total	No	38	41	16	95	100
	%	40.0	43.2	16.8	100	X
Indicators	Test χ2	Significance threshold				
	≤	0.1	0.05	0.01	0.001	
Chi theoretical	≥	15.18	23.11	28.19	35.82	**
Chi calculated	32.12					

Source: Questionnaire regarding the evaluation of agricultural associative structures, in Călărași county [17].

Table 11. Analysis of the correlation between the size of the respondents' farm and the perception of the way in which the activities are organized that lead to the cohesion of the group within the association

Size of farm	MU	Activities that lead to group cohesion are carried out			Total	
		Disagreement	Partial agreement	Total agreement	No	%
< 10 ha	no	10	7	2	19	20.0
10.1 -50 ha	no	3	20	8	31	32.6
50.1 ha-100 ha	no	13	11	X	24	25.3
100.1 ha -200 ha	no	11	2	4	17	17.9
>200 ha	no	1	1	2	4	4.2
Total	no	38	41	16	95	100
	%	40.0	43.2	16.8	100	X
Indicators	Test $\chi 2$	Significance threshold				
	$\leq$	0.1	0.05	0.01	0.001	
Chi theoretical	$\geq$	18.16	23.01	27.24	33.17	**
Chi calculated	29.71					

Source: Questionnaire regarding the evaluation of agricultural associative structures, in Călărași county [17].

Table 12. Evaluation of the activities and aspects pursued, correlated with the scale of values, within the association

CODE	Activities	Aspects pursued	Value scale		
			Disagreement	Partial agreement	Total agreement
AJ	**Legal activities**	-aspects related to application of legal procedures of functionality and development	24.21	41.05	34.74
AM	**Managerial activities**	- members active involvment in organization life	29.47	45.26	25.27
		- functionality of conflict and communication management	22.10	51.58	26.32
		-organization of some activities that lead to group cohesion and some activities of counseling and trainings for the members of the associative structure	40.0	43.2	16.8

Source: Own calculations based on the applied questionnaire [17].

Table 13. Evaluation of short-term results, correlated with the activities carried out within the association

CODE	Results	Condiții/Activități	Value scale		
			Disagreement	Partial agreement	Total agreement
RTS1	**The legal procedures of establishment and development are carried out without difficulties**	- information/debates and courses related to legislation topics	32.6	55.8	11.6
		-active involvement of initiative group and of the members with exprience in the field.	29.47	45.26	25.27
		aspects related to application of legal procedures of functionality and development	24.21	41.05	34.74
RTS2	**Communication and conflict management are functional**	- elaboration of some procedures related to functionality conflict management and communication	22.10	51.58	26.32
		-sessions of counseling and training on communication withn the team and management of conflict situations	32.6	55.8	11.6
RTS3	**The group is cohesive**	-organization of some activities that lead to group cohesion and of some activities of counseling and trainings for the members of the associative structure	40.0	43.2	16.8

Source: Own calculations based on the applied questionnaire [17].

Table 14. Evaluation of medium-term results, correlated with the activities carried out within the association

CODE	Results	Conditions/Activities	Value scale		
			Disagreement	Partial agreement	Total agreement
RTM1	**Day to day activity of the association is carried out without major problems**	- The legal procedures of functionality and development are correspondingly applied	24.21	41.05	34.74
		- functionality conflict management and communication	22.10	51.58	26.32
RTM2	**The members of the associative structure are actively involved in its life**	-organization of some activities that lead to group cohesion and of some activities of counseling and training for the members of the associative structure	40.0	43.2	16.8

Source: Own calculations based on the applied questionnaire [17].

Regarding the correlation of the medium-term results with the specific activities, the quantified responses from the 95 respondents were summarized in 2 categories, respectively, the way the activity is carried out within the association and the active involvement of the associated members in its life. As can be seen from Table 15, the responses of the majority of interviewees fall into the **partial agreement** category, with a distribution between 41.05% and 51.58%, the largest gap being recorded in the **total agreement** response option, in which the distribution is between 16.8% and 34.74%.

CONCLUSIONS

In the case of associative structures, counseling aims to provide assistance at the establishment but also over time in different situations, such as: court processes, changes in statute and/or constitutive act, European projects. Most respondents mention that they faced with difficulties at the time of establishment and admit that they needed help to overcome them;

Respondents who participated in social activities, such as study visits, community activities, specialized conferences, fairs and exhibitions, usually held annually, appreciated that these activities helped the associative structure a lot in terms of improving relations between members.

When asked about development prospects, most respondents had well-defined objectives to achieve for the development of the organization, among which the most relevant are: accessing external financing for investments in purchasing equipment and creating storage spaces, increasing the land area owned, facilitating the professional development of members, attracting new members and further supporting their interests in relation to local institutions.

Developing entrepreneurial culture, by facilitating access of the population in rural communities to vocational training courses, information seminars, counseling and dissemination of information of real interest for the rural area, employment services, through viable partnerships between profile NGOs and local decision-makers can be a solution for the sustainable development of rural areas and the promotion of equal opportunities for unoccupied social categories in rural areas, such as: youth, women or middle-aged persons. They can also contribute to the socio-economic relaunch and stabilization of rural areas by promoting agrarian structures integrated into market flows and economically efficient.

In this regard, from the discussions held with the representatives of the local public authority, to whom we informed the fact that a significant part of the rural population not only does not know about the existence of some organized communities at the level of the commune to which they belong, but also does not know the meaning of the terms and, even more so, the activity of community NGOs, we noted, at least in writing, the existence of partnerships for the purpose of developing and adapting local strategies to the specific conditions of rural communities, which support sustainable development.

From the discussions held with the representatives of NGOs, we noted that their consultative role in the community is beginning to be perceived by public authorities, who have begun to invite them to dialogue when strategies for balanced and sustainable development are being developed and adopted, who have understood that, through these organizations, citizens express their agreement and commitment to the economic and social development of their community.

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SELECTING THE PROPER WHITE WINE VARIETIES ACCORIDNG TO MULTIPLE-CRITERIA DECISION ANALYSIS: CASE STUDY SERBIA

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Abstract

Viticulture and winemaking are two interconnected lines of agri-food sector that over the centuries had, currently have and will have significant importance in human nutrition. Mainly pushed by requirements from the global market, trends in wine production represent a relatively changeable category. Nowadays, within the overall structure of vineyards, or further produced wines, such a small share has been taking by autochthonous (local) grapevine varieties, that usually act as rising stars at many of regional markets. Full utilization of their natural attributes and production capacities could induce growth and sustainability in certain local and even regional viticultural sectors. As mentioned above, the main goal of the paper is to assess through the multicriteria decision-making analysis (appliance of DiWeC and MABAC methods) what could be the best fitted alternative (there were confronted local versus commercial white wine varieties) for vineyard establishment, enlargement or replacement according to experts' opinions analysis. Derived results underline the criteria with decisive importance, while make the ranking of preselected white wine varieties, showing that commercial varieties (primarily Sauvignon Blanc and Chardonnay) still play crucial role in establishment of modern vineyards in Serbia and wider region.

Key words: *white wine varieties, MCDA, DiWeC & MABAC methods, Serbia*

INTRODUCTION

Globally, grape growing and winemaking are two significantly important activities within the sector of agriculture [69]. From ancient times, several civilizations have been considered the wine as drink (nectar) of Gods [12; 49], although nowadays it has still having very important role in many religious events of various religions [20; 21].

Someone can say that in line to current trends linked to viticulture (Table 1), wine could be observed as a drink of future. According the value of produced output, grapes are still ranked as one of the top horticultural crops worldwide [1].

Table 1. Global trends in viticulture and wine production production

Year/ Element	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Average
Viticulture / grape production at global level											
Areas (000 ha)	7,027	7,024	7,108	6,900	6,835	6,875	6,909	6,919	6,882	6,730	6,921
Yield (t/ha)	10.9	10.5	10.8	10.8	10.8	11.6	11.2	11.1	11.2	11.1	11.0
Quantity (000 t)	76,508	73,906	76,594	74,517	73,601	80,097	77,055	76,828	76,751	74,943	76,080
Value (mld USD)	68.26	71.75	64.46	64.51	69.10	73.66	75.20	83.34	86.02	85.13	74.14
Wine production at global level											
Quantity (000 t)	28,907	28,268	28,689	27,652	25,410	29,460	26,931	27,073	26,871	-	27,696

Source: [18].

Having in mind that over 70% of grapes are processed into wine, while less than 30% is consumed as fresh or dried fruit [11]. Grapes could be grown in any country worldwide, except in polar and extremely cold climate. It could be grown even in greenhouses [8]. It grows the best in areas with temperate climate [29], while it is commercially grown in over than 80 countries [53].

Territorially, winemaking usually follows the grape growing areas [66]. In recent years, the wine industry, or rather the wine market has experienced a steady but constant growth in revenues (Table 2).

Table 2. Growth of wine industry revenues at global level (in mld. USD)

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Total revenues	286.0	303.6	315.1	330.1	339.1	347.7	356.6	266.0	371.5	378.4

Source: [58].

According to some projections, it is expected that its overall growth during one decade could be over 32% (observed period 2020-2029.). The observed rise in revenues is mainly not the subject of growth in volume of produced grape, or wine, while it corresponds to certain changes in demand for wines at global market. Generally, demand structure moves to wines of better quality, as well as to some countries with growing economies that have experienced rise in middle class while previously they were not usual wine consumers (they are experiencing the certain changes in nutrition and life habits), [6; 37; 32].

In last 30 years, consumption of wine has been experienced significant growth in Asia, north of the Europe, USA and Canada, while simultaneously there has come to dramatic decrease at the south part of the Europe that was well-known as former wine consuming region [44]. Good example of mentioned could be France. Wine consumption per capita there was decreased for even three times during the period of between the WWs and nowadays (from 136 l/capita in 1926 to 40 l/capita in 2020), [57]. As top wine producers have still stayed the same (Spain, France, and Italy), [48], there come to intensification of wine export to certain rapidly growing wine markets, primarily China [19].

There are several wine grapevine varieties that rule the world for many decades, such are Cabernet Sauvignon and Franc, Merlot, Tempranillo, Chardonnay, Syrah, Sauvignon Blanc, Pinot Noir, Sangiovese, Riesling, etc. [2].

In recent couple decades, no matter to type of wine, there has happened certain segmentations of wine production and consumption at global level. Wines are extremely pronounced grouped into the cheap and expensive [10], or premium and less quality wines [9], branded or those that brings the cult of small domestic wineries [67], organic than conventionally produced wines [61], globally well-known (commercial) contrary to local (autochthonous) wines [26], etc. As a part of marketing strategy, performed wine segmentation is rather complex issue, usually involving few elements at specific moment in shaping final decision of wine producer/seller.

What is happening in Serbian viticulture and wine production sector? Briefly, in previous decade there has come to slight decrease in areas under the vineyards (Table 3), while in observed period started certain trend as the clearing of old and establishment of new, small but intensive vineyards (followed by adequate family wineries), that implies implementation of contemporary growing technology, mechanization and equipment, as well as involvement of both commercial or local wine varieties. They are usually turned to production of quality wines, while with produced volume, unfortunately, they cannot cover the current demand at the domestic market [22; 51; 3]. Although Serbia has on disposal well natural and climate conditions for viticulture [68], achieved yields are far behind those gained at global level, underlining still extensive production at small estates [33]. Meanwhile, value of wine market at national level is slightly increasing, but mostly due to high ranking of Serbia related to annual wine consumption per capita, and much higher value of import than export of wines [47; 5].

Nowadays, at national level there are produced 224 grapevine varieties, while 31 of them represent local wine varieties [25]. International commercial grapevine varieties dominate in Serbia and over the years, vineyards with old local grapevine varieties have been largely cleared [62]. Their share in the total vineyard area (excluding the widespread local variety Grašac) is just over 15%, with a share in the total number of vineyards being slightly less than 34% [23].

Table 3. Trends in viticulture and wine production in Serbia

Year/ Element	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Average
Viticulture / grape production at Serbian level											
Areas (000 ha)	21.2	21.2	21.2	21.2	21.2	20.3	20.5	19.8	20.1	20.0	20.7
Yield (t/ha)	9.4	5.8	8.1	6.9	7.8	7.4	8.0	8.1	7.7	8.1	7.7
Quantity (000 t)	200.0	122.5	170.6	145.8	165.6	149.4	163.5	160.3	155.7	162.5	159.6
Value (mil USD)	120.0	110.7	110.7	82.6	115.5	80.1	109.8	128.4	150.5	132.3	114.1
Wine production at Serbian level											
Quantity (000 t)	23.1	19.8	24.1	24.1	36.0	34.8	30.2	27.3	26.6	-	27.3

Source: [18].

In line to white wine varieties, in Serbia are mostly grown Riesling, Sauvignon blanc, or Chardonnay as commercial varieties, as well as Smederevka, Tamjanika bela, or Bagrina, as local varieties [30]. According to relatively diverse assortment of grown wine varieties, the most commonly grown wine varieties at national level are usually results derived both, from the requests at national and regional market, or they represent the dictate of locally known wine producers that could perceive and affect the trends at national wine market.

Focusing primarily on local wine varieties, making them globally well-known could not be based just on natural preconditions, tradition in wine growing, or gained habits in wine consuming at certain territory. Local variety could be a promising star out the national market just in case if it involves in itself sincere and proved story about specific terroir, underlying intensive branding. As highly desirable concept, current trends in wine sector highlight the terroir as it truly describes sensory attributes of produced wine (previously grapes) that perfectly corresponds to local environment. Wines labeled with adequate terroir proves that they are produced in predefined location and under the specific and predictable circumstances, while remaining the same over the long time. Briefly, it serves as proof of wine quality, and necessary step to wider recognition of specific wine [64; 50; 24].

In recent time, there are examples of establishing new vineyards in Serbia, that in one part are under some of local (autochthonous) grapevine varieties (no matter to purpose or color of grown grape). In seeking for sustainability and additional profit, with re-introduction of local varieties in larger volume, producers are expecting to satisfy previously set goals, to maximize the profit while to contribute the recognizability of region they belong through the production and processing of grapes from local grapevine varieties [7; 28; 26].

Decision-making is the essence in exercising the entrepreneurial ideas or running a business in wine sector, or agriculture at all [55]. Among the many methods that can be used to support decision-making in agriculture, no matter to their complexity, modernity, precision, or overall purpose [38], Multiple-Criteria Decision Analysis (MCDA) could serve as one of the most reliable [54].

Specifically, some of previously developed MCDA methods could be used for trimming the optimal level of irrigation in plant production [59], finding the crop that fits the best to available agricultural land [17], selection of adequate input supplier [40; 39], assessing the optimal level of crops fertilization [35], selection of the most suitable crop species or variety to given production circumstances [56; 41; 42; 43], testing the possibility to use the renewables in agriculture [27], selecting the most suitable table grape variety for organic agriculture [16], grouping and organizing the most useful wine grape harvest operations that will maximize the gained yields [65], decreasing the diseases infestation risk in grape growing [36], etc.

Within the available literature sources, there are lack of papers based on the use of established MCDA methods or their hybrids (experts' opinions analysis) focused to viticulture, especially to selection of the best possible grapevine (wine or/and table) variety that fits the natural and production conditions of certain territory, or more specifically making the proper choice between available commercial and local grapevine varieties.

The main goal of the paper is presentation of possible support to decision-making at the farm level (testing of adequate MCDA model established for that purpose that will support generation of the best possible decision). The decision should include selection of the most suitable wine variety that will be the base for establishment of new vineyards (and later wine production) that will in future contribute to strengthening of farm sustainability and enlargement of gained profits.

MATERIALS AND METHODS

In line to performed research it has been applied the model based on multi-criteria decision-making. For this purpose, it was used the expert decision-making based on predefined criteria and pre-set alternatives from which was selected optimal one. Research was conducted through following stages: a) Starting (initial) phase; b) Data collecting; c) Overview of research done so far; d) Presentation of derived research results with discussion; and e) Formalization of concluding remarks.

In initial phase, there has been done contacting and later selection of experts from the observed field (professionals and scientists recognized at regional level, while involved in viticulture and winemaking). They would have to assess (give relevant opinion) to producers' doubt (what wine grapevine variety is currently the best solution for vineyard establishment), according to preselected criteria and defined alternatives. After the selection of experts, by the Delphi technique there have been selected the criteria and alternatives required for further research exercising.

In following tables (Table 4 and Table 5) is presented the brief overview of used criteria and alternatives.

Table 4. Criteria for expert assessment

ID	Criteria	Description	Cost/Benefit
C1	Yieldness of the variety	Average output per unit of measure (hectare, square meter, vine, etc.)	Benefit
C2	Size of individual grape berries in cluster	Average size of individual grape berries (from very small to vary large)	Benefit
C3	Compactness (density) of grape berries in cluster	Formation and movable of the berries and visibilities of the pedicles (from very lax to very dense)	Benefit
C4	Aromaticity of grape (grape must of a given variety)	Specific aroma and taste intensity of grapes, or later produced wine	Benefit
C5	Balance of total acids and sugars in grape (grape must of given variety)	Total sugar - total acid ratio could indicate expected level (potential) of wine quality	Benefit
C6	Impact of leading vine rootstock (*B x R* Kober 5BB) on grape quality	Used rootstock is usually a guarantee of grapevine vitality and resilience to certain external factors	Benefit
C7	Sensitivity of variety to extreme ecological conditions (e.g. high/low temperature, frost, drought, etc.)	Measure of volume and quality of gained output due to expected occurrence of climate extremes	Benefit
C8	Resistance of the variety to pests and diseases	Measure of volume and quality of gained output due to exposure to health risks	Benefit
C9	Suitability of variety for processing into the wine (thickness of berry skin, firmness of flesh of berry, must yield in wine production, etc.)	Variety potential due to gained wine quality	Benefit
C10	General marketability and sales price of grape of given variety	Profit capacity of produced grape	Benefit
C11	General marketability and sales price of wine produced from grape of given variety	Profit capacity of produced wine	Benefit
C12	Costs of vineyard establishment and maintaining (grape producing)	Level of economic efficiency for vineyard running	Cost
C13	Processing costs (wine production)	Level of economic efficiency for winery running	Cost
C14	Suitability of variety for production of wines with geographical indications (limited conditions for high-quality grape and wine production)	Capacity for gaining the extra profit	Benefit

Source: Developed by authors.

It should be noted that this study did not consider the specific ecological requirements of each white wine variety necessary to achieve optimal oenological potential and produce high-quality wines, or characteristics of wines from studied varieties.

Within the phase of data collecting, a survey questionnaire was defined. Later, questionnaire has been sent to preselected experts (9 persons) to be filled in. On this way there have been gained assessments prepared for further processing and presentation in the form of research results.

Table 5. Used alternatives (white wine varieties)

ID	Alternatives	Local (autochthonous /regional)/ international grapevine varieties
Local varieties		
A1	Smederevka	Autochthonous
A2	Tamjanika bela	Regional
A3	Bagrina	Autochthonous
Commercial varieties		
A4	Riesling	International
A5	Sauvignon blanc	International
A6	Chardonnay	International

Source: Developed by authors.

It has to be underlined that in previous period there have been done insufficient number of researches linked to same or similar thematic field, while their overview involves few published papers. Some authors were examined the suitability of land parcels for viticulture in Serbia using the GIS [46; 24]. In some other countries, such as Italy, Iran or Turkey, due to their importance in spatial planning, and later sustainability in performing the production activities, the MCDA-GIS model was used [34; 63; 36]. Other were selected the most suitable grapevine genotypes in Brazil, due to development of novel table grapevine variety primarily characterized by higher yields and better fruit quality, using the Promethee MCDA method [14].

Aouadi and associates (2021) were used the ELECTRE Tri-C and ELECTRE III MCDA methods, in order to perceive the production system in viticulture that fits the best to current global agro-ecological requirements [4], while Macary (2023) has been examined advancing the sustainability in exercised practices in sector of viticulture by the use of ELECTRE Tri-C MCDA method [31].

Meanwhile, Tsafarakis and associates (2010) were used MCDA trying to advance marketing and e-commerce in wine selling [60].

In phase of research results presentation and discussion, there are considered all results derived by the appliance of preselected multi-criteria decision-making methods (MCDAs). This research has been involved Direct Weight Calculation (DiWeC) method and Multi-Attributive Border Approximation Area Comparison (MABAC) method.

The use of the DiWeC method serves to calculate the weights of the pre-set criteria [13] that were previously evaluated through a survey questionnaire by selected experts (Table 6.).

Table 6. Scale of weight values

Weight	Value
Weight	Value
Very Low	1
Low	2
Moderate	3
High	4
Very High	5

Source: [13].

Used MCDA method is innovative, while developed by Puška and associates (2024), [52]. It represents easy and quite a usable way to calculate the weights of criteria, following the next steps:

Step 1. Assessment of criteria importance by experts

$X_{ij} = x_1, x_2, \ldots, x_n$..(1)

Step 2. Calculating the aggregate score for the criteria

$v_{ij} = \sum_{j=1}^{n} x_{ij}$..(2)

Step 3. Calculating criteria weights

$w_{,} = \frac{x_{ij}}{\sum_{j=1}^{n} x_{ij}}$...(3)

In order to rank the assessed alternatives, it was used the Multi-Attributive Border Approximation Area Comparison (MABAC) multi-criteria decision-making method. The method was developed by Pamučar and Ćirović (2015), while it is characterized by relatively easy to use [45]. Appliance of mentioned method considers next steps:

Step 1. Development of initial decision-making matrix (X)

$$X = \begin{array}{c c} & \begin{array}{cccc} C_1 & C_2 & \ldots & C_n \end{array} \\ \begin{array}{c} A_1 \\ A_2 \\ \ldots \\ A_m \end{array} & \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \ldots & \ldots & \ldots & \ldots \\ x_{m1} & x_{m2} & \ldots & x_{mn} \end{bmatrix} \end{array} \text{.................................(4)}$$

Step 2. Normalization of initial decision-making matrix (N)

$$N = \begin{array}{c c} & \begin{array}{cccc} C_1 & C_2 & \ldots & C_n \end{array} \\ \begin{array}{c} A_1 \\ A_2 \\ \ldots \\ A_m \end{array} & \begin{bmatrix} n_{11} & n_{12} & \cdots & n_{1n} \\ n_{21} & n_{22} & \cdots & n_{2n} \\ \ldots & \ldots & \ldots & \ldots \\ n_{m1} & n_{m2} & \ldots & n_{mn} \end{bmatrix} \end{array} \text{.................................(5)}$$

a) For Benefit criteria

$n_{ij} = \frac{x_{ij} - x_i^-}{x_i^+ - x_i^-}$..(6)

b) For Cost criteria

$n_{ij} = \frac{x_{ij} - x_i^+}{x_i^- - x_i^+}$..(7)

Step 3. Calculating the weight matrix

$$V_{ij} = w_i g(n_{ij} + 1) \quad (8)$$

Step 4. Determining the matrix of marginal approximative surfaces (G)

$$g_i = \left(\prod_{j=1}^{m} v_{ij}\right)^{\frac{1}{m}} \quad (9)$$

Step 5. Calculating the elements of alternative matrices distance from marginal approximative domain (Q)

$$Q = \begin{bmatrix} q_{11} & q_{12} & \cdots & q_{1n} \\ q_{21} & q_{22} & \cdots & q_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ q_{m1} & q_{m2} & \cdots & q_{mn} \end{bmatrix} \quad (10)$$

Step 6. Ranking the alternatives

$$S_i = \sum_{j=1}^{n} q_{ij} \quad j = 1,2, \dots, n \quad i = 1,2, \dots, m \quad (11)$$

It has to be mentioned that in concluding remarks is briefly described contribution of performed research, while there are defined possible paths for some future research.

RESULTS AND DISCUSSIONS

Does the maxim „think globally, act locally” correspond to sector of viticulture? Considering the wine as a lifestyle, mentioned is surely true [15]. No matter to socio-economic system, both local and global wine markets are mainly segmented in certain extent. Nowadays, contrary to more demanding consumers, that are generally willing to step-out the adopted common patterns in wine consuming, producers have to be the trendsetting side that will offer something new related to wine and wine culture. Much like in haute couture, trends within wine industry have a cyclical nature, with new styles often echoing past fashions. To appeal to a contemporary audience, the offerings must strike a balance between diversity and tradition, introducing subtle yet meaningful advancements that can draw new enthusiasts while deepening connections with existing aficionados. In this context, autochthonous (local) wine varieties can serve as a distinctive advantage for a particular region, adding unique value to the local producers’ repertoire and enhancing community's cultural image.

Tourism, and the "silent exports" it engenders, plays a crucial role in promoting local varieties beyond their native borders, with every bottle consumed abroad potentially is converting new admirers to these distinctive regional flavors. The development of new tastes in a specific area is not merely a result of the new grapevine clones or technological innovations in winemaking. It could be also a result of reminding, primarily the new generations to some old and proved tastes that are part of national tradition and material heritage, momentarily forgotten or out of sight. Similar scenario could be carried out with local wine varieties from Serbia, or wider region (Balkan), that have been retreated in some moment upon the gust of commercial varieties. Today's search for diversity in tastes, quality, color, way of packaging, or time of consuming, etc., may be the ideal time for their return with a style. Serbia and the Balkans have available some old autochthonous (local) varieties that deserve to be in a focus, letting to consumers to decide what will be with their future.

In line to main goal of the paper, there are presented the potential of MCDA in decision-making process in the sector of viticulture. More precisely, hybrid method based on DiWeC and MABAC methods have been served as support to grape and wine producer in making proper decision related to selection of the most suitable white wine variety (choice between commercial and local varieties) which would dominate in newly established vineyard.

In Table 7 it is presented the importance of individual criteria, whose values were obtained by applying the subjective method of multi-criteria decision-making, i.e. DiWeC.

Specifically, experts have been given the greatest importance to the fifth criterion (C5), i.e. "Balance of total acids and sugars in grape (wider of given variety)". It is also interesting that the most of observed criteria have been gained the same values, i.e. the same significance or importance according to assessment of preselected experts.

Table 7. Calculation of criteria's weights

Element	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
E1	4	4	4	5	5	3	4	3	4	4	5	3	3	4
E2	4	3	4	5	5	3	5	4	4	4	5	3	3	3
E3	2	3	3	4	4	3	3	3	3	4	4	4	4	3
E4	4	3	3	4	5	5	5	5	4	5	5	4	2	3
E5	5	4	4	4	5	4	4	4	4	4	5	4	4	4
E6	4	3	4	5	5	2	4	3	2	3	3	3	1	4
E7	3	3	3	5	5	4	4	5	5	5	5	4	4	4
E8	5	3	3	3	5	3	5	5	5	4	4	4	4	4
E9	5	3	3	4	5	4	5	5	5	4	3	4	4	3
Sum	36	29	31	39	44	31	39	37	36	37	39	33	29	32
w	0.07	0.06	0.06	0.08	0.09	0.06	0.08	0.08	0.07	0.08	0.08	0.07	0.06	0.07

Source: According to authors calculations.

Conditionally with the lowest value were assessed the criteria C2, C3, C6 and C13, i.e. „Size of individual grape berries in cluster", "Compactness (density) of grape berries in cluster", "Impact of leading rootstock (B x R Kober 5BB) on grape quality", and "Processing costs (wine production)".

Further research steps consider performing of ranking process of observed alternatives (preselected white wine alternatives), while through calculations defined by MABAC method there would come to final rank of alternatives (Tables 8, 9, 10, 11).

Table 8. Decision matrix

Element	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
Weights	0,07	0,06	0,06	0,08	0,09	0,06	0,08	0,08	0,07	0,08	0,08	0,07	0,06	0,07
C/B	*B*	*B*	*B*	*B*	*B*	*B*	*B*	*B*	*B*	*B*	*B*	*C*	*C*	*B*
A1	3.89	3.67	3.44	2.67	3.00	3.33	3.11	3.78	3.11	2.89	2.78	2.00	2.11	3.22
A2	3.89	3.44	3.56	4.44	3.44	3.44	3.33	3.67	4.33	4.67	4.56	2.00	2.44	1.67
A3	3.33	3.00	3.22	3.22	3.56	3.22	3.11	3.44	3.67	4.11	4.11	2.56	2.44	1.89
A4	3.44	3.11	3.56	4.11	4.44	3.44	4.11	3.78	3.67	3.89	3.67	2.44	2.22	2.44
A5	3.67	3.22	3.89	4.44	4.44	3.33	3.89	3.89	4.11	4.44	4.22	2.44	2.22	2.22
A6	3.67	3.33	3.67	3.89	4.33	3.44	3.67	4.00	4.22	4.44	4.22	2.22	2.00	2.33
Max.	3.89	3.67	3.89	4.44	4.44	3.44	4.11	4.00	4.33	4.67	4.56	2.00	2	3.22
Min.	3.33	3.00	3.22	2.67	3.00	3.22	3.11	3.44	3.11	2.89	2.78	2.56	2.44	1.67

Source: According to authors calculations.

Table 9. Normalized decision matrix

Element	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
Weights	0.07	0.06	0.06	0.08	0.09	0.06	0.08	0.08	0.07	0.08	0.08	0.07	0.06	0.07
C/B	*B*	*B*	*B*	*B*	*B*	*B*	*B*	*B*	*B*	*B*	*B*	*C*	*C*	*B*
A1	1.00	1.00	0.33	0.00	0.00	0.50	0.00	0.60	0.00	0.00	0.00	0.00	0.25	1.00
A2	1.00	0.67	0.50	1.00	0.31	1.00	0.22	0.40	1.00	1.00	1.00	0.00	1.01	0.00
A3	0.00	0.00	0.00	0.31	0.38	0.00	0.00	0.00	0.45	0.69	0.75	0.99	1.01	0.14
A4	0.20	0.17	0.50	0.81	1.00	1.00	1.00	0.60	0.45	0.56	0.50	0.79	0.51	0.50
A5	0.60	0.33	1.00	1.00	1.00	0.50	0.78	0.80	0.82	0.88	0.81	0.79	0.51	0.36
A6	0.60	0.50	0.67	0.69	0.92	1.00	0.56	1.00	0.91	0.88	0.81	0.40	0.00	0.43

Source: According to authors calculations.

Table 10. Weighted normalized matrix

Element	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
Weights	0.07	0.06	0.06	0.08	0.09	0.06	0.08	0.08	0.07	0.08	0.08	0.07	0.06	0.07
C/B	*B*	*B*	*B*	*B*	*B*	*B*	*B*	*B*	*B*	*B*	*B*	*C*	*C*	*B*
A1	0.14	0.12	0.08	0.08	0.09	0.09	0.08	0.13	0.07	0.08	0.08	0.07	0.08	0.14
A2	0.14	0.10	0.09	0.16	0.12	0.12	0.10	0.11	0.14	0.16	0.16	0.07	0.12	0.07
A3	0.07	0.06	0.06	0.11	0.12	0.06	0.08	0.08	0.10	0.14	0.14	0.14	0.12	0.08
A4	0.08	0.07	0.09	0.15	0.18	0.12	0.16	0.13	0.10	0.13	0.12	0.13	0.09	0.11
A5	0.11	0.08	0.12	0.16	0.18	0.09	0.14	0.14	0.13	0.15	0.15	0.13	0.09	0.10
A6	0.11	0.09	0.10	0.14	0.17	0.12	0.12	0.16	0.13	0.15	0.15	0.10	0.06	0.10
Gi	0.11	0.09	0.09	0.14	0.15	0.10	0.11	0.13	0.11	0.14	0.14	0.11	0.09	0.10

Source: According to authors calculations.

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Table 11. Distance of Alternatives from the BBA

Element	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
Weights	0.07	0.06	0.06	0.08	0.09	0.06	0.08	0.08	0.07	0.08	0.08	0.07	0.06	0.07
C/B	*B*	*B*	*B*	*B*	*B*	*B*	*B*	*B*	*B*	*B*	*B*	*C*	*C*	*B*
A1	0.03	0.03	-0.02	-0.06	-0.06	-0.02	-0.04	0.00	-0.05	-0.06	-0.06	-0.04	-0.02	0.03
A2	0.03	0.01	-0.01	0.02	-0.03	0.01	-0.02	-0.02	0.02	0.02	0.02	-0.04	0.02	-0.04
A3	-0.04	-0.03	-0.04	-0.04	-0.03	-0.05	-0.04	-0.05	-0.02	-0.01	0.00	0.03	0.02	-0.03
A4	-0.03	-0.02	-0.01	0.00	0.03	0.01	0.04	0.00	-0.02	-0.02	-0.02	0.01	-0.01	0.00
A5	0.00	-0.01	0.02	0.02	0.03	-0.02	0.02	0.01	0.01	0.01	0.00	0.01	-0.01	-0.01
A6	0.00	0.00	0.00	-0.01	0.02	0.01	0.00	0.03	0.01	0.01	0.00	-0.01	-0.04	-0.01

Source: According to authors calculations.

In Table 12, it is shown the final rank of preselected, i.e. observed white wine varieties.

Table 12. Ranking of alternatives

S_i	Rank	Alternative
-0.35	6	A1
-0.02	3	A2
-0.32	5	A3
-0.03	4	A4
0.09	1	A5
0.02	2	A6

Source: According to authors calculations.

It could be seen that the alternative A5, i.e. the variety Sauvignon blanc was chosen as the best solution for vineyard establishment, while it is followed by the alternatives A6 and A2, i.e. the varieties Chardonnay and Tamjanika bela. Adequate visualization of the performed ranking of white wine varieties has been done in Figure 1.

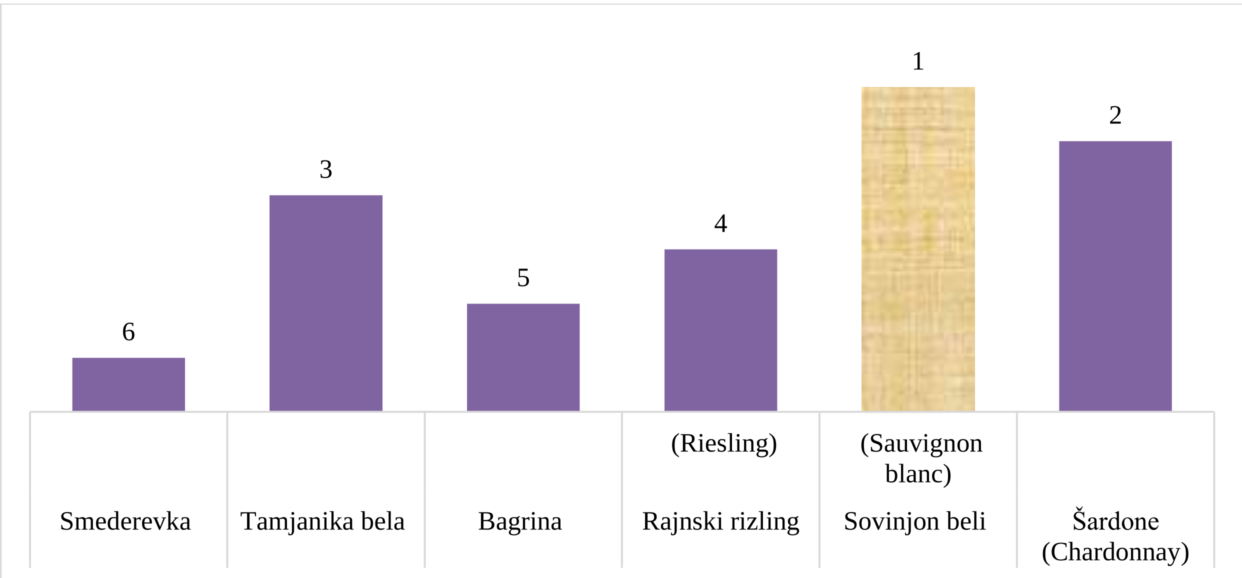

Fig. 1. Ranking the white wine varieties
Source: According to authors calculations.

CONCLUSIONS

Grapes and wine are among the most valuable agri-food products at the global market. Global market recognizes various grapevine varieties, while in previous decade there come to strengthening in confrontation between the commercial, globally well recognized wine varieties, and local (autochthonous) one. Observing the grapevine as perennial crop with the mighty impact on further wine production, determining the adequate structure of grapevine varieties in vineyard seems to be strategic decision for any farmer (additional changes in vineyard structure are costly in any aspect).

The research was performed in order to examine which white wine variety stands out as the best possible alternative (confrontation of commercial vs. local varieties) for wine producers and further spreading of vineyards at national level, related to assessment of presets criteria made by viticulture-oenology experts active in observed sector of agri-food production (viticulture and wine production). Besides, through the successful application of multi-criteria decision-making (MCDM), there are determined the ranges of weighting coefficients for individual (preselected) criteria. Thus, the criterion Balance of total acids and sugars in grape (wider of given variety) stands out by its importance as the most significant, while several others have equal by significant importance too. As one of results derived from the MCDM analysis, Sauvignon blanc has been marked as the most promising variety, while the Chardonnay and Tamnjanka bela are quite behind it. In these types of research, the use of MCDM provides overall importance to researched topic, while it serves as excellent tool for further development and selection of future varieties of grapevines and wines, i.e. it could have impacted the on science-based change in structure of vineyards and wine assortment at the national level or wider region in upcoming mid-term period.

Derived research results could serve both to professionals (grape and wine producers) and policy makers. First to shape and use in the best manner available potential of the local offer at wine market, while the second one to actively support current market trends. Future research could be directed to selection of the best fitting red wine varieties, or it could involve the same alternatives but under changed circumstances (change in used criteria for assessment).

In emerging economies, prioritizing locally produced wines, especially those made from local (autochthonous) grapevine varieties, supports economic stability and cultural identity. Serbian wines produced from local varieties can act as cultural ambassadors, showcasing the nation's rich traditions and unique terroir. Thus, promoting local varieties and wines is not only an economic initiative but also a celebration of the country's authentic heritage and diversity.

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MANAGING FARM AGRO WASTE IN RURAL AREAS: EMERGING POTENTIALS AND CHALLENGES OF BIOCHAR PRODUCTION AND USE AMONG SMALLHOLDERS

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Abstract

The agricultural sector plays a crucial role in driving rural economic growth, with various government agencies at the forefront of rural agricultural development. Programs such as Young Agropreneur, Contract Farms, and Smallholder Assistance significantly aid farmers in cultivating land outside urban areas. In return, agriculture provides employment opportunities and income, ensuring that rural areas continue to function as food producers for both the local community and the growing urban population. The pressure to increase farm production to meet market demand directly raises the amount of waste produced by rural farmers. Consequently, waste management is often a significant issue for rural smallholders. In addition to the lack or absence of appropriate facilities to process agricultural waste, small rural farmers also lack exposure to methods of converting their agricultural waste and manure into biochar, an organic fertiliser. Biochar can help farmers reduce the cost of chemical fertiliser inputs and promote environmentally friendly agricultural practices. This article aims to identify the potential and challenges of biochar application among rural smallholders through a review of literature and by learning from the previous experience of smallholders under a cluster farming program in the Hulu Terengganu district, who utilised biochar for managing farming waste in a sustainable way. The article concludes that with awareness programs and constant supervision by agencies and agricultural experts, the wider usage of biochar for reducing farming input costs for small rural farmers and also encourage environmentally friendly green farming practices can be achieved.

Key words: *Rural farm waste, biochar, organic farming, rural smallholders, cost reduction*

INTRODUCTION

Managing plantation waste among smallholders in rural areas is often a significant challenge, especially in the context of environmental sustainability. The long-standing practices of open burning of agricultural waste or leaving it to decompose in fields are low-cost and easy for farmers to execute, but they also lead to the accumulation of agricultural waste, including crop residues, plant matter, and manure, on farms without proper disposal methods [3, 4]. This accumulation can result in environmental problems such as methane emissions, soil degradation, and water pollution due to the runoff of nutrients and organic matter [1, 16]. In worse situations, when farm areas are located near settlements, improper waste disposal and stagnant water hidden behind plant waste create ideal breeding grounds for mosquitoes and other pests that spread diseases. Also, in many rural areas, limited access to waste management infrastructure exacerbates these issues, leading to inefficient and environmentally harmful disposal practices [12, 14].

Thus, managing farm waste sustainably is crucial and must consider a "double-edged sword" strategy to safeguard environmental quality and improve the livelihoods of rural smallholders [6, 15]. To address these challenges and seize these opportunities, farmers need to adopt value-added activities and projects, such as converting agro waste, plant residue, and manure into biochar and other organic products [8, 10, 13]. By doing so, rural farmers can improve their environmental footprint, enhance soil health, and achieve greater economic sustainability.

This article was formulated with the intention of identifying the emerging potentials and challenges of managing farming waste among smallholders in rural areas and the potential adoption of biochar production and use as a value-added project. The information shared in this article was obtained through a review of the literature on related topics and results from field observations involving a group of smallholders under a cluster farming program in the Hulu Terengganu district. The findings highlighted the potential for rural smallholders to use biochar production and usage to manage their farm agro waste sustainably, reduce farming input costs, and promote organic or semi-organic farming in rural areas.

Literature review

Farm Agro Waste and Biochar Production

Farm agro waste management is a critical component of sustainable agriculture. It directly impacts environmental sustainability by influencing greenhouse gas emissions, soil health, water quality, and biodiversity [14, 17]. By adopting sustainable waste management practices, such as converting waste into biochar, composting, integrated farming etc., farmers can reduce their environmental footprint, improve resource efficiency, and contribute to the broader goals of sustainable development and climate change mitigation [7, 16] (Figure 1). Review of literature explains that in general, farm agro waste management refers to the process of handling, treating, and disposing of waste materials generated from agricultural activities [9]. This waste includes crop residues, plant matter, manure, and other organic materials produced on farms [17]. There has been a growing debate on managing farm waste more sustainably, as agricultural expansion in rural areas has become a significant issue for environmental sustainability. Rural landscapes are dominated by agricultural lands, water bodies, and forested areas, maintaining their primary function as food production areas to feed growing markets and urban populations. The pressure to increase farm production to meet market demand directly raises the amount of waste produced by rural farmers.

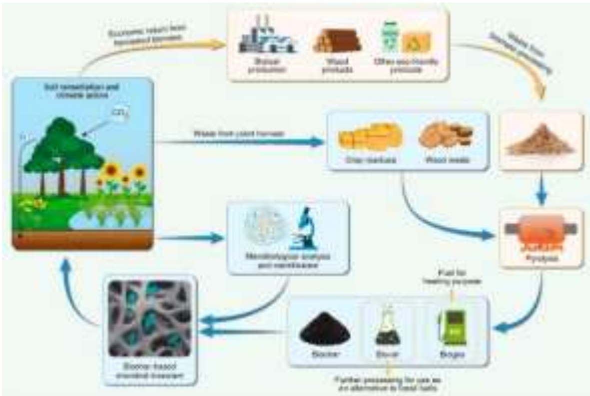

Fig. 1. Farm agro waste management for biochar production and soil remedy.
Source: [17].

Consequently, waste management is often a significant issue for rural smallholders. In addition to the lack or absence of appropriate facilities to process agricultural waste, small rural farmers also lack exposure to methods of converting their agricultural waste and manure into value-added products such as biochar, an organic fertiliser [1]. In a simple term, biochar is a stable, carbon-rich form of charcoal that is produced from biomass through a process called pyrolysis [2]. Pyrolysis involves heating organic material in the absence of oxygen, which results in the decomposition of the material and the release of volatile compounds. The remaining solid product is biochar, which can be used as a soil amendment [17].

As shown in Figure 1, farm ago waste management involves several stages, from the generation of agricultural waste to the final production of biochar which is summarised in Table 1 below.

As shown in Table 1, each stage of the process plays a crucial role in determining the characteristics and effectiveness of the final biochar product. The selection of feedstock, pyrolysis conditions, and post-processing treatments can be optimised based on the desired application of the biochar. As for this study, the researchers focus only on the production and usage of solid biochar by a rural farming group which will be explained in the following section.

Table 1. Main process or stages involved in biochar production and use

Stage	Explanations
1. Farming and Agro Waste Generation	Agricultural and forestry activities generate organic residues like straw, stalks, husks, branches, and leaves, which are often seen as waste but can be valuable materials for producing biochar.
2. Collection and Preparation	The agro-waste is collected and prepared by drying and shredding to improve processing efficiency.
3. Pyrolysis	The prepared biomass undergoes pyrolysis, a process heating it to 350°C–700°C without oxygen, decomposing it into solid biochar, liquid bio-oil, and gaseous syngas.
4. Biochar Production	The solid component remaining after pyrolysis is biochar. Its properties, such as porosity and nutrient content, depend on the type of feedstock used and the pyrolysis conditions.
5. Cooling and Collection	After pyrolysis, the biochar is cooled and collected. It may undergo further processing, such as grinding or sieving, to achieve the desired particle size for its intended use.
6. Application	Biochar can be used in various applications, most notably as a soil amendment to improve soil fertility and water retention, reduce nutrient leaching, and sequester carbon.

Source: [2, 12, 17].

Biochar and Rural Smallholders

As explained in the previous section, the sustainable farm agro waste management for rural smallholders involves several key practices to optimise resource use, reduce waste, and improve environmental health [16]. The concept of producing solid material through decomposing under high temperature and controlled burning of farm waste without (or limited presence) of oxygen have been practiced widely by many rural small farming entities around the world [7].

Photo 1. Examples of biochar kitchens used by rural smallholders in various countries.
Source: [2, 11].

As shown in Photo 1, rural farmers developed the "biochar kitchen" to "cook" farm agro waste hence producing a solid biochar product with the three basic principles of locally-sensitive technology, low-cost and rapid execution [11].

Based on Photo 2, it is clear that rural smallholders opted for biochar with a strong connection to the three basic principles as previously mentioned which are:

(i)Locally-sensitive technology – Local farmers developed biochar kitchen to cook local farm agro waste depending on the crops the planted including maze, rice, wood/timber and other sorts of vegetables [2]. The complexity of technology ranges between very simple/basic by using mud and clay to construct biochar kitchen, to recycle drums and proper stove unit. Regardless of these scales of complexity, the technology must be acceptable by local farmers to use it on the long run basis.

(ii)Low-cost – With the increasing cost for farming over the years, rural farmers facing a tough time to sustain the farming project. Hence, a low-cost solution in managing farm agro waste and the potential for reducing farming cost input and even with some potential of earning extra income through production of biochar as organic fertiliser, will be regarded as a good new for the farmers. Most of the biochar kitchens as shown in the above figure have been constructed using low-cost materials which easily available at local level, hence reducing the initial cost for biochar production and operations [9].

(iii)Rapid execution – One of the key successes for any technologies to be introduced for rural farmers is its ability to offer rapid implementation and execution. Slow or difficult for implementation often hindered the potential users hence could end up with low support and lack of commitments for a long run. Rapid execution also will increase the interest for other farming communities to adopt to a similar project, more inclusive rather than exclusive, and also allowed for a timely assessment for any return of their initial investment in biochar kitchen project [16].

MATERIALS AND METHODS

Case Study of Vegetable Farmers in Hulu Terengganu

In early 2020, a field observation was conducted in the Kampung Sungai Ara agriculture group in Hulu Terengganu (located in the east coast of peninsular Malaysia) [11], where an informal interview session was held with several respondents about the use of biochar kitchens for processing farm leftovers into organic fertiliser (Map 1).

Map 1. Location of Hulu Terengganu in the East Coast Malaysia and the study site Kampung Sungai Ara (marked in star shape)
Source: [11, 18].

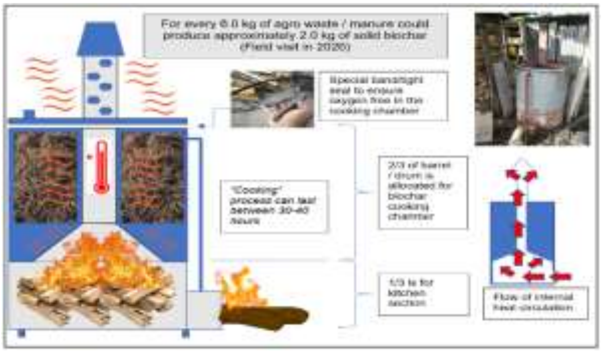

Fig. 2. Cross section of biochar kitchen that used by smallholders in Hulu Terengganu.
Source: [1]

The project was initiated by researchers from a local university in Kuala Terengganu, beginning with the distribution of two biochar kitchen units about six months prior. This number has now increased to 12 units, providing one unit for each farmer. For the farmers, the biochar kitchen is a simple yet practical tool for converting agricultural waste and livestock manure into organic fertiliser, which is then returned to their own farming projects (Figure 2). Some farmers who dedicate more time to the biochar project often produce an excess of fertilizer, which they sell to other farmers for additional income.

Key Informant Interviews

During the field visit in Kampung Sungai Ara, the researchers met *Pak Lah*, a retiree who spends his time cultivating cucumbers and red chilies in his *kebun* (farm) using the hanging fertigation method. During the visit, Pak Lah showed us his biochar station and the finished product, i.e., solid biochar, which he stores for future use (Photo 2). According to *Pak Lah*, the cooking process typically takes between 30 to 40 hours, requiring him to constantly add firewood to the main intake to maintain the burning process. It is essential to keep the barrel tightly sealed throughout the burning process.

Another respondent, *Pak Lan*, also demonstrated his biochar unit, which can produce up to 30 kg of solid biochar in a single burning cycle. Since *Pak Lan* and other farmers now use biochar, they are busy at the end of the harvest season turning agro waste and plant leftovers into biochar.

However, since the majority of farmers live nearby, biochar production offers them convenience and safety. They start the burning process, leave, and return after a few hours to add more firewood to the intake until the 30-to-40-hour of burning and cooling stages are complete. Additionally, the biochar produced is used locally, reducing the need for transportation between production and utilisation within the same farming area. According to *Pak Lah*, if they continuously burn waste, they can produce enough organic fertiliser stock for the next farming season. *Pak Lah* agrees with *Pak Lan's* statement because he manages to save up to 30% on farming inputs each season using biochar. Currently, all 12 farmers participating in the project have received 30 farm canopies from the Agricultural Department. Each canopy, measuring 8' x 60', can accommodate 40 polybags, or approximately 1,200 polybags in total.

Photo 2. From left – Pak Lah showing his biochar station; solid biochar; hanging fertigation project utilising biochar from the processing of agro-waste.
Source: Research Fieldwork [11].

Based on the field visit, the production of biochar by rural smallholders offers an alternative method for processing farm agro-waste into a value-added product, specifically solid biochar as organic fertiliser. For the farmers, producing their own biochar reduces farming costs and helps keep their farms tidy and more organised. However, the primary challenge they face is the market price for their produce, which is currently not favourable. Even if they manage to reduce farming costs by producing more biochar, the instability of vegetable prices affects their overall income. If their income remains low or stagnant, it becomes difficult for them to sustain their farming activities over the long term. The following section shall discuss the advantages and challenges of biochar.

RESULTS AND DISCUSSIONS

Advantages and Challenges of Biochar Production and Use

The literature review and field observation and interviews uncovered various benefits for smallholders in producing biochar and the extent to which biochar transforms farm waste into valuable resources, thereby improving farming practices among rural farmers. As shown in Figure 3, biochar offers a multifaceted solution to agricultural challenges by transforming waste and improving farming sustainability [16]. Through the process of pyrolysis, agricultural waste such as crop residues, manure, and other organic materials are converted into biochar, which helps mitigate waste management issues and reduces greenhouse gas emissions.

This transformation not only enhances soil fertility by retaining essential nutrients and improving soil structure and water-holding capacity but also benefits regions with arid climates or dry seasons [5]. Additionally, biochar aids in balancing soil pH, making acidic soils more productive [10]. As a stable form of carbon, biochar sequesters carbon dioxide for hundreds to thousands of years, contributing significantly to climate mitigation by reducing reliance on chemical fertilisers and enhancing soil organic matter. Economically, converting waste into biochar adds value to materials that would otherwise be discarded and boosts productivity by increasing crop yields, thus providing tangible economic benefits to farmers.

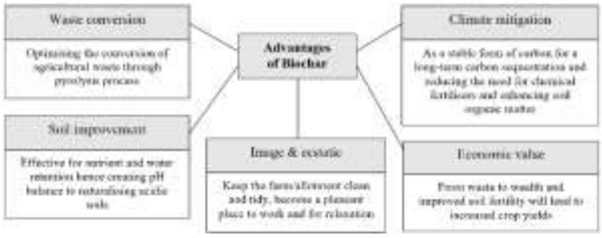

Fig. 3. Advantages of producing biochar from the agricultural farm waste
Source: [2, 11, 16, 17].

On the other hand, applying biochar in farming projects presents several challenges for rural farmers. As shown in Figure 4, rural farmers face several significant challenges in adopting biochar production, primarily due to limited access to technology and equipment like pyrolysis units. This technological gap is exacerbated by the lack of electricity in many rural areas, hindering the large-scale production of biochar. Additionally, a general lack of knowledge and training further complicates the situation, as farmers often remain unaware of the potential benefits and correct application methods for biochar.

Fig. 4. Challenges of producing biochar from the agricultural farm waste
Source: [2, 9, 11, 17].

Economic barriers also play a crucial role, as the high initial costs associated with setting up biochar production can be prohibitive for smallholders who already face financial constraints. Compounding these issues is the lack of established markets for biochar products, which diminishes economic incentives for farmers to invest in production. This problem is further aggravated by inconsistent or non-existent supportive policies, making it difficult for farmers to navigate and commit to biochar projects. Finally, poor infrastructure and logistics in rural areas add to the challenge, as inadequate transportation networks increase costs and reduce the feasibility of transporting materials needed for biochar production.

Addressing these interconnected challenges requires a comprehensive approach that includes improving access to resources, providing education and training, developing supportive policies, and establishing market structures. Addressing these challenges involves improving access to resources, providing education and training, developing supportive policies, and establishing market structures. These efforts can help unlock the potential of biochar for sustainable agricultural practices in rural areas.

CONCLUSIONS

Based on the literature review and a field visit with interviews highlighting the benefits and challenges of biochar for the on-going rural farming project [2, 9, 16, 17], this conclusion section will present preliminary recommendations for enhancing biochar production and use through a comprehensive approach involving promotion, integration into farming practices, economic support, monitoring, and collaboration for sustaining biochar application by the rural farmers:

(1)Promoting biochar production requires educating farmers on its benefits and production techniques, ensuring access to affordable pyrolysis equipment, and encouraging the use of locally available materials.

(2)Investment in research and development is crucial to optimise biochar production processes and tailor its application to different soil types. Integrating biochar into farming practices involves conducting soil tests to determine the appropriate type and amount of biochar needed, developing guidelines for effective application, and providing crop-specific recommendations to maximise benefits.

(3)Economic incentives such as subsidies and grants can motivate rural farmers to adopt biochar practices, while market development efforts can encourage the production and sale of biochar and related products.

(4)Policy support is necessary to implement sustainable agriculture practices, including the use of biochar.

(5)Monitoring and evaluation should focus on assessing the environmental and economic impacts of biochar application, establishing feedback mechanisms for continuous improvement, and developing sustainability metrics to measure productivity gains.

As a summary, a collaborative approaches as stated above should involve engaging stakeholders such as governments, NGOs, research institutions, and private sector players. Knowledge sharing through workshops, seminars, and online platforms is important, along with community involvement in biochar production projects to create local employment opportunities and enhance community resilience. Furthermore, biochar production and application, as demonstrated by rural farmers in Hulu Terengganu present a sustainable solution for transforming farm agro waste into valuable resources, promoting soil health, sequestering carbon, and enhancing economic growth in agricultural communities. By implementing the above strategies, farmers can adopt biochar as a key component of sustainable agriculture, leading to long-term environmental and economic benefits.

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TOMATO PRODUCTION AND PRICE IN THE EUROPEAN UNION

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Abstract

Tomato production within the European Union (EU-27) is a vital component of the agricultural sector, providing significant economic and nutritional value. This study examines the trends in tomato production and the impact of agricultural input prices across key EU countries: Italy, Spain, Portugal, Poland, Greece, the Netherlands, and France from 2015 to 2022. The research investigates the influence of climate change, fluctuations in input costs, and shifts in production conditions on tomato production levels. Climate change, characterized by increased frequency of extreme weather events such as high temperatures and prolonged droughts, poses a substantial challenge to tomato cultivation, affecting yield and quality. Rising costs of essential inputs—seeds, fertilizers, plant protection products, and fuel—further exacerbate production challenges. Specifically, fertilizer prices have surged significantly, particularly after 2020, due to global economic factors including trade wars and supply chain disruptions. The study employs data from the Eurostat database and various scientific sources to analyze production trends and price indices, using graphical and regression analyses to assess the impact of these factors. Results indicate a 9.2% decline in overall EU tomato production from 2015 to 2023, with notable reductions in Greece, the Netherlands, and Spain. Despite these declines, some countries, such as Italy and Portugal, have increased their production shares, reflecting a shift towards more efficient agricultural practices. Findings suggest that while higher tomato prices can incentivize increased production, rising input costs significantly impact profitability. The analysis underscores the importance of adopting sustainable agricultural practices and supportive policies to mitigate cost pressures and enhance production efficiency. Future strategies should focus on investing in innovative technologies and adaptive practices to ensure the resilience and sustainability of tomato production in the EU.

Key words*: *tomato producer's price, climate change, input prices

INTRODUCTION

Tomatoes have emerged as a crucial economic and nutritional resource within the agricultural sector of the European Union (EU). The production of tomatoes is significant across various European countries, particularly in Italy, Spain, Portugal, Poland, Greece, the Netherlands, and France. These nations are prominent players in EU tomato production, assuming a strategic role in both domestic consumption and export of the product [14, 28]. However, recent years have witnessed various challenges in the production processes, leading to significant changes that threaten the sustainability of tomato cultivation. In this context, it can be clearly stated that climate change, fluctuations in agricultural input prices, and shifting production conditions are among the principal factors affecting this sector.

Increasing temperature, drought, cold and salinity are important abiotic stresses that cause serious cellular damage in the most of plant species including tomate and other vegetabales and are considered as the results of global climate change [8]. This situation is one of the critical factors that significantly affect both agricultural production and tomato cultivation. Climate changes associated with global warming have led to more frequent and severe extreme weather events. This situation negatively affects agricultural production and causes yield and quality losses not only in tomatoes but also in many species. Extreme weather conditions such as high temperatures and prolonged droughts directly affect tomato growth, development and yield. For example, [6] determined the effects of meteorological events such as temperature fluctuations, excessive rainfall and low humidity on tomato production and indicated the important effects of climate change. In addition, [41] stated that it is necessary to develop salt-tolerant tomato varieties to increase productivity and overcome socio-economic challenges, especially in saline environments. In this context, development of adaptation strategies to both climate change and abiotic stress conditions is necessary to increase sustainability and yield in tomato production. Therefore, the effects of climate change on tomato production need to be examined in detail, current production strategies need to be re-evaluated and new strategies need to be put forward to improve tomato production under these changing environmental conditions.

In addition to environmental factors, the costs of agricultural inputs such as seeds, fertilizers, plant protection products, fuel and herbicides used in tomato production are the most important factors determining the economic aspects of the production process. Recent years have seen substantial increases in the prices of these agricultural inputs, significantly raising production costs. Specifically, the rising prices of fertilizers and plant protection products have adversely affected the profitability of producers and complicated production processes. It is an accepted fact that changes in agricultural input prices directly affect production costs and, consequently, the profitability of producers. Therefore, it is essential to utilize resources efficiently. Indeed, resource use efficiency refers to the ability of a farm firm to obtain maximum output per unit of resources used in the production cycle [36]. Additionally, the European Commission provides crucial data on the relationship between input price indices and production [12]. This study analyzes the effects of input price indices on costs in detail, with price indices calculated using 2015 as a baseline and annual variations illustrated graphically.

EU agricultural policies also play a significant role in production. The European Commission's 2022 report offers a detailed evaluation of EU agricultural policies and production trends. This report encompasses regulations aimed at supporting agricultural production and ensuring sustainability in member contries [12]. Moreover, studies on agricultural input price indices and production trends contribute to understanding the effects of these policies [27].

The data used in this paper are sourced from the Eurostat database and various scientific publications. The period from 2015 to 2022 has been comprehensively examined, with production and price data analyzed in detail [13]. Graphical presentations of the data have helped in identifying annual changes and differences between countries. Regression analysis was used in this study to determine the trends in tomato production and the reasons for price increases. With these analyses aim to better reveal the effects of climate change and other economic factors on production. In addition, the current situation can be evaluated with the results of these analyses and future strategies can be determined. Similarly, the effects of agricultural input prices were determined not only for tomatoes but also for vegetable species such as lettuce and their effects on production costs were determined [33]. Furthermore, [39] reported that there has been a decrease in cereal production in the EU in recent years due to the negative effects of climate change. Additionally, it has been reported that not only changing climate conditions but also increasing production costs affect both the competitiveness of countries in plant production and the domestic and international trade of fresh vegetables [1, 2].

By examing the effects of climate change and economic factors on crop production including tomato, the current situation can be better understood. A better understanding of these factors can help developed more effective strategies for future agricultural production. Additionally, the study has the potential that can provide important suggestions for sustainable tomato production with improving new agricultural policies by better understanding the difficulties faced by producers. Therefore, this study was conducted to present a comprehensive analysis of tomato production and agricultural input prices in EU member states.

MATERIALS AND METHODS

The paper is based on extensive data collected from various publications, including scientific articles and reports from the European Commission. The Eurostat database was utilized to gather statistical data. The primary indicators studied include:

1- Tomato production at the EU level from 2015 to 2022, specifically in the main tomato-producing countries: Italy, Spain, Portugal, Poland, Greece, the Netherlands, and France. Graphical illustrations were created to highlight the differences in production between countries over the years. The tomato prices considered in this study are expressed in price indices, calculated relative to the price level in 2015, which serves as a fixed baseline.

2- The analysis covers:

- Producer prices
- Farm input prices, including seeds, NPK fertilizers, products for plant protection against diseases, pests, and herbicides, as well as fuel.

Regression analysis was conducted to identify trends in tomato production within the EU. The study also discusses the impact of climate change, particularly extreme meteorological events, to explain the decline in tomato production in the EU and its main producing countries. Additionally, the study explores the reasons behind the recent price increases.

Finally, the study attempts to reveal the effect of various factors influencing tomato production within the European Union-27 through regression analysis. The functional form of the estimated model is as follows:

PRD = ƒ (TP, PIS, PINPK, PIF, PIH)

PRD:Tomato Production (EU-27)
TP:Tomato Price
PIS:Price indices of Seed
PINPK: Price indices of NPK
PIF: Price indices of Fuels
PIH: Price indices of Herbicides

RESULTS AND DISCUSSIONS

Climate change is one of the most significant threats to crop production and natural biodiversity in the 21st century [3, 9, 10]. In addition to climate change, high input costs, price increases in inputs and abiotic stress factors negatively affect vegetable production. The impact of the COVID-19 pandemic, which continued from 2020 to 2022, can also be added to these factors. In particular, according to the available findings in this work, a 9.2% decrease in production was determined in the nine-year period in tomato production in the European Union. While a decrease was detected in production, no decrease was detected in tomato production areas. Therefore, this decrease in tomato production can be attributed to climate change and abiotic stress factors rather than high input costs and increasing prices.

While the tomato production of EU-27 was determined as 17,628,000 tons in 2015, it was determined that it decreased to 16,014,000 tons in 2023. In addition, the change in tomato production over the years is also supported by the trend equation (Y= -16.2 x^2 + 65,368 x - 65,720,597) in Figure 1. It is clearly seen that there is a decreasing trend over time both in Figure 1 and in the given equation.

Italy, Spain, Portugal, Poland, Greece, the Netherlands and France are the leading tomato producing countries in the EU and the changes in tomato production quantities of these contries are presented in Figure 2. Among these countries, the highest decrease in tomato production between 2015 and 2023 was determined in Greece with 30.5%, followed by the Netherlands and Spain with decreases of 18.4% and 17.9%, respectively. Among these major tomato-producing countries in the European Union, only Portugal and Poland did not see a decline in production. All other countries experienced varying degrees of reductions in tomato production.

The extreme weather events experienced in Italy, France, and Spain in 2022, exacerbated by intense heat waves, have adversely affected agricultural production [39]. It is clear that European countries, particularly those in the Mediterranean region, have been significantly impacted by negative climatic events occurring globally in recent years. As a result, studies and statistical data indicate a decline in agricultural productivity and production [14, 39]. In the EU, prolonged droughts combined with reduced rainfall and vegetation stress have led to a decrease in agricultural output [16, 18]. Similarly, reductions in the production of maize and wheat have also been determined [39].

These declines highlight the multifaceted challenges faced by the agricultural sector, including climate change, economic pressures, and shifts in agricultural practices. Climatic extremes occurring at different times during the crop cycle can significantly reduce productivity beyond typical yield losses [5]. In South Florida, rising temperatures have decreased tomato fruit numbers and yield due to lower pollen viability and fruit set, and continued warming may further impact productivity [4]. The increasing frequency and intensity of extreme weather events may elevate the risks of simultaneous crop failures, including tomatoes, both regionally and globally [30, 35, 40].

Along with climate change, economic factors and rising costs of inputs such as seeds, fertilizers, and plant protection products can reduce profit margins and complicate production. The [25] further corroborate this by noting that input price volatility presents a major risk to agricultural profitability.

However, the resilience observed in Portugal and Poland, where production levels remained stable, suggests that effective adaptation strategies are in place. In the context of climate change, alterations in the concentrations of gases such as CO_2 and O_3, changes in temperature and precipitation, long-term water shortages, unsuitable soil conditions, drought, and desertification, as well as outbreaks of plant diseases and pests, are expected to significantly impact plant growth and increase both biotic and abiotic stress factors [7]. Tomato production has been affected by various biotic and abiotic constraints. Abiotic stresses are frequently interconnected; individually or in combination, they cause alterations at various biological levels that harm plant growth and productivity, ultimately leading to reduced yields [7, 8]. Climate-smart practices, such as enhanced irrigation and drought-resistant crops, can help mitigate the adverse effects of climate change. Additionally, supportive government policies are essential for farmers to adopt sustainable practices and technologies [26].

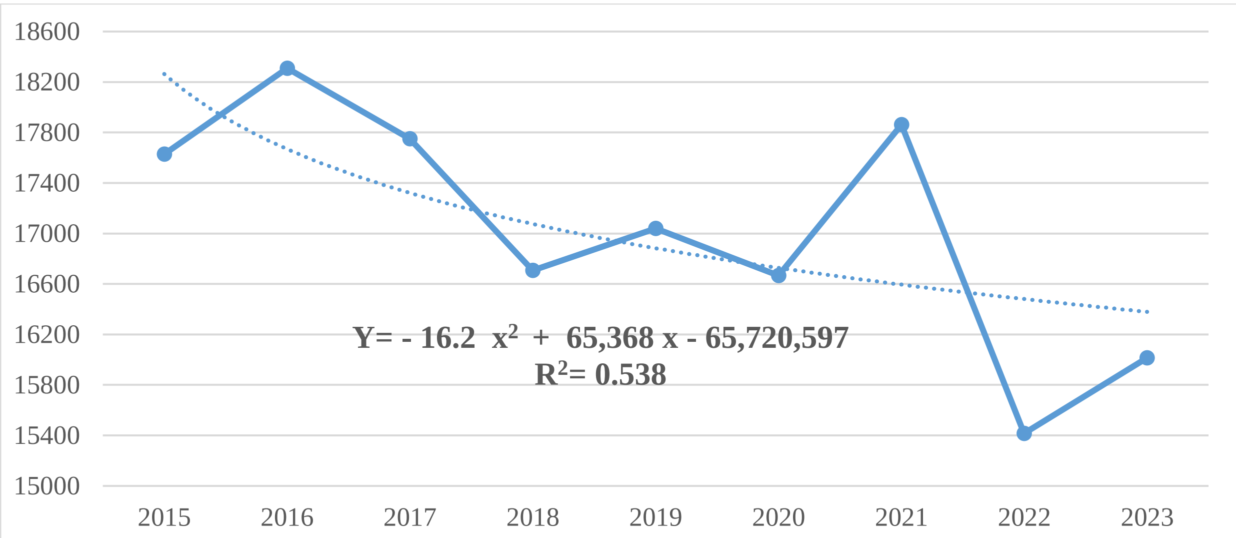

Fig. 1. Dynamics of tomato production in the EU, 2015-2022 (Thousand tonnes)
Source: Own design and calculations based on the data from [13].

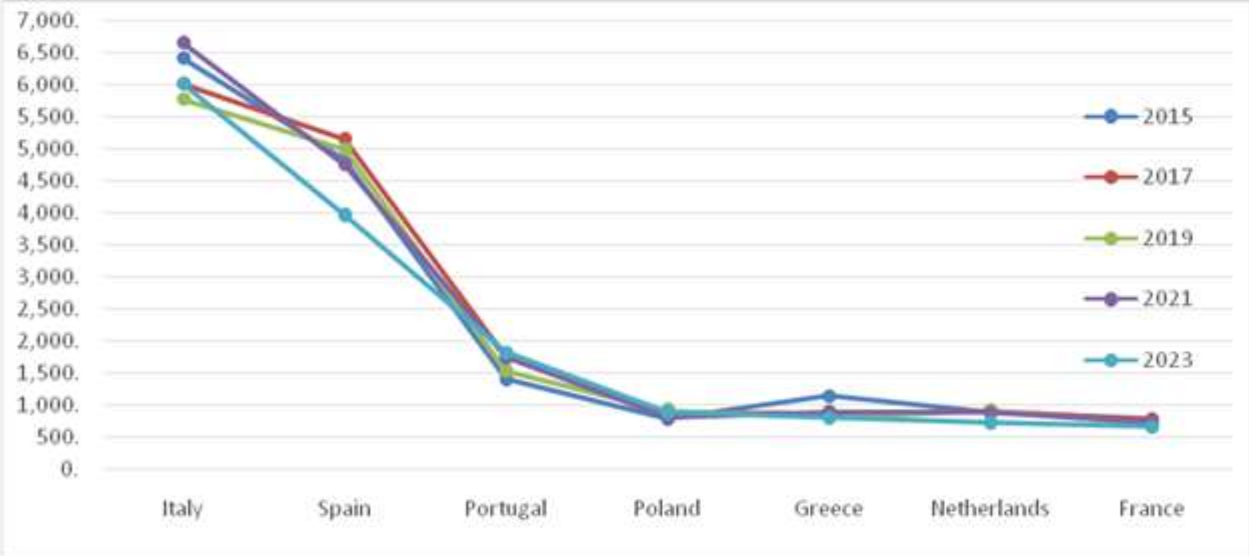

Fig. 2. Dynamics of tomato output in the EU main producing countries, 2015-2022 (Thousand tonnes)
Source: Own design based on the data from [17].

An analysis of the changes in production shares from 2015 to 2023 reveals that Italy, which held the largest share of tomato production in 2015 at 36%, experienced an increase in its share to 38% of total production by 2023. Similarly, Portugal's share of total tomato production rose from 8% to 11%. While the Netherlands, France, and Poland maintained their shares of total production during the examined period, Spain's share decreased from 27% to 25% (Figure 3). Despite fluctuations in the production shares among these countries, the combined share of the leading tomato-producing countries within the EU-27 increased from 92% in 2015 to 93% in 2023.

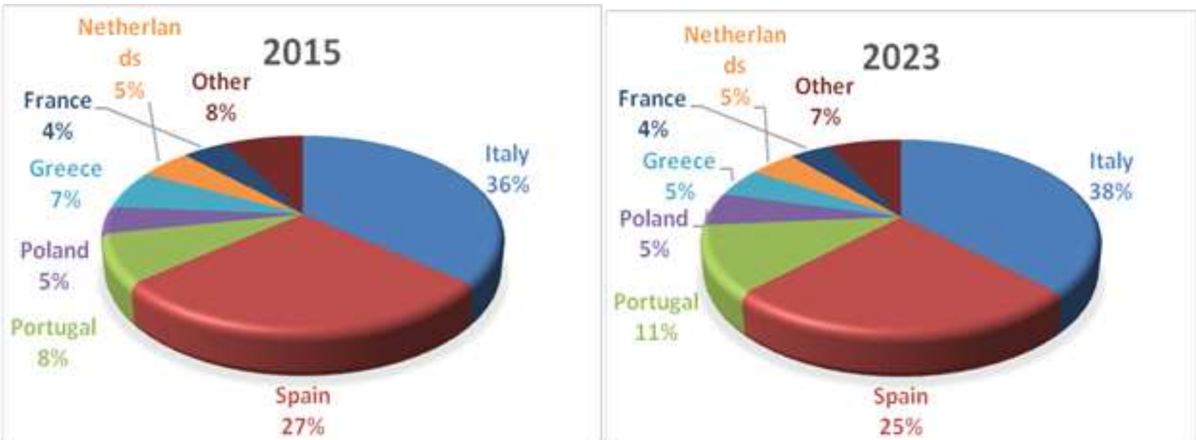

Fig. 3. The contribution of the major producing member states to the EU tomato production in 2023 versus 2015 (%)
Source: Own design and calculation based on the data from [19].

During the period from 2015 to 2022, the tomato price index was set to 100 based on the year 2015, and changes relative to this base year were analyzed. Across the European Union, there was a detected increase of 44.28% in 2022 compared to 2015. While producer prices vary between countries, the highest increase was recorded in Poland, with a rise of 71.65%. Conversely, the lowest increase occurred in the Netherlands, at 24.00% (Figure 4).

Certified seeds, essential fertilizers, pesticides for pest control, advanced agricultural machinery, and irrigation water, among other variable costs, account for a significant portion of agricultural production expenses. These variable costs, particularly in crop production, constitute the largest share of total production costs and substantially impact the gross profit margin per hectare [34, 37, 38].

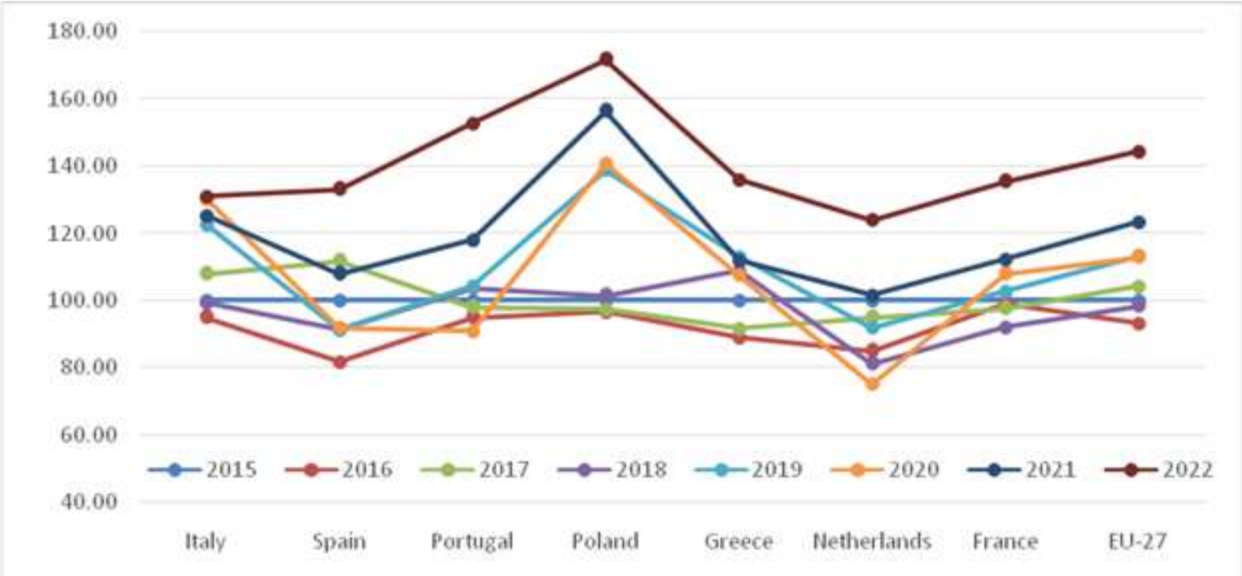

Fig. 4. Tomato price indices in the EU main producing countries, 2015-2022 (%), 2015=100
Source: Own design based on the data from [20].

During the examined period within the European Union, the seed price index was found to have increased by 34.38%. In the leading tomato-producing countries within the EU, the highest increase in seed prices was recorded in Poland at 57.58%, followed by Italy at 44.60%. The lowest increase in seed prices within the EU was observed in France, at 8.37% (Figure 5).

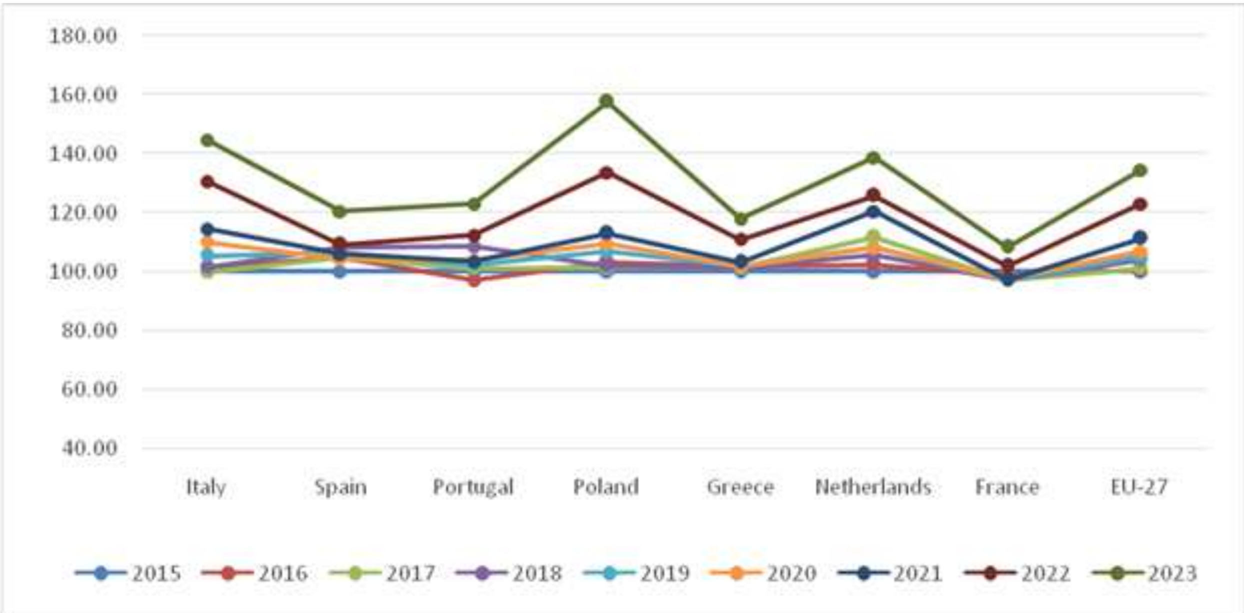

Fig. 5. Price indices of the means of agricultural production, Seeds input (2015 = 100) - annual data in the EU main producing countries, 2015-2022 (%), 2015=100
Source: Own design based on the data from [21].

Fertilizers are among the most critical inputs in agricultural production. Specifically, nitrogen and phosphorus fertilizers are fundamental plant nutrients widely used both in general agriculture and in vegetable production [31, 32, 33].Consequently, significant fluctuations in fertilizer prices can lead to reduced fertilizer use, ultimately resulting in decreased production.

The basic fertilizer index within the EU-27 has shown a substantial increase, with a rise of 94.05% from 2015 to 2022. Notably, while the increase was relatively stable from 2015 to 2020, nearly all of this increase occurred in the last year of the period (Figure 6). Portugal exhibited the highest increase, with a rise of 141.17%, followed by Spain with an increase of 87.92%. The lowest increase in the basic fertilizer price index was observed in Greece, at 57.33%. It is noteworthy that while no significant increases were recorded in the leading tomato-producing countries between 2015 and 2020, there were substantial increases observed in the last two years.

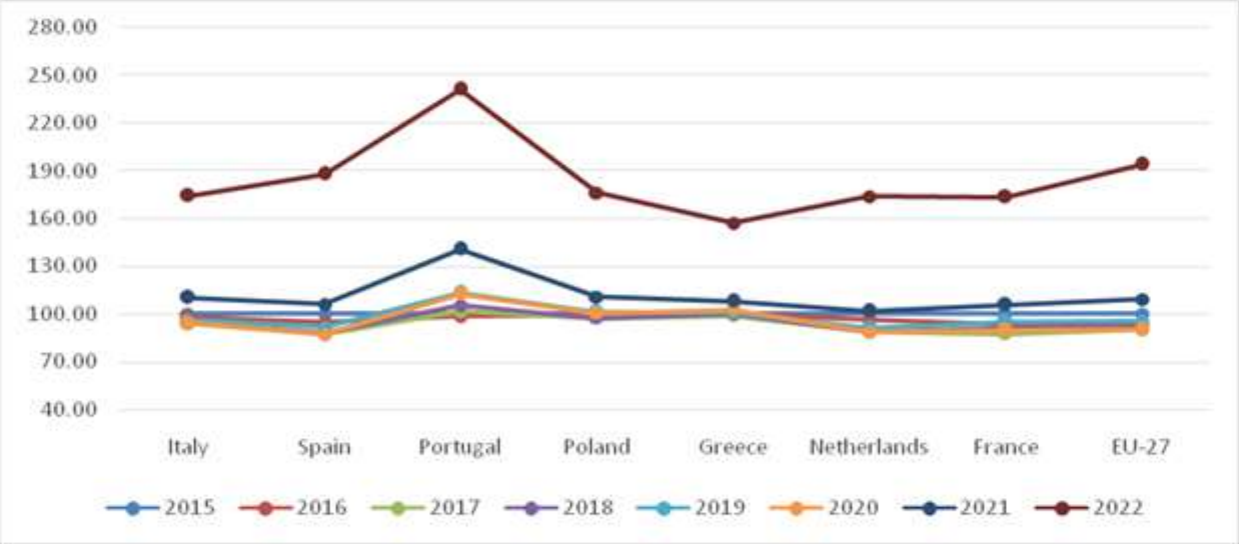

Fig. 6. Price indices of the means of agricultural production, NPK fertilizers input (2015 = 100) - annual data in the EU main producing countries, 2015-2022 (%), 2015=100
Source: Own design based on the data from [22].

An examination of the plant protection products price index reveals an increase of 14.46% from 2015 to 2022. Over the eight-year period analyzed, only France experienced a decrease of 4.02%. The countries with the highest increases in plant protection product prices were Portugal, with a rise of 56.23%, followed by Spain with 28.14%, and Italy with 24.90% (Figure 7).

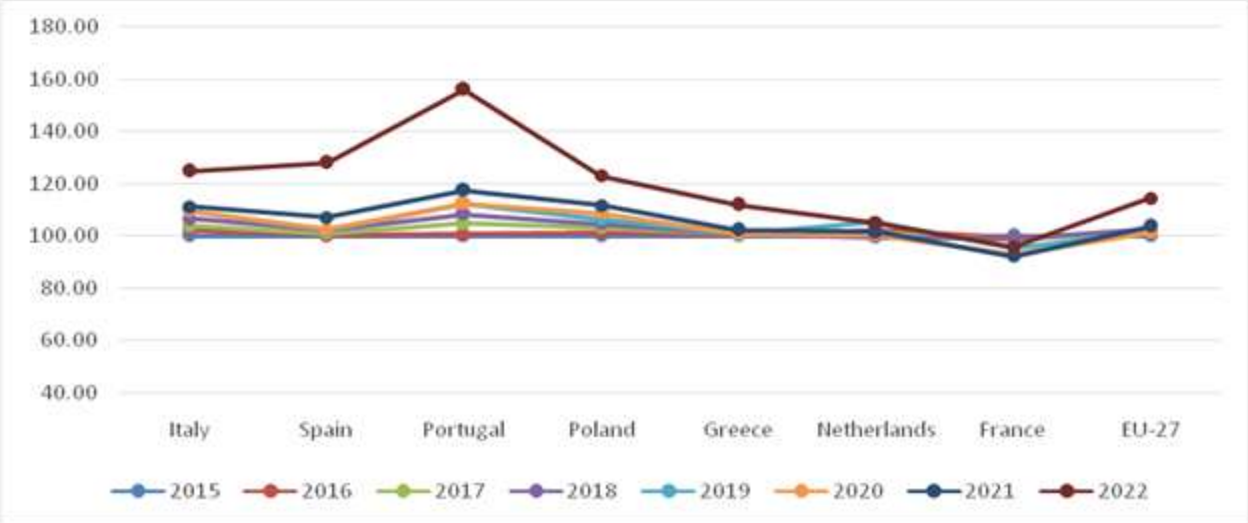

Fig. 7. Price indices of the means of agricultural production, Plant protection products input (2015 = 100) - annual data in the EU main producing countries, 2015-2022 (%), 2015=100
Source: Own design based on the data from [23].

In the EU-27 countries, the fuel price index for agricultural use was 100 in 2015, increased to 115.40 in 2021, and reached 166.13 in 2022, indicating a 66.13% rise from the base year (Figure 8). While there was no significant increase in fuel price indices among the leading tomato-producing countries from 2015 to 2021, an average increase of 45% was observed in 2022 compared to 2021. The most substantial increases in fuel prices were recorded in France (90.97%) and Spain (87.00%), whereas the least increases were noted in Poland (51.33%) and Greece (54.74%).

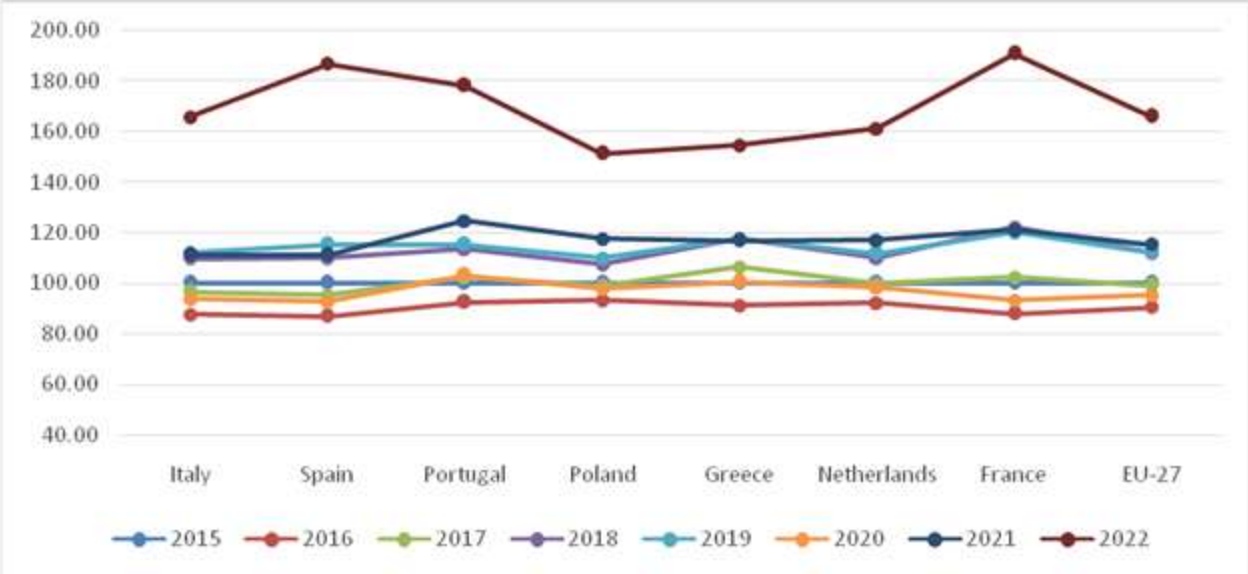

Fig. 8. Price indices of the means of agricultural production, Fuel input (2015 = 100) - annual data in the EU main producing countries, 2015-2022 (%), 2015=100
Source: Own design based on the data from [24].

Based on the analysis, the tomato production model for the EU-27 can be explained with a high R^2 value of 0.955 (Table 1). This high R^2 value suggests that the model captures the variability in tomato production effectively. The analysis reveals that an increase in tomato prices is associated with an increase in tomato production. However, there is an inverse relationship between tomato production and the price indices of key inputs such as seeds, fertilizers, and fuel. Despite the high R^2 value, statistically significant relationships between the dependent and independent variables were not identified.

Table 1. Estimation Results of the EU-27 Tomato Production Model*

	$R^2 = 0.955$			
	Coefficients	**Std**. deviation	t Stat	*P*-values
Constant	-48121.317	28885.689	-1.666	0.344
Tomato price	13.360	30.479	0.438	0.737
Price indices of seed	-334.686	116.242	-2.879	0.213
Price indices of fertilizers	-110.675	53.163	-2.082	0.285
Price indices of fuels	-58.569	29.508	-1.985	0.297

Source: Calculated by authors.

The production of tomatoes in the EU-27 is significantly influenced by both economic and environmental variables. The changes in production shares observed from 2015 to 2023 highlight the variations in agricultural practices among these countries. For instance, the increase in production shares in countries like Italy and Portugal indicates a transition towards modern agricultural techniques and more efficient production methods. This situation can be explained by the fact that countries like Portugal and Italy have enhanced their agricultural production

systems' adaptive capacities in response to both economic and climate change challenges.
The relationship between rising tomato prices and increased production is consistent with well-established principles of agricultural economics. Higher prices provide farmers with the opportunity to generate greater income, thereby serving as an incentive to enhance production. However, increases in the prices of essential inputs such as seeds, fertilizers, and fuel are significant factors adversely affecting profitability in the agricultural sector. The limited advancements in optimizing the productivity of land, labor, energy, fertilizers, and other critical inputs in food production necessitate increased usage of these resources to meet growing demand, which is projected to result in elevated food prices [29].
The notable rise in fertilizer prices, particularly after 2020, can be attributed to global economic factors such as trade wars, supply chain disruptions, and increases in energy costs [26]. These factors have contributed to significant cost increases in input prices, even within developed agricultural markets like the EU-27. Regulatory policies and support programs play a critical role in alleviating these cost pressures. As highlighted by the [11, 15], promoting sustainable agricultural practices is crucial for managing input costs and enhancing overall production efficiency.

CONCLUSIONS

In conclusion, tomato production in EU-27 countries has not only been affected by environmental factors. Market dynamics such as seed, fertilizer and fuel have also affected tomato production. In addition, changes in production shares may have been affected by the agricultural policies and applied agricultural techniques of these countries. For example, the increase in production shares in countries such as Italy and Portugal or the decrease in Greece may be under the joint effect of these factors. Furthermore, the increasing costs of basic inputs such as seed and fuel, and the increase in fertilizer prices, which became especially evident after 2020, have been identified as critical factors that negatively affect production in the agricultural sector.
Tomato production in the EU-27 will continue to be affected by the process of adapting to market dynamics and environmental changes. Investing in new technologies and sustainable agricultural practices is critical to increase cost efficiency and productivity. In this context, policy makers and industry stakeholders should continue to develop supporting strategies and innovations for the sector.

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CREDIT SUPPORT FOR THE AGRICULTURAL SECTOR IN BULGARIA: STRUCTURAL ANALYSIS AND ECONOMIC DIMENSIONS

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Abstract

This paper examines the dynamics and significance of lending in the agricultural sector of the Republic of Bulgaria and its connection with the sector's economic contribution. Using data from the Bulgarian National Bank and FAO for 2000-2023, the analysis focuses on the structure of loans by size and term and a comparative analysis of Bulgaria with EU-27 countries. The study includes the calculation of the Agricultural Orientation Index (AOI), which normalises credit support against the economic contribution of agriculture. The results show that Bulgarian agriculture faces more limited access to credit, which restricts its investment potential compared to other EU countries. The regression analysis reveals a positive correlation between lending and the gross value added of the agricultural sector, with lending explaining approximately 52% of the variation in the sector's economic contribution. The study emphasises the need to develop a more targeted credit policy that meets the specific needs of agricultural producers in Bulgaria and supports their competitiveness and sustainability.

Key words: *agricultural sector, agricultural credit, economic contribution, Agricultural Orientation Index, Bulgaria*

INTRODUCTION

The enhancement of agriculture is becoming more vital problem in modern times as there is a growing urgency to ensure food security and stable pricing of farm products. Achieving these targets requires the establishment of effective credit policies and better access to long-term loans, facilitating the agricultural firms in their investment in modern and sustainable technological solutions. This is essential for increasing the competitiveness and sustainability of the agricultural industry globally and locally, including in the Republic of Bulgaria.

Agricultural credit plays a fundamental role in mobilising resources at all levels, aimed at increasing productivity and production capacity in agriculture. This type of credit is provided with various forms of security - trust-based, pledged, or guaranteed- creating conditions for sustainable agribusiness financing [16]. In the short run borrowing from the banks to secure working capital is a fundamental source of funding for the ongoing production process. At the same time, long-term loans play a critical role in investments in long-term assets and support of projects related to agriculture, livestock farming and processing of agricultural products. The shortage of long-term financing is a critical factor that can limit the efficiency of farms and slow the development of agriculture as a whole [7].

Agricultural loans are also considered a primary factor for stimulating growth in the agricultural sector, which can improve economic welfare and social stability in rural areas [1, 22]. Financial capital is vital for production and economic growth, as providing credits for agriculture strengthens the sector's development and helps develop rural areas. Capital is not simply another resource similar to labour and land but is a key instrument for transforming the agricultural sector's potential into actual production and added value [25]. However, compared to other economic sectors, productivity in agriculture is typically lower, which leads to higher financing requirements and specific conditions for agricultural loans, especially in developed countries [3]. Encouraging investment and increasing the agricultural’s sector influence on the economy and employment requires the implementation of sound macroeconomic policies and the provision of institutional financial support. Numerous investigations have been dedicated to exploring the difficulties of securing loans in the agricultural field. [9, 17, 4, 8]. Research shows that access to credit is a crucial stimulus for improving productivity in the agricultural industry in Central and Eastern Europe. However, the relationship between credit constraints and farm behaviour, including the choice of agricultural resources and productivity, often remains less studied. This lack of research may be due to insufficient data and the complexity of credit markets for the agricultural sector, which require adaptation to the specific needs of farms.

Access to credit is closely linked to the production capacity of agricultural producers [22]. Farmers lacking adequate financial means for investment frequently face challenges in boosting their output and adopting innovative technologies. This limitation affect resource distribution in the sector and results in decreased productivity overall. Conversely, those with access to credit can improve their production capacity and expand their market positions, leading to increased cash flows and improved future access to credit. Investments in new technologies and better production practices, supported by credit, play a fundamental role in the sustainable development of the agricultural sector.

The functioning of financial markets in agriculture is accompanied by a high degree of uncertainty due to information asymmetry and limitations in access to capital [13]. Smaller farms often have no obligations for public disclosure of their financial condition, which makes it difficult for banks to assess their creditworthiness. The borrower's credit history is of decisive importance, but there are also moral risks arising from the sole proprietorship nature of farms. All this contributes to increasing the risk in agricultural lending compared to other sectors, which requires commercial banks to take specific measures for risk assessment.

In Bulgaria, the agricultural sector is particularly vulnerable to financial constraints due to the risky nature of production, underdeveloped secondary financial markets and frequent seasonal fluctuations in resource demand [7, 18, 24]. Agricultural financial markets in the country are poorly developed and are characterised by insufficient capitalisation, which limits access to credit for agricultural producers. The lack of securitisation, increased transaction costs, and low profitability of the sector lead to greater caution from banks when serving farmers. The low profitability in the agricultural sector, combined with high risks, creates specific challenges for creditors, which necessitates the development of innovative financial products and policies to support agribusiness.

Credits and subsidies are essential for Bulgarian agricultural producers' ability to invest in innovations and long-term assets. Common Agricultural Policy (CAP) subsidies guarantee credits, reducing risk for banks and stimulating farmer lending [20, 26, 2, 23, 12, 14, 15, 5]. Production-decoupled subsidies have an effect similar to long-term credits, while production-coupled subsidies are aimed more at short-term borrowing [8]. This shows that subsidies can play a decisive role in improving the investment potential of Bulgarian farms and strengthening financial stability in the sector.

The agricultural financial market in Bulgaria continues to develop but faces numerous challenges. Insufficient capitalisation, high transaction costs, and a lack of reliable financial infrastructure limit the possibility of attracting capital to the agricultural sector.

The existing literature emphasises the importance of lending for agricultural sector development but also indicates limited access to credit, especially for small farms, which challenges their growth and competitiveness [10]. The present study complements the existing literature by focusing on the specific case of Bulgaria and providing a comparative analysis with EU-27 countries. Using the Agricultural Orientation Index (AOI), the significance of credits in the agricultural sector is analysed, with the index normalising the share of credits relative to agriculture's economic contribution to GDP. This makes it possible to establish to what extent credit support is adequate relative to the sector's needs and contribution in Bulgaria compared to other European countries.

The article aims to examine the dynamics and structure of lending in the agricultural sector of the Republic of Bulgaria for the period 2009-2023, looking at trends in the number and size of loans granted and their distribution by term and type. The analysis focuses on different categories of loans by size and term, which allows for identifying changes in agricultural producers' preferences and the impact of investment activity on lending structure.

Additionally, the article examines the relationship between lending and agriculture's economic contribution through regression analysis, which assesses the impact of credits on the sector's gross value added. Through the presented results, the study aims to provide an empirical basis for formulating a more effective credit policy that is better modified to meet the requirements of Bulgaria's farm industry and aids in the sustainability and competitiveness on both national and European scales.

MATERIALS AND METHODS

The current study focuses on credit dynamics in the agricultural sector in Bulgaria and EU-27 countries, with the primary aim of establishing the relationship between credit activity and the sector's economic contribution. The analysis uses data from FAO [11] and the Bulgarian National Bank (BNB) [6], covering the period 2000–2022 for international context and 2009–2023 for Bulgaria. Also used are dates from National Statistical Institute [21], and Agricultural Report from Ministry of Agriculture [19]. The duration of these periods allows detailed tracking of long-term trends in agricultural sector lending and assessment of farm financial resource access.

The analysis includes a macroeconomic perspective examining agricultural credit share against total credit activity in Bulgaria and EU-27 and specific factors influencing agricultural credit structure in Bulgaria. This approach enables investigation of how credit policy differences affect the agricultural industry in Bulgaria in relation to other EU nations.

By comparing Bulgaria and the EU-27, a better understanding of Bulgaria's international position and the agricultural sector's significance for the national economy is achieved.

The Agricultural Orientation Index (AOI) assesses banking finance's significance in agriculture, normalising agricultural credit share against the sector's GDP contribution. The index reflects relative banking sector support, with values below 1 indicating financing shortages relative to the sector's economic contribution, while values above 1 indicate more significant support. The AOI analysis seeks to determine how much credit policies in Bulgaria align with the agricultural sector's economic potential compared to the EU-27.

The second stage of analysis examines credit structure in Bulgaria's agricultural sector by size and term. Issued credit data are categorised by size (e.g., up to 12,500 EUR, 12,500–25,000 EUR, etc.), allowing tracking of farm preferences for different credit sizes. The analysis shows increasing interest in more extensive credits, potentially linked to expanding farm scales and enhanced investment activity.

Credits are also examined regarding terms and types, primarily focusing on overdrafts, which are crucial in supporting smaller farms' current needs. Area subsidies serving as guarantees for these credit types provide additional sector financial stability. Data on credits with different terms (up to 1 year, 1–5 years, and over 5 years) provide insight into farms' long-term and short-term needs and the transformation of short-term credits into long-term, reflecting sustainable financing requirements.

The final research stage applies regression analysis to establish the relationship between lending and agricultural gross added value (GAV) in Bulgaria. The regression model's independent variable represents agriculture, forestry, and fishing credit values (in millions of euros), with the dependent variable being agricultural GAV (in millions of euros). Results demonstrate a positive relationship between lending and the sector's economic contribution, with the regression model confirming credit support's significance for Bulgaria's agricultural sector development.

RESULTS AND DISCUSSIONS

Dynamics of Agricultural Credits Relative to Sector Economic Contribution in Bulgaria and EU-27

The data in Figure 1 demonstrate the increasing share of agricultural credits against total commercial credit values for Bulgaria and EU-27 countries. When these values are compared with the gross added value (GAV) generated by the sector, differences in dynamics emerge between Bulgaria and other European states.

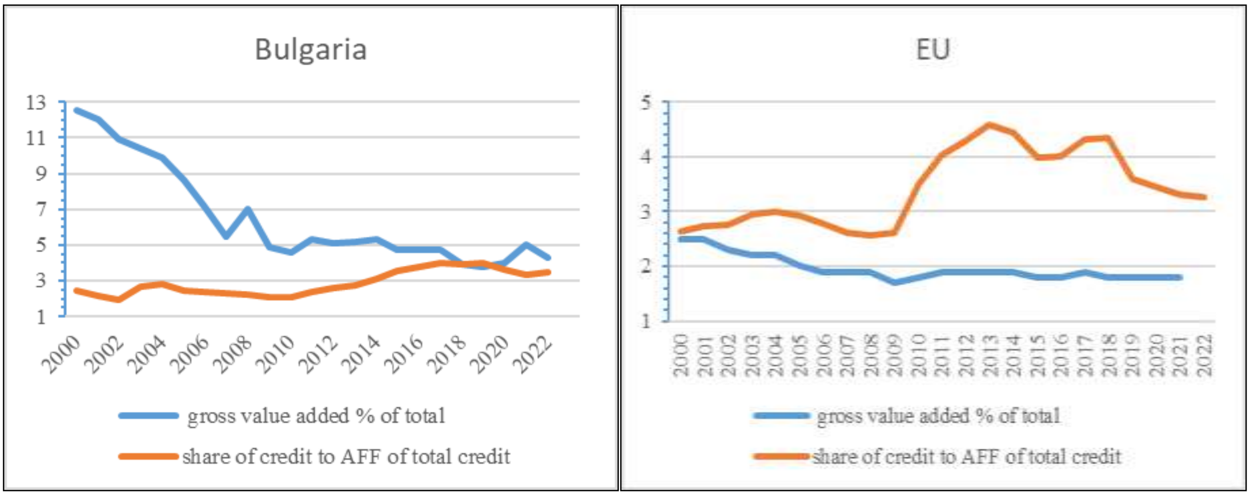

Fig. 1. Share of Agricultural Loans and Gross Added Value in Bulgaria and the EU-27 for the period 2000–2022 (%)
Source: FAO data.

In EU-27 countries, the gross added value from agriculture remains below the credit value for this sector, indicating greater readiness to provide credits compared to agricultural activity's economic contribution. In Bulgaria, however, the industry demonstrates a higher GAV contribution than credit volume, except for 2017-2018, when both values almost equalise.

This difference suggests that Bulgarian agricultural producers face more difficulties accessing credits, with credit policies not always matching the sector's specific needs and characteristics.

The average credit share for agriculture in Bulgaria during the analysed period is 2.88%, lower than the EU-27 average of 3.42%. These results highlight the need for better-adapted financing mechanisms that address Bulgaria's sector requirements.

FAO measures banking finance significance for agriculture through the Agricultural Orientation Index (AOI), which normalises agricultural credit share against their total value, comparing it with the sector's GDP contribution.

An index value below 1 indicates agriculture receives fewer credits relative to its economic contribution, while a value above 1 means greater financing than its GDP contribution.

The data in Figure 2 shows that the EU-27 index maintains stable values that have not fallen below 1.5 over the years despite some fluctuations.

This reflects consistent banking sector support for agricultural financing. In Bulgaria, AOI crosses 1 value only during 2018-2020, highlighting a lower focus on agricultural financing than EU-27.

This difference again suggests the need to develop a credit policy that provides greater sector support in Bulgaria and aligns it with its economic contribution.

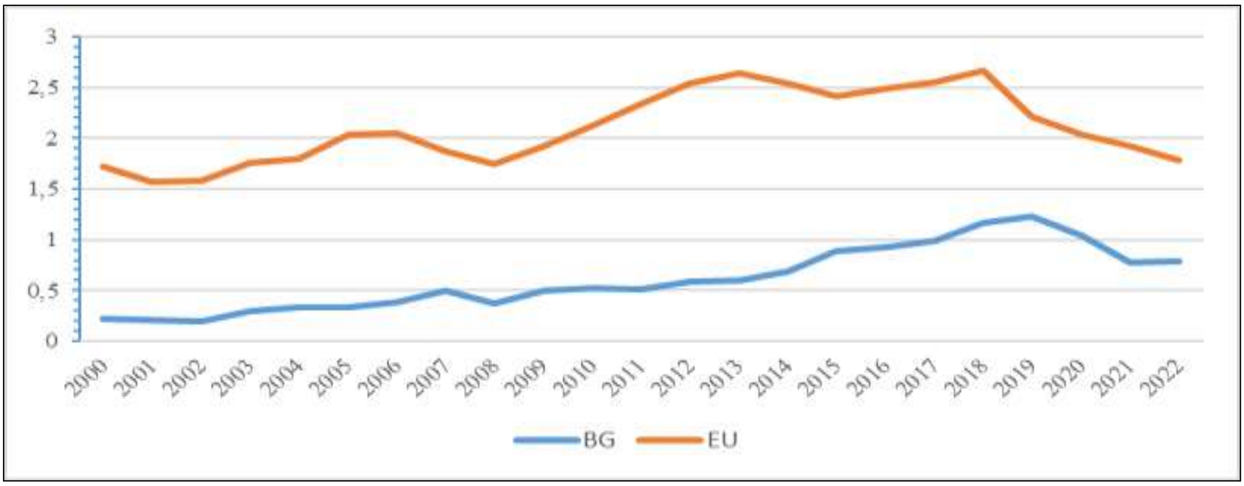

Fig. 2. Agricultural Orientation Index in Bulgaria and the EU-27 for the period 2000–2022
Source: FAO data.

Development of Lending in the Agricultural Industry in Bulgaria

The period from 2009 to 2023 has shown a consistent increase in both the quantity and amount of loans granted to Bulgaria's agricultural industry. Data from the Bulgarian National Bank indicates that the proportion of loans allocated to this sector has risen. In 2023, the agricultural sector comprises 9.49% of total non-financial enterprise credits, rising from 5.26% in 2009.

Additionally, agricultural credits' share of total non-financial enterprise lending increases from 3.38% in 2009 to 6.49% in 2023.

This indicates the growing agricultural sector's significance in economic lending, which occupies an increasingly more significant loan proportion.

Data in Table 1 illustrate steady growth in agricultural sector credit numbers and total financing volume in thousands of EUR.

Table 1. Loans to non-financial enterprises and the agricultural sector (2009–2023)

Year	Total Loans		Non-Financial Enterprises		Agricultural Sector	
	Number	Thousand EUR	Number	Thousand EUR	Number	Thousand EUR
2009	3,004,628	25,605,398	126,479	15,818,219	6,650	534,516
2010	2,763,350	25,918,263	125,227	16,210,338	6,632	541,344
2011	2,655,401	26,757,972	125,939	17,093,451	7,150	629,512
2012	2,734,408	27,511,831	131,485	17,941,822	8,003	713,863
2013	2,786,268	27,518,923	131,944	17,964,487	8,690	750,329
2014	2,822,090	25,302,048	134,289	15,902,708	9,122	793,810
2015	2,750,103	24,928,767	133,773	15,652,984	9,783	893,627
2016	2,741,743	25,143,523	139,231	15,680,077	10,180	941,665
2017	2,746,507	25,988,233	148,555	15,952,165	11,230	1,039,518
2018	3,065,552	27,987,785	147,495	16,826,647	11,427	1,103,743
2019	3,171,576	30,077,541	148,676	17,853,626	12,392	1,171,888
2020	2,913,561	33,680,168	139,926	18,412,172	12,979	1,223,451
2021	2,931,529	36,584,225	141,025	19,242,902	12,757	1,230,412
2022	2,982,449	41,248,650	150,295	21,245,323	13,714	1,438,941
2023	2,966,477	46,357,543	149,651	22,853,752	14,204	1,484,413

Source: Bulgarian National Bank (BNB Statistics).

In 2009, the agricultural sector had a credit number 6,650, with a total value of 534.3 million euros.

By 2023, credit numbers reach 14,204, with total issued funds increasing to over 1.48 billion euros. The more than twofold credit increase demonstrates heightened financial institution interest in sector financing and growing farm capital needs for operational expenses and investments.

Over the years, average agricultural sector credit values also increase, potentially linked to producers' needs for more significant investment and production modernisation funds.

In 2009, average agricultural sector credit value is approximately 80,000 euros, rising slightly above 104,000 euros by 2023.

This loan value growth indicates sector requirements and increased bank confidence in agricultural producers expanding their holdings and investing in new technologies and equipment.

Credit value and number increases form part of a broader financing trend in the agricultural sector, playing a crucial role in its sustainable development.

Lending growth contributes to sector modernisation and overcoming financial barriers for agricultural holdings.

Credit Structure by Size

The analysis of issued agricultural sector credits reveals significant dynamics during the period (Figure 3).

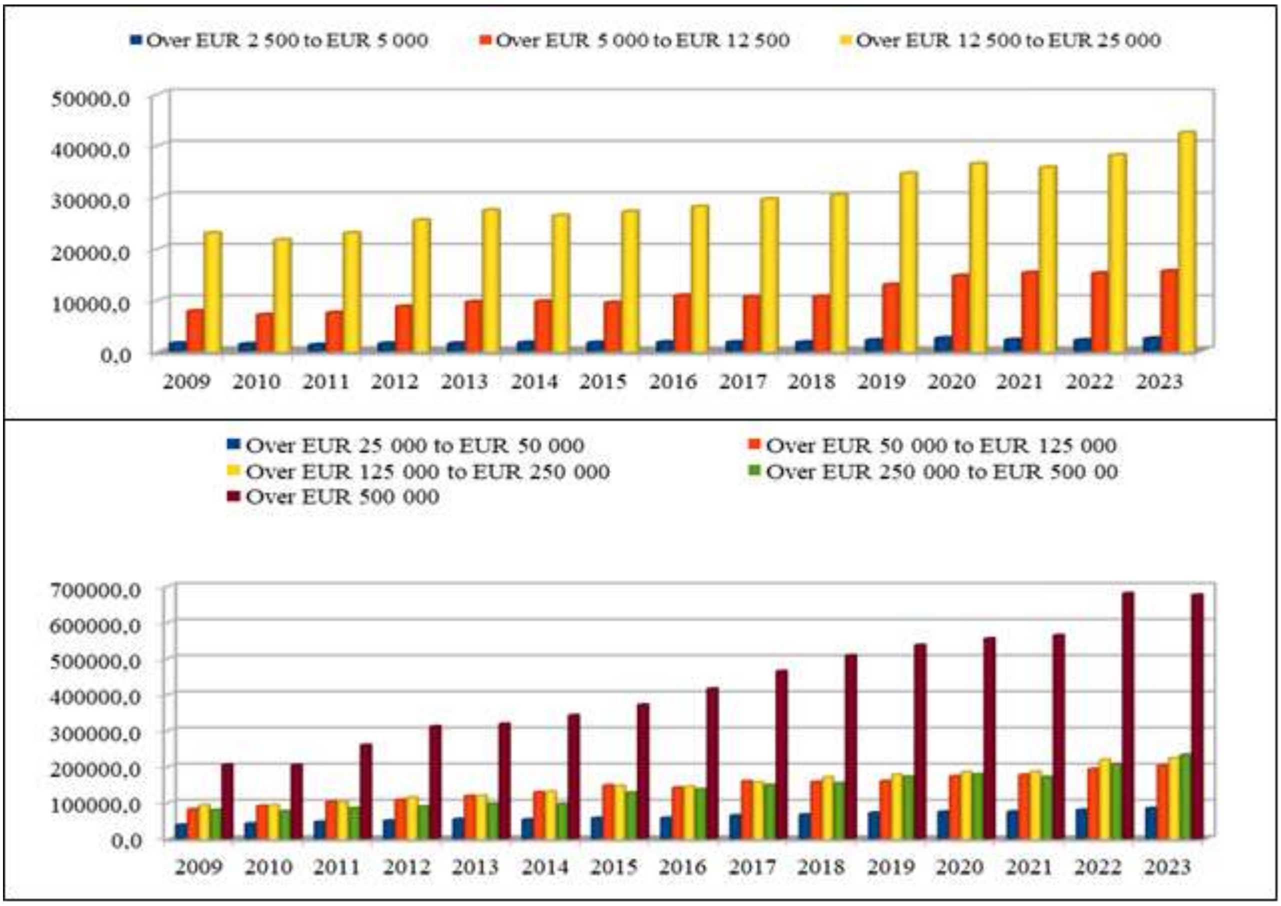

Fig. 3. Distribution of agricultural sector loans by size for the period 2009–2023
Source: Own calculations based on data from the BNB.

Despite overall credit number increases, their size structure remains relatively stable. With credit numbers growing, the most significant increase occurs in credits ranging between 50,000 and 125,000 euros, followed by credits between 25,000 and 50,000 euros, and between 12,500 and 25,000 euros.This suggests agricultural holdings have leveraged more significant investment opportunities corresponding to their growing needs and operational scale.

In 2023, a slight decline occurs in credits up to 12,500 euros, representing 35.24% of total credits, compared to 38.86% in 2009.

Meanwhile, credits from 12,500 to 25,000 euros reduce their share from 17.72% to 15.39%. A similar decline appears in credits between 25,000 and 50,000 euros, standing at 15.85% in 2023 versus 15.35% in 2009.

Conversely, credits between 50,000 and 125,000 euros increase from 14.54% in 2009 to 17.26% in 2023, indicating heightened financial resource demand in this range. The same trend emerges for credits between 125,000 and 250,000 euros, whose share increases from 7.62% to 8.58%, and for those between 250,000 and 500,000 euros, rising from 3.22% to 4.51%.Credits exceeding 500,000 euros also demonstrate growth, with their share increasing from 2.63% in 2009 to 3.16% in 2023. This indicates enhanced investment activity and agricultural holding expansion, which are increasingly oriented towards more significant, long-term investments. The trend towards more extensive credits potentially stems from increased sector investment needs, including purchasing modern machinery, expanding production areas, and implementing new technologies, necessitating higher-value financial resources for these endeavours.

Structure of Credits by Term and Type

The analysis of credit data by term and type reveals an exciting transformation in the agricultural sector's credit structure (Figure 4 and Figure 5). The increase in overdrafts by more than three times - from 2,415 in 2009 to 7,833 in 2023 - shows a clear preference of agricultural producers for this type of lending. Overdraft is a key instrument for securing the necessary funds for operational expenses, particularly for smaller farms that often experience liquidity shortages. This lending plays a vital role in maintaining the financial stability of these enterprises until they realise revenue from crop sales. Moreover, using area-based subsidies as a guarantee contributes to greater security and stability in the sector, providing banks with better protection against default risk.

At the same time, there is a significant decrease in the number of short-term loans with terms up to 1 year (different from overdrafts), suggesting that more farms prefer the flexibility of overdrafts to traditional short-term loans. This transformation reflects farmers' desire for greater financial flexibility, which is necessary to cope with revenue fluctuations characteristic of the agricultural industry. At the same time this method enables farms to address their monetary requirements more efficiently, reducing the stress of repaying set payments in the near future. The rising significance of overdrafts as a popular funding option highlights the needs within the agricultural field. This lending approach reflects how credit institution are adjusting to the unique demands of the sector, where revenues are highly seasonal, while expenses for crops, machinery, and materials are constant.

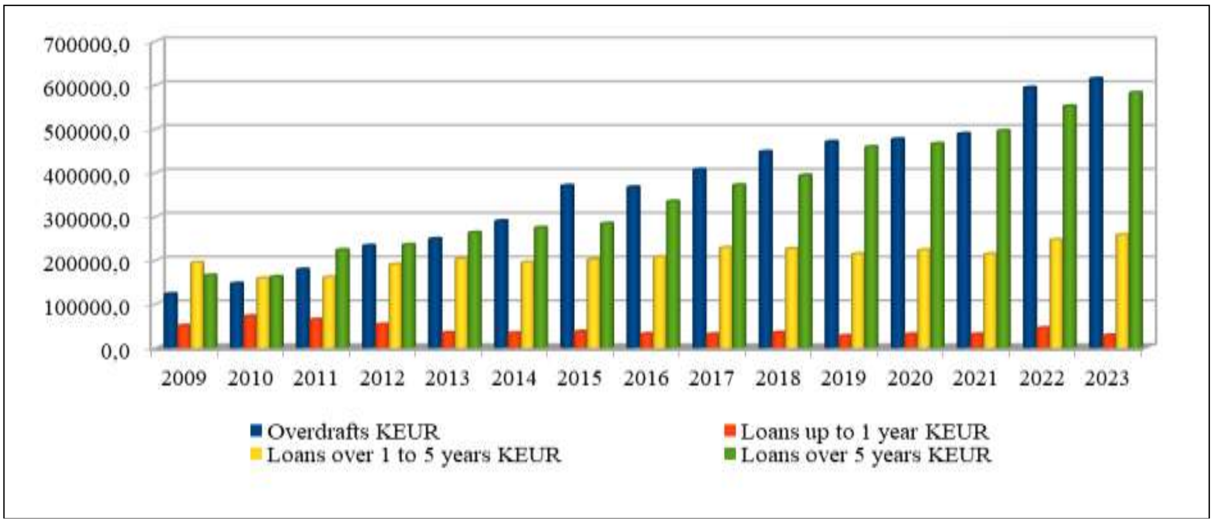

Fig. 4. Distribution of agricultural sector loans by type, size, and loan term for the period 2009-2023
Source: Own calculations based on data from the BNB.

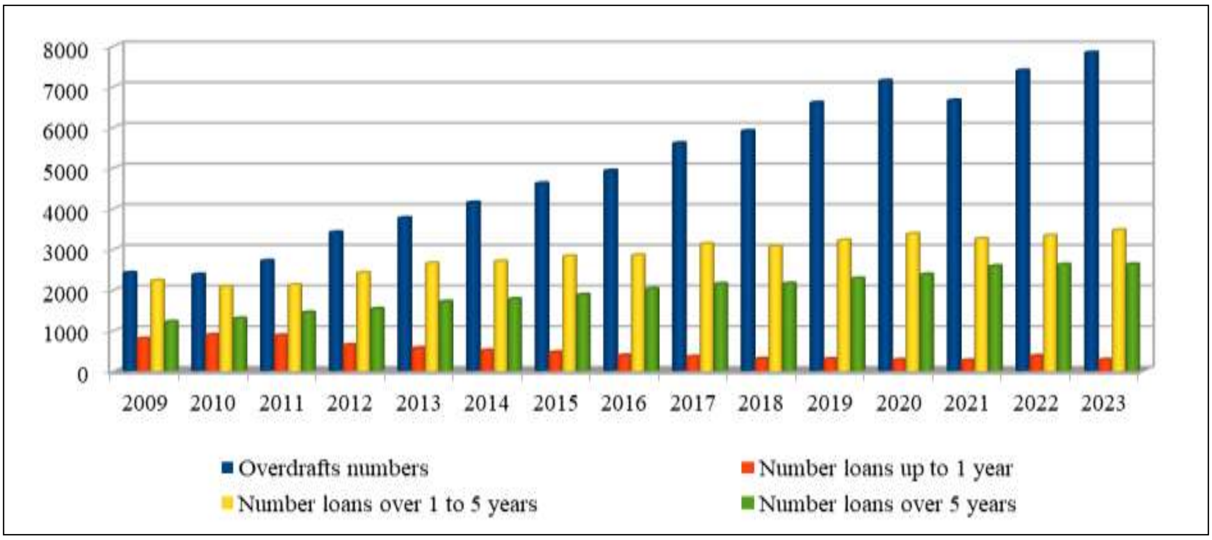

Fig. 5. Distribution of agricultural sector loans by type, number, and loan term for the period 2009-2023
Source: Own calculations based on data from the BNB.

Analysis of the Relationship Between Agricultural Lending and Gross Value Added in Bulgaria

The present study examines the relationship between agricultural lending and its contribution to Bulgaria's national economy. This relationship is explored through regression analysis, where the indicator for credits provided to agriculture, forestry and fishing (in millions of euros) is used as an independent variable, and the gross value added (GVA) of agriculture at current prices (in millions of euros) as a dependent variable. The study period covers 23 years (2000-2022), with data collected from FAO and Eurostat.

The analysis results show a correlation coefficient (Multiple R) of 0.7187, indicating a strong positive relationship between the variables examined. The R square value of 0.5165 indicates that around 52% of the fluctuation in Bulgaria's GVA are attributable to sector lending, while the remaining 48% is due to the influence of other factors. This result emphasises the significance of lending for the economic contribution of agriculture.

The analysis of variance (ANOVA) confirms the adequacy of the regression model, with the value of Significance F being less than 0.05 (F = 22.435, Significance F = 0.0001), which means the model is statistically significant. The parameter estimates are also critical, confirmed by the t-statistics and p-value values (Intercept: t Stat = 11.947, p-value < 0.0001; X Variable 1: t Stat = 4.737, p-value < 0.0001).

The regression equation describing the relationship between agricultural credits and GVA takes the following form: $y=0.7466x+2853.61$

This result shows that with an increase in agricultural credits by 500 thousand euros, the sector's gross value added increases by an average of 0.382 million euros. This positive relationship between lending and the economic contribution of agriculture emphasises the need to form a more stable credit policy for the sector. The current state of lending in the agricultural industry is not optimal, and there is a need for additional measures to support its sustainable development and increase its contribution to the national economy.

CONCLUSIONS

The study of lending dynamics and significance in Bulgaria's agricultural sector reveals several key aspects that influence the sector's economic contribution. In Bulgaria, agricultural lending, although increasing as a share of total credit activity, continues to lag behind the greater support the industry receives in the EU-27. Credit share indicators and the Agricultural Orientation Index (AOI) show that Bulgarian agriculture has more limited access to credit resources than its contribution to the economy, limiting its potential for development and modernisation.

The analysis of credit structure in Bulgaria's agricultural sector for the period 2009-2023 shows increasing demand for larger loans, which reflects the growing scale and investment needs of farms. The increased importance of overdrafts, especially among smaller farms, emphasises the importance of short-term financing for securing operational funds. At the same time, the demand for long-term loans shows growing investment activity, supported by national and European subsidies.

The regression analysis confirms a positive relationship between agricultural industry borrowing and its economic contribution. Approximately 52% of the variation in the sector's gross value added can be attributed to its lending, which emphasises the significance of financial support for stimulating production and sustainable development.

The results indicate the need to build a more adapted credit policy that meets the specific needs of agricultural producers in Bulgaria. Better-tailored financing mechanisms and stimulating credit policy would help increase the sector's competitiveness and sustainability.

In conclusion, improved lending would contribute to a more significant economic contribution of agriculture and its stable development in the context of the national economy.

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ECONOMIC FEASIBILITY OF PRODUCING FUNCTIONAL PRODUCTS BASED ON GOAT'S MILK

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Abstract

The Strategy for Scientific and Technological Development of the Russian Federation provides for the achievement and formation of independence in critical areas of life support due to the high efficiency of scientific research and development aimed at popularizing safe and high-quality products, as well as the stimulation of the functional food market as one of the key priorities. The aim of the study is to analyze and evaluate the economic efficiency of production of functional food products based on goat milk. The study substantiates the advantages of goat milk, and also presents in detail the technological scheme of yoghurt production.In the production of yoghurts, a thermostatic method was used: pasteurization at 92±2 °C, fermentation at 38-42 °C with the addition of starter (lactic acid bacteria) and fillers (carob, cereals, raspberry jam). Based on the obtained products, calculations of the economic efficiency of producing yoghurts with different fillers were made using seven samples as an example. The high prospects of producing yoghurts in general were substantiated, with those samples that contain fillers and have high profitability being especially profitable. Directions for developing the functional food market based on stimulating the introduction of innovative production technologies and developing new recipes for yoghurts with different fillers in order to increase the competitiveness of manufactured products in the Russian and world markets were proposed.

Key words*: functional food products, dairy goat farming, technological process, market, innovation, strategy*

INTRODUCTION

According to the Decree of the President of the Russian Federation "On the Strategy for Scientific and Technological Development of the Russian Federation", approved on February 28, 2024, the development of safe and high-quality food products, including functional ones, is highlighted as one of the strategic guidelines and opportunities for scientific and technological development [6]. Experts note that about 80% of Russian residents, including children, experience a deficiency in micro- and macronutrients. At the same time, their diet is 40% dominated by sugar-containing and refined products with low nutritional value and a high glycemic index. This, in turn, can cause various diseases, such as osteoporosis, anemia, etc.

At the same time, natural functional products have high nutritional value and comply with the principles of healthy eating. These products can replenish the deficiency of essential nutrients in the diet and become an effective tool for the prevention of a number of diseases, as well as improve the quality and duration of life.

The formation of a number of new national projects in the field of healthy eating and improving the quality of life have determined the development of the functional food market. In this regard, the following target indicators have been established: an increase in the share of functional products in the total consumption volume to 30% by 2030, the creation of a register of certified natural functional products, the development of a program for the development of the natural functional food market aimed at regulatory and informational and educational activities to stimulate both the production and consumption of such products [8].

Functional food products based on goat's milk are becoming essential components of diets and are as close as possible to the composition of human milk in terms of protein and fat fractions, which is why it is the basis of healthy nutrition for both infants and sick and elderly people [3,24]. And given the currently increasing demand for environmentally friendly products and the increased interest in alternative food sources, the popularization of these types of products has high socio-economic significance. Goat's milk contains a large number of macro- and microelements. It contains essential amino acids, polyunsaturated fatty acids, minerals, and vitamins [23,28,33]. Research by many scientists has proven its unique biological value, since many parameters have been found to be similar to human milk, which is why it is beneficially absorbed by children's bodies [19,20].Thus, the development of functional dairy products is becoming a major task for the dairy industry. And goat milk, in turn, is becoming an increasingly popular raw material due to its exceptional nutritional properties and ease of absorption by the human body [4].

Goat milk as a raw material has unique properties that give it significance among other food products of the population [11]. Hypoallergenicity is due to the low content of βs1-casein, which makes it safer for allergy sufferers [9]. The predominance of β-casein contributes to the formation of easily digestible clots in the stomach of children, ensuring comfortable digestion [13,16].Goat milk also has a high degree of fat dispersion, which promotes effective absorption of fatty components by the child's body [29, 30, 32]. It should also be taken into account that, despite the fact that goat's milk is often considered an optimal alternative to human breast milk, it has a number of specific characteristics, including changes in lipid composition [14]. The high amount of polyunsaturated fatty acids in milk, such as linoleic and linolenic acids, increases the body's immunity and normalizes cholesterol, and also has anti-inflammatory properties, promoting normal growth and metabolism [12]. Goat milk is also rich in useful elements, including phosphorus, cobalt and magnesium, which complement its nutritional value. Goat milk exceeds cow milk in vitamin A content by two times, β-carotene - almost three times, ascorbic acid (vitamin C) - one and a half times and nicotinic acid (vitamin PP) - three times. This abundance of vitamins can be explained by the fact that goats eat a variety of herbs. Their menu is much richer than that of cows, which gives milk a special taste. For example, scientists Monllor, P., Zemzmi, J., Muelas, R. et. al. It was reliably determined that the use of silage from artichoke by-products as a 40% supplement to dairy goat feed for a month showed that it is a good option not only for the rational use of agricultural and agro-industrial by-products in feeding ruminants, careful attitude to the environment, but also does not harm the physicochemical composition of milk, and, importantly, the health of animals [15, 18]. Goat milk is also used in the treatment of serious diseases, such as Graves' disease (goiter) and enlarged thyroid gland. It can serve as a preventive measure against cancer, and also has a positive effect on respiratory diseases, tuberculosis, allergies and eczema. It is important to note that any milk, including goat milk, helps to restore the body after exposure to radiation. Therefore, it is completely justified to call goats wet nurses and "home doctors" [31]. The production of fermented milk products with plant components is an area that is receiving increasing attention in the food industry. Adding plant ingredients to the recipe improves the nutritional value of the product and its effect on the body [17, 21].

Enrichment of fermented milk products with vitamins, minerals, organic acids and dietary fibres increases their beneficial properties and makes them more popular on the market [1]. The combination of animal and plant raw materials is also extremely important to achieve a balance in the composition of the nutritional components of the products. Numerous studies confirm the positive effect of the use of plant components in fermented milk products on their quality and functional properties [5,10,27]. For example, in the work of Bartoń, M., Waraczewski, R., &Sołowiej, B. G., the properties of the obtained fermented organic drink from goat whey enriched with sea buckthorn or wild rosehip juice were studied [2]. Their research has shown that adding organic fruit juices, such as sea buckthorn or rosehip juice, improved the physicochemical and rheological properties of drinks(Fig.1).

Fig.1. Appearance of final fermented organic goat whey drink with labels.
Source: Own calculations based on data [2].

The results of this work show that the produced fermented goat whey drinks can potentially be used as new products that could provide pleasure from consumption and useful properties compared to conventional drinks.
The use of goat milk in food production is a promising direction, as its potential has not yet been fully realized. Increasing the range of products based on goat milk can satisfy the growing consumer interest in functional and healthy food products [26].
The aim of the study is to analyze and evaluate the economic efficiency of production of functional food products based on goat milk.

MATERIALS AND METHODS

The research is based on the synthesis of publications and analytical materials, regulatory documents.
The paper presents:
-The technological process for producing yoghurts with fillers including:
(i) the raw goat milk pasteurization,(ii)the starter culture of lactic bacteria, (iii)the fillers of various type, (iv)cooling, (v)fermentation, (vi) mixing, (vii) cooling, (viii) storage, (ix) sale.
-A number of 8 types of yoghurts were studied comparatively with the Control variant regarding their content in raw materials.
-The economic efficiency for each type of yoghurts was determined taking into account production cost, selling price, profit per package and profitability of production of yoghurts with various fillings.
The differences among the studied variants have been commented in order to establish which is more profitabile.

RESULTS AND DISCUSSIONS

Yoghurts are the most popular fermented milk drinks in the world, since many note their high consumer properties, variety of assortment and the presence of a huge number of probiotics and prebiotics in their composition, then it is undeniable that this type of functional food needs to be promoted among people who care about their health, as well as active advertising among young groups of the population. The technological scheme for the preparation of yogurts with carob powder and other flavor fillers is shown in Fig. 2.
The technological process of producing yoghurts with fillers was also carried out using a thermostatic method: goat milk was pasteurized at 92±2 °C for 2-8 minutes and cooled to a fermentation temperature of 38-

42 °C. A starter culture containing lactic acid bacteria *Streptococcus thermophilus*, *Lactobacillus delbrueckii* subsp. bulgaricus, *Lactobacillus casei* and fillers (carob with sugar, cereals with sugar or raspberry jam) was added to the milk mixture prepared for fermentation and fermented for 10 to 12 hours to an acidity of 93±2 ºT, after which simultaneous mixing was carried out until a homogeneous consistency was achieved, and cooled at a temperature of 2-6 °C.

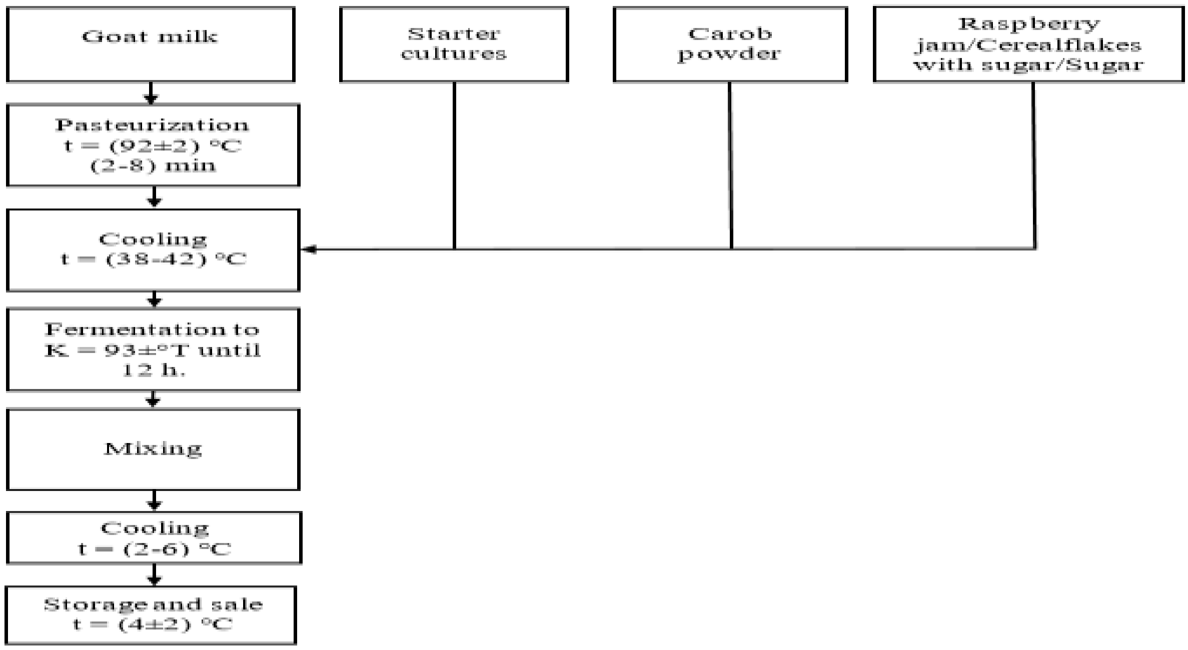

Fig.2. Technological scheme for making yogurts with carob and various flavors
Source: Own determination.

All necessary experiments related to the study of physical and chemical, sanitary and hygienic indicators of raw milk and yoghurts obtained from it, indicators allowing to evaluate the content of toxic elements and pesticides in fermented milk products, microbiological indicators of developed fermented milk products, as well as their nutritional and energy value, are reflected in early publications. The increase in the volume of production of fermented milk products is associated with the increased concern of end consumers about their health.

It is worth noting that the prospects for the production of such products also lie in the diversity and constant addition of their range. And given the fact that yoghurts obtained using various innovative methods, consisting in "enriching" them with valuable components based on plant materials in their physicochemical composition, their final cost will have a higher added value and demand among consumers. Based on the obtained products, calculations of the economic efficiency of producing yoghurts with different fillings were made and are presented in Table 1.

Analyzing Table 1, we can note, firstly, that the prospects for highly profitable production are traced in all experimental yoghurt samples. Secondly, the costs of producing all yoghurt samples are characterized by fairly low values.

At the same time, it is worth considering the environmental friendliness and compliance with all regulatory requirements and regulations governing the quality and safety of fermented milk products, each ingredient used in the composition of our yoghurt samples.

The lowest costs were for the control sample - 22.3 rubles, since this sample did not include any fillers, but consisted exclusively of milk and a starter culture added to it containing lactic acid bacteria *Streptococcus thermophilus, Lactobacillus delbrueckii subsp., Bulgaricus and Lactobacillus casei*.

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Table 1. Economic efficiency of production of yoghurts with various fillings based on goat milk

Indicator	Types of yoghurts studied								
	Control	№ 3	№ 3.1	№ 3.2	№ 3.3	№ 3.4	№ 3.5	№ 3.6	№ 3.7
Name of raw materials used, including:	-	-	-	-	-	-	-	-	-
Goatmilk, g	100	100	100	100	100	100	100	100	100
Sourdough, g	0.7	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
Carob, g	-	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Cereal flakes, g	-	-	-	-	15	-	-	6	-
Sugar, g	-	-	-	-	10	-	-	10	10
Raspberry jam, g	-	-	15	-	-	10	-	-	-
Blackcurrant jam, g	-	-	-	15	-	-	10	-	-
Total raw materials	100.37	100.97	115.97	115.97	125.97	110.97	110.97	116.97	110.97
Cost of production of yogurt, rub.	22.3	24	31.8	39.3	29.2	29.2	29	26.5	24.7
Selling price, RUB	52	68	72	75	70	71	73	65	70
Profit per 1 package, RUB.	29.7	44	40.2	35.7	40.8	41.8	44	38.5	45.3
Profitability of production of yoghurts with different fillings, %	133.2	183.3	126.4	90.8	139.7	143.2	151.7	145.3	183.4

Source: Own calculations.

The highest level of costs was found in sample No. 3.2 - 39.3 rubles. On average, the cost of production of all types of yoghurts was 28.4 rubles. Selling prices were set based on the average price for similar types of fermented milk products. The control sample also had the lowest price – 52 rubles. The price for sample No. 3.2 was 75 rubles. The average selling price for experimental yoghurt samples was 68.4 rubles. This pricing policy seems moderate and optimal for target consumers according to research (what percentage of people are willing to pay a high price for yoghurts).

Among all types of manufactured products, sample No. 3.2 had the lowest profitability – 90.8%. Sample No. 3.7 had the highest – 183.4%. On average, the profitability of all types of experimental yoghurt samples was 144.1%.

Thus, we can focus on the high prospects of yoghurt production in general, with those samples that contain fillers and have high profitability, such as sample No. 3.7, being especially profitable.

The prices for the products are affordable for consumers. In addition, the required quality and safety standards were observed during the production of the samples under study. The shelf life of products that include natural and environmentally friendly components is limited. In this regard, the time of their delivery and sale to the end consumer should be minimized as much as possible due to the logistics of goods movement, covered by the percentage of high added value for these types of fermented milk products. Thus, the production of yoghurts based on goat milk with various fillers is a promising and highly profitable production.

By "incentives" we mean the use of innovative production technologies and the development of new recipes for yoghurts with different fillers for the functional nutrition of the population of our country [22]. Bringing new products to market allows for increased production volumes and the creation of new jobs [7, 25]. In addition, goat milk is an easily digestible product and has a low level of allergenicity. The production of goat milk-based yoghurts is a promising business and makes a positive contribution to the development of the industry and improving the quality of life of the population.

CONCLUSIONS

One of the priority areas of the Strategy for Scientific and Technological Development of the Russian Federation is the creation of safe and high-quality, including functional, food products.

Functional food products based on goat's milk are the basis of a healthy diet. Research by many foreign and Russian scientists has proven its unique biological value, since many parameters have been found to be similar to breast milk, due to which it is beneficially absorbed by the body of children and is used to prevent various diseases.

Also, a number of foreign scientists have substantiated the improvement of the physicochemical and rheological properties of drinks by adding organic fruit juices, such as sea buckthorn or rosehip juice.

The study substantiates the advantages of goat milk and presents a detailed technological scheme for the production of yoghurts.

The high economic efficiency of yoghurt production, especially samples with added fillers, is proven. The directions for the development of the functional food market on an innovative and investment basis are formulated in order to increase the competitiveness of manufactured products in the Russian and world markets.

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MAIN ASPECTS OF FORMING A PRODUCTION STRATEGY FOR THE DEVELOPMENT OF DAIRY GOAT BREEDING

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Abstract

Improving the food supply of the population with livestock products can be achieved by increasing the efficiency of production in individual sub-sectors, including dairy goat breeding. The purpose of the work: to study theoretical approaches to managing production processes in dairy goat breeding in Russia and to substantiate the production strategy for the development of the industry at the level of the country and individual regions. A study of individual aspects of the Russian and global goat milk and processed products market has been conducted. An assessment of the efficiency of milk production using Saanen and Nubian goat breeds in the Saratov region has been presented. The need for further improvement of goat milk production and processing technologies has been substantiated. A project for the production of goat milk on a farm for various breeds has been substantiated. Based on the calculation results, a conclusion was made about a higher level of productivity and profitability of milk production by goats of the Saanen breed. In order to increase production, the author's concept of a production strategy for the dairy goat breeding industry based on a multi-level approach is proposed. The concept is aimed at increasing production volumes primarily in farms and households. The practical value of the obtained results lies in the possibility of using them in the development of regional strategies for the development of dairy goat farming in small businesses in order to meet the population's demand for dietary products.

Key words: *dairy goat farming, production strategies, concept, Nubian and Saanen breeds, productivity, efficiency*

INTRODUCTION

Scientific and technological development of agriculture in Russia is aimed at developing and implementing modern production technologies aimed at increasing animal productivity [6]. Dairy goat farming has a wide distribution area in most countries of the world. The prospects for its further development will be determined by the growing demand for hypoallergenic products and healthy nutrition.

Dairy goat farming has limited production areas and is concentrated in small farms. The extremely low marketability of goat milk limits the possibilities of its industrial processing.

The development of dairy goat breeding in Russia largely depends on the state of selection and breeding work and the adaptation of goat breeds to the conditions of specific regions. To improve the efficiency of production and the competitiveness of goat milk and its processed products, it is necessary to develop industry and regional modernization strategies [23].

The works of authors such as M. Dayoub, Saida Shnaigat, Radi Tarawneh et al. [4] Biswas, C., Nagarajan, V.,& Biswas, D. [1]. present various approaches to choosing the appropriate strategy for a particular enterprise.

The main trends of the modern livestock industry are increasing productivity, improving product quality, reducing labor, energy and resource costs. To achieve this, it is important to develop and use innovative technologies, automated control and monitoring systems, digital technologies and the Internet of Things [7, 24]. It is also necessary to improve breeding work in order to increase the genetic potential of animals, improve their health and other indicators.

Scientific articles [5] present an assessment of the results of the application of digital technologies in dairy cattle breeding in foreign countries. In particular, precision livestock farming technologies are aimed at improving production management, monitoring the health and productivity of livestock. Particular attention is paid to interaction with animals, optimization of production systems to achieve environmental sustainability [14].

In Brazilian agriculture, artificial intelligence technologies and the development of computer vision algorithms are quite popular. [5]. Promising areas of agricultural research include the transformation of the production structure to meet consumer demand for certain types of products,development and adaptation of marketing strategies that will allow the sale of the created products on the market and obtain maximum revenue.

A. Latif, M.F. Cahyandito consider the most promising technology for dairy farming to be a closed-loop economy based on the most efficient use of available resources [15].

As a rule, large livestock farms have a shorter payback period for investments, which is confirmed by research by scientists [8, 18]. In small and medium-sized agricultural businesses, due to high investment risks, as well as the risks of feed shortages, it is necessary to introduce innovative management methods. The purpose of the work is to study theoretical approaches to managing production processes in dairy goat breeding in Russia and to substantiate a production strategy for the development of the industry at the level of the country and individual regions.

MATERIALS AND METHODS

As an information base, the authors used scientific publications on the topic of the study, statistical data, as well as the results of expert assessments.

New data on actual indicators of production and productivity of dairy goat farming in Russia and around the world were used. A detailed analysis of the market for raw goat milk and its processed products in Russia and around the world was conducted. Regional differentiation and localization of dairy goat farming in Russia is reflected. The author's concept of the production strategy of the dairy goat farming industry based on a multi-level approach is presented.

The study also used generally accepted methods used by scientists and experts dealing with agricultural issues. Such methods as monographic analysis, synthesis, critical assessment and compilation of scientific approaches by other authors, comparison, and visualization of statistical data were used. For the development of the Russian dairy goat breeding sub-sector, it is of great importance to study the experience of European countries in organizing the production and processing of milk. This will allow developing effective management strategies for different regions

RESULTS AND DISCUSSIONS

Currently, about 19.5 million tons of goat milk are produced in the world, which is 2.5% of the world's total production of milk of all types. The bulk of this product is produced in two groups of countries: poor developing countries (African countries and India) and countries with a developed consumer culture (mainly Europe). Studies devoted to the study of the beneficial properties of products made from goat milk confirm their easier and better digestibility in comparison with similar dairy products made from the milk of other animal species.

Russian scientists have discovered the qualitative advantages of goat milk kefir in the course of experimental tests [13]. Compared to cow's milk, the fat content of goat milk ensures better absorption by the human body [2, 3].

Cheeses are a key product of goat milk processing.

They occupy a significant place in the human diet due to their high nutritional and biological value [22]. The undisputed leader in goat milk processing is France, which produces 100 thousand tons of goat cheese. This product is used primarily to meet the needs of the country's population, and only 10% of the production is exported. Greece and Spain also have historical traditions of goat milk consumption[17]. Spain is a major exporter of goat cheese and supplies a large volume of goat milk to France [12]. The Netherlands is a major exporter of dry goat milk, supplying products mainly to China.

The cheese market in Russia is developing dynamically; according to experts, in the long term, the culture of consumption of goat and sheep cheeses can reach the level of European countries (1.5-2%) of the level of consumption of cheese of all types.

In Russia, about 740 thousand tons of raw goat milk were produced in 2020-2022; more than 90% is non-commercial milk from small peasant farms and private subsidiary farms [9,16]. According to experts, the annual commercial volume is 20-30 thousand tons. About 50% of goat milk is pasteurized and directly bottled, the rest is for cheeses. The production of fermented milk products, primarily yoghurts, is becoming more popular. An important trend is the production of baby and healthy food from goat milk. A study was conducted on the state of raw goat milk production in the world.

Figure 1 presents data on the key countries producing raw goat milk for 2020-2022. India ranks first among the countries. In the period under review, the volume of goat milk production in India was more than 20 times greater than in Russia. However, dairy goat farming in India is carried out extensively, and the marketing system remains imperfect. Increased funding and government support for the industry is required. Improving the efficiency of dairy goat farming requires a mandatory transition to intensive and semi-intensive goat farming technologies. Dairy goat farming plays a key role in the agricultural economy of many developing countries. The main areas of scientific research in these countries should cover animal health issues, production technologies, resource use, and population demand for products [10].

The main potential of the goat milk market is hidden in the segment of hypoallergenic dairy products for children, since 28% of babies under one year of age suffer from intolerance to cow's milk. However, there is no practice of using goat milk and recommendations from the Ministry of Health in the Russian Federation yet.

The market for hypoallergenic infant formula is highly concentrated. The capacity of the Russian market is more than 1 billion rubles, and the market itself is controlled by the largest company DGC, which produces dry mixtures from goat milk. In the world market, the demand for hypoallergenic infant formula is gradually increasing, especially in developing countries.

For large farms with breeding stock, significant additional income can be provided by selling breeding animals to farmers and private farms.

The state provides support to family farms and beginning farmers engaged in breeding dairy goats. For example, large farms are compensated for part of the production costs [1].

The volumes of goat milk and processed products are small. According to Soyuzmoloko experts, the goat milk market accounts for only about 1% of the total amount of commercial milk of all types.

Among the regions, the leaders in milk production in agricultural organizations are the Leningrad, Pskov, Sverdlovsk and Chelyabinsk regions. Commercial resources of goat milk of large and medium-sized enterprises are estimated at 3.5 - 4 thousand tons.

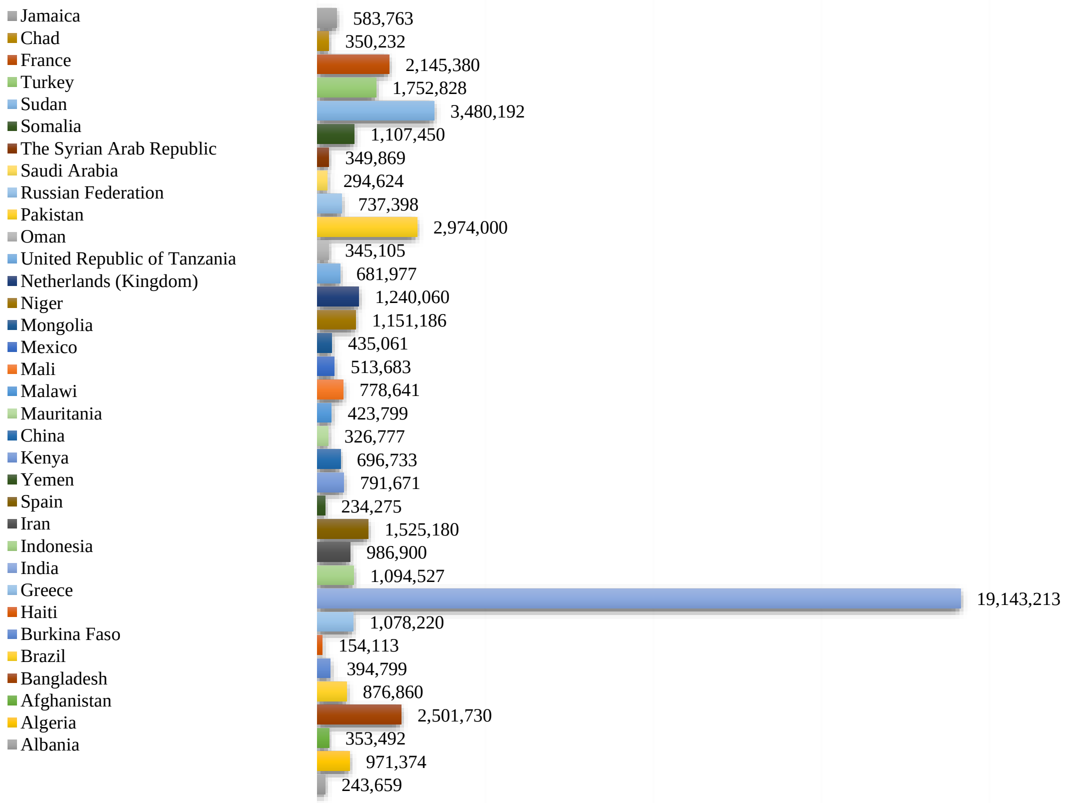

Fig. 1. Goat milk production volumes in major producing countries, 2020-2022
Source: Own calculations based on data [11].

The market has a certain niche mainly for people with allergies to cow's milk. About 70% of purchases are made by residents of large cities with higher incomes. The high cost of production and the price of the final product remain a restraining factor [19].
The structure of the goat milk and processed products market is presented in Fig. 2.

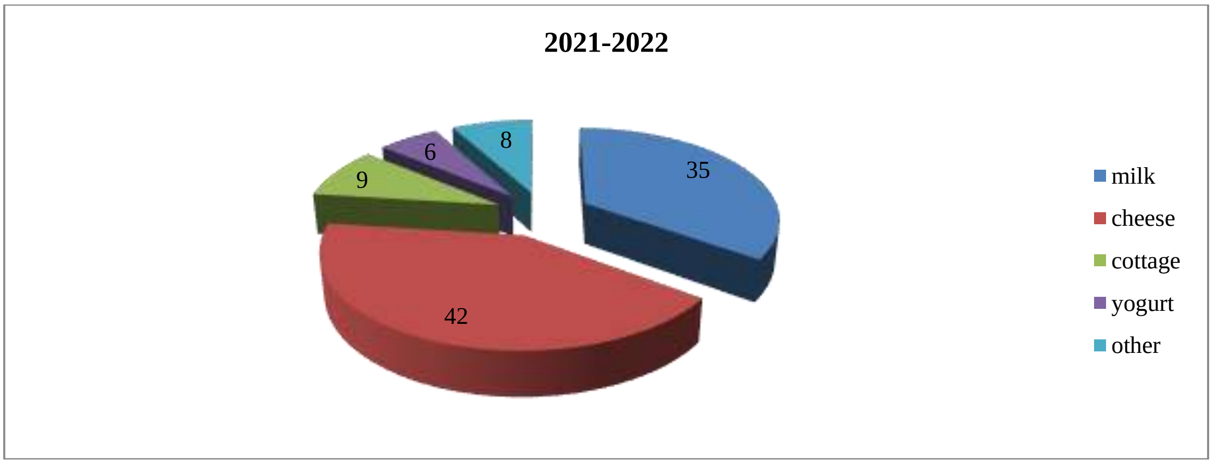

Fig. 2. The structure of the goat's milk and processed products market in Russia
Source: Own calculations based on data [20].

The greatest demand on the market is for milk (35%) and cheeses (42%). To a lesser extent, consumers buy cottage cheese and yogurt (9% and 7%).
[2] The main dairy goat breeds bred in Russia are the Saanen and Alpine. Currently, the use of a meat and dairy breed in goat farms is gaining momentum - the Nubian, or it is also called the Anglo-Nubian breed of goats. In 2022, the total number of dairy goats was 51 thousand heads. There are regional differences

in the distribution of dairy goat populations across the regions of Russia (Fig. 3).

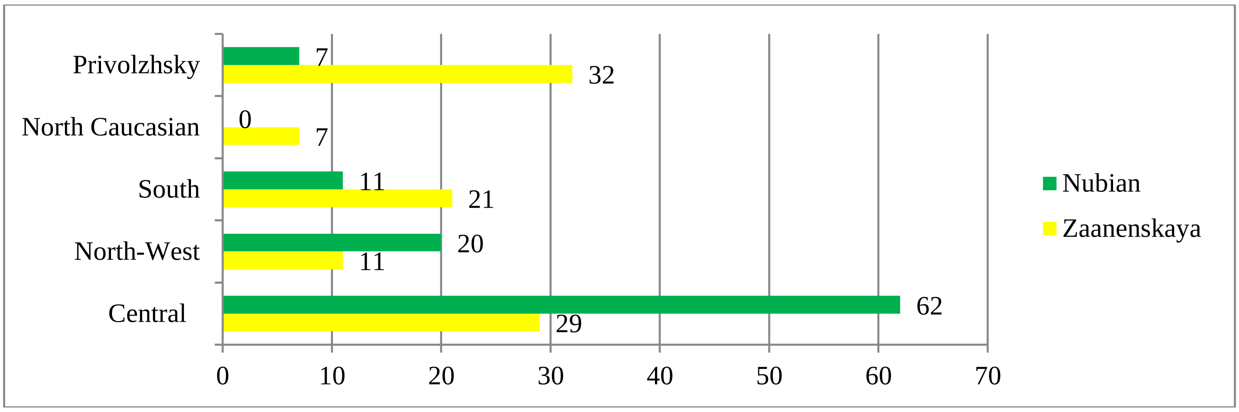

Fig.3. Distribution of dairy goat population by federal districts of Russia, 2022 ,%
Source: Own calculations based on data [25].

In 2022, the largest share of the Nubian goat population was in the Central Federal District (62% of the total population), while Saanen goats predominated in the Volga Federal District (32%). The Saanen breed was found in 24 regions, the Alpine breed in 10 regions, and the Nubian breed in 8 regions. Among the regions of Russia, the largest population of Saanen goats in 2022 was concentrated in the Republic of Adygea (5.6 thousand heads), Leningrad and Moscow regions (3.1–3.8 thousand heads, respectively). Alpine and Nubian goats were characterized by a lower degree of concentration. In the Nizhny Novgorod and Sverdlovsk regions, the leaders in raising the Alpine breed, the goat population was 1–1.9 thousand heads. The Kostroma and Tula regions had the maximum number of Nubian goats, 0.2-0.3 thousand heads, respectively [3].

The dynamics of goat milk production in Russia is shown in Fig. 4.

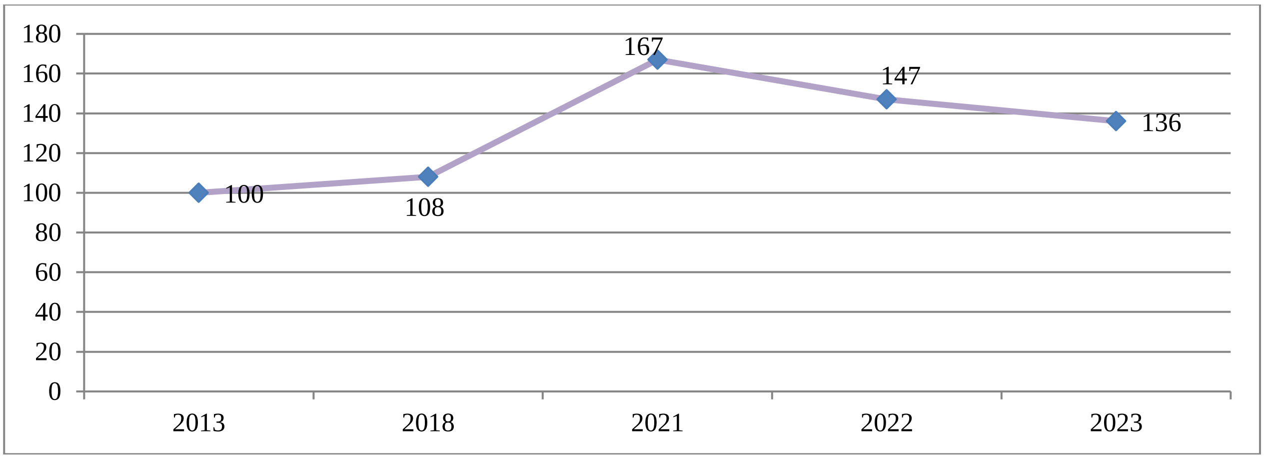

Fig. 4. Growth rates of raw goat's milk production in Russia, %
Source: Own calculations based on data [21].

According to official statistics, in 2023, the volume of Russian goat milk production amounted to 320 thousand tons, increasing by 36% over 10 years. In the period under review, the highest growth rates were observed in 2021.

[4]The level of profitability of the industry as a whole in Russia in 2019 was -8.3%, and in 2020 -16.5% [20].

The efficiency of goat milk production is largely determined by the size of the farm and the breed composition. Large farms with processing capabilities have clear advantages.

[5] On the Russian market, the production of baby food based on goat's milk has not yet received sufficient development; mainly imported products predominate. Processing enterprises of the Stavropol Territory plan to

develop a range of baby products from goat's milk in the coming years.

In the production strategy for the development of dairy goat farming, an important place is given to selection work in order to develop the most productive breeds. Attention should be paid to improving the conditions of keeping and preserving the offspring.

To improve the conditions of keeping goats, it is necessary to provide them with high-quality feed and water, reduce stress, which often occurs during periods of moving. An important component of improving the production strategy is improving the process of processing goat milk.

Improving the production strategy of dairy goat farming in Russia will improve the production indicators of the industry in accordance with the increasing demand for goat milk. In order to strengthen and develop the material and technical base of the industry, it is necessary to improve the supply system, improve quality control of raw materials and finished products, and increase the efficiency of standardization systemof production stocks; improving operational planning and production management in accordance with the corporate development strategy, marketing program, production base development strategy; ensuring a more complete equipment load; improving and timely updating the material base of production; joint work of technologists and production managers in the direction of improving production technology, using the latest equipment, materials, and raw material processing methods.

The concept of modernization of the production strategy of the goat breeding industry in the Russian Federation based on a multi-level approach includes several levels of action, each of which is aimed at improving processes and improving results in this industry:

1. The level of genetic potential of goats. It involves work on selection and selection of breeds that show the best indicators of milk and meat productivity. Modern goat breeding technologies must be used to improve survival conditions.

2. The level of goat keeping conditions. It involves providing high-quality feed and water, improving the conditions of animal keeping (especially in winter), as well as reducing stress, which often occurs during periods of driving, weaning of kids and other moments related to production.

3. The level of goat milk processing at which it is proposed to improve production technologies and intensify quality control of the final product.

4.Organizational level. It includes managing and improving production processes, optimizing business models, implementing effective management and marketing systems, as well as training personnel and supporting local goat breeders. A multi-level approach to the development of the goat breeding industry allows for the improvement and enhancement of all aspects of the production process, which should ultimately lead to increased efficiency and productivity of the industry, improved product quality, and meeting the growing demand for goat milk.It is also advisable to develop a production strategy through the following activities:

1. Developing a personnel policy for enterprise development, reviewing the personnel composition of departments, clarifying the staffing schedule;

2. Developing a system for coordinating actions between departments, possibly introducing an appropriate coordinating position;

3. Developing and implementing an effective personnel service for the selection and placement of personnel at workplaces;

4. Improving the criteria and requirements applied for the selection of personnel at the level of executive positions, paying special attention to managerial positions;

5. Conducting certification of enterprise management personnel, assessing their performance, possibly replacing some employees in key positions and other activities;

6. Developing measures to implement a non-material system of employee motivation.

The production strategy for dairy goat breeding was developed based on the author's concept of modernization of the production strategy for the goat breeding industry in

Russia based on a multi-level approach (Fig. 5).

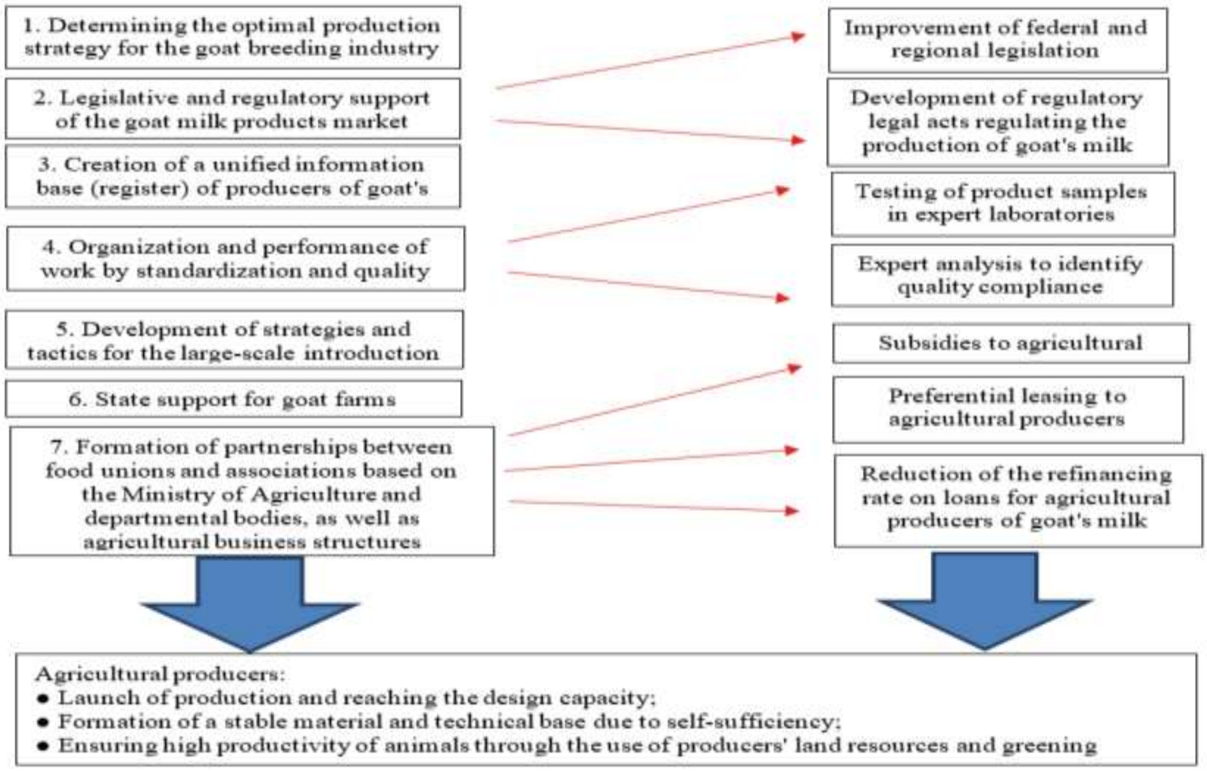

Fig. 5. The concept of modernization of the production strategy of the goat breeding industry
Source: Own conception.

Table 1. Feed costs per 1 kg of milk

Breed	Spent during lactation		Milk of basic fat content obtained (3.5%)	Feed costs per 1 kg of milk with basic fat content (3.5%)	
	Energy Feed Unit	Digestible protein, kg		Energy Feed Unit	Digestible protein, g
Saanen	543	52.4	600.28	0.91	87.29
Nubian	543	52.4	593.54	0.91	88.28

Source: Own calculations.

The Saratov region has significant resource potential for further development of the goat breeding industry in small business.
The authors substantiated the project for breeding various breeds of goats on farms for the Saratov region. The parameters of the project's efficiency are largely determined by the level of production costs.
In the design calculations, it was assumed that the energy feed costs were identical for goats of different breeds and amounted to 543 EFU and 52.4 kg of digestible protein per lactation.
During the same period, it is planned to obtain 600.28 kg of milk with basic fat content (3.5%) from Saanen goats, and 593.54 kg from Nubian animals (Table 1).
When analyzing feed costs for production, it was found that, per 1 kg of milk with basic fat content (3.5%), the EFU costs are the sameand Nubian goats consume only 0.99 g more digestible protein compared to Saanen goats.
Calculations of the efficiency of goat milk production are presented in Table 2.
[4]The author's calculations of the efficiency indicators of goat milk production were carried out for the Saanen and Nubian breeds within the framework of the developed project for the creation of a farm in the Saratov region. It was found that the cost price of 1 kg of milk is slightly lower for the Saanen breed (42.14 rubles), and the profit per 1 kg of milk of basic fat content and per 1 head was higher than for the Nubian breed, by 1.5% and 2.6%, respectively.

Table 2. Economic efficiency of milk production

Indicator	Breed	
	Saanen	Nubian
Milk yield per lactation, kg	575.61	488.80
Fat content in milk, %	3.65	4.25
Milk yield in terms of basic fat content (3.5%)	600.28	593.54
Productioncosts, rubles	25, 299.25	25, 299.25
Cost of 1 kg of milk of basic fat content, rubles	42.14	42.62
Selling price of 1 kg of milk of basic fat content, rubles	75	75
Profit per 1 kg of milk of basic fat content, rubles	32.86	32.38
- per 1 head	19, 725.20	19, 218.82
Profitability of production of milk of basic fat content	77.96	75.96

Source: Own calculations
Note: Exchange rate Euro/Ruble: 1 Euro = 96.06 Russian ruble on February 24, 2025.

With the same production costs, the cost price of milk from Saanen goats was lower by 0.48 rubles compared to milk from Nubian goats.

The profitability of milk production with the accepted basic fat content (3.5%) from Saanen goats was higher by 2% and amounted to 77.96 versus 75.96 for goats of the Nubian breed. Thus, taking into account the fairly high milk yields, it can be concluded that keeping such animals seems promising to farmers, allowing them to fully, almost 1.5 times, recoup the costs of feed. It is also necessary to take into account the main risks that farms engaged in this area of cattle breeding will face. They arise at the stage of capital investments and can be classified as follows: excess of the estimated cost of the project; force majeure, material damage; risks associated with the functioning of the enterprise: failure to reach the design capacity (emergence of technological or raw material limitations); supply of low-quality raw materials; unsatisfactory organization of production; products are not sold in the required value terms and within the estimated time frame (emergence of price restrictions, overestimation of market capacity or underestimation of competition in sales); cost inflation (outstripping growth in prices for raw materials, electricity, water and other cost items); force majeure, material damage [8].

[6] The state provides support measures to producers of goat milk. The main ones are: subsidies to compensate for part of the costs associated with the production and sale of milk; subsidies to reimburse part of the costs of processing goat milk; subsidies for the purchase of new machinery and equipment. An important issue in the problem of ensuring food security in the Russian Federation is the provision of professional personnel. By 2030, it is planned to create 16 thousand new jobs in peasant (farming) households of all categories. Dairy goat breeding accounts for a small share, about 1%. Therefore, in the updated programs of state support for agricultural production in the Russian Federation, increasing the importance and significance of this sub-sector is given more and more attention. according to the policy of the ministry of agriculture of the Russian federation, these goals can be achieved by stimulating goat farms in terms of reimbursement of costs for improving the forage base, building new high-tech milk processing facilities, as well as stimulating breeding work aimed at increasing the milk productivity of animals.

There may be a wide variety of formsof guarantees for partners and investors: insurance, collateral of real estate and securities, bank guarantees.

CONCLUSIONS

A detailed analysis of the market for raw goat milk and its processed products in Russia and other countries is carried out. Regional differentiation and localization of dairy goat farming in Russia are reflected. The dynamics of production indicators for various goat breeds are studied. As a result of the analysis of the efficiency of dairy goat farming in Russia, the need to improve the process of milk production and processing in order to meet the growing demand of the population is noted. The economic efficiency of the project for the production of goat milk in the Saratov region for various goat breeds is substantiated. Based on the calculation results, a conclusion is made about a higher level of productivity and profitability of milk production by goats of the Saanen breed: the profitability of basic fat milk production (3.5%) for Saanen goats was 2% higher.

The possibilities for developing the goat milk market in Russia in the direction of producing hypoallergenic dairy products for baby food are noted. Based on a multi-level approach, the author's concept of a production strategy for the dairy goat breeding industry is proposed, including the creation of a unified information base for goat milk producers, increasing the volume of production of goat milk products, and strengthening state support for milk producers.

The concept is aimed at increasing production volumes primarily in farms and households.

It can be used in developing regional strategies for the development of dairy goat farming in order to meet the population's demand for dietary products.

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TOMATO MARKET DYNAMICS IN ROMANIA: INSIGHTS FROM 2018 TO 2023

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Abstract

Tomatoes (Solanum Lycopersicum L.) belong to the Solanaceae family and are widely cultivated worldwide due to economic and nutritional importance. The aim of the paper was to assess the trend on the tomato market in Romania during 2018-2023. Thus, some specific indicators were analyzed such as: cultivated area, average production, total production, average selling price, average annual consumption per inhabitant, average monthly consumption of tomatoes per person, quantities of tomatoes bought by a household. It studied the evolution of foreign trade as well. The results have shown that during the period studied, the average production per hectare, decreased by 23% and the area cultivated with tomatoes having also the same trend, decreased by approximately 16%. Also, during this period, an increasing consumption trend was observed, but the highest growth rate was registered for the price, from 3.09 lei/kg in 2018 to 4.86 lei/kg in 2022.

Key words: *consumption, price, import, export, tomatoes*

INTRODUCTION

Tomatoes (*Solanum Lycopersicum*) are one of the most important vegetables worldwide and they are native to South America. They were brought to Europe by Spanish Explorers in the mid-1500s, and today are the second most consumed and cultivated species after potatoes [15].
Tomatoes can be cultivated in different geographic areas, in open fields or greenhouses, and the fruits can be harvested manually or mechanical [14]. They can be consumed fresh or processed in various forms [18] such as salads, sauces, concentrated pasta, juices, etc., offering numerous benefits for human health.
Tomatoes are a good source of phytochemicals and nutrients, such as lycopene, potassium, iron, folate and vitamin C [4]. Tomato consumption regulates the digestive and the cardiovascular function, having an impact on the transport speed of the product due to its perishable nature [7]. From a biochemical point of view, tomatoes are mainly composed of water (80%), sugar and proteins, to which are added vitamins (A, B, C, E, K), minerals (bromine, calcium, cobalt, copper, iron, phosphorus, iodine, sodium, potassium, magnesium, sulfur, zinc, nickel), malic, citric, and pectic acids [16]. The potential benefits of tomatoes for health include the anti-cancer properties of lycopene in relation to its anti-angiogenic properties, reducing insulin-like growth factor (IGF) in the blood, and can help reduce high blood pressure, the risk of cardiovascular disease, and the risk of atherosclerosis [5].
The main tomato producing countries worldwide are China, India, Turkey, the United States of America and Egypt. Currently, China is the largest tomato-producing country in the world, with an area of 1,137,416 ha, and production reached 68,241,811 tons in 2022 [8].
In Europe, the first tomato-producing countries are: the Russian Federation, Italy, Ukraine and Spain, and Romania is in fifth place.
Tomatoes in Romania can be cultivated both in protected areas and in open field, aiming to ensure a continuous flow of production

throughout the year. In present, the species is widely studied by researchers around the world to improve the culture technology [9] and the production. The management of the crop influences the yield, acceptability and price depending on the cultivar [20].

Regarding production, on average, the indoor high-tech greenhouse systems have higher production compared to the open-field system [12]. To increase productivity, it is recommended to increase the genetic diversity in breeding this species to obtain germplasm with a wider range of tolerance to different stress factors and marketable traits. Increasing economic efficiency can also be made by improving the technology or applying methods that increase the precocity, the commercial quality of the fruits, the realization of the earliest possible harvests which can be valued at high prices. Therefore, the authorities from Romania must take into consideration the existing potential for tomato cultivation and the components of a better management of the total demand [13].

In Romania, despite the agro-ecological conditions favorable the production of most vegetable species, current production is insufficient and usually the price is uncompetitive compared to imported vegetables. On the other hand, vegetable export of national fresh and processed vegetables is low in terms of value and quantity.

In this context, the aim of the research was to study the Romanian tomato market to identify the main trends that can be the base of future decisions regarding measures to increase production and marketing sector.

MATERIALS AND METHODS

The paper presents the main trend on tomato market in Romania during 2018-2023. The data were retrieved from specialized websites such as National Institute of Statistics and the International Trade Center. For this study, research was conducted on the topic by analyzing the data statistically.

In the study, it was done an analysis aimed at determining the degree of concentration of imports and exports, and for this the Gini coefficient was determined, using the following formula [17]:

$$GS = \sqrt{\frac{n\sum_{i=1}^{n} g_i^2 - 1}{n-1}} \qquad ....(1)$$

where:

Gi – the share of product "i" in total sales;

n – represents the number of cases.

The degree of inequality in a frequency distribution is measured by the Gini coefficient.

A value close to 1 of the Gini-Struck coefficient suggests a high degree of concentration, while a value close to 0, it indicates a weak degree of concentration of the analyzed market.

For the detailed analysis of data on imports, processing methods were used that included: descriptive statistics on the mean, standard deviation, and coefficient of variation.

The mean represents the total sum of values of a series divided by the number of values in that sample [19].

Standard deviation and variance are measures of variability. The average of squared deviations from the mean is known as the variance, in other words the variance reflects the degree of dispersion in the data set, while the standard deviation represents the average level of variability in the dataset (is the square root of the variance) [2, 3].

In order to identify if there is a link between the import and consumption of tomatoes in Romania, a linear regression model was determined. The linear regression determines the influence of an independent variable on the interaction with a dependent variable [1, 11] and determines the line the best fits the data, by looking at the regression coefficient that minimizes the total error [2]. For a better understanding of the results, in the study it was included a graph (plot) that simply represents the observations on the x and y axes, including the regression line.

RESULTS AND DISCUSSIONS

In Romania, one of the key factors that influences the production obtained, is represented by the area cultivated with tomatoes. At national level, the area cultivated with tomatoes in 2018 was over 40,741 hectares, decreasing in 2023 to 33,862 hectares, a drop of over 16% (Table 1). The average area for the period was 36,323 hectares cultivated.

Regarding the average tomato production/ha, the analysis showed that from 2018 to 2023, tomato production registered a decreasing trend, with values between 14,003 kg/ha in 2023 and 21,858 kg/ha in 2021, with an average of 17,967 kg/ha. The percentage difference in the period analyzed was -23%.

Total production had the same trend, the values ranging between 474,182 tons in 2023 and 753,377 tons in 2021, the average of the period being 652,499 tons. The percentage difference in 2023 compared to 2018 was -36%. It can be observed that production has decreased drastically, while the consumption of tomatoes has increased, because we are in a consumer society, so the production has gone against the natural trend. Improving tomato yield was due to applying modern technologies, by using competitive biological material (varieties and hybrids), high-performance agricultural machines and equipment, but also the effective use of plant protection methods.

According to FAO [8], productivity in the last 40 years has registered major changes, from 1,873,000 t/ha in 1982 it reached 298,920 t/ha in 2022.

Table 1. Evolution of main technical indicators for tomato crops in Romania

Indicator	2018	2019	2020	2021	2022	2023	2023/ 2018 (%)	Average
Area (ha)	40,741	40,845	34,115	34,747	33,631	33,862	83.12	36,323.5
Average production (kg/ha)	18,235	16,879	21,858	21,681	15,148	14,003	76.79	17,967.33
Total production (t)	742,899	689,401	745,682	753,377	509,455	474,182	63.83	652,499.33

Source: [21].

Table 2 contains indicators regarding the consumption and the quantity of tomatoes purchased. The average price of tomatoes in the analyzed period had a strictly upward trend, increasing from 3.09 lei/kg in 2018 and reaching 4.86 kg in 2022, equal to an increase of 57%. The selling price of tomatoes can be influenced by demand and supply, and by the period of early and extra-early sales, which ensure the recovery of expenses from peak season periods, which are less economically favorable. Also, during the harvest season for producers it is recommended to forecast the recovery price [7]. Regarding average annual consumption in the period 2018-2022, it decreased by 11.86% from 41.3 kg to 36.4 kg. The volatility of capitalization price affects the consumption trend of tomatoes.

In addition, the trend of average monthly consumption per person, it can be observed that during the analyzed period it was stable, with fluctuation between 1.124 kg/month in 2018 and 1.191 kg/month in 2021. In 2022, it was registered a slight decrease reaching 1.138 kg/month. The drop can be due to the high price in that period.

Table 2. Evolution of main indicators for tomato market in Romania

Indicator	2018	2019	2020	2021	2022	2022/2018 (%)
Average price (lei/kg)	3.09	3.69	4.16	4.17	4.86	157.28
Average annual consumption per inhabitant (kg)	41.3	41.4	41.8	45.1	36.4	88.14
Average monthly tomato consumption per person (kg)	1.124	1.133	1.148	1.191	1.138	101.25
The quantity of tomatoes bought by a household (kg)	0.861	0.867	0.939	0.980	0.943	109.52

Source: [21].

The average amount of tomatoes bought by a household increased, although the price was higher. Thus, the quantities gradually increased from 0.861 kg in 2018 to 0.943 kg in 2022.

Romania, in order to cover its need for fresh vegetable, is still dependent on imports (mainly from Turkey and Netherlands), although for increasing investments in the sector, at the national level financial aid was granted through direct payments, but also through opportunities to access European funds [6].

The analysis of tomato export has shown that in 2023, Romania exported 3,747 t worth 5,494 thousand USD (Table 3). Concerning the export, the first three countries that imported tomatoes from Romania were Poland, Hungary and Republic of Moldova with 1,580 t, 500 t and respectively 652 t.

Table 3. Total export and the main countries where Romania exported tomatoes, 2023

Indicator / Country	Value exported (thous. USD)	Quantity exported (tons)
Total (world)	5,494	3,747
Poland	2,669	1,580
Hungary	840	500
Republic of Moldova	598	652
Gini coef.	0.48	

Source: [22].

From a value point of view, the ranking is slightly changed, so that tomatoes worth 2,669 thousand USD were exported to Poland, followed by Hungary with 840 thousand USD and the Republic of Moldova with 598 thousand USD. On the other hand, analyzing tomato imports, it is found that in 2023 the total quantity imported was 92,990 t and the first three importing countries were Turkey with 66,838 tons, Germany with 10,806 tons and Netherlands with 3,369 tons (Table 4). Regarding the value, Romania imported tomatoes with a total value of 167,812 thousand USD, the ranking of the three main countries remaining the same as in the case of quantity. The Gini coefficient for import value is 0.48, suggesting a moderate distribution of imports for 2023.

Table 4. The total import and the main countries from which Romania imported tomatoes, 2023

Indicator / Country	Value imported (thous. USD)	Quantity imported (tons)
Total (world)	167,812	92,990
Turkey	99,539	66,838
Germany	30,007	10,806
Netherlands	12,550	3,369
Gini coef.	0.56	

Source: [22].

In 2023, regarding the exporting countries, the value of the Gini coefficient is 0.56, indicating a higher degree of export inequality, due to a greater concentration of exports in some countries.

If we consider the value of imports in total, it varied between 106,801 thousand dollars in 2019 and 135,780 thousand dollars in 2022 and in the analyzed period it increased by 24.67% in 2021 compared to 2018 (Table 5).

Table 6 presents descriptive statistics for the period 2018-2022 for indicators of the value of Romanian tomato imports. Following the analysis of tomato import value in the period 2018-2022, it was recorded an average of 119,753 thousand dollars (Table 6).

Table 5. Tomato imports value in Romania (US Dollar thous.)

Indicator	**2018**	**2019**	**2020**	**2021**	**2022**	**2022/2018 (%)**
Total (world)	108,910	106,801	112,710	134,564	135,780	124.67
Turkey	48,116	40,376	55,498	62,962	69,225	143.87
Germany	13,952	16,152	17,076	22,056	21,445	153.71
Netherlands	12,426	14,185	14,379	18,570	16,954	136.44

Source: [22].

Regarding Turkey, the lowest recorded value was 40,376 thousand dollars in 2019 and the highest values was 69,225 thousand dollars in 2022. The average of the period represented approximately half of the total in the world, 55,235,40 thousand dollars. For Germany, the values ranged from 13,952 thousand dollars in 2018 to 22,056 thousand dollars in 2021, the average being around 18,136 thousand dollars. In Netherlands, the minimum imports value was 12,426 thousand dollars in 2018, increasing until 2021 to a maximum of 18,570 thousand dollars. Thus, the imports values emphasize that the trend is increasing gradually in the period analyzed, a fact due to the larger quantity imported, but also being influenced by the price.

Table 6. Descriptive statistical indicators regarding the value of tomato imports in Romania, 2018-2022

	N	Min.	Max.	Mean	Std. Deviation	Variance
Total (world)	5	106801	135780	119753,00	14240,429	202789813,000
Turkey	5	40376	69225	55235,40	11477,868	131741459,800
Germany	5	13952	22056	18136,20	3495,769	12220398,200
Netherlands	5	12426	18570	15302,80	2438,233	5944979,700
Valid N (listwise)	5					

Source: Own calculation based on data from [22].

Regarding the total imported quantity in Romania, it is noted that the highest value was recorded in the 2021 of 92,561 tons (Figure 1). The ranking regarding the countries in 2022 was the following: Turkey was the country that imported the largest number of tomatoes to Romania of 52,914 tons (more than half of the total quantity), followed by Germany with 9,223 tons and the Netherlands with 7,858 tons. Turkey runs first in terms of the amount of tomatoes imported in Romania, as the country is a leader in tomato production in Europe, even if the area cultivated decreased gradually until 2022 [10].

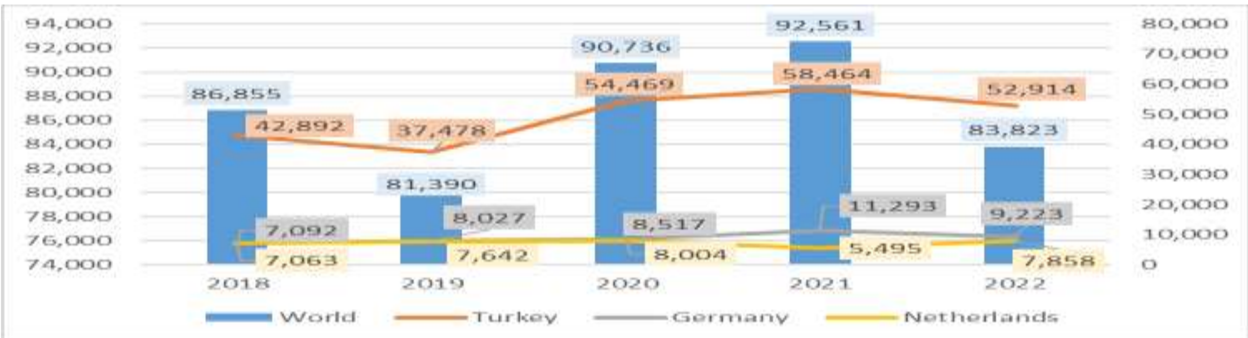

Fig. 1. The quantity of imported tomatoes in Romania
Source: [22].

Regarding the value of tomato exports in the world in 2022, this was 3,129 thousand dollars, Poland being the country with the highest export value of 959 thousand dollars, followed by Hungary with 609 thousand dollars and Spain with 120 thousand dollars (table 7). In the period 2018-2022, there were changes in terms of value, so that in the world the increase was 383.62%, and in terms of countries, the most spectacular increase was recorded in Hungary by 950%.

Table 7. Tomato export value (US Dollar thousand) in Romania

Indicator	**2018**	**2019**	**2020**	**2021**	**2022**	**2022/2018 (%)**
Total (world)	647	1,689	1,596	1,248	3,129	483.62
Poland	213	403	446	563	959	450.23
Hungary	58	34	24	33	609	1,050.00
Spain	90	150	87	81	120	133.33

Source: [22].

Analyzing the exported quantity of tomatoes in 2022, it can be noticed that in world were exported a total of 3,142 tons, of which Moldova exported 901 tons, followed by

Poland with 680 tons and Spain with 90 tons (Figure 2). In the period 2018-2022, the number of exports fluctuated, thus, at world level the increase represented 435%, and regarding the countries, Moldova registered an increase of 439%, followed by Polonia with 277% and Spain with 15%.

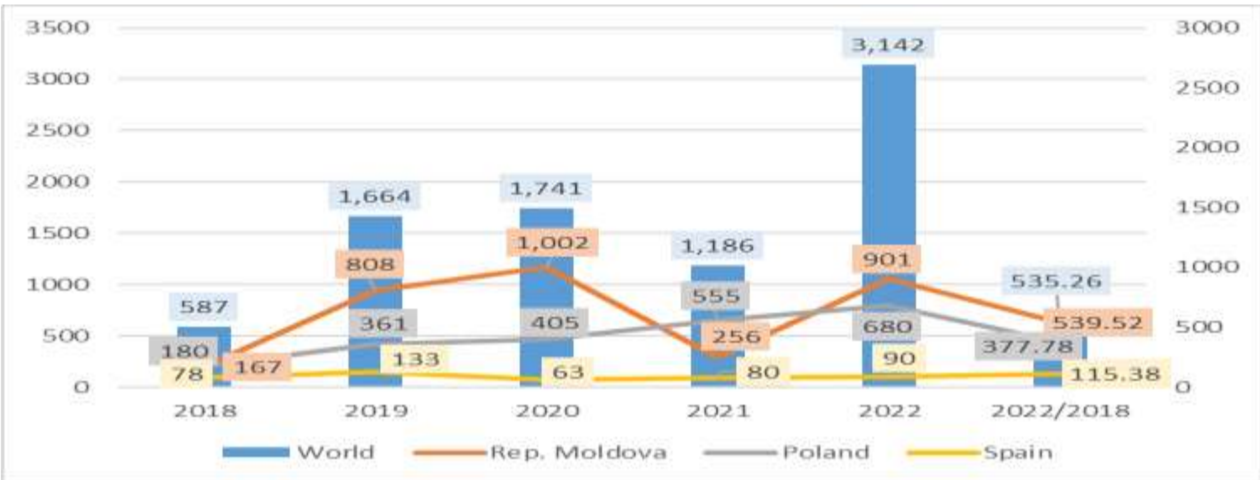

Fig. 2. The quantity of tomatoes exported by Romania
Source: [22].

Analyzing the relationship between the "import" and "consumption" variables, the linear regression between the two variables is presented and resulted in the coefficient of determination of 0.843, so that the dependent variable import is explained in proportion to 84% of the independent variable (Figure 3). It can be said that consumption was based on the import of tomatoes and not necessarily based on the domestic product.

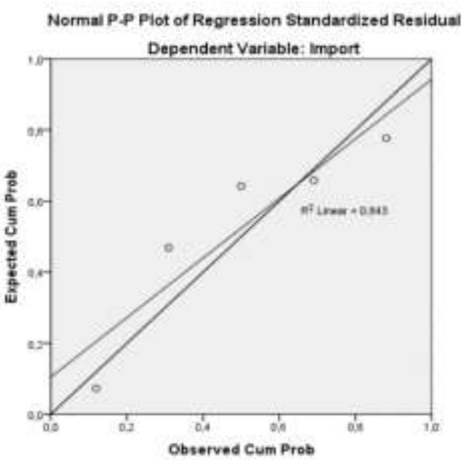

Fig. 3. The relationship between the tomatoes "import" and "consumption"
Source: own processing based on data available on [22].

The evolution of the national trade balance with tomato is presented in Figure 4. Both at the total level and in terms of trade with specific countries, the trade balance is negative (Fig 4). It can be noted that imports are 3 times more meat than exports.

Fig. 4. Romania's trade balance with tomatoes
Source: own processing based on data available on [22].

Thus, Romania is a net importing country regarding the tomato sector, in the period 2018-2023 the total value of the trade deficit gradually increasing from -108,263 thousand dollars to -162,318 thousand dollars. Therefore, the trade balance deficit in the period 2018-2023, increased by 50%.

CONCLUSIONS

Following the research conducted, it was found that the tomato market in Romania is dynamic, both regarding the demand and supply having an upward trend, nevertheless, only domestic production cannot satisfy the national demand, so that imports have increased significantly in recent years.

The total production of tomatoes registers significant fluctuations influenced directly by the cultivated area, but also by other factors that play a key role in achieving higher productions. The analysis of tomato production per ha showed that from 2018 to 2023, there was a downward trend, the percentage difference in the analyzed period was -23%.

The annual consumption of tomatoes per inhabitant is decreasing, from 41.3 kg to 36.4 kg in the period 2018-2022, being influenced by the increase in the selling price. Also, the average amount of tomatoes bought by a household increased gradually, although the price was higher, from 0.861 kg in 2018 to 0.943 kg in 2022.

As a result, that tomato production has decreased, and Romania is unable to meet its needs of tomatoes during off-season periods, imports have increased.

The analysis of tomato export has shown that in 2023, Romania exported 3,747 t. In terms of exports, Poland, Hungary and the Republic of Moldova Regarding the export, the primary nations receiving tomatoes were Poland, Hungary and the Republic of Moldova. However, examining tomato imports in 2023 reveals that the overall amount imported totaled 92,990 t, with Turkey, Germany and the Netherlands being the first three importing countries.

It can be stated that, in the studied period (2018-2023), the situation between exports and imports is unfavorable, the balance being negative. Consequently, investing in modern agricultural holdings is required to stimulate productivity growth.

Tomato market in Romania can also be influenced by the seasonality of the production at national level. The demand on the market is increasing and producers must satisfy these needs. Since the supply cannot cover the demand, to balance the trade balance, it was resorted to imports, which increased during the analyzed period. However, trying to reach an equilibrium this way does not represent a viable solution for Romania's economy, the balance of external payments may suffer from imbalances, tomato imports both quantitatively and especially in terms of value being quite large.

Identifying the main trends on the tomato market in Romania can represent the basis of future decisions regarding the development strategy of this production and marketing sector.

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ON UNDERSTANDING THE PREDICTORS OF CORN PRODUCTION USING REGRESSION MODEL: THE CASE OF SIQUIJOR, PHILIPPINES

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Abstract

The research paper aims to determine the influence of farmers' socio-demographic and economic characteristics on their corn production in Lazi, Siquijor, Philippines using regression analysis. Indeed, 17 selected barangays in Lazi, Siquijor were included in the study, and data were obtained from 313 corn farmers out of 1443 corn farmers in Lazi. In determining the required number of respondents, Slovin's formula and proportionate sampling were utilized to find the number of respondents in each barangay. Both secondary and primary data were utilized. Regression analysis was used to analyze the variables influencing corn production in the target area. Robust regression was used as the statistical model to analyze the data and test assumptions. The software used was R Studio, jamovi, and Microsoft Excel. Results showed that in terms of the socio-demographics of the farmers, only sex was found to be significant. In contrast, age, civil status, educational attainment, and household size were found to be insignificant. However, socioeconomic, household income, major occupation, land tenure, and farm size were found to have a significant relationship with corn production. Participation in association, attendance at training, access to financial assistance, and extension services were found to have no significant influence. Based on the result, more interventions must be given to farmers, and farmers must also be active and be registered to the registry system of the Department of Agriculture so that the interventions can reach them. Moreover, governments must share some piece of the public lands in Lazi for the farmers who only own little land to till.

Key words: *corn farmers, corn production, production level, determinants, regression approach*

INTRODUCTION

In [12], it is mentioned that corn (*Zea mays* L.) is an important crop from the grass family Graminae (Poaceae) that spring up in the United States of America. Corn is considered globally as one of the most consequential grain crops, placed third behind wheat and rice. Yet in the country the Philippines, it succeeded in the use of agricultural assets, after rice which impacted its economy. In fact, it is one of the major staple grains in the country. Approximately, for about 1.8 million Filipino farmers recognized corn as the primary source of their income, especially in remote areas [13]. In addition, in [20] and [22], it is portrayed that maize's importance is also recognized in the development of the manufacturing and livestock industries as it is not only used for humans as a food source but also for industrial applications and for animal foods. Yellow corn in the Philippines' animal industry serves as the primary source of feed [4]. Apparently, corn as food for humans and animals is being progressively utilized by the production sector as an economic resource [22]. On the other hand, during the rice shortage, white corn was the most important replacement staple, especially for people in the countryside [13], [25].

In the place of Siquijor, Philippines, corn or maize is grown in all municipalities [11]. According to the data from the Office of the Provincial Agriculturist (OPA) in Siquijor, the average yield (mt per ha) of corn on the island for the year 2020 was about 2.1 mt/ha. However, in the year 2021, the average yield of corn declined by about 5.6% having a total of 2.19 mt/ha of yield. Moreover, in the year 2022, the average yield of corn on the island comprised a total of 1.40 mt/ha, implying a great decline in the average yield of 36.07%

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compared to the year 2021. The said decline could be attributed to the decrease in the area harvested per year. The data from OPA in Siquijor indicates that in the year 2020 the total area harvested on the island was 3,304.00 ha, while in 2021, the area harvested decreased by about 21.39% having a total of 2,597.21 ha. However, in the year 2022, a continuous decrease in the area harvested was experienced having 1,920.78 ha, implying a 26.04% decline from the year 2021. This decline could be due to some characteristics of the corn growers on the island of Siquijor considering that these features impose pressure on an individual's attitude and behavior [2]. Previous studies in the country of the Philippines about corn production concentrated only on technical efficiency, enhancement of crop aspects, production systems, and constraints [16], [17], [24], but no mention of farmers' socio-demographic characteristics influencing corn production. In that case, finding out the predictors that will have a bearing on farmers' corn production will provide information to the Municipal Agricultural Office and other leading agencies of the government, to plan out interventions to facilitate the increase of corn production. Moreover, the issues and constraints faced by the farmers regarding pest problems, price, and cost will also be determined to provide solutions and recommendations to increase corn production. Thus, this study is realized.

In general, the study aimed to determine the influence of farmers' socio-demographic and economic characteristics on their corn production. Specifically, the study determined the socio-demographic and economic characteristics, corn yield for the last three years, and corn production-related problems of the respondents. The study also identified which socio-demographic and economic variables predict the corn production of the respondents and generated a regression model of corn production.

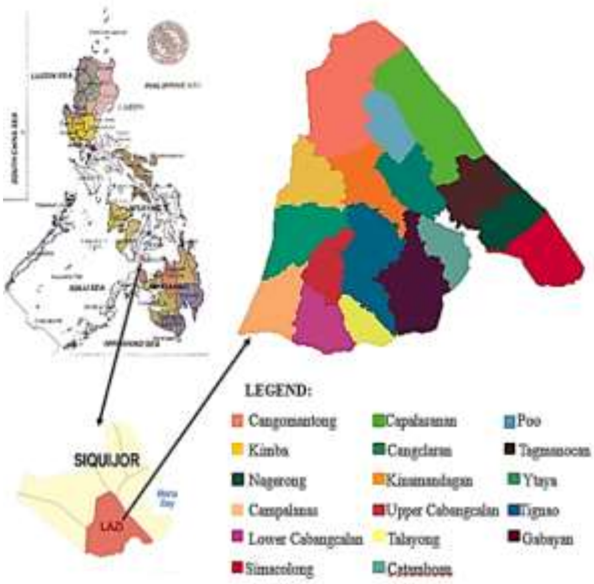
MATERIALS AND METHODS

Research Design

Quantitative and qualitative data were gathered through a primary cross-sectional survey and secondary data. To capture the different factors affecting corn production in Lazi, Siquijor, this study engaged a descriptive and complex correlational research design that involves descriptive measures and multiple regression. The purpose of the designs is to give a sound description of the characteristics of the farmers and their corn production in their place. In addition, the study targeted forecasting and logical arguments that explain the influence of independent variables on corn production.

Locale of the Study

Lazi, Siquijor is the chosen target area for the study. According to the data from the Office of the Provincial Agriculturist (OPA) on the island of Siquijor, the municipality of Lazi had the biggest area harvest with 969.57 ha in terms of corn, followed by San Juan having 147.75 ha. In terms of production, Lazi also had the highest having 1,207 metric tons which was followed by Maria having 925.09 metric tons. Shown in Map 1 is the location of the study.



Map 1. Location of the Study.
Source: [15].

Sampling Techniques

According to data from the Local Government Unit of Lazi, there were 18 barangays in Lazi's municipality. However, in the study 17 barangays were only included since during the visit, it was observed and as the farmers have stated many of the corn farmers in Tigbawan

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were no longer planting corn since the area is mainly populated with market area since it is the center of Lazi where people primarily get their daily work in selling and several businesses, leaving 17 barangays with registered farmers of a total of 1,443. Slovin's formula was used to find the total of respondents in each barangay. In that case, 313 corn farmers out of 1443 corn farmers in Lazi, Siquijor were considered as participants in the study. Proportionate sampling was done as depicted in Table 1 in choosing the respondent

Table 1. Proportionate sampling for the number of farmer-respondents in each barangay.

BARANGAY	TOTAL NUMBER OF FARMERS	PERCENTAGE (%)	NUMBER OF FARMER RESPONDENTS
Campalanas	206	14.27	45
Lower Cabangcalan	125	8.66	27
Gabayan	132	9.15	29
Kimba	119	8.25	26
Cangomantong	121	8.38	26
Simacolong	112	7.76	24
Talayong	86	5.95	19
Tignao	75	5.19	16
Capalasanan	67	4.64	14
Kinamandagan	67	4.64	14
Nagerong	64	4.43	14
Tagmanocan	59	4.08	13
Cangclaran	55	3.81	12
Upper Cabangcalan	59	4.08	13
Poo	46	3.18	10
Ytaya	22	1.52	5
Catambuan	28	1.94	6
TOTAL	**1443**	**100.00**	**313**

Source: Author's computations (2024).

Data Collection

Both primary data and secondary data were utilized in this survey study. Primary data or the data on corn farmers' characteristics (that is Sex, Civil Status, Highest Educational Attainment, Household Size, Farming Years, Household Income, Major Occupation, Land Tenure, Farm Size, Training Acquired, Association Membership, Financial Assistance, and Extension Services), corn production (yield), issues, farming practices, and constraints faced by them using an organized and developed questionnaire. In a year, there are two seasons for corn production, the wet and dry season. Corn yield is calculated as sacks per average farm size (ha) where 1 sack is equal to 50 kilograms and converted into kilograms per hectare per year (kg/ha/year). Data gathering was obtained through face-to-face interviews. Secondary data was collected from annual reports, documents, and baseline data from the Office of the Provincial Agriculture in Siquijor and from the Local Government Unit of Lazi, Siquijor, and from other relevant literature. Table 2 presents the different acronyms used in this study.

Table 2. Acronyms were involved in the study

Abbreviation	Meaning
OPV	Open-Pollinated Varieties
OPA	Office of the Provincial Agriculturist
MAO	Municipal Agricultural Office
LGU	Local Government Unit
4Ps	Pantawid Pamilyang Pilipino Program
PCIC	Philippine Crop Insurance Corporation
DSWD	Department of Social Welfare and Development
AICS	Assistance to Individuals in Crisis Situations
ASA	Association for Social Advancement, a non-profit, non-stock corporation specializing in microfinance
GSIS	Government Service Insurance System
CARD	Center for Agriculture and Rural Development, a microfinance institution
DA	Department of Agriculture
SAAD	Special Area for Agricultural Development
DAR	Department of Agrarian Reform
PCA	Philippine Coconut Authority

Source: Author's guide (2024).

Data Analysis

After all the needed data had been gathered, it was encoded in Microsoft Excel, and the necessary coding for statistical analysis was applied. The data was analyzed with descriptive measures and multiple regression models using various software such as R Studio, jamovi, and Microsoft Excel analysis. For descriptive analysis, Microsoft Excel was utilized which yielded the mean, median, standard deviation, and range. Multiple linear regression analysis was used to identify the variables that influence the corn yield in the study area. Robust regression was utilized as the statistical model in analyzing the data so with the testing of assumptions [7]. The formula of a linear regression model (1) is given below:

$$Y_i=b_0+b_1X_1+b_2X_2+\ldots+b_{14}X_{14}+e_i \quad \ldots\ldots\ldots.(1)$$

where Y_i= Yield of corn (sacks (50 kg) per average farm size (in hectare)), X_2=Sex, X_3=Civil status, X_4=Highest Educational Attainment, X_5= Household size, X_6=Farming years, X_7= Household income, X_8=Major Occupation, X_9=Land tenure, X_{10}=Farm size, X_{11}= Training acquired, X_{12}=Association membership, X_{13}= Financial assistance, X_{14}= Extension Services, b_0= Intercept Y, b_i= Coefficient of Variable X_i and e_i=error term.

RESULTS AND DISCUSSIONS

Socio-demographic Characteristics

Table 3 depicts the socio-demographic profile of the corn farmers in Lazi, Siquijor, Philippines. Results showed that the average age of the corn farmers is around 54 (SD=15.41) years old, 31.9% percent of them were between the ages of 51-60, followed by 21.73% with the ages between 41 and 50, 21.41% were between 61 and 70 years old, 10.54% were between 31 and 40 ages. In [10], it is also stated that most of the farmers are relatively old and the average age is higher than 50 years old. Some of the corn farmers (8.31%) have ages between 71 and 80 while 3.83% have ages between 21 and 30, 1.92% have ages 80 and above, and lastly, 0.32% or only one farmer has the age of 20 and below. There are marginally more female farmers (57.5%) than male corn farmers (42.5%). Approximately, about 71.2% of the corn farmers are married, 18.2% are single, 7.7% are widowed and 2.2% are separated as civil status. In addition, the majority of corn farmers attained high school (45.4%) as their highest educational attainment, followed by elementary (40.3%), next is college (9.3%), and lastly vocational (5.10) school. This result is parallel to the findings in [5], that most of the farmers are high school level as their highest educational attainment. Most (48.88%) of corn farmers consist of 4-6 family members followed by 37.38% having 1-3 family members, 12.1% comprising 7-9 members, and lastly, 1.6% consisting of more than 10 members in a household.

Socio-economic Characteristics

Table 4 also presents the socioeconomic profiles of the corn farmers in Lazi, Siquijor, Philippines. Findings revealed that corn farming is the primary and major occupation of the respondents, bearing 68.4%, followed by other occupations outside farming (18.2%) like office work, government employee, etc., then fisherman/fish vendor (5.4%), vegetable farmer (4.5%), livestock farming (3.2%), lastly 0.3% of the farmers focuses more on rice farming. In fact, corn production in the Philippines plays a major role in improving its gross domestic product (GDP) and national income [13], [17], [18]. In terms of farming experience, 36.42% have experienced between 16-30 years, followed by 25.24% of corn farmers having 31-45 years of farming experience while 18.85% have experienced farming between 6-15 years. Moreover, 13.10% have 46-60 years of experience, 4.79% have been farming for 5 years and below, and lastly only 1.60 of the corn farmers have been tilling their land for more than 60 years. The study also shows that corn farmers have around 29 years of farming experience on average. Additionally, most of the corn farmers (98.4%) have a household income of less than 15,375 while 1.6% of the corn farmers have a household income that ranges between 15,375 and 30,251. On the other hand, nearly half (49.5%) are tenants, while 45% own or inherit their land. A small percentage (5.4%) own some land and also rent additional plots.

The average farmer manages roughly 2 land parcels totaling 0.59 hectares. Most of the corn farmers (88.82%) have a land parcel between 1-2, while 8.95% have 3-4 land parcels. However, only 2.24% have 5-6 parcels of land tilled. In terms of farm size, most of the corn farmers (75.08) have less than 1 hectare of land while 23% have between 1-2 hectares of land. Moreover, only 1.92% of the corn farmers have between 2-3 hectares of land. This implies that corn farmers in Lazi, Siquijor mostly have small pieces of land used for their production. Moreover, there are more farmers engaged in any agricultural association/organization (51.8%), while farmers who don't participate in associations or do not have an association to join hold 48.2%. However, participation in training programs is low, with around 24% of farmers attending relevant workshops and 75.7% not participating in training.

Table 8. Socio-demographic profiles of the farmers in Lazi, Siquijor (n=313).

			Frequency	Percentage
Farming Years	5 years &below		15	4.79
	6-15 years		59	18.85
	16-30 years		114	36.42
	31-45 years		79	25.24
	46-60 years		41	13.10
		Mean	28.85	
		SD	15.41	
		Range	2-70	
Major Occupation	Corn farmer		214	68.4
	Vegetable farmer		14	4.5
	Rice farmer		1	0.3
	Livestock farmer		10	3.2
	Fisherman/seller		17	5.4
	others		57	18.2
Land Tenure	Owned/Inherited		141	45.0
	Tenant		155	49.5
	Owned/Inherited & Tenant		17	5.4
Land Parcel	1-2		278	88.82
	3-4		28	8.95
	5-6		7	2.24
		Mean	1.59	
		SD	0.912	
		Range	1-6	
Farm Size	Less than 1 ha		235	75.08
	1-2 ha		72	23
	2-3 ha		6	1.92
		Mean	0.59	
		SD	0.515	
		Range	0.015-3	
Household Income	Less than 15,375		308	98.4
	15,375-30,251		5	1.6
		Mean	3,500	
		SD	3,945	
		Range	300-30,000	
Members of Organization	No		151	48.2
	Yes		162	51.8
Attended Trainings	No		237	75.7
	Yes		76	24.3
Access to Financial Assistance	No		146	46.6
	Yes		167	53.4
	Grant		163	97.6
	Credit/Loan		4	2.4
Extension services	No		108	34.5
	Yes		205	65.5

Source: Author's computations (2024).

Moreover, Table 3 revealed that many farmers have access to financial assistance (53.4%), in particular, in the form of grants (97.6%) while only 2.4% is in the form of credit or loan.

Finally, a significant portion (65.5%) have access to extension services in the area while 34.5% may have not experienced or have not recognized extension service.

In [6], it is mentioned that extension services are helpful assistance in progressing production by providing their needs and necessary technology.

Fig. 1 presents a breakdown of farmer participation or access to various financial assistance programs offered in Lazi, Siquijor. The figure reveals that few farmers have availed themselves of financial assistance programs such as for Senior Citizens, 4P's, PCIC, DSWD AICs, and fewer farmers tried to acquire financial assistance in the form of credit or loan like ASA Microfinance, GSIS, and CARD.

A previous study mentioned that financial assistance is badly needed by farmers to start planting and endure the agricultural inputs for the whole season until harvesting [1].

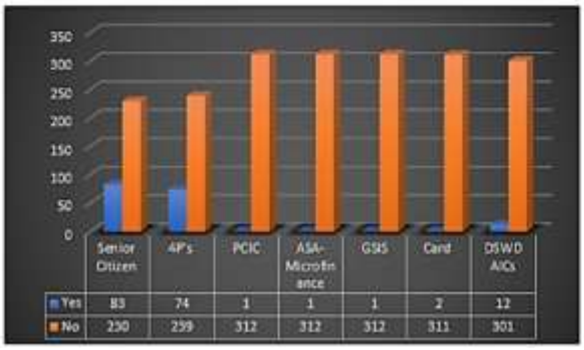

Fig. 1. Availability of financial assistance.
Source: Author's construction (2024).

Fig. 2 illustrates the distribution of labor utilized by farmers across various farming activities in Lazi, Siquijor.

The data suggests a strong reliance on family labor for most tasks, including land preparation, planting, fertilization, harvesting, and post-harvest activities.

However, a notable amount of hired labor is evident in land preparation and this finding is consistent in [14].

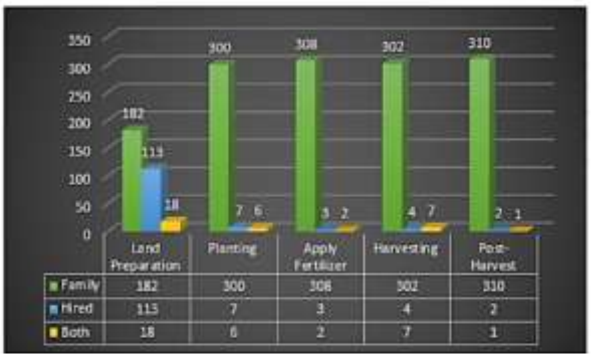

Fig. 2. Available labor across farming activities. Source: Author's construction (2024).

Fig. 3 shows the various extension services received by farmers in Lazi, Siquijor. The data reveals that a significant portion of farmers did not access services from MAO, DA OPA, SAAD, DAR, and PCA. However, while the majority of farmers did not benefit from services offered by MAO, DA OPA, and SAAD, a noteworthy number still received them. This implies that corn production in Lazi, Siquijor is capable of being improved if more extension services are provided by the local government that will support their needs [1], [6].

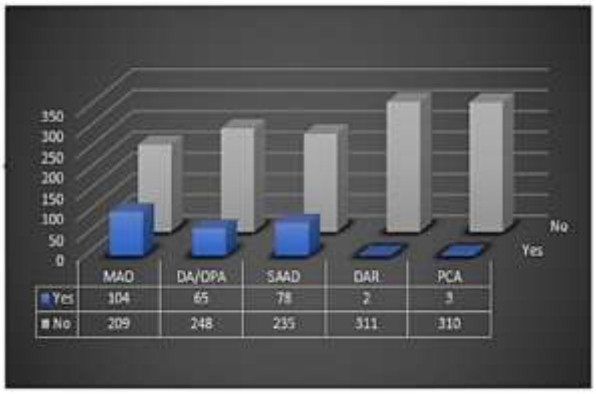

Fig. 3. Extension services provider
Source: Author's construction (2024).

Fig. 4 below details the various farming inputs utilized by surveyed farmers. When it comes to fertilizers, most farmers rely on options like complete and urea. Chicken dung, vermicast, muriate of potash, and ammonium phosphate appear to be less popular choices. Only a very few farmers used herbicides and insecticides as pest repellants. For seeds, traditional OPV seeds seem to be widely used compared to hybrid white and yellow and sige-sige seeds. Regarding farm machinery, most of the farmers have no tractors, corn shellers, or sprayer machines. Moreover, watering tools, sprayers, and wheelbarrows are not common tools and equipment for farmers. A significant number of farmers used digging tools, trapal, drums, and plows but not many. Finally, the data highlights majority of the farmlands are accessible by road. Despite this accessibility, most farmers have limited storage areas and milling facilities. All of the farmers practice sun drying as their drying method for corn. It is stated in [8] and [19] that modern technology in farming is necessary to increase farmers' production and profitability.

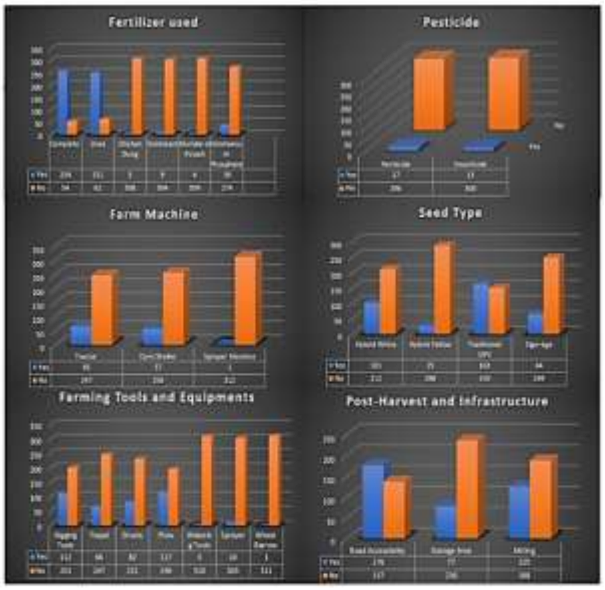

Fig. 4. Availability of farming inputs, post-harvest, and infrastructures.
Source: Author's construction (2024).

Corn Production Trends in Lazi, Siquijor

Fig. 5 presents the average corn production in Lazi, Siquijor, for the years 2020 to 2022 in terms of kilogram per hectare per year (kg/ha/year). In that case, in year 2020, the average corn yield is 2,544.07 kg/ha. This yield decreased to 2,377.97 kg/ha in year 2021 and further down to 2,125.42 kg/ha in year 2022. The series of data indicates a decreasing trend in corn yield over the observation period. This decreasing trend supports the data shown from the Office of the Provincial Agriculture in Lazi, Siquijor.

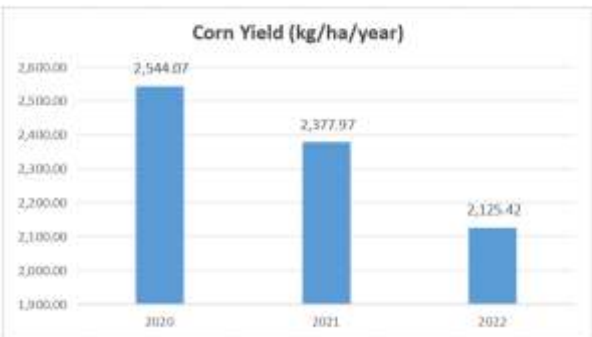

Fig. 5. Corn production (kg/ha/year) in Lazi, Siquijor, 2020-2022.
Source: Author's construction (2024).

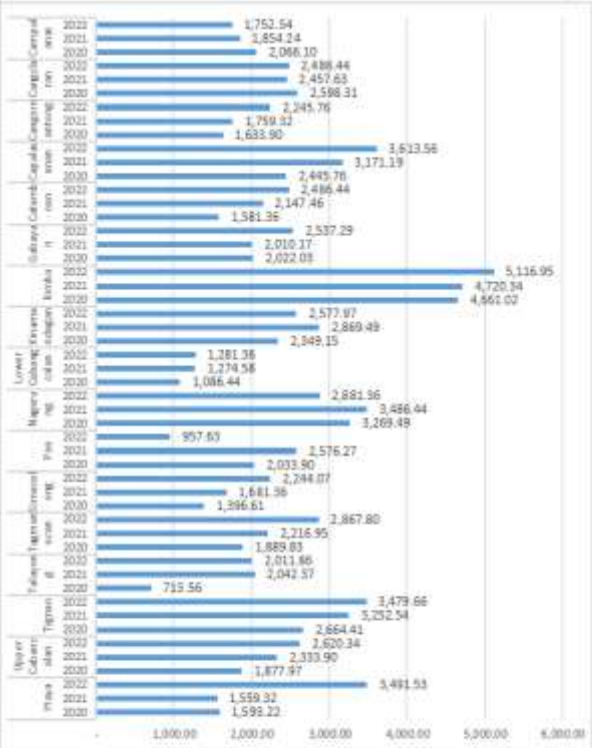

Fig. 6. Corn production (kg/ha/year) per Barangay in Lazi, Siquijor, 2020-2022.
Source: Author's construction (2024).

Fig. 6 suggests that Barangay Kimba had the highest average corn yield across the years 2020-2022, followed by Barangays Capalasanan, Nagerong, and Tignao. Conversely, Barangay Lower Cabangcalan appears to have had the lowest average yield during the observation period. Interestingly, Barangay Campalanas exhibits a distinct trend. While the majority of barangays show a decreasing yield in corn production from 2020 to 2022, Barangay Campalanas demonstrates a positive trend with increasing yield over the same period.

Problems Faced by Corn Farmers

As illustrated in Fig. 7, corn farmers in Lazi, Siquijor face several significant issues that contribute to lower crop yields. These challenges include a lack of support from relevant organizations, limited resources, insufficient access to fertilizer, low overall yield, soil infertility, and persistent pest problems. In [3] and [23], local farmers must be guided and supported by extension agents to be more competitive in solving their agricultural problems and improving their profitability.

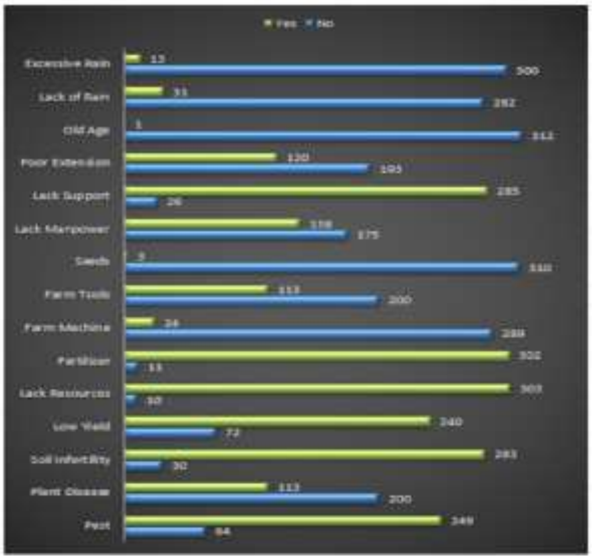

Fig. 7. Problems encountered in Lazi, Siquijor.
Source: Author's construction (2024).

Fig. 8 depicts the recommendations proposed by the farmers themselves to address these challenges. Interestingly, the majority of farmers highlighted the need for increased governmental support and improved availability of fertilizer. While a significant portion also expressed a desire for assistance with traditional farming practices, personal effort improvement, access to cheaper fertilizer options, and financial aid, the majority did not prioritize these additional forms of help. In that case, to increase the efficiency of the farmers, extension agents must be sent by the local government to help and guide them with the right information on how to solve agricultural problems [6].

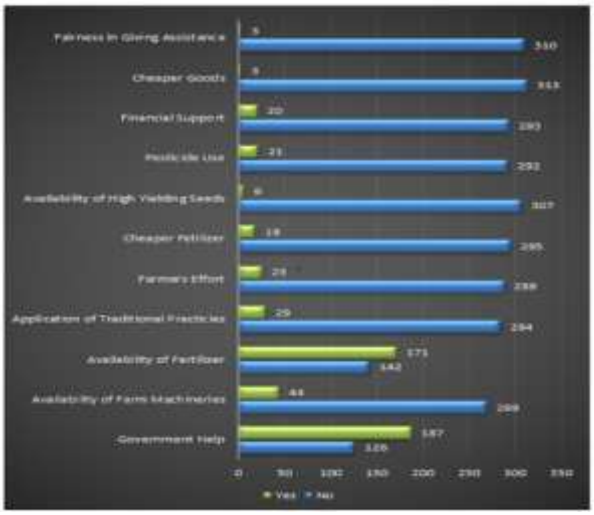

Fig. 8. Recommendations perceived by the farmers in Lazi, Siquijor.
Source: Author's construction (2024).

Corn Production and its Predictors

Table 4 shows the results of a robust regression model examining the socio-demographic and socio-economic factors influencing corn production among farmers in Lazi, Siquijor. The dependent variable in this regression model is the corn yield for the year 2022 and it is calculated as bags per average farm size (ha) where 1 bag (bulk) is equal to 35 kg. Out of the tested socio-demographic variables, only sex has exhibited a significant relationship to corn production (corn yield). However, age, civil status, educational attainment, and household size did not significantly predict corn production. Among the socio-demographic factors, only sex showed a significant effect. Male farmers were found to produce more corn compared to their female counterparts (β=0.238, p=0.009). This means that male farmers are predicted to have corn yields that are about 27% higher than female farmers, on average, controlling for other factors. This agrees with the result of the study of [10], which stated that the production will likely become lower when a female leads the household, especially in farming in contrast to male headed family. Female farmers have other responsibilities in the household but male farmers can focus on farming. In general, male farmers engage in farming while female farmers engage in household activities.

Additionally, there are more men farmers due to the assumption that farming is a heavy work that requires male strength leaving women to the less heavy job. Households with a male in the lead are more expectedly to gain access to much more farm resources than households with a female as the head. Additionally, males may be productive since they have the propensity to be more competent in terms of labor efficiency [21].

Socio-economic factors, on the other hand, presented a clearer picture. Among the socioeconomic factors, household income (β<0.001, p=0.004), major occupation, land tenure, and farm size (β=0.421, p<0.001) were found to have a significant effect on corn production. On the other hand, farming experience (β=-0.002, p= 0.690), participation in organizations (β=-0.064, p=0.553), attendance at training (β =-0.135, p=0.246), access to financial assistance (β=-0.095, p= 0.294), and access to extension services (β= 0.117, p=0.243) did not significantly influence corn production.

Household income demonstrated a positive and significant relationship with corn production (β< 0.001, p=0.004), implying that higher income allows farmers to invest in resources that can boost production. The study of [10] also found a significant relationship between income and agricultural production. This could be further supported by the study in [19] that stated that income or profit is seen to be the driving force for farmers to invest more in farming. The author also added that farmers who have higher incomes will have more demand for extension services thus improving their farming and will cause higher production.

The major occupation significantly predicted corn yield. Corn farming is found to have a positive relationship with the production. Compared to corn farmers, those engaged in livestock farming (β=-0.705, p=0.008), vegetable farming (β=-1.572, p<0.001), rice farming (β=-0.339, p=0.003), and fishing (β=-0.529, p=0.013) produced significantly less corn. In particular, livestock farmers yielded 51% less corn, vegetable farmers yielded 79% less corn, rice farmers yielded 29% less corn, and fishers yielded 41% less corn compared to corn farmers. Farmers with other occupations also yielded less corn, producing about 23% less than corn farmers, β = -0.265, p = 0.026. This could be justified by the claim in [5] that stated that when farmers engage in other occupations, their production would be lesser due to competition for labor in farming. Major occupation being a significant variable agrees with the results in [2] and [10], which also found a significant and positive influence on the major occupation of farmers.

Land tenure significantly influenced corn production. Farmers who rented their land (β= 0.247, p=0.021) produced more corn compared to those who solely owned/inherited their land. Holding other factors constant, tenants yielded about 28% more corn compared to sole owners/inheritors. This could be the fact that tenant farmers would double their efforts because it will be a great loss to them if the production is low since the yield will be divided according to their agreement with the owner. In this sense, the share of the tenant is usually lower than that of the owner. A distinguished ability of the farmers to persevere and be diligent in utilizing the land or to a greater extent, proving themselves dependable by following their agreement with the owner.

Tenant farmers were also found to be efficient in making use of the farm inputs [10] and in general work in farming to increase production which could lead to maximizing revenue, profit increase, and minimizing farm spending [19]. In contrast, those who both owned/inherited and rented land (β=-0.202, p=0.445) had no significant difference from those who solely owned or inherited their land.

Table 4**.** Robust regression model of corn production (corn yield) of Lazi, Siquijor, Philippines.

PREDICTORS	β	SE	t-value	p-value
Intercept	2.988	0.282	10.604	< .001*
Socio-demographic				
Age	-0.009	0.006	-1.592	0.112
Sex				
Female[a]	-			
Male	0.238	0.090	2.636	0.009*
Civil Status				
Single[a]	-			
Married	0.164	0.122	1.345	0.180
Widowed	0.262	0.212	1.234	0.218
Separated	0.429	0.503	0.854	0.394
Highest Educational Attainment				
Vocational[a]				
Elementary	-0.118	0.187	-0.633	0.527
High School	-0.123	0.168	-0.732	0.465
College	-0.130	0.209	-0.620	0.536
Household size	-0.005	0.019	-0.260	0.795
Socio-economic				
Farming years	-0.002	0.005	-0.399	0.690
Household income	< .001	< .001	2.937	0.004*
Major Occupation				
Corn farmer[a]	-			
Livestock farmer	-0.705	0.264	-2.666	0.008*
Vegetable farmer	-1.572	0.386	-4.070	< .001*
Rice farmer	-0.339	0.111	-3.050	0.003*
Fisherman/seller	-0.529	0.212	-2.495	0.013*
Others	-0.265	0.118	-2.243	0.026*
Land Tenure				
Owned/Inherited[a]	-			
Tenant	0.247	0.107	2.312	0.021*
Owned/Inherited & Tenant	-0.202	0.265	-0.765	0.445
log(Farm size)	0.421	0.046	9.179	< .001*
Members of association				
No[a]	-			
Yes	-0.064	0.108	-0.595	0.553
Attended trainings				
No[a]	-			
Yes	-0.135	0.117	-1.163	0.246
Access to financial assistance				
No[a]	-			
Yes	0.095	0.090	1.052	0.294
Extension services				
No[a]	-			
Yes	0.117	0.100	1.170	0.243
Adjusted R^2	0.435			
Convergence in 25 IRWLS iterations				

Source: Author's computations (2024).

Farm size showed a strong positive association with corn production (β=0.421, p<0.001), suggesting economies of scale where larger farms are associated with higher yields. On average, for every 20% increase in farm size, corn yield increases by approximately 8%. In [9], it is mentioned that farm size significantly influences, but their study found that farm size was negatively related which means that small farmers adopt and do more than large farmers.

CONCLUSIONS

The main aim of this study is to capture the different factors affecting corn production in Lazi, Siquijor, Philippines. In terms of the socio-demographic profile of the respondents from Lazi, Siquijor belonged to age 51-60, the great majority are married and are high school graduates. The majority of them have a household size of 4 to 6 members. In terms of the socioeconomic profile, the majority of them are tenants to the land they tilled with sizes less than 1 hectare with 1-2 parcels of land. In terms of farming years, the majority have 16-30 years and have the major occupation of corn farming with the great majority of farmers with an income of less than 15,375 pesos. The majority of farmers have joined the association but most (75.7%) of them have not attended training. A great number have access to financial assistance, in particular, in the form of grants and the majority have access to extension services in their area. The corn production in Lazi from 2020-2022 was found to be decreasing. From the average of 15.01 kg in 2020, 14.03 kg in 2021 to 12.54 kg in the year 2022. The challenges that the corn farmers faced included limited resources, lack of support from the government, insufficient access to fertilizer, low overall yield, soil infertility, and persistent pest problems. As for their recommendations, farmers suggested increased governmental support and improved availability of fertilizer.

Only sex was found to be significant while age, civil status, educational attainment, and household size were found not significant. However, socioeconomic, household income, major occupation, land tenure, and farm size were found to have a significant relationship with corn production. Participation in associations, attendance at training, access to financial assistance and extension services, and years of farming experience were found to have no significant influence. Household income was also found to be significant thus farmers must have funds to be used for farming like the ones from rice farmers where they have Seed, Fertilizer and Ameliorant discount voucher and Bio-fertilizer voucher. Especially for the availability of fertilizer since it is one of the top problems that the corn farmers were facing. Even though in this sense, the farmer's income won't go higher they will have money or ways to still acquire the important inputs for their farming. Same as to the tenurial of the farmers, farmers who were tenants have higher yields compared to those who owned their land since when a farmer is a tenant to the land, the owner of the land could help in providing the outputs that the farmers need. The fund is also applicable to this in that even if the farmer is the owner of the land, they still have available support for their farming. Corn farming as the major occupation was seen to have more yield than other occupations. Thus, giving more attention to corn farmers for more interventions will help the production to increase. After the data collection, it was found that there were still corn farmers who were not registered in the Registry System for the Basic Sectors in Agriculture (RSBSA), and some of the registered ones were not corn farmers or did not plant corn. Corn farmers that were currently planting corn must be registered in this system so that if interventions are ready for them, they can acquire the help that they need.

In this study, farmers with larger farm sizes have higher yields. According to the data from DENR and as depicted in their cadastral map, the government owns a total of 103 public lands in Lazi, Siquijor, and sharing it with those corn farmers who only have a small piece of land might be a good solution. Since the existence of pests is prevalent in the area, cropping calendar, crop rotation as well as intercropping patterns must be further studied in the area. Since the majority of the corn farmer respondents were female but the study yielded a negative relationship between women and production, gender-sensitive studies are recommended in order to recognize the reason behind this result.

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RESEARCH OF COMPLEX MILK PROTEINS GENOTYPES IN THE CONTEXT OF THEIR QUALITY IMPROVEMENT

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Abstract

Recently, scientists increasingly use the achievements of genetics in the practical selection of dairy cattle. Special attention is paid to genes associated with indicators of cows' milk productivity. These include genes for CSN2, CSN3, BLG and others. The CSN2 gene genotype of animals is being studied especially intensively today, which is explained by the assumption of its influence on human health. Two groups of animals derived from local Lebedyn cattle has been studied. The difference in frequencies of complex genotypes CSN2/CSN3/BLG has been found. Brown breeds characterized by a high frequency of complex genotypes CSN2A2A2BLGBB, CSN3BBBLGAB, CSN2A2A2CSN3AB, CSN2 A2A2CSN3BB. Black and white breeds characterized by a high frequency of complex genotypes CSN2A1A2BLGAB, CSN3AABLGAB, CSN2A1A2CSN3AA, CSN2A2A2CSN3AA. According to the distribution of individual loci, no cows with complex genotypes CSN2A1A1BLGAA, CSN2A1A2BLGAA, CSN2A1A1CSN3AB found among brown breeds of animals, among black and white breeds of cows there were no animals with CSN2A1A2BLGBB, CSN2A1A1CSN3AB complex genotypes. A statistically significant difference in terms of milk productivity found between several genotypes. We consider the number of livestock recommended by the FAO for studies of the genetic structure by individual loci does not allow to fully research the genetic structure according to complex genotypes.

Key words: *beta-casein, kappa-casein, beta-lactoglobulin, breed, genotype, milk productivity*

INTRODUCTION

Modern cattle breeding widely uses the achievements of genetics [6, 15]. Thanks to its rapid development, breeders have the opportunity to research and use the polymorphism of individual genes in practical breeding. Scientists believe that among all agricultural animals, cattle are the most studied in terms of molecular genetics. This is because these animals have the highest number of productivity markers. Among the large number of genes that have an impact on the milk productivity of cows, scientists single out a certain group of genes that have the greatest impact on this productive trait. Among them, the genes of kappa-casein (CSN3), beta-lactoglobulin (BLG), prolactin, pituitary-specific transcription factor and others can be distinguished [4, 16].

Researchers debate about the possibility of improving the quality characteristics of milk using animal selection based on molecular markers. In this regard, scientists recommend using population parameters (genotype and allele frequencies) as a tool for improving selection. Thus, studies of polymorphism of milk protein genes are increasingly used in individual breeding programs for dairy cattle. The advantage of DNA technologies, according to scientists, can be considered the possibility of determining the genotype of animals regardless of their age, physiological state, and sex. In turn, they make it possible to significantly increase the accuracy and efficiency of breeding, while simultaneously reducing the generation of intervals, which allows to accelerate the effect of breeding [13, 17]. Among the genetic markers associated with the technological properties of milk, scientists are conducting research on CSN3, BLG and other genes. However, more and more often, scientists do not study individual genes, but complex genotypes. It should be noted that such studies conducted on local dairy cattle are few [14].

The use of any genetic material can also be attributed to the advantages of using molecular genetic markers. It can be blood, urine, pus, semen, wool with hair follicles, and others. Scientists pay attention to the value of the information obtained from the genetic assessment, which consists in the early (even immediately after birth) determination of the animal's genetic potential [12].

In countries with developed dairy farming, molecular genetic methods have been used together with mathematical modeling for a long time. Thanks to this, marker-associated selection has been implemented in leading agricultural enterprises. It has been proven that the identification of certain genes and their mutations, which determine the degree of development of a certain economically useful trait, allows to accelerate breeding progress, and as a result increases the profits of the industry [12]. Genes such as CSN2, CSN3, and BLG considered to be components associated with the technological properties of milk [2].

Therefore, scientists believe that the selection of dairy cattle, focused on the maximum realization of its productive potential, should include molecular genetic research of animals. The absence of the latter will not allow fixation of the "desired" alleles of the corresponding genes [1, 7].

In this context, the study of the genetic structure of complex genotypes of cattle milk proteins is relevant. This will help to improve the productive characteristics of dairy cattle and will allow increasing the quality characteristics of cows' milk. This was the main aim of the work.

MATERIALS AND METHODS

The experiment conducted on the production facilities of the State Enterprise "Experimental Farm of the Institute of Agriculture of the North East of the National Academy of Sciences of Ukraine" in the Sumy oblast. In accordance with the purpose of the work, we used the firstborn of two domestic dairy breeds, respectively Ukrainian brown dairy (UBD) and Ukrainian black and white dairy (SITUBWD) breeds. The population of experimental animals consisted of 30 heads, which met the requirements of the FAO for genetic research [3]. The genotypes of the following genes were determined in experimental animals: kappa-casein (CSN3), beta-casein (CSN2) and beta-lactoglobulin (BLG). Cows were genotyped according to kappa-casein (CSN3), beta-casein genes (CSN2) and beta-lactoglobulin (BLG).

The selection of biological samples and the study of CSN2 and CSN3 gene polymorphisms were carried out according to the method described in our publications [9,10, 11].

Genetic studies conducted on DNA samples taken from hair bulbs of cows. To study the single nucleotide polymorphism of the BLG gene of cattle (chromosome 11, GenBank: X14710.1, exon 4, rs458095482 (Gcc/Ccc, 270A>P) and rs109625649 (gCc/gTc, 270A>V) we used the PCR-RFLP method with specific primers and HaeIII restriction endonuclease. DNA was isolated from hair follicles using the commercial kit "DNK-Sens"). Amplification of BLG gene fragment conducted in thermocycler “Tertsick” (DNA-techologies) using primers: F-5'-TGTGCTGGACACCGACTACAAAAAG-3' IR-5'-CTCCCGGTATATGACCACCCTCT-3" [5].

The PCR mixture (10 ml) contained: 5 μl master mix (10x buffer for DNA polymerase (1 μl), DNA polymerase (Fermentas, Lithuania, 0.25 units), 2.5 mM DNATP (1 μl), deionized H2O (3 μl)), 1 μμ mixture of primers (5 μl) and DNA (5 μl). Temperature regime: initial denaturation — 2.5 min at 94°C, next 38 cycles — 94°C 20 sec., 64°C 30 sec., 72°C 1 min., final elongation at 72°C 7 min. The size of the amplicon is 247 bps. The studied fragment has one monomorphic restriction site for HaeIII (GG↓CC) and one polymorphic one. Expected restriction patterns for genotypes: AA (HaeIII-) – 148/99 bps; BB (HaeIII+) –74/74/99 bps; AB - 148/99/74 bps.

Amplification products were treated with HaeIII endonuclease according to the manufacturer's instructions (Fermentas, Lithuania). The number and length of the restriction products were determined by electrophoresis in a 3% agarose gel (with the addition of 0.5 μg/ml ethidium bromide) in Tris-borate buffer (TBE: 0.089 M Tris, 0.089 M boric acid, 0.002 M EDTA pH 8.0) with using a molecular weight marker (100 bps Ladder, Simgen). Electrophoresis results visualized on a transilluminator in the UV spectrum (312 nm).

The polymorphism of the locus of the pituitary-specific transcription factor PIT 1 (chromosome 1, GenBank: Y15995.1, exon 6, synonymous transition 1256 G>A, ctG>ctA) studied by the PCR-PDRF method using HinfI endonuclease (G↓ANTC restriction site). Primers: Forward: 5'-CAATGAGAAAGTTGGTGC-3'; Reverse: 5'-TCTGCATTCGAGAT GCTC-3') [5].

The conditions for PCR amplification of the PIT 1 gene are as follows: initial denaturation — 2.5 min at 94°C, the next 35 cycles — 94°C 20 sec., 52°C 30 sec., 72°C 1 min., final elongation at 72 °C 7 min. The size of the amplicon is 1301 bp. The studied fragment has two monomorphic and one polymorphic (1256 G>A) restriction sites for HinfI (G↓ANTC). Restriction fragments with a length of 617, 424 and 260 bp. correspond to allele A (NinfI), fragments 617, 379, 260 and 45 bp. indicate the B allele (NinfI+) [5].

The electronic database of Dairy stock management system "Orsek" was used to assess productive characteristics. Indicators of reproductive capacity and milk productivity were assessed. A counter - indicator “ИУ-1” was used to take milk samples. The milk sample was stored in a plastic container (25 ml) and preserved with a 0.2 ml solution of potassium dichromate (concentration 10%). The content of milk components was determined in the laboratory of the Sumy National Agrarian University using the Ultrasonic milk analyzer Master Classic.

Statistical data processing was performed using the licensed software STATISTICA 10.0 (StatSoft) for Windows.

RESULTS AND DISCUSSIONS

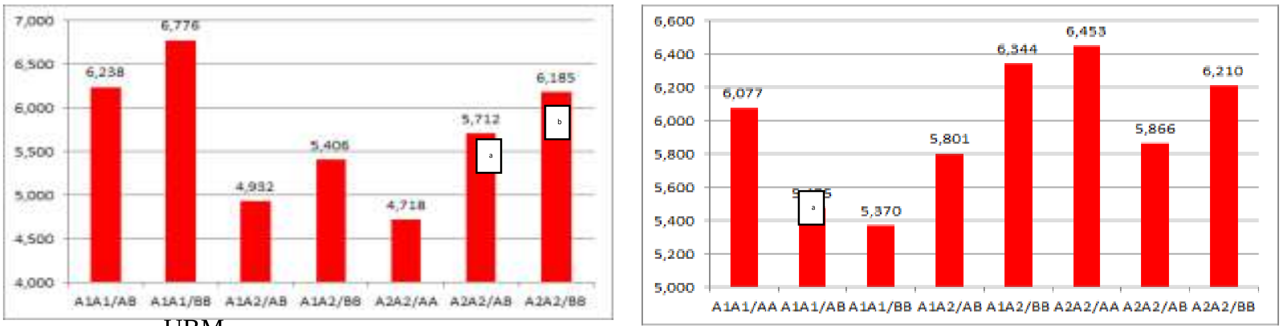
Having analyzed the results of genetic research, we can note that the majority of UBD cows had the A2A2 CSN2 gene genotype (74%). Animals with other genotypes A1A1 and A1A2 accounted for 6% and 20%, respectively. Most of the animals of this breed had the heterozygous AB BLG gene genotype (60%). Animals with other AA and BB genotypes accounted for 9% and 31%, respectively. According to the distribution of these genotypes, the CSN2/BLG complex genotype was represented by seven genotypes out of nine possible ones (Table 1).

Table 1. Frequency distribution of the studied combinations of CSN2 and BLG milk protein genotypes

CSN2	BLG		
	AA	AB	BB
	UBM		
A1A1	0.00	0.03	0.03
A1A2	0.00	0.10	0.10
A2A2	0.09	0.47	0.18
	SITUBWD		
A1A1	0.03	0.18	0.03
A1A2	0.00	0.26	0.10
A2A2	0.13	0.20	0.07

Source: Own research.

Genotypes CSN2A1A1BLGAA and CSN2A1A2BLGAA were absent in UBD breed cows. The highest frequency was the complex genotype CSN2A2A2BLGAB, the share of which was almost half. Among the animals of the SITUBWD, the majority had the CSN2 gene genotype A1A2 and A2A2, the share of which was 36% and 40%, respectively. Most animals of this breed having BLG gene, had the AB genotype, the share of which was 64%. The complex genotype CSN2A1A2BLGAA was not found in SITUBWD cows, and most animals had genotypes CSN2A1A2BLGAB and CSN2A2A2BLGAB, the share of which was 26 and 20%, respectivelyAnimals with different complex genotypes had a statistically significant difference in milk yield (Fig. 1).



UBM

Probability: a – to genotype A2A2/AA (P<0.05); b – to the A2A2/AA genotype (P<0.01)

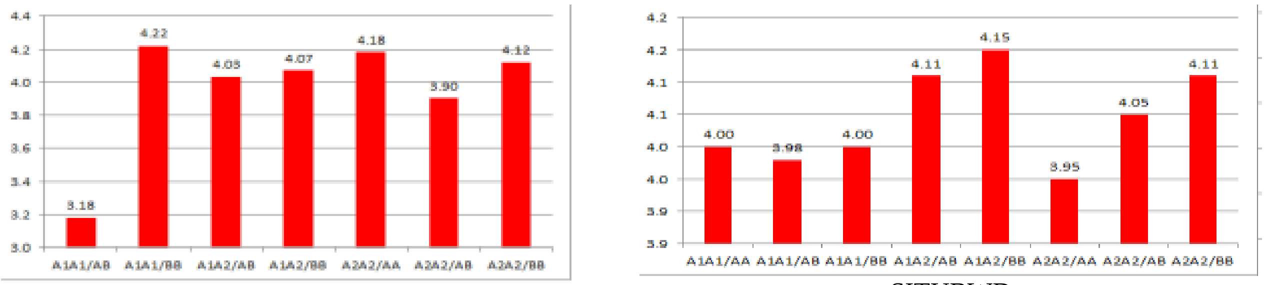
SITUBWD

Probability: a – to genotype A2A2/AA (P<0.01)

Fig. 1. Milk yield of cows with different CSN2-BLG complex genotypes, kg
Source: Own research.

Thus, the first time calving animals of UBD with complex genotypes CSN2^{A2A2}BLG^{AB} and CSN2^{A2A2}BLG^{BB} with different degrees of probability prevailed in terms of average milk yield over cows with complex genotype CSN2^{A2A2}BLG^{AA} by 994 kg and 1467 kg, respectively. Between animals with complex genotypes CSN2^{A1A1}BLG^{AB} and CSN2^{A2A2}BLG^{AA} there is a significant difference in favor of the genotype CSN2^{A2A2}BLG^{AA}.

There is no significant difference in the fat content of milk between the animals of the experimental breeds (Fig. 2).

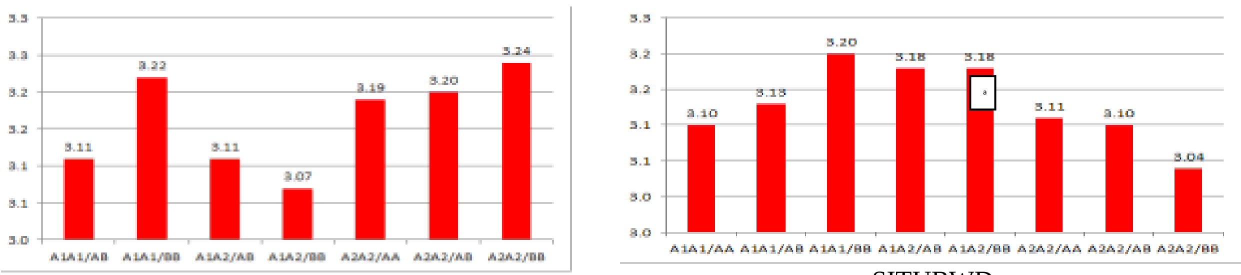


UBM

SITUBWD

Fig. 2. Study of fat content in milk in animals with different complex genotypes CSN2-BLG, %
Source: Own research.

There is a likely difference in milk protein content between SITUBWD animals with complex genotypes CSN2^{A1A2}BLG^{BB} and CSN2^{A2A2}BLG^{BB}. Animals with the CSN2^{A2A2}BLG^{BB} genotype predominated. There is no significant difference between animals (UBD) (Fig. 3).



UBM

SITUBWD

Probability: a – to genotype A2A2/BB (P<0.01)

Fig. 3. Milk protein content of cows with different complex CSN2-BLG genotypes, %
Source: Own research.

Among the animals of the UBD, having CSN3 gene, the majority had the heterozygous AB genotype, the share of which was 51% (Table 2).

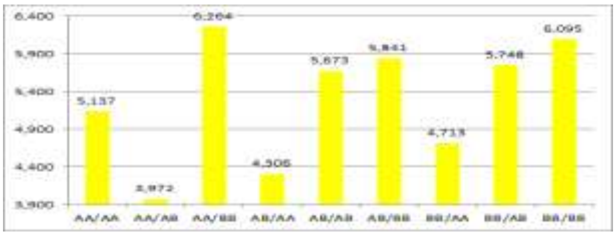
Table 2. Frequency distribution of the studied combinations of CSN3 and BLG milk protein genotypes

CSN3	BLG		
	AA	AB	BB
	UBM		
AA	0.03	0.03	0.07
AB	0.03	0.31	0.17
BB	0.03	0.26	0.07
	SITUBWD		
AA	0.06	0.40	0.14
AB	0.07	0.17	0.03
BB	0.03	0.07	0.03

Source: Own research.

The share of homozygous AA and BB genotypes was 13% and 36%, respectively. Among the first time calving animals of both breeds, all possible nine complex genotypes according to the studied genes were present. Accordingly, the majority of animals of this breed had the complex genotype $CSN3^{AB}BLG^{AB}$ and $CSN3^{BB}BLG^{AB}$, the shares of which were 31% and 26%, respectively. Among the animals of SITUBWD, the majority had the complex genotype $CSN3^{AA}BLG^{AB}$

While animals of the UBD having different complex genotypes, showed no statistically significant difference in the amount of milk yield, cows of the SITUBWD with the complex genotype $CSN3^{AB}BLG^{AB}$ were inferior in terms of milk yield to animals with the genotypes $CSN3^{AA}BLG^{AA}$, $CSN3^{AA}BLG^{AB}$, $CSN3^{AA}BLG^{BB}$, and $CSN3^{AB}BLG^{AA}$ with different degree of probability. A probable difference between $CSN3^{AA}BLG^{AA}$ and $CSN3^{BB}BLG^{AB}$ genotypes was also established in favor of the first animals (Fig. 4).



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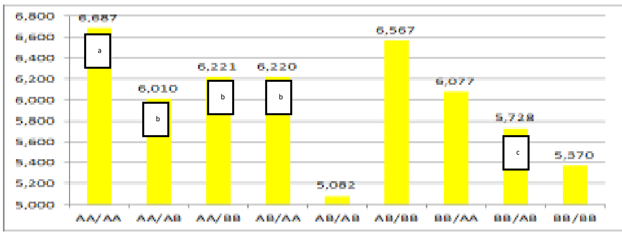
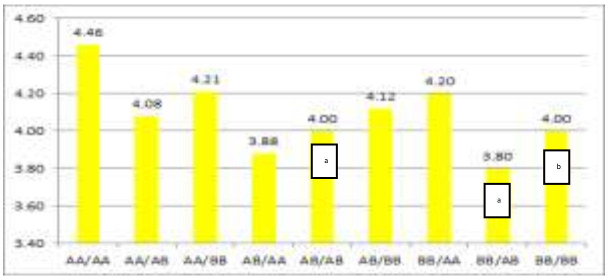


SITUBWD

Probability: a – to genotype AB/AB (P<0.01); b – to the AB/AB genotype (P<0.05); c – to genotype AA/AA (P<0.05);

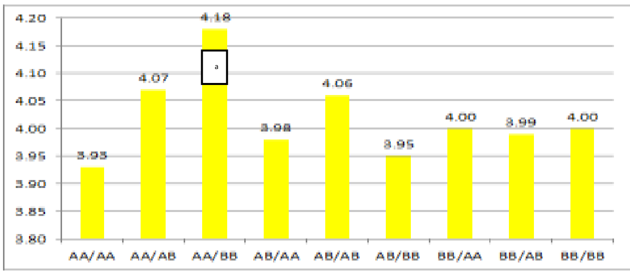
Fig. 4. Milk yield in cows with different CSN3-BLG complex genotypes, kg
Source: Own research.

According to the content of fat in milk among the first time calving animals of UBD, a statistically significant difference was established between animals with genotypes $CSN3^{AA}BLG^{BB}$ and $CSN3^{AB}BLG^{AB}$, $CSN3^{BB}BLG^{AB}$ in favor of the first genotype, $CSN3^{BB}BLG^{BB}$ and $CSN3^{AB}BLG^{BB}$ in favor of the latter (Fig. 5).



UBM

Probability: a – to genotype AA/BB (P<0.05); b – to genotype AB/BB (P<0.05);

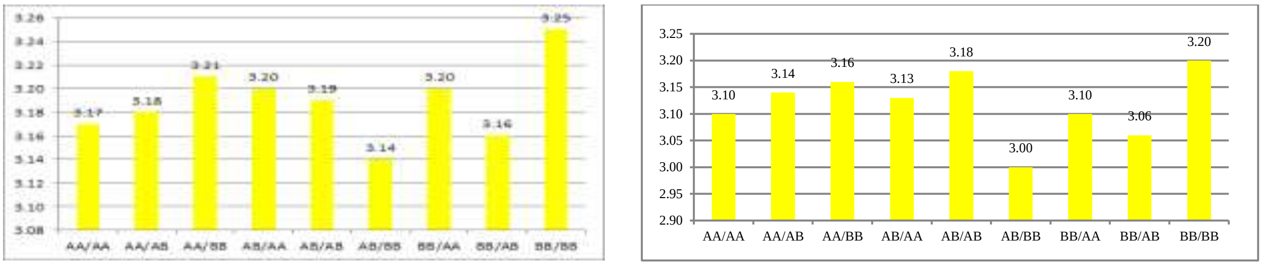


SITUBWD

Probability: a – to genotype AA/AA (P<0.01);

Fig. 5. Milk fat content in cows with different complex CSN3-BLG genotype
Source: Own research.

Among UBD, a probable difference was established between the first time calving animals with genotypes $CSN3^{AA}BLG^{AA}$ and $CSN3^{AA}BLG^{BB}$ in favor of the latter The studied genes of complex genotype did not have a statistically significant effect on the protein content in milk (Fig. 6).



UBM SITUBWD

Fig. 6. Milk protein content in cows with different complex CSN3-BLG genotypes
Source: Own research.

Assessing the animals of the test breeds having CSN2/CSN3 complex genes, we found that out of nine possible complex genotypes, only seven were found among UBD cows, and eight among SITUBWD cows. Among animals of the UBD, there were no animals with complex genotypes CSN2^{A1A1} CSN3^{AB} and CSN2^{A1A2} CSN3^{BB}, and among cows of the SITUBWD - CSN2^{A1A2} CSN3^{BB}. The majority of the first time calving animals of UBD breed had complex genotypes CSN2^{A2A2} CSN3^{AB} and CSN2^{A2A2} CSN3^{BB}, respectively 34% and 33%. The majority of the SITUBWD cows had CSN2^{A1A2} CSN3^{AA} and CSN2^{A2A2} CSN3^{AA} genotypes (Table 3).

Table 3. Study of frequencies of complex genotypes CSN2/CSN3

CSN2	CSN3		
	AA	AB	BB
	UBM		
A1A1	0.03	0.00	0.03
A1A2	0.03	0.17	0.00
A2A2	0.07	0.34	0.33
	SITUBWD		
A1A1	0.07	0.07	0.10
A1A2	0.26	0.10	0.00
A2A2	0.27	0.10	0.03

No statistically significant difference in milk yield was found among the first time calving animals of UBD having different complex genotypes. (Fig. 7).

UBM SITUBWD

Probability: a – to genotype A1A2/AA (P<0.05); c – to the A2A2/AA genotype (P<0.05), c – to the A2A2/AB genotype (P<0.05)

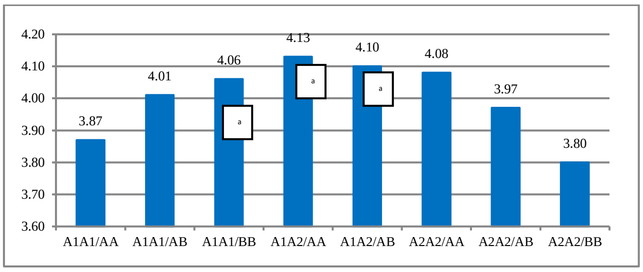
Fig. **7.** Milk yield in cows with different CSN2-CSN3 complex genotypes, kg
Source: Own research.

Whilst, the first time calving animals of the SITUBWD having the complex genotype CSN2^{A1A2} CSN3^{AA}, CSN2^{A2A2} CSN3^{AA}, CSN2^{A2A2} CSN3^{AB} prevailed over animals with the genotypes CSN2^{A1A1} CSN3^{AA} and CSN2^{A1A2} CSN3AA.

The complex genotype of the studied genes had a statistically significant effect on the fat content in milk. Among the first time calving animals of UBD, a probable difference was found between animals with genotypes CSN2^{A1A2} CSN3^{AB} and CSN2^{A1A2} CSN3^{BB}. Among SITUBWD animals, cows with complex genotypes CSN2A1A1CSN3BB, CSN2A1A2 CSN3AA, CSN2A1A2 CSN3AB showed the higher content of fat in milk (Fig. 8).

UBM

Probability: a – to genotype A2A2/AB (P<0.05)

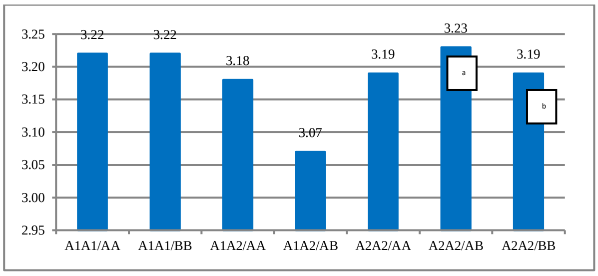


SITUBWD

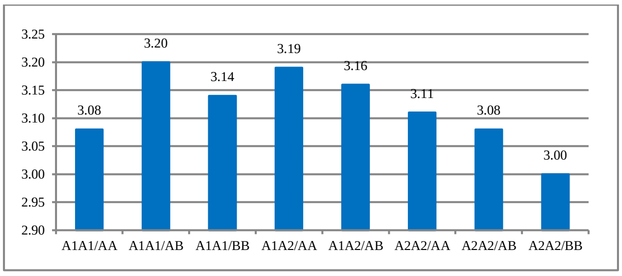
Probability: a – to genotype A1A1/AA (P<0.05)

Fig. 8. Fat content in milk of cows with different complex genotype CSN2-CSN3, %
Source: Own research.

According to the content of protein in milk, among the animals of UBD, animals with complex genotypes CSN2^{A2A2} CSN3^{AB} and CSN2^{A2A2} CSN3^{BB} had higher values (Fig. 9).



UBM



SITUBWD

Probability: a – to genotype A1A2/AB (P<0.05); b – to genotype A1A2/AB (P<0.01)

Fig. 9. Protein content in milk of cows with different complex genotype CSN2-CSN3, %
Source: Own research.

They probably prevailed in this feature over animals with the CSN2^{A1A2} CSN3^{AB} genotype. Among the SITUBWD animals, no probable difference was found

CONCLUSIONS

At the first stage of our research, it was planned to research separately the polymorphism of each of the studied genes: CSN2, CSN3 and BLG among animals of the UBD and SITUBWD, which originates from the local Lebedyn breed. This aim determined the study of thirty animals from each breed, according to the minimum recommendation of FAO. Recently, in Ukraine, much attention has been paid to the formation of dairy herds for the production of A2 [10] milk. Therefore, in our opinion, for this purpose it was desirable to conduct an analysis of the possibility of using complex genotypes for the needs of marker selection. A similar practice has already been encountered by other researchers on other local Ukrainian breeds of dairy cattle [7, 8].

Research of complex genotypes of the local breed included CSN2 and CSN3 genes genotypes. Research of the BLG gene was not conducted on the stock of these breeds. According to the results, the majority of brown cattle had complex genotypes CSN2^{A2A2}CSN3^{AB}, CSN2^{A2A2}CSN3^{BB} and CSN2^{A1A2}CSN3^{AB} [9]. These results fully correspond to our results. The only difference is the absence of animals with two complex genotypes in our studies. According to the results of previous studies, animals of SITUBWD have a higher frequency of complex genotypes CSN2^{A1A1}CSN3^{AB}, CSN2^{A1A2}CSN3^{AA}, and CSN2^{A2A2}CSN3^{AA} [9].

Two complex genotypes in animals of the experimental breeds had an advantage over the others in terms of their frequency. These are such genotypes as CSN2^{A1A2}CSN3^{AA} and CSN2^{A2A2}CSN3^{AA}. Interbreed differentiation is also established by this feature. There is a certain difference in genotypes that do not occur among experimental animals. Thus, according to the results of our research, genotype $CSN2^{A1A2}CSN3^{BB}$ is not found. Other authors claim the absence of the following genotypes ($CSN2^{A1A2}CSN3^{AB}$ and $CSN2^{A2A2}CSN3^{BB}$). The results of our research on the frequency of the CSN2 and CSN3 genes also do not correspond to the results of other researchers to some extent. Thus, according to the A2A2 genotype and the CSN2 gene, the difference among animals of the UBD was - 20%, and SITUBWD - 13%. According to the BB genotype of the CSN3 gene, the difference between brown animals was 6%, and SITUBWD - 3%.

Most of the animals of the UBD breed have the genotype of the BLG gene BB, and the SITUBWD - AB. According to the distribution of the studied genes, the majority of the animals of the UBD had the $CSN2^{A2A2}BLG^{AB}$ genotype; $CSN3^{AB}BLG^{AB}$, $CSN3^{BB}BLG^{AB}$ and SITUBWD - $CSN2^{A1A2}BLG^{AB}$; $CSN3^{AA}BLG^{AB}$.

Accordingly, among the animals of the UBD breed, regardless of the CSN2 gene genotype, animals with the BB BLG gene genotype, and animals of SITUBWD with the AA genotype, respectively, had a greater amount of milk yield. For the latter, a similar trend was preserved when the CSN3 and BLG genes were combined.

The content of milk components (fat and protein) showed no clear dependence on complex genotypes.

In our opinion, when working on the formation of a breeding nucleus in a dairy herd, it is desirable to increase the number of animals for genotyping. Number of animals recommended by FAO is appropriate to use with one locus. The use of the recommended number of animals when studying complex genotypes and selection based on its results is insufficient. Similar conclusions are made by other researchers [7, 8].

It is worth noting, that in order to increase efficiency of herd creating work with the desired genotype based on a single gene, or a complex genotype based on a group of loci, it is necessary to perform herd bulls genotyping. This will make it possible to use sperm production from animals with the desired genotype, which in turn will allow in subsequent generations to obtain replacement animals with the necessary complex genotype.

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STUDY ON THE IMPACT OF CLIMATE CHANGES FROM THE LAST DECADE ON TOURIST DEMAND IN ROMANIA

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Abstract

The purpose of this study was to identify and analyze how climate variables influence the behavior of tourists and the evolution of economic indicators specific to tourism, highlighting the relationships between climate change and tourism dynamics.The research methodology integrates the analysis of some essential climatic and economic indicators. The TCI (Tourism Climate Index) and HCI (Holiday Climate Index) indicators were used to measure the climatic attractiveness of tourist destinations, based on variables such as average temperature, relative humidity, hours of sunshine, precipitation and wind speed. The correlations of these indicators with the economic ones, such as: the total number of tourists, the share of foreign tourists, income from tourism, the degree of occupancy of tourist units and the contribution of tourism to GDP, allowed us a comprehensive analysis of the interactions between climate and tourist demand. The statistical analysis revealed correlations between climatic and economic indicators. For example, sunshine hours and average temperature had a positive influence on the number of tourists and tourism income, while precipitation and high wind speed reduced the attractiveness of certain destinations, affecting the occupancy of accommodation units. In addition, moderate thermal amplitude was associated with greater thermal comfort and increased demand during peak periods. The study's conclusions indicate that climate change has generated both opportunities and risks for Romanian tourism. Rising temperatures and the extension of warm seasons have favored tourist flows in certain regions, such as the coast and mountainous areas in the warm season. On the other hand, extreme phenomena, such as heat waves, drought or rains have affected the predictability of tourist seasons, underlining the need to adapt the infrastructure and diversify tourist offers.

Key words: *tourism, climate changes, tourism demand, TCI, HCI*

INTRODUCTION

In recent decades, globally, the climate has undergone significant changes, characterized by rising average temperatures, melting glaciers and rising sea levels. These climate changes have had important environmental and societal consequences. Thus, rising temperatures have contributed to rising sea levels, which threaten coastal communities and marine ecosystems, leading to the risk of flooding and shoreline erosion. Changes in rainfall patterns have led to more frequent and severe droughts in some regions, affecting agriculture and freshwater resources. In other areas, heavy rainfall caused devastating floods, destroying infrastructure and homes.

Climate change has also impacted biodiversity, causing species to migrate to higher altitudes or latitudes in search of suitable climatic conditions, which disrupts the balance of ecosystems and may lead to the extinction of species that cannot quickly adapt to new conditions [22, 25, 26]. To the same extent, all these changes also have effects on the economy, therefore tourism, which occupies a significant place in the economy, being an engine of economic growth, employment and regional development. Its economic contribution is manifested through the generation of income from various activities, such as accommodation, public catering, transport, cultural and leisure activities [18]. Tourism also stimulates investment in infrastructure and services, having a multiplier effect on other economic sectors such as agriculture, trade and industry. The tourism sector represents a significant percentage of the GDP, but it also contributes to the development of local economies, especially in rural or isolated areas, where it represents an important source of income [23].

Moreover, tourism supports the valorization of natural and cultural heritage, transforming these resources into economic advantages. By promoting local destinations and attractions, tourism helps improve a country's image internationally and attracts foreign investment. Thus, the tourism sector has a strategic role in the global and local economy, being a key factor for sustainability and progress [6].

On the other hand, it has a significant impact on the environment, with both positive and negative effects, depending on how it is managed. The development of tourism can lead to the degradation of natural resources through overloading of ecosystems, pollution and uncontrolled urbanization. Tourism activities, such as transport, accommodation and associated infrastructure, contribute to greenhouse gas emissions, affecting climate change. In highly frequented destinations, overexploitation of water and energy resources, as well as poor waste management, can have a negative effect on biodiversity and environmental quality.

On the other hand, responsible and sustainable tourism can have a positive impact on the environment [17]. By generating funds and support for the conservation of nature and cultural heritage, tourism can help protect ecosystems and promote sustainable practices.

Thus, the impact of tourism on the environment largely depends on the policies and practices adopted. A sustainable approach that integrates environmental protection, environmental education and the involvement of local communities is essential to minimize negative impacts and maximize long-term benefits

In order to mitigate these effects on climate change, specialists agree that it is essential to implement policies to reduce greenhouse gas emissions and adopt measures to adapt to the new climate conditions. Concerted global action can help limit global warming and protect the environment and society from the consequences of climate change [4, 20, 24].

The relationship between climate change and tourism demand is complex and multidimensional, being influenced both by the direct effects of climate change on destinations and by changes in the behavior of tourists. These changes may reduce tourism demand for affected destinations and cause tourists to redirect their preferences to less vulnerable locations, but at the same time, these changes influence the behavior of tourists, who become increasingly aware of the impact of travel on the environment. This awareness can lead to an increase in demand for sustainable tourism and ecotourism, at the expense of mass tourism or polluting destinations. Thus, climate change not only transforms tourism demand, but also generates challenges and opportunities for tourism development in the future.

In Romania's economy, tourism has a high potential for economic growth and regional development. Although its direct contribution to GDP is moderate, being around 2-3%, its total impact, including indirect and induced effects, is much higher, considering the fact that it generates jobs, both in direct fields such as hotels and restaurants, as well as in related sectors such as transport, trade or agriculture, offering opportunities especially in rural and mountainous areas [21].

Romania benefits from a special tourism diversity, which includes natural landscapes such as the Danube Delta, the Carpathian Mountains and the Black Sea coast, alongside a rich cultural heritage, with traditional villages, medieval castles and fortified churches included in the UNESCO heritage. These attractions attract both national and international tourists, contributing to the increase in tourism export revenues [5, 19]. However, tourism in Romania is underdeveloped compared to other European countries, with considerable potential for capitalization by improving infrastructure, digitizing services and more intensive promotion of destinations.

The sustainable development of tourism can amplify its economic impact, contributing to the reduction of regional disparities and the diversification of the national economy. Investments in ecotourism, cultural and spa tourism can transform this sector into a strategic pillar for Romania's economy.

In this context, the research aimed to analyze the impact of climate change on tourists' behaviour and to emphasize the relationship between these two aspects.

MATERIALS AND METHODS

The relationship between climate change and tourism demand can be analyzed using 2 indicators, namely: TCI (Tourism Climate Index) and HCI (Holiday Climate Index), which are tools developed to assess the climatic attractiveness of tourist destinations. These indicators combine climate variables such as temperature, humidity, precipitation, wind speed and solar radiation level, providing an integrated assessment of climate comfort from the tourists' perspective.

TCI is the indicator that focuses on measuring general comfort for tourism activities, such as walking and urban exploration, being calculated based on sub-indices that measure thermal conditions, physical comfort, precipitation and sunshine. Each of these factors is weighted, resulting in a total score that indicates the level of climatic attractiveness of a destination at a certain time of the year. By analyzing TCI scores over several years, it can be seen how climate change, such as rising temperatures or variations in rainfall patterns, affects the attractiveness of destinations.

TCI is determined as follows:

$$TCI = 2\times CID + CIA + 2\times P + W + S \qquad [7]$$

where:

CID – the thermal comfort during the day, calculated on the basis of the maximum average temperature and the maximum average relative humidity.

CIA – the thermal comfort during the day, calculated based on the average temperature and the average relative humidity.

P – average monthly amount of precipitation.

W – average wind speed

S – sunshine duration.

CID and P have the greatest impact, as daytime thermal comfort and lack of precipitation are considered most important for tourists.

CIA, W and S have normal weights, reflecting their moderate contribution to the overall rating.

Each sub-index is rated on a scale from 0 to 100, where 100 represents ideal conditions for tourism. The total TCI score can range from 0 (completely unfavorable conditions) to 100 (perfect conditions).

If a destination has climatic conditions with optimal temperatures, low humidity, low rainfall, moderate wind and many hours of sunshine, its TCI will be close to 100. Conversely, a destination with extreme temperatures, high humidity, frequent rainfall and conditions of severe wind will have a low TCI.

HCI, is an indicator specific to modern requirements, placing greater emphasis on recreational activities and tourist preferences and integrating factors such as perceived temperature and thermal comfort during vacations. Unlike the TCI, the HCI is based on a more detailed approach to tourist preferences for various activity categories (beach, skiing, hiking), providing a more nuanced perspective on tourism demand. The use of this indicator allows the identification of changes in seasonality and tourist preferences according to climate changes.

The calculation formula is the following:

$$HCI = \sum(\text{ Weight } i \times \text{Variable } i) \qquad [7]$$

where:

The weight i, shows the importance of each climate variable for the desired activity.

Variable i represents the measured climate values (temperature, humidity, precipitation).

The main variables used are:

Perceived temperature that integrates air temperature and relative humidity to assess thermal comfort, being essential for activities such as relaxing at the beach or urban exploration.

Precipitation refers to the average monthly amount of precipitation, with a low value being preferred for most tourist activities.

Wind speed evaluates physical comfort based on average wind speed. Moderate winds may be beneficial in warm areas, but may reduce attractiveness in other contexts.

Sunshine hours show the percentage of daily sunshine, being important for beach tourism and other outdoor activities.

Sunny days represent the number of days with clear skies in a month, contributing to the climate attractiveness.

The HCI provides a score on a scale from 0 to 100, where 100 represents ideal conditions for the activity being analyzed. Each tourist activity (beach tourism, urban tourism, etc.) has a specific HCI calculation formula, with adapted weights for the relevant variables.

The research methodology involved both the collection of climate data for the period 2014-2023, as well as their integration into the TCI and HCI models, the climate comfort scores being calculated. These scores were correlated with tourism demand data such as visitor numbers, length of stay and revenue generated. Thus, we were able to identify the trends and risks associated with climate change, as well as the opportunities for adapting and diversifying tourist offers**.**

RESULTS AND DISCUSSIONS

The indicators analyzed and which were the basis for the calculation of the two indices were: average temperature, thermal aptitude, relative humidity, amount of precipitation, degree of sunshine and wind speed. The indicators analyzed and which were the basis for the calculation of the two indices were: average temperature, thermal aptitude, relative humidity, amount of precipitation, degree of sunshine and wind speed.

In the last decade, the average annual temperature in Romania has increased constantly, varying between 10.7°C in 2014 and 2017 and 12.5°C in 2023, in line with global warming trends. This evolution reflects the impact of climate change, with more pronounced increases in the lowland regions (Muntenia, Oltenia, Dobrogea) and a more moderate warming in the mountainous areas. The average temperature increase in Romania was approximately 1.8°C compared to the pre-industrial period, following European trends. These changes underscore the need to adapt infrastructure and policies to manage climate impacts on the economy and the environment.

Thus, the climate influences regional tourism through the attractiveness of destinations and seasonality. In the plains of Muntenia, Oltenia and Dobrogea, high temperatures and hours of sunshine stimulate summer tourism, but drought and heat waves affect the resources and comfort of tourists. In mountain areas, shorter winters and less snow limit winter tourism, but milder summers favor hiking, Adventure tourism, etc. In Transylvania and Moldova, seasonal variations support cultural tourism, but extreme phenomena, such as storms or torrential rains, can reduce the attractiveness. In Banat and Crisana, the moderate climate supports diversified tourism, but local droughts affect long-term sustainability.

Therefore, climate change requires adaptation of the tourism offer and risk management.

Thermal amplitude, in turn, significantly influences thermal comfort in the tourist season in Romania, because large amplitudes, characteristic of mountainous and plain areas, create discomfort through large differences between day and night temperatures, affecting tourist activities. In regions with moderate amplitude, such as the coast or hilly areas, thermal comfort is more moderate, attracting tourists through more constant climatic conditions. Excessively high or low temperatures, amplified by thermal amplitude, can reduce the duration of outdoor activities and the attractiveness of destinations, underscoring the importance of adapted infrastructure and tourism promotion during periods with favorable conditions. In Romania, the thermal amplitude shows an increasing tendency in the lowland regions, as a result of global warming, with warmer summers and milder winters, although the differences remain marked between day and night. In mountainous areas, the thermal amplitude decreases slightly due to the reduction in the duration of winters and the snow cover. These changes demonstrate the need to adapt tourist activities to the new climatic realities, by diversifying the season and modernized infrastructure.

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In Romania, the thermal amplitude shows an increasing trend in lowland regions, as a result of global warming, with warmer summers and milder winters, although the differences remain marked between day and night.

In mountainous areas, the thermal amplitude decreases slightly due to the reduction in the duration of winters and the snow cover.

These changes demonstrate the need to adapt tourist activities to the new climatic realities, by diversifying the season and modernizing the infrastructure.

Areas with more hours of sunshine, such as the coast and the southern plains, attract tourists during the summer, favoring outdoor activities and leisure tourism.

In mountainous and rural regions, the hours of sunshine stimulate spring and autumn tourism, supporting hiking and nature exploration. Periods with abundant sunshine are preferred by tourists for thermal comfort and predictability of the weather, reinforcing the seasonality of tourist flows.

Wind speed is another factor that directly influences thermal and tourist comfort, moderate winds being beneficial for reducing discomfort in hot periods, and strong ones affecting outdoor activities. In recent years, average wind speed has fluctuated moderately, with a slight increase in lowland and coastal regions, where strong winds can reduce the attractiveness of summer tourism. The most affected regions are Dobrogea and Muntenia, where strong winds can disrupt beach activities or water sports. In mountainous areas, strong winds can limit access to trails and the safety of seasonal activities.

Thus, the combination of average temperature, relative humidity and wind speed influences the comfort perceived by tourists. Moderate temperatures and low wind speed, combined with low relative humidity, offer optimal conditions for tourism, especially in the mountainous and rural areas of Romania. High humidity, associated with high temperatures, increases thermal discomfort in the southern and coastal plains, especially in summer.

Moderate winds can relieve discomfort in hot periods, but strong ones reduce the appeal of outdoor activities, especially in Dobrogea and Muntenia. The balance between these factors is essential for a positive tourist experience.

Climate variations influence peak tourism periods by changing seasonality and reducing the predictability of the weather.

Extreme temperatures and severe weather events, such as heat waves, torrential rains or droughts, can shorten the summer season in coastal areas and affect the consistency of snow in the winter season in mountain regions. Conversely, periods with moderate temperatures and more stable conditions become more attractive, expanding tourist flows in spring and autumn.

These variations underline the need to adapt tourism offers to new climatic realities and diversify activities to reduce dependence on seasonality.

Table 1 presents the dynamics of TCI and HCL in Romania in the period 2014-2023.

In Romania, climate patterns favor different types of tourism. Thus, mountain tourism is supported by moderate temperatures and low humidity in spring and autumn for hiking, and in winter, snow in the Carpathians supports winter sports. Coastal tourism in Dobrogea is favored in summer, with high temperatures, many hours of sunshine and moderate winds, ideal for relaxation and water sports. Cultural tourism is practiced in spring and autumn, when comfortable temperatures and stable weather conditions allow visits to sights in Transylvania, Moldova or Muntenia. Adapting offers to these particularities can extend the seasons and attract more tourists.

Table 1. Evolution of TCI and HCL in Romania in the period 2014-2023

Year	Average temperature (°C)	Thermal amplitude (°C)	Humidity relative (%)	Amount of precipitation (mm)	Hours of sunshine (h/year)	Speed wind (km/h)	TCI	HCI
2014	10.70	22.00	75%	700	2,100.4	9.00	579.40	838.01
2015	10.70	21.80	74%	592	2,100.5	9.40	590.03	838.15
2016	11.20	22.50	76%	713	2,150.3	8.60	593.47	858.12
2017	10.70	21.90	75%	636	2,120.7	9.00	591.89	846.13
2018	11.60	22.30	74%	750	2,180.2	9.00	598.50	870.48
2019	11.90	22.70	73%	551.7	2,150.8	9.00	609.43	858.97
2020	11.88	23.10	75%	650	2,180.2	9.40	608.81	870.52
2021	10.90	22.80	74%	705.2	2,160.5	8.60	596.79	862.25
2022	11.77	22.40	73%	512.07	2,170.3	9.00	619.19	866.71
2023	12.50	22.60	72%	***	2,190.7	9.00	676.61	875.33

Source: own processing based on the data from [1, 2, 3].

Based on the data analyzed for Romania, the TCI and HCI indices highlight a moderate to high climatic attractiveness for tourism, with notable variations between years, influenced by factors such as average temperature, relative humidity, precipitation, hours of sunshine and wind speed.

The average annual temperature had an increasing trend, from 10.7°C in 2014 to 12.5°C in 2023, reflecting an influence of climate change on the region. This increase in temperature favors climatic comfort for general tourism and vacations, but can generate discomfort during summer periods, especially if combined with high humidity. The thermal amplitude remained relatively stable, with values between 21.8°C and 23.1°C, indicating a predictable but tolerable seasonal variation for tourism activities. The average annual relative humidity varied between 72% and 76%, being moderate. Higher humidity, such as that of 2016 and 2021 (76% and 74%, respectively), reduced the comfort perceived by tourists, especially in combination with heavy rainfall. Conversely, years such as 2019 and 2023, with values of 73% and 72%, provided greater comfort due to lower humidity. Precipitation showed significant variability, from 512 mm in 2022 (a dry year) to 750 mm in 2018 (a wet year). High rainfall reduced tourism appeal, especially for outdoor activities, while drier years were more favorable for general tourism. The hours of sunshine, with values between 2,100 and 2,190 hours annually, were a constant positive factor, providing a competitive advantage for Romania in recreational tourism, especially in the years 2018, 2020 and 2023, when the number of hours of sunshine was maximum. The wind speed remained constant, around 9 km/h, having a minimal impact on tourist comfort.

An improvement in the TCI and HCI climate indices can increase the tourist flow, due to more favorable weather conditions for recreational and vacation activities. At the level of Romania, a general growth trend can be observed during the period 2014-2023. The TCI increases from 579.40 in 2014 to 676.61 in 2023, reflecting an improvement in climate conditions favorable to tourism. Also, the HCI rises from 838.01 to 875.33, indicating greater attractiveness for vacations due to better climatic comfort conditions and greater sustainability for tourist activities throughout the year.

With more attractive climates, local economies can benefit from increased visitor numbers and tourism spending, and tourism operators can plan seasons optimally, increasing occupancy and revenue.

Romania's tourism data, presented in Table 2, reflects the evolution of tourism in the period 2014-2023, highlighting fluctuations in the total number of tourists, incomes, and contribution to GDP.

Table 2. The evolution of Romania's tourist data in the period 2014-2023

An	Total number tourists (millions)	Foreign tourists (%)	Income from tourism (billion euros)	Degree of occupancy (%)	GDP (billions of Euros)	Contribution in GDP (%)
2014	8.44	22.6	7.65	24.80%	150.00	5.1
2015	9.90	22.6	8.33	25.60%	160.30	5.2
2016	10.92	22.6	8.99	26.40%	169.60	5.3
2017	12.10	22.7	9.95	30.90%	187.80	5.3
2018	12.81	21.8	11.03	31.20%	204.30	5.4
2019	13.26	20.1	12.08	31.50%	223.70	5.4
2020	6.34	6.9	6.35	22.90%	219.00	2.9
2021	9.22	9.1	1.50	26.40%	241.90	3.1
2022	11.30	14.0	3.50	30.20%	284.00	4.0
2023	13.65	20.1	3.50	30.40%	321.00	4.5

Source: Own processing based on the data from [8, 9, 10, 11, 12, 13, 14, 15, 16].

The total number of tourists increased steadily between 2014 and 2019, reaching a maximum of 13.26 million. The COVID-19 pandemic had a significant impact in 2020, reducing the number of tourists to 6.34 million, with a drastic decrease in the percentage of foreign tourists (6.9%) and tourism income (6.35 billion €). After 2021, tourism gradually recovered, reaching 13.65 million tourists in 2023, although tourism revenues (3.50 billion €) remain below pre-pandemic levels.

Facility occupancy followed a similar trend, decreasing in 2020 (22.90%) and returning to 30.40% in 2023. Tourism's contribution to GDP decreased significantly in 2020 (2.9%), but gradually increased up to 4.5% in 2023.

Although tourism was severely affected by the COVID-19 pandemic, it has gradually recovered, although revenues and percentage contribution to GDP have not yet reached pre-pandemic peaks. The revitalization of tourism requires strategies to attract foreign tourists and increase revenues, and tracking and analyzing the impact of climate change contributes to improving these strategies.

Table 3. Matrix of correlations between the relevant variables for tourism

	Average Temperature (°C)	Total Tourists (million)	Sunshine Hours (hours/year)	Tourism Revenues (billion EUR)	Precipitation (mm)	Occupancy Rate (%)
Average Temperature (°C)	1	0.371522822	0.838778689	-0.157697437	-0.324929423	0.357657
Total Tourists (million)	0.371522822	1	0.233001801	0.29575065	-0.199684007	0.934611
Sunshine Hours (hours/year)	0.838778689	0.233001801	1	-0.336049836	0.068079164	0.282522
Tourism Revenues (billion EUR)	-0.157697437	0.29575065	-0.336049836	1	0.067921246	0.268944
Precipitation (mm)	-0.324929423	-0.199684007	0.068079164	0.067921246	1	-0.28492
Occupancy Rate (%)	0.357656878	0.934610567	0.282522045	0.26894439	-0.284922433	1

Source: own processing.

Table 3 and Fig. 1 show the correlation between the average temperature and the number of tourists indicates a moderate positive relationship (coefficient of 0.37), which suggests that an increase in the average temperature attracts a larger number of tourists. This is due to the fact that higher temperatures favor tourist activities, especially in the summer season, and contribute to the attractiveness of destinations. However, there are other factors, such as tourist infrastructure, seasonal events or marketing, which also play an important role in attracting tourists.

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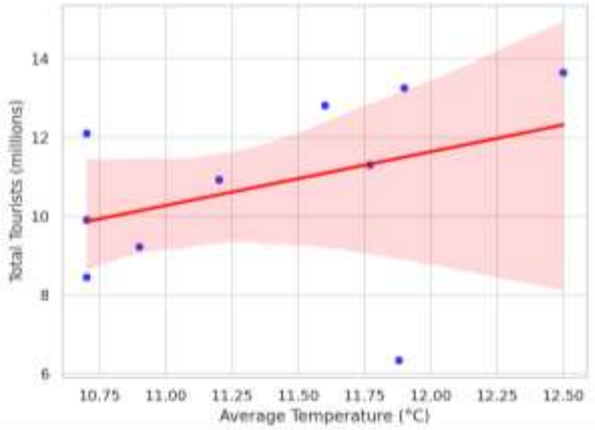

Fig. 1. The correlation between average temperatures and the number of tourists
Source: Own processing.

In the case of the correlation between sunshine hours and tourism income, the high coefficient of 0.84 reflects a direct and very strong relationship (Fig. 2).

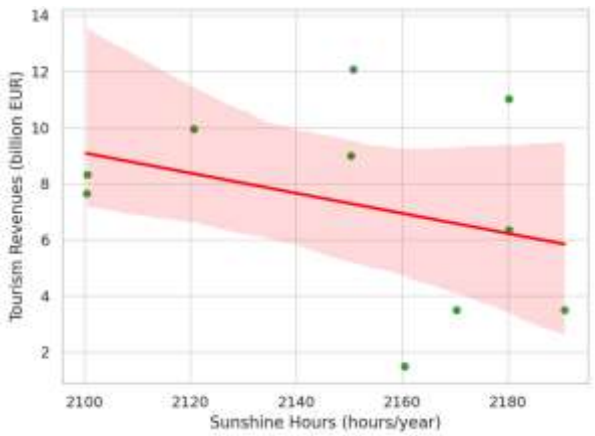

Fig. 2. Correlation between sunshine hours and tourism income
Source: Own processing.

Regions with more hours of sunshine are more attractive to tourists, which causes an increase in their spending and implicitly in tourism income. This aspect underlines the importance of promoting sunny destinations, especially in the context of seaside or nature tourism. Also, this correlation shows that sunshine hours are one of the main climatic factors that stimulate the tourism economy.
The correlation between precipitation and the degree of occupancy of accommodation units is negative (-0.28), which shows that frequent or heavy precipitation can discourage tourists from traveling or staying in the respective destinations (Fig. 3).

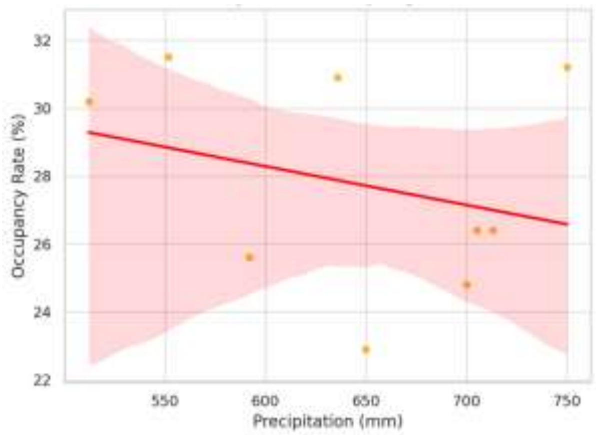

Fig. 3. The correlation between the amount of precipitation and the degree of occupancy of accommodation units
Source: Own processing.

Regarding the correlation between average temperature and tourism income, the coefficient is slightly negative (-0.16), which shows a weak and indirect relationship (Fig. 4).

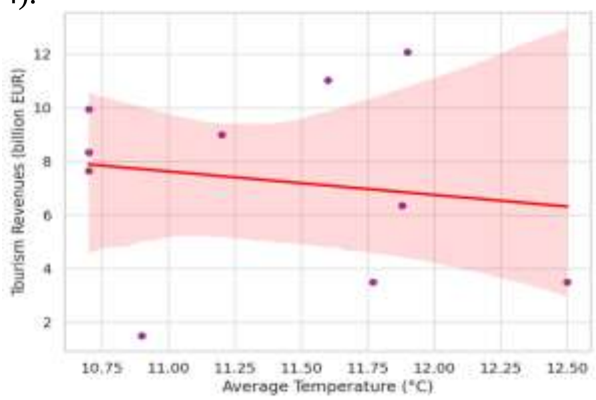

Fig. 4. Correlation between average temperature and tourism income
Source: Own processing.

Also, excessively high temperatures associated with heat waves can have a deterrent effect, especially in the context of climate change and tourists' preference for more comfortable conditions.
Therefore, tourism development strategies should focus on adapting the offer to climatic conditions and promoting destinations in seasons with moderate temperatures. These correlations demonstrate the importance of tourism management adapted to local climatic conditions and tourists' preferences, highlighting at the same time the crucial role of diversifying the offer and promoting

destinations in the context of climate variability.

Climate has an essential role in influencing GDP, having direct and indirect effects on economic sectors sensitive to climate variables. Average temperature has a moderate positive correlation with GDP (0.78), demonstrating that comfortable temperatures stimulate economic activities such as tourism, agriculture and trade. However, extreme temperatures can reduce productivity, especially in sectors dependent on outdoor work, such as agriculture. Sunshine hours have a strong positive correlation with GDP (0.84), indicating that a sunny climate favors tourism, increased tourist numbers and associated spending, which contribute significantly to the economy. Sunny destinations benefit from a steady flow of tourists, which indirectly boosts other related sectors such as transport and hospitality.

On the other hand, precipitation has a moderate negative correlation with GDP (-0.47), highlighting that unstable or rainy weather conditions can affect tourism and other economic activities. For example, floods or heavy rains can lead to economic losses in agriculture, destroy infrastructure and reduce the attractiveness of tourist destinations.

Tourism acts as a major channel through which climate influences GDP. Favorable climatic variables such as moderate temperatures and hours of sunshine increase tourism revenues, which contribute directly to GDP. The strong correlation between sunshine hours and tourism income (0.84) underlines the importance of a pleasant climate in attracting tourists. At the same time, the occupancy rate of accommodation units decreases in high rainfall conditions, affecting tourism income and local consumption.

Climate change presents risks and opportunities. Higher temperatures and longer periods of sunshine can boost the economy in certain regions, but extreme events such as heat waves, droughts and floods can cause significant damage, reducing the contribution of affected sectors to GDP. Adapting the infrastructure to cope with these changes and diversifying the economy are essential measures to minimize the negative impact.

Tourism revenue has a strong correlation with tourism's contribution to GDP, indicating that as revenue increases, the sector contributes significantly to the economy through job creation, increased consumption and infrastructure development. Occupancy of accommodation units is closely correlated with tourism revenue, reflecting that a high demand for accommodation boosts revenue both directly (accommodation rates) and indirectly (tourists' expenditure on transport, restaurants and entertainment).

The number of tourists has a moderate to strong correlation with tourism revenue, showing that although more tourists contribute to an increase in revenue, this effect is influenced by the expenditure per tourist and the type of tourism practiced (luxury vs economy). The relationship between GDP and tourism's contribution to GDP is positive but moderate, indicating that tourism plays an important but more limited role in diversified economies. In contrast, in tourism-dependent regions, the occupancy rate of establishments and the income generated are key factors for GDP growth.

Rainfall has a negative impact on tourism, affecting employment and income, which underlines the economy's vulnerability to climate conditions. In conclusion, the relationships between tourism and the economy are essential for strategic planning, and maximizing the impact of tourism requires sustainable infrastructure management and promotion.

CONCLUSIONS

The study of climate impacts on the economy and economic correlations highlights the importance of understanding the relationships between climate variables and economic sectors, particularly tourism, as a driver of economic growth. The analysis of this topic is important for the foundation of economic strategies and adaptation to climate change, offering solutions for capitalizing on opportunities and minimizing risks, especially because tourism has a multiplier effect, generating benefits in sectors such as transport, trade and agriculture.

Climate change brings both risks and economic opportunities. Extreme temperatures and severe weather events can reduce tourism attractiveness, affecting climate-dependent sectors. However, they can extend tourist seasons in regions where conditions become more favorable.

The use of TCI and HCI indicators allows making strategic decisions in tourism, including the development of climate change adaptation policies, the promotion of alternative destinations or the optimization of the tourist calendar. By understanding the climate impact on tourism demand, operators and authorities can develop sustainable strategies to ensure the competitiveness of the sector in the long term.

The results of the study demonstrate the need for investments in resilient infrastructures, renewable energy and sustainable tourism, which counteract the negative impact of climate change. Effective public policies, such as tax incentives, VAT reduction in tourism and international promotion, can amplify the positive economic impact. Digitization and diversification of tourist offers are also essential for extending the season and increasing competitiveness.

In conclusion, the analysis highlights the role of the integrated strategy between tourism, climate and economy, to ensure sustainable development and long-term economic growth.

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THE IMPACT OF TRANSPORTATION ON THE WHEAT PRODUCTION COSTS

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Abstract

Cereals play an important role in both human and animal nutrition. Their transportation from cultivated areas to warehouses and/or silos requires detailed and efficient planning, so that deliveries to consumers are made in a timely manner, with minimal losses in the supply chain. The performance of agricultural producers is negatively impacted by infrastructure constraints related to the sustainability of crop production, which artificially raise transportation costs and hazards. Maintaining an agricultural enterprise's profit margin requires effective fuel cost management. Cost optimization involves adopting measures to reduce all cost elements, starting from those that have the highest share in total expenses and eliminating those considered less useful in the respective process. The paper aims to determine the share of transport costs, in this case diesel, in production costs and their influence on total expenses. The methods used included a bibliometric study of the literature and a study case was presented based the technologial sheet and also the substantiated wheat crop budget, at Research Institute for Agricultural Economy and Rural Development (ICEADR). Based on the data, a model was created to highlight the share of diesel transport costs in total variable costs, respectively total cost. The results proved that the cost of diesel for moving specialized means of transport has a significant share of the total expenses. Farmers have to carefully plan trasnportation taling into account the types of means of transportation, the distance, the wheat amount, the cost of diesel so that to minimize these costs.

Key words*: *transportation, grain, diesel, production costs

INTRODUCTION

Wheat and corn are part of the primary crops category, constituting staple foods for the majority of the world's population. Globally, cereal production in 2022, according to FAOSTAT, was 3,698,383 thousand tons [9].
World wheat production in 2022 was 944,928 thousand tons, representing 25.6% of global cereal production. In the same year, corn production was 1,439,302 thousand tons, representing 38.9% of global cereal production. The world population was 9.37 billion people in 2022. It is estimated that in the next 25 years it will reach 9.8 billion people. In order to feed everyone, cereal production would have to increase by 70-100% [13, 32, 9].
This problem is exacerbated by the drastic reduction in the area of fertile land available for cereal cultivation and by the reduction in yields, with climate change having a major impact on them [34] which determine farmers to adapt wheat technologies. L. You and collaborators stated in 2009 that a 1°C increase in temperature during wheat cultivation would lead to a 3-10% decrease in yield [15, 16, 30, 33].
Cereal production in the European Union decreased as a result of climate change and rising agricultural input costs, particularly for fuel, which have an impact on farmers [24].
According to Gammans, Mérel, and Ortiz-Bobea's 2017 analysis of the effects of climate change on French wheat crops, wheat yields would decline by 3.5–12.9% over the medium term (2037–2065) and by 14.6–17.2% over the end of the century [10].
Consequently, “in a world where population size is increasing and reaching unsustainable levels, a drastic reduction in agricultural

yields of the main cereal crops could significantly hinder food security" [32].

The opening of domestic markets to international competition from around the world has resulted in a shift in focus from the farmer level to the supply chain level. It is essential to look at whether there are more effective ways to plan and run a supply chain in order to handle these new problems [1].

Planning is crucial to reducing food waste and maximizing food quality because crops are prone to spoiling both before and after harvest.

An essential component of the supply chain is the transportation of products from the place of production to the place of consumption, at the right time and with minimal loss of quantity and quality. Intermediaries can buy grains, store them and sell them to processors, but small farmers can carry out these activities limited by the lack of good intermediate storage and transportation conditions. To reduce losses, better coordination between production, transportation and processing capacities is needed [18].

According to estimates by the Food and Agriculture Organization (FAO) of the United Nations, approximately 1.3 billion tons, or 32% of the total weight of food produced for human consumption, was wasted across the food supply chain [9]. Improper transportation planning, timely deliveries, inappropriate demand-production scenario, inadequate infrastructure, and highly inefficient supply chain are the main causes behind this [20].

Also, the exiting conflicts in thee Black Sea Basin has created huge problems related to cereals transportation from Ukraine to the harbour of Constanta [6], affecting the Romanian producers and transporters.

Logistics is one of the many aspects that must be integrated to improve the financial performance and sustainability of agricultural producers.

A crucial component of creating long-lasting connections between farmers, storage and transportation firms, and consumers along food supply chains is the establishment of economical and efficient transportation. In this sense, transportation costs and hazards are artificially raised by infrastructural limitations on the sustainability of crops, which lowers agricultural producers' performance.

Since fuel consumption is the most significant expense in agricultural logistics and is especially susceptible to interruptions in the infrastructure for loading, transportation, and storage, controlling fuel costs is essential to maintaining an agricultural business's profit margin.

Cost optimization must take into account the atomization of the storage structure, the fluctuation of fuel consumption depending on the degree of loading of vehicles and last but not least the use of own means of transport vs. outsourcing it [11].

In this paper we focus on determining the share of transport costs (diesel) in production costs and their influence on total costs.

MATERIALS AND METHODS

As other researchers have emphasized in their works, the cost of fuel is the part with the largest share in transport costs. Therefore, the work was based on a bibliometric analysis that was substantiatedon the SCOPUS database for searching, filtering and extracting scientific articles relevant to the subject addressedwith 2005-2023 as the reference period. The review began by studying the identified scientific articles, filtered by title, abstract and keywords.

During the analyzed period, the number of published research shows an increasing trend, with most of the analyzed works focusing on short-term perishable products, such as fruits and vegetables, not on cereals.

Based on the Technological Sheet and the Substantiated Crop Budget, by Research Institute for Agricultural Economy and Rural Development (ICEADR), a model was created that highlights the share of transport costs (only diesel), in total variable costs, respectively total costs.

RESULTS AND DISCUSSIONS

The transportation of cereals means placing on the market safe products intended for human or animal consumption. Regulation (European Comission) No. 852/2004 lays downfood hygiene requirements [27]. Cereals delivered by farmers are transported by agricultural trailers or trucks, with farmers having the obligation to keep the internal and external cleanliness of the means of transport, to check and record the nature of previous loads. Food safety must be ensured at all times during the transport.

Road transport may be provided by own means or by external transport companies. Supply by sea is rarer, but in our country, even if the cereals have been transported by water, they are picked up at the harbor by the Romanian Railways (CFR) and National Railways Transportation Company (UAGPS) hopper cars or trucks for transportation to the beneficiary. In the case of the trains, the equipment provided is specialized, i.e. intended exclusively for the transport of raw agricultural products (cereals, oilseeds, pulses, other plant products and products derived from them).

Studying the available literature, it emerged that there are a number of external factors that the farmer cannot influence to increase profit: weather, market demand, available offers for grain transport and handling, but also many others that can be controlled,e.g. on-farm or third-party storage costs,transportation costs that add to the value of production.

Reducing transportation costs relies on organizing an efficient flow from the field to the warehouse.

The dependence on transportation increases as on-farm storage capacity decreases. Since demand is at its highest during the harvest season, transportation expenses are typically at their highest. On-farm storage allows farmers to supply during periods of low demand, which lowers transportation expenses. How is it more cost-effective for farmers to transport grain? With their own or rented transport means?

Simplified theoretical calculation model regarding the share of diesel expenses in total expenses

The choice involves an estimation of the transportation cost, in which sense we will build a theoretical example.

Traditionally, cereals are transported by road using tractors with trailers and trucks or by rail usinghopper cars. Trucks are, however, used more often in recent years, becoming the most common means of grain transportation. A large part of the total costs of wheat production are logistical costs, which is why their reduction is a major objective for any farm manager [2, 4, 17, 31].

Numerous factors influence how logistics costs are calculated, which is why several ways of grouping the cost elements that make up logistics costs have been suggested. Rushton et al. [28] added administrative costs to the three cost components that Sople [29] had identified: inventory, warehousing, and transportation. In contrast to Lambert et al. [19], Zeng and Rossetti [34] developed a different set of five essential logistics cost components: transportation, storage, order processing/customer service, administration, and warehousing. Ayers [3] identified five components of logistics costs: purchased materials and related labour, transportation, warehousing, inventory, and packaging.

Table 1. Systematization of logistics expenses

COSTS	*LOGISTICS EXPENSES*	*GENERAL EXPENSES*
DIRECT EXPENSES	- transportation costs - handling costs - storage costs - customs duties - documentation costs	- storage costs - time value - operating cost
INDIRECT EXPENSES	- packaging cost including materials - logistics equipment cost - costs related to logistics support functions	- a decline in sales - customer support - the price of non-marketable products - the exchange rate

Source: [26].

Rantasil and Ojala [26] systematized logistics costs by arranging them according to the direct, indirect and general cost size (Table 1). In current terminology, fuel, insurance, and car rentals are examples of direct costs, while general expenses resulting from operating a business (general, administrative or set-up costs) are known as indirect costs and are distributed equally between vehicles in use [28].

We will explain only two terms from Table 1, the others are clear from the name. Within the general expenses, the value of time refers to the costs associated with the use of a specific amount of time - an employee's time or equipment, to accomplish an activity. These represent an operatingcost and are not subject to depreciation. However, depreciation can be indirectly influenced by the value of time, namely: the depreciation of a truck or piece of equipment is related to the time of its actual use.

An asset that is used more intensively or more often may lose its value more quickly, and its depreciation will reflect this.

In the case of grain transport, non-tradables refer to products or services that do not have a distinct brand or are not clearly differentiated on the market, but are rather standardized and not linked to a recognized brand.

These goods are generally characterized by lower prices and less active promotion and are more difficult to differentiate from similar ones.

Cereals such as wheat, maize or barley, which are not associated with a specific brand or label are non-marketable products. They are transported without an identificationmark and sold “in bulk” on the market, under generic names.

In general, companies transport grain in bulk without providing special services and therefore cannot add additional value to the transport through monitoring technologies or premium services.

This fact integrates them into the category of non-marketable or unbranded service.

A truck or train car used to transport grain, which is not part of a specialized vehicle fleet associated with a known brand, can also be a non-marketable good or equipment.

Regardless of the means of transport used, the carrier is responsible for guaranteeing the safety of the transported products, so that during loading and transport itself, the risk of chemical, microbiological and/or physical contamination of the product is as low as possible.

For the model built, we will supose that the area cultivated with wheat is irrigated. This is 250 ha, and the production achieved is 6,150 kg/ha.

In order to determine the share of transport costs in production costs and their influence on total costs, we will take into account several pieces of information:

Table 2. Characteristics of means of transport

	Truck with trailer	Semi-trailer truck
Load capacity (Tons)	20-25	40-42
Volume (m^3)	60-80	70-100
Distance travelled/trip (round trip) (km)	10	10
Average fuel consumption (liters/ 100 km)	23-25	30-40

Source: [7].

In 2024, the price per liter of diesel varied between 7.67 lei (July 15, 2024) and 6.98 lei (September 30, 2024), the calculated average being 7.30 lei/liter.

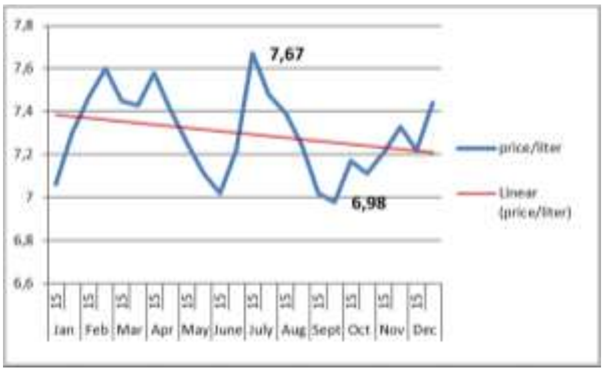

Fig. 1. Evolution of the price per liter of diesel, bimonthly, 2024
Source: [23].

Table 3. Calculation of the diesel for mechanized works

	Amount of diesel fuel consumed (liters/hectare)	Cultivated area (ha)	Total diesel fuel consumed (liters)	Average price per liter of diesel during the period (lei/liter)	Total diesel cost (lei/total cultivated area)
Mechanized works from crop harvesting (July) to sowing (October)	51.3	250	12,825	7.325	93,943
Mechanized work from crop harvesting (February) to harvesting (July)	35.9	250	8,975	7.272	65,266
TOTAL			**21,800**		**159,209**

Source: own calculations.

The total cost of mechanized work per hectare is obtained by dividing the total cost of diesel by the area or by multiplying the amount of diesel per hectare by the average price per liter. The result is an average cost of diesel of 637 lei/hectare.

From the framework estimate for wheat cultivation prepared by ICEADR, the calculation of the diesel costs for mechanized works is shown in Table 3.

According to GEO no. 115/2023, art LIII (120), a state aid for diesel is granted which in the period January 1 - June 30 was 1.746 lei/liter and in the period July 1 - December 31 of 2.079 lei per liter. It follows that accessing the state aid for diesel reduces the expenses for the fuel necessary for mechanized works by 42,567 lei (26.74%) for the total cultivated area (Table 4).

Table 4. Calculation of the cost of diesel for mechanized works in case of accessing the subsidy

	Average price per liter of diesel during the period (lei/liter)	**Total diesel cost (lei/total cultivated area)**
Mechanized work from crop harvesting (July) to sowing (October)	5.19	66,562
Mechanized work from crop harvesting (February) to harvesting (July)	5.58	50,081
TOTAL		**116,642**

Source: own calculations.

To this cost of diesel for mechanized work is added the cost of diesel necessary to transport the harvest from the field to the farm. The total production achieved on the 250 ha area is obtained by multiplying it by the production per hectare (6,150 kg/ha) and converting the result into tons:

250 ha · 6,510 kg/ha = 1,537,500 kg = 1,537.5 tons

We will suppose that the farmer has the following means of transportation to transport the entire production:

– truck with trailer: 1,537.5 tons / 25 tons (maximum load capacity) = 62 roads
– truck with semi-trailer: 1,537.5 tons / 40 tons (maximum load capacity) = 38 roads

We calculated the cost of diesel fuel required for transport from the field to the on-farm warehouse when using a truck with a trailer, as well as when using a truck with a semi-trailer. In the case of subsidizing diesel fuel, the average price per liter was 5.19 lei per liter. This results in a reduction in the costs of diesel fuel required for transport from the field to the warehouse from 1,135.38 lei to 804.45 lei for the truck with a trailer, respectively from 1,113.40 lei to 788.88 lei for the truck with a semi-trailer (Table 5).

Table 5. Calculation of the cost of diesel for wheat transportation from field to warehouse

	Total distance from field to farm (km)	Specific consumption of means of transport (liters/100 km)	Required amount of diesel	Average price per liter	Total cost of diesel for harvest transport (lei)
Truck with trailer	620	25	155	7.325	1,135
Semi-trailer truck	380	40	152	7.325	1,113

Source: own calculations.

These expenses will be added to those incurred with the diesel fuel necessary for mechanization works:

A. in case the diesel fuel is not subsidized and the harvest is transported by truck with trailer:
159,209 lei + 1,135 lei = 160,344 lei
B. in case the diesel fuel is not subsidized and the harvest is transported by truck with semi-trailer:
159,209 lei + 1,113 lei = 160,322 lei
C. in case the diesel fuel is subsidized and the harvest is transported by truck with trailer:
116,642 lei + 804 lei = 117,446 lei
D. in case the diesel fuel is subsidized and the harvest is transported by truck with semi-trailer:
116,642 lei + 788 lei = 117,430 lei.

According to the Framework Budget for irrigated wheat crop, carried out by ICEADR, the variable expenses per hectare are 4,359 lei. For 250 ha, the value of these expenses will be 1,089,750 lei.

<u>The calculated percentage of diesel expenses was:</u>

– 14.71% of total variable expenses when using non-subsidized diesel;
– 10.78% of total variable expenses when using subsidized diesel;

– 12.71% of total expenses when using non-subsidized diesel;

– 9.31% of total expenses when using subsidized diesel.

Fuel costs are the largest component of transport costs [8, 28]. Fuel is especially important in agriculture, because specialized agricultural machinery and transport vehicles consume more fuel than typical commercial vehicles. Hence, farms must set up and store large fuel reserves during the winter months due to the seasonality of farming activities.

Fuel costs are more volatile due to the constant increase in fuel prices [8]. Reducing fuel costs contributes most to increasing the profit rate of farms and expanding market areas, allowing more agricultural producers to localize and specialize. [14, 22].

In many countries, the current trend in the agricultural sector is the concentration of farms, food industries and wholesalers into fewer large-sized ones. [5, 25].

Large farms (horizontal integration) arise even in nations with plenty of land as a result of the infrastructural and market shortcomings that agricultural producers face, particularly logistics. [12].

Furthermore, in response to the deficiencies found, vertical integration helps agricultural producers responding to infrastructure and market imperfections.

CONCLUSIONS

Climate change is an increasingly important issue due to its increasingly devastating consequences on every aspect of our lives, from health to the economy. The greatest negative impact of climate change is observed on agriculture, generating significant production losses.

Extreme events that result in a sharp decline in the amount of arable land available for farming are partially to blame for the losses, while other factors include a decline in production yields brought on by undeveloped, sunburned, etc. plants.

In agriculture, methodologies for assessing logistics costs are uncommon. This is a result of the wide range of cost elements involved and the complex interactions within the logistics system. As a growing number of agricultural enterprises contract out their transportation needs to specialist companies, understanding and evaluating transportation and fuel costs becomes critical to profitability.

The paper presents a simplified calculation model to understand the importance of logistics in the wheat production process. It was highlighted that a significant share of the total expenses is the cost of diesel for moving specialized means of transport. Minimizing these costs remains a topic of interest for farmers, and careful planning of transport is recommended, as well as the choice of technically appropriate means of transport. In the case of large farms, requesting specialized help from logistics specialists should not be neglected, their presence bringing considerable benefits to the farm.

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THE IMPORTANCE OF RISK MANAGEMENT CONCEPT FOR AGRICULTURAL BUSINESS

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Abstract

Risk in the agricultural sector remains one of the most current and important concepts to research, taking into account the importance of this sector worldwide, a sector that faces increasingly greater challenges in terms of ensuring global socio-economic stability, but especially in supporting and fulfilling people's primary need, that of having access to food. We face an urgent need for innovative strategies to manage risks and mitigate losses, and risk management is essential to control costs and ensure stability of farmers' incomes, especially in an area exposed to major risks. The purpose of this research is to find out what are the main sources of risk in this sector, what are the risk management tools preferred by farmers, but also the current state of the agricultural sector at European level. Regarding the research method, we used direct observation and statistical description to search for information, identify indicators and conduct their analysis. Thus, the economic indicators showed the major differences between countries and the reasons why some states fail to keep up with others. Also, it was noticed that countries willing to adapt to economic changes and use technology processes in the agricultural sector have much better results and significantly higher growth than others.

Key words: *risk management, agricultural sector, risk strategies, European Union*

INTRODUCTION

Risk, in a broad sense**,** refers to an uncertainty or the possibility that a certain hazard will occur. There is no universally accepted definition of risk, it's being conceptualized in the literature as expected value, probability distribution, uncertainty or event. Common definitions include: risk as expected loss [1], expected disutility, the probability of a negative outcome, predicting the chances of occurrence and severity of adverse effects, combining the possibilities of occurrence of these effects with the level of severity to which the consequences could reach, the triplet (scenario, probability, consequence), a multidimensional association of negative incidents/outcomes and the uncertainties that come with them, the uncertainty of the outcome of actions and events, a situation or event in which human values are involved and whose outcome is uncertain, as well as an unexpected consequence of an event or activity [22]. These definitions can be structured and understood from two perspectives:

(1) risk quantified through probabilistic methods and expected values and

(2)risk conceptualized through the relationship between events, consequences and uncertainties.

Risk management in agriculture involves the identification and assessment of possible sources of risk, a process that contributes to the adoption of measures aimed at reducing the negative impact. Management, performance and learning could reduce risk [26]. The main objective is to prevent or reduce losses in the agricultural sector, both in plant and livestock production, caused by controllable or uncontrollable factors. Research in this field aims to help make better decisions in the future, taking into account the new types of risks that arise with the development of various fields, such as technology, which can expose farmers to risks that are difficult to control and predict. The more complex the risk, the harder it is for farmers to make an appropriate decision [15].

Therefore, „*agriculture has become increasingly risky as farmers have become increasingly commercial, forcing them to understand risk and develop risk management skills to better anticipate problems and reduce losses"* [21].

More than this, even the projects carried out with the EU for funding agriculture involves risks [19]. In this context, the aim of the study is to identify the main sources of risk in agriculture, which are the risk management tools preferred by farmers, and also to assess the current state of the agricultural sector at the European level.

MATERIALS AND METHODS

The article is based on a bibliographic study destined to identify the main sources of risk and the strategies used to prevent them.

At the same time, the data provided by the European Union for the agricultural sector was also researched, analyzing the situation of agricultural holdings. There were researched indicators such as: economic dimension of farms, the use of agricultural areas in 2020 and the net entrepreneurial income from agriculture in order to have an overview about the current situation in European countries compared to Romania and, also, about the factors that influence these differences.

The current tools used to study the risk management in agriculture were another important point to research in order to find out, based on the existing scientific literature, which risk mitigation methods are most used by farmers and why.

RESULTS AND DISCUSSIONS

In a general perspective, risk management is the process of reducing losses that aims to improve final results and performance, which arose from people's desire to rely on their own strengths and to be able to control or prevent certain events.

So, *risk management includes all processes regarding risk identification, assessment, establishing responsibilities, taking measures to mitigate or anticipate them, periodic review and progress monitoring* [24] .

The agricultural sector faces an increasing need to identify innovative strategies for a better risk management in order to reduce losses.

Although risk exists in every field, the agricultural sector is exposed to increasing uncertainty, which does not give farmers the courage to think and invest in the long term.

The steps in the correct application of risk management are detailed in the Table 1, each with its specific role.

Table 1. Stages of risk management

1. identification of risk typologies and their origin;
2. prediction of the chances of occurrence, the level of severity and the consequences associated with the types of risks identified (risk analysis);
3. create risk reduction and prevention plans (assessment of the risks involved);
4. to track the progress and effectiveness of risk treatment actions (follow-up);
5. to make decisions about risks (communication and reporting).

Source: data processing from the methodology.

Table 2. The main risk categories in the agricultural sector

Types of risk	Detailing
Production risks	climate change (drought, floods, storms, excessive rain, extreme temperature variations, strong winds, hail), due to diseases and pests affecting plants and animals, but also due to pollution.
Marketing risks	loss of market visibility and decreased revenue due to competitors, competitive pricing, consumer preferences, loss of market access due to non-compliance with market and packaging standards.
Market risks	falling output prices and rising input prices
Institutional risks	change in government policies, agricultural policies, quality standards, contracts and non-compliance thereof
Human risks	deaths, lack of professional training, lack of qualified staff, lack of poor communication, lack of guidance and people management skills
Financial risks	increase in the cost of capital, increase in input prices, lack of liquidity, decrease in share prices, exchange rate risks, lack of income to support financial obligations, increase in interest rates
Technological risks	lack of educational training, reluctance to change and use new technologies, high costs, small farm size, poor or non-existent access to finance or credit.

Source: data processing from the methodology.

Main risk categories identified in scientific articles and literature studies refers to production risks, marketing risks, market risks, institutional risks, human risks, financial risks, technological risks [22, 17, 16, 2]. All these types of risk are detailed in Table 2.

The agricultural sector faces several interrelated risks, but from of all these risks, **price and production risks are usually considered the most significant** challenges for farmers in effectively managing their operations.

Climate change will intensify extreme weather events, affecting yields and global structural imbalances between supply and demand, such as population growth and resource scarcity, will increase price variability.

Table 3 presents the tools available for risk management in agriculture, depending on the type of strategy and provider [25].

It is important to take into account the interactions between the tools. Some tools prevent the use of others, reducing the marginal gains for the farmer.

For example, the safety of some insurance schemes reduces the use of production diversification; or the existence of strong revenue coverage reduces or even eliminates the demand for price coverage.

Table 3. Tools available for risk management in the agricultural sector

	Farm/ household/ community	Market	Government
Risk reduction	Adoption of technological solutions	Training programs for risk management	-Macroeconomic policies -Disaster prevention (flood control) -Prevention of animal diseases
Risk mitigation	- Diversification of production - Sharing cultures	-Floods and options -insurance -Vertical integration -Contracts in production or marketing -Distribution of sales (throughout the year) -Diversified financial investments -Work off the farm	-Smoothing the income of the fiscal system -Countercyclical programs -Quarantine measures 629 and other measures in case of outbreak of a contagious disease
Dealing with risk	Borrow from neighbors/family	-Sale of financial assets -Saving/borrowing from banks -Off-farm income	-Disaster support -Social assistance -Support programs for agriculture

Source: data processing from the methodology.

As a result of research carried out by ***Deutsche Bank Research*** in 2010, which aimed to survey several agricultural producers in five countries, Germany, Hungary, Poland, the Netherlands and Spain, to obtain responses regarding their perceptions and practices of risk management, it was found that farmers prefer the following risk management solutions:

-*property and crop insurance* (holding financial reserves and avoiding credit)

-*vertical integration and marketing agreements*.

Credit avoidance is used by about 40% of surveyed farmers and is equally important in all countries. Insurance is used most often in Spain and Germany (60-70% of farmers), a phenomenon explained by the high level of public subsidies in Spain (49%), and in Germany by a general tendency to resort to insurance [25].

Hedging is another risk management strategy used to offset investment losses by taking an opposite position in a related asset. The reduction in risk provided by hedging usually results in a reduction in potential profits [18].This strategy works as a kind of insurance policy, offsetting any steep losses in other investments. This strategy is used the most in Germany, but, overall, it is a very rarely used method in the countries of the European Union (5%).

Most farmers seem to be more interested in continuing to use classic risk management methods, which shows a reluctance to change considerably. Interest in the use of new technologies and hedging is more prevalent among farmers who own larger farms: " *About 30% of farmers on medium and large farms intend to engage in hedging, as opposed to 15% of smaller farm owners*" [11].

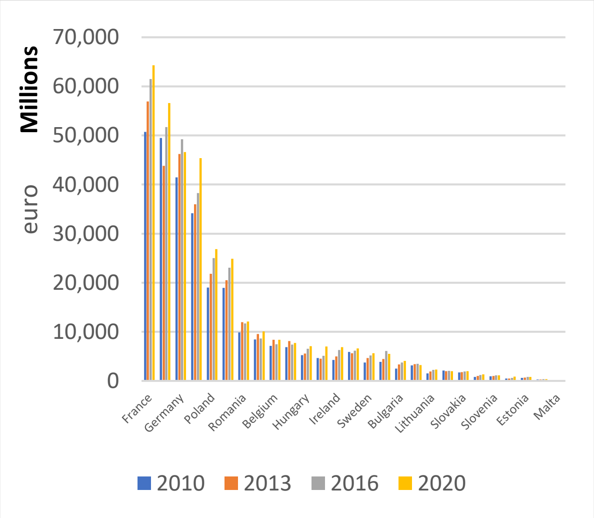

Fig. 1. Analysis of the economic size of the farm through the standard production indicator per EU country
Source: [8].

As can be seen from the results obtained from the analysis presented in Fig. 1, the economic indicators of farms in Bulgaria and Romania have recorded a significant increase, especially from the economic perspectives of farms, which shows that there is development potential for these countries. Bulgaria has seen an increase from €2.5 billion in 2010 to over €4 billion in 2020, which shows a substantial improvement in the economic performance of farms. Similarly, Romania has seen an increase from almost €9.9 billion in 2010 to over €12 billion in 2020.

Romania continues to be acknowledged by the European Union member states as a key player in the agricultural sector, as evidenced by the cultivated agricultural land and the yields achieved [28].

These increases can be associated with the expansion of the agricultural area used, investments in agricultural technology and changes in farm management, potentially including a diversification of the age and gender structures of managers [9, 10].

Also, "farmers' experience is an extremely important indicator of their work and performance" [17].

From the analysis of the number and distribution of agricultural holdings presented in Fig. 2, significant variations can be observed between the different European countries.

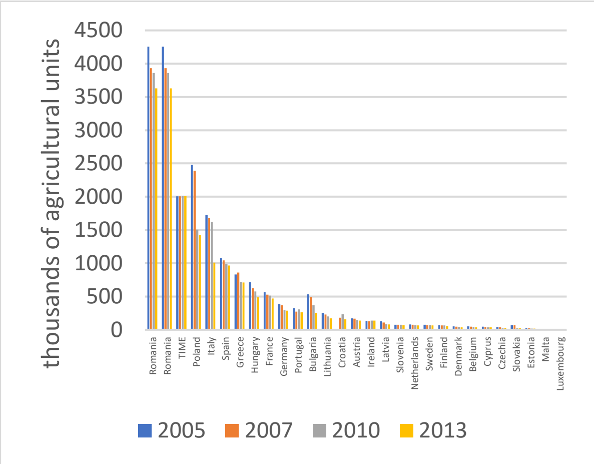

Fig. 2. Agricultural holdings according to the economic size of the farm (standard production in Euros)
Source: [11].

Regarding the economic size of the farms in the EU, in standard output, it was found that in Romania, most farms (3,071 thousand out of a total of 3,629.68 thousand) have a standard production below 4,000 euros, indicating an agricultural sector dominated by small farms. The same trend is observed in Poland, where 686 thousand farms out of a total of 1,429 thousand fall into this category.

In contrast, Germany and France have a significantly lower number of small farms, with only 8 thousand and 55.4 thousand farms under 4,000 euros respectively, but have a higher proportion of farms with larger economic sizes, indicating a more consolidated and more mechanized [11].

The analysis highlights the diversity of the agricultural structure in Europe (Fig. 3). For example, Romania, with a total agricultural area of 14,734,040 hectares and 12,565,500 hectares of UAA, it is one of the countries that can boast the largest agricultural areas, paying a significant importance to arable land, which totals an area of 8,570,730 hectares and permanent pastures (3,723,530 hectares).

At the same time, the area dedicated to permanent crops and kitchen gardens is relatively small, indicating a major orientation towards extensive crops.

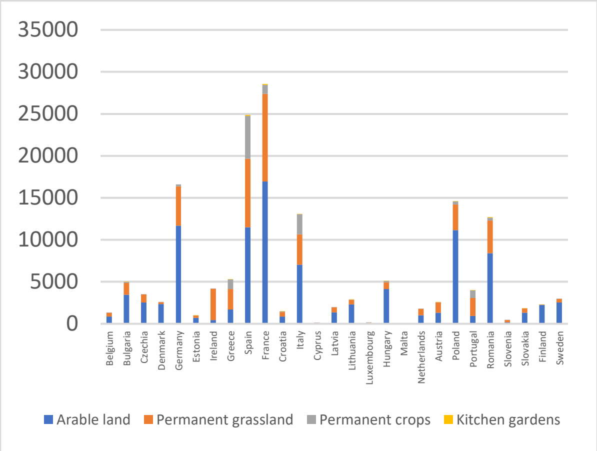

Fig. 3. Main use of agricultural land by category in 2023
Source: [12].

Western European countries such as France and Germany have well-established and diversified agricultural structures. In comparison, smaller and island countries such as Malta and Cyprus have smaller agricultural areas, but with intensive and specialized uses. These variations underline the influence of climatic conditions, agricultural policies and local traditions on the structure and use of agricultural land in different European regions [13].

EU support in risk management and mitigation in agriculture

Access to European funds for agriculture has played and continues to play an extremely important role in the development of agricultural holdings and rural areas [23].

The multi-annual financial framework 2014-2020 included expenses in the amount of 408,313 billion euros (Table 4).

Table 4. Distribution of CAP expenses in 2027 compared to 2020

Year	Direct payments	Rural development	Market measures
2020	71.3%	24.4%	4.3%
2027	72%	25%	3%

Source: European Parliament, 2023, Financing of the CAP: facts and figures [4], [3].

For 2020-2027, the CAP expenses account for 386.602,8 million euros, targeting the transition towards a sustainable agriculture and forestry in EU countries.

Although the budget breakdown has undergone minor changes, we can see that income stabilisation and rural development are still priorities for the CAP.

As a result of supporting and respecting the CAP priorities, in December 2020, according to the budget plan allocated by the EU to support the agricultural sector, farmers benefited from funding equivalent to 31% of the total European Union budget. Rural development measures will benefit from an additional support which represent approximately €8.1 billion from the *Next Generation EU (NGEU),* program which was allocated for post-COVID-19 revitalization of the economy and society, increasing the total value of financial support provided to beneficiaries for the 2021-2027 period amounts to €386.6 billion [4].

As described by the European Commission, direct payments provide basic income support for EU farmers. The income support function of direct payments contributes to long-term economic viability and a smooth structural adjustment of the agricultural sector [14].

Also, the European Parliament issued*(a)"Regulation (EU) 2021/2115 of the European Parliament and of the Council of 2 December 2021 lays down rules for support to Member States in drawing up strategic plans under the Common Agricultural Policy (CAP), to be financed by the European Agricultural Guarantee Fund (EAGF), in accordance with Regulations (EU) No 1305/2013 and (EU) No 1307/2013."* [5].

(b)"Regulation (EU) 2021/2116 of the European Parliament and of the Council of 2 December 2021 on the financing, management and monitoring of the common agricultural policy and repealing Regulation (EU) No 1306/2013" [6].

(c)"Regulation (EU) 2021/2117 of the European Parliament and of the Council of 2 December 2021 amends Regulation (EU) No 1308/2013 establishing a single market management system for agricultural products, as well as Regulation (EU) No 1151/2012 on

quality schemes for agricultural products, Regulation (EU) No 228/2013 laying down specific measures for agriculture in the outermost regions of the EU and laying down rules on the labeling, presentation and protection of geographical indications of aromatized wine products" [7].

Table 5. EU-27 CAP budget for engagement credits in 2021 and in the Multiannual Financial Framework 2021-2027 (Euro Million)

CAP BUDGET, EU-27 (commitment appropriations - EUR million at current prices)	(A) Year 2021	(B) Multiannual financial framework 2021-2027 (MFF)	% (B)
(1) CAP PILLAR 1 Direct payments and agricultural market measures	40 368.0	290 534.0	76.8%
(2) CAP PILLAR 2 (2a) Rural development measures under MFF	15 345.0	87 998.3	23.2%
(2b) Additional rural development measures under NGEU (temporary recovery instrument)	2 387.7	8 070.5	---
(3) TOTAL CAP 2021-2027, EU-27 [(1) + (2a)]	55 713.0	378 532.3	100%
(4) TOTAL EU COMMITMENTS	168 496.0	1 221 719.5	---
(5) % of CAP [(3) / (4)]	33.1%	31.0%	---
(6) TOTAL CAP: MFF 2021-2027 + NGEU 2021-2022 [(1) + (2a) + (2b)]	58 100.7	386 602.8	---
(7) TOTAL MFF 2021-2027 + NGEU 2021-2022	333 108.9	1 642 788.7	---
(8) % of CAP [(5) / (6)]	17.4%	23.5%	---

Source: [4].

By means of these regulations, a new performance model was created for the agricultural sector in order to obtain the financial support offered by the CAP, a model that is based on the national strategic plans made by each member state. The new CAP legislation targets performance and results, opting for a tailored approach with the aim of giving Member States greater flexibility in implementing the policy at local level [23].

At the same time, *the introduction of European standards in agriculture, the rules that favor intensive agriculture and limit the production of certain traditional agricultural goods, is expected to have a negative impact in countries with a tradition of small-scale agricultural production* [27, 20].

CONCLUSIONS

Effective risk management is crucial for stabilizing and strengthening the agricultural sector. Through this research, we examined the primary sources of risk in agriculture, identified current management tools and analyzed their applicability in different EU countries. The results suggest that while current risk management strategies focus heavily on yield variability, there is an under emphasis on price stabilization, which remains a critical gap in supporting long-term agricultural stability. In addition, the observed reluctance to adopt new risk management technologies highlights the need for increased education and support mechanisms, especially for smaller farms.

Agricultural risk management tools in Europe have mostly focused on yield variability (marketing excess production, technological innovation and yield insurance) and neglected price stabilization tools such as futures and forward contracts, storage options and management.

Our analysis highlights the importance of an adaptive risk management framework that integrates both traditional and innovative approaches, addressing production and market risks alongside climate change-induced uncertainties. For policymakers, the continued refinement of the Common Agricultural Policy (CAP) offers a way not only to stabilize agricultural incomes, but also to foster resilience in the face of evolving global and environmental challenges. As the sector progresses, aligning risk management tools to the diverse needs of farms will be the key to promote a sustainable and productive agricultural landscape across Europe.

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THE PERCEPTION OF ROMANIA AS A WINE PRODUCING COUNTRY – A PERSPECTIVE OF INTERNATIONAL WINE SPECIALISTS

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Abstract

On an increasingly competitive world wine market, faced with the decrease in consumption, the orientation of consumers (especially younger ones) towards other types of drinks and overproduction, the battle between the wine producing countries is more intense than ever. The vast majority of these countries have understood the need to support their wine-producing industries, and this support is manifested at all levels, including development and implementation of strategic, marketing and sectoral branding programs. A common element of these efforts is the need for differentiation, both at the offer and communication level. This differentiation (necessary at the industry, producer and brand level) has the role of improving or changing the perception of consumers towards a certain product, producer or even the country of origin and giving them reasons to purchase the respective product. In order to be successful, Romania and its wine-producing industry must rally behind this quasi-generalized approach. Starting from the premise that any strategic differentiation effort at the marketing and branding level must be preceded by an accurate understanding of the existing situation, the purpose of this paper based on qualitative research, is to support the evaluation of the current situation by identifying the perception of foreign wine specialists regarding Romania as a wine-producing country. This perception was investigated on several levels, such as those related to awareness, image, attributes, benefits and attitudes associated with Romania as a wine-producing country. The main results indicated that Romania ranks in the top 3 of Eastern Europe in terms of aided awareness as a wine-producing country, but there is low recognition of its indigenous grape varieties, with 70.4% of respondents unfamiliar with them. The study also found that perceptions of Romanian wine's attributes, such as price and quality, are unclear, with a notable portion of respondents undecided, so Romania requires a strong branding strategy to boost its international market presence and to enhance the perceived value of its wine products.

Key words: *brand awareness, brand image, differentiation, perception of Romania as a wine producing country*

INTRODUCTION

Strategy has been defined and understood as the process by which an organization couples its internal resources and abilities with the opportunities and risks present in its external economic environment. This approach is perhaps best illustrated by Porter [15], which focused on the analysis of industry structure and competitive advantage [6]. Competitive advantage is the potential of an organization evaluated in relation to its competitors. According to Porter [15], the sustainability of a competitive advantage is determined by five factors that characterize an industry, namely: the threat of new entrants, the threat of substitute products, the bargaining power of buyers, the bargaining power of suppliers and the rivalry among existing competitors.

In a development and update of what was stated by Porter and McGarth [15], [11] claims that the competitive advantage has never been really sustainable in the long term, and even less so today. In the dynamic world in which we live, the competitive advantage is fleeting, and the continuous change of strategy is a necessary condition to achieve the organization's objectives [11]. The same author is of the opinion that success-oriented organizations must develop dynamic competitive advantages, with which to cope in this world of changes, and in order to obtain them, openness and vigilance are necessary for the planning process to be continuous.

In addition, McGarth [11] argues that the current economy is a creative one. This type of economy is based on a multitude of technological innovations that involve dramatic reductions in costs, size, time, and effort, new infrastructure systems, new ways of socializing, new meanings about how time is spent, and new ways of living these possibilities. In the creative economy, where the search for the next opportunity is a priority, "companies are becoming better at understanding what people really need, what they are willing to pay more for in order to design better experiences, and at achieving increased efficiency from existing assets" [5].

The most profitable strategies are based on differentiation, offering customers something they value and that competitors don't have [10]. All goods and services can be differentiated [9]. The author states that differentiation is most visible in branded packaged consumer goods, in design, in the composition of industrial goods, or in the features of intangible goods. Equally, differentiation can manifest in the way the business is operated or in the way the marketing process is managed. An organization can also differentiate itself through the way it interacts with its customers. A creative attitude and thinking, oriented towards the customer, allows organizations to position their offerings in ways that neither they nor their competitors would have ever imagined [10].

Product differentiation is primarily a matter of customer perception, the image they form about a product or service, and organizations have many means at their disposal to influence the formation of this image, of this perception. In its most direct understanding, perception is the value of a product or service seen through the eyes of customers. It represents the cumulated effect of interactions, experiences, and emotions associated with the product or service in question. Perception is not just about being different, but about being better in a way that is relevant to customers. A product must distinguish itself through its physical characteristics and equally must be perceived as having a unique value. Thus, perception plays a critical role in the success of a product, because more often than not, perception is stronger than reality, so building a strong brand with a high level of equity must take into account its image and perception [12].

Battistoni et al. [2] argue that brand equity is directly correlated with market share, purchase intentions and consumer preferences, price insensitivity, and product resilience in difficult situations. The authors argue that building brand equity can be achieved through various models, the most common being those based on a financial perspective or strategic brand management. The first perspective deals with the financial value that brands can generate for the organization, while the latter is based on market perceptions and consumer behaviours. Consumer-oriented approaches are generally preferred because they rely on information that comes from careful and detailed examination of customer opinions and preferences. Approaches from a financial perspective often ignore the customer's point of view and rely almost exclusively on indicators that are more or less objective and difficult to measure [2].

Among the most relevant models for building a strong brand with a high level of brand equity are those developed by Aaker [1] and Keller [8], both having consumer perception and brand image as their central pillar. Aaker [1] argues that the five categories of brand equity assets create value for both the customer and the company. These different categories of assets are: brand loyalty, brand awareness, perceived quality, brand associations, and other proprietary brand assets. Keller [8] develops the consumer-based brand equity model for a practical reason, namely to support an organization's management in efforts to build a strong brand. This model involves the following steps: (1) establishing the correct brand identity, i.e., establishing the breadth and depth of brand awareness, (2) creating appropriate meaning through strong, favourable, and unique brand associations, (3) generating positive reactions towards the brand, and (4) establishing brand relationships with customers, characterized by intense and active loyalty.

In their study that analyses the prominent determinants of consumer-based brand equity, Battistoni et al. [2] emphasize the importance of maintaining a good brand reputation over time. Such a reputation must be supported by the high quality of the products or services offered by a positive image. In addition, customers strongly desire brands that are emotionally consistent with their values, with whom they can dialogue and that attend to their feedback and needs.

In the specific case of wine brands, Dressler and Paunovic [4] mentioned that research is dominated by three major directions: identity, image, and wine brand personality. It is demonstrated once again that place, region, and country play a critical role in constructing a wine brand's identity [19], [7], [13]. Moreover, Muhonen et al. [14] and Saaksjarvi and Samiee [16] state in their research that the most important components of brand identity are values, vision, and brand positioning. There are researchers [18] who claim that in the specific case of sparkling wines, brand image is a significant factor in the purchasing decision and is influenced by expert reviews and recommendations, as well as by reputation, prestige, and equally by online reviews.

A critical observation made by Dressler and Paunovic [4] targets the specialized literature on wine brand personality, noting that it largely relies on the elements developed by Aaker [1]. This quasi-unilateral perspective may overlook recent developments as well as ignore other models, such as the one designed by Davies et al. [3]. Brand personality, its effects, and its dynamics are areas of intense research in the context of building a strong brand [4].

The purpose of this research is to assess and analyze the perception of Romania as a wine-producing country from the perspective of international wine specialists. The objectives include evaluating brand awareness, image, and attitudes towards Romania’s wine industry and understanding the level of recognition of Romanian wine brands and indigenous grape varieties. The study aims to provide insights for developing strategic marketing and branding efforts that can enhance Romania's position in the global wine market.

MATERIALS AND METHODS

The research methodology is based on the "honeycomb" model developed by Wilson [20]. From the perspective of research philosophy, the epistemological approach is interpretivist, while the ontological approach focuses on subjectivism [20]. The research follows an inductive process, and the adopted strategy is qualitative. The research is exploratory, and the research plan combines elements of action plan and case study. The data used is primary, and its interpretation is predominantly qualitative, also including elements of quantitative analysis [20].

The study was conducted from March 2 to 12, 2024, during the largest international wine fair, ProWein Düsseldorf. The information was collected through an online questionnaire, with email addresses gathered from the organizers' database. The questionnaire was sent to 1,684 participants, and 71 responses were received (a response rate of 4.22%). The questionnaire consisted of 13 questions, including 11 closed-ended questions (with single or multiple-choice answers) and 2 open-ended questions.

The first 3 questions of the questionnaire were aimed at identifying the respondents (gender identification, the main business activity of the company represented by the respondent and the geographical location of that company).

Questions 4 and 5 aimed to identify the awareness of wine-producing countries in Eastern Europe (including Romania). Question 4 sought to assess unaided awareness, asking respondents to mention only the first Eastern European wine-producing country that came to mind, which is similar to the top-of-mind unaided (brand) awareness metric. Question 5 was designed to identify the aided brand awareness metric (a list of the most important Eastern European countries was provided, and respondents were asked to name those they recognized as wine-producing countries).

Through questions 6-9, the aim was to delve deeper into the awareness of Romania as a wine-producing country. Q6 sought to identify to what extent Romania is recognized as being among the top 10 European wine-producing countries. Q7 aimed to determine the aided awareness of indigenous grape varieties used in wine production, while questions 8 and 9 sought to find out whether respondents had consumed Romanian wine in the last 3-6 months and if they recalled the brand of the wine consumed (awareness of Romanian wine brands).

Questions 10 and 11 (multiple-choice questions on a 5-point Likert scale) were structured to evaluate the attributes, benefits, and attitudes associated with the consumption of Romanian wine. Q12 aimed to highlight the general attitude towards Romania as a wine-producing country, while Q13 sought to understand how strong this general attitude is towards Romania as a wine-producing country.

RESULTS AND DISCUSSIONS

For the first question (*Q1 – Gender identification)*, 50 respondents identified as male (70.4%), 20 as female (28.2%), and only one person preferred not to disclose their gender (1.4%).

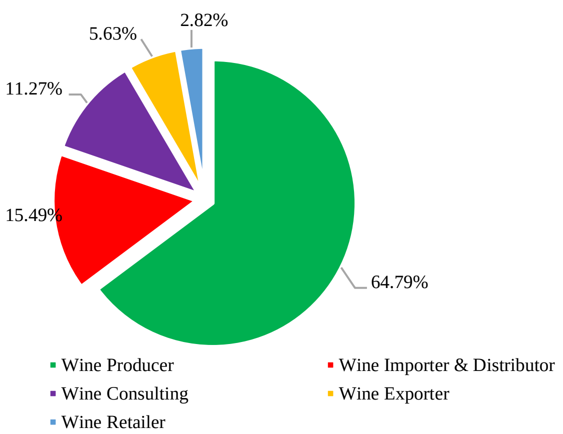

Fig.1. The main field of activity of the respondents' companies
Source: Own calculation.

Regarding the main field of activity of the company they represent (*Q2 – Your company's main field of activity*), 46 respondents come from wine-producing companies (64.6%), 11 represents wine importing and distributing companies (15.5%), 8 are from wine consultancy (11.3%), 4 from wine exporters (5.6%), and only 2 (2.8%) are from wine retailers (Fig.1).

In terms of the geographical region they come from (*Q3 – Company location*), 40 respondents (companies) are from Europe (56.3%), 10 of them are from North America (14.1%), and 9 are from South America (12.7%). The remaining geographical regions have a representation of less than 10% (Australia & New Zealand – 8.5%, Asia and Africa – 2.8% each, and the Middle East and Central America – 1.4% each).

Through *Q4 – What is the first wine-producing country from Eastern Europe that comes to mind?*, we aimed to evaluate unaided awareness (specifically, top-of-mind unaided awareness) of the wine-producing countries in Eastern Europe (Table 1).

Table 1. The top wine producing countries which come to mind

Crt. No.	Top wine producing countries which come to mind (Top of Mind - Unaided Awareness)	%	No of responses
1	Armenia	1.41%	1
2	Austria	1.41%	1
3	Bulgaria	9.86%	7
4	Croatia	2.82%	2
5	France	4.23%	3
6	Georgia	9.86%	7
7	Greece	8.45%	6
8	Hungary	12.68%	9
9	Italy	1.41%	1
10	Moldova	15.49%	11
11	Romania	8.45%	6
12	Slovenia	1.41%	1
13	None	22.54%	16
	Total responses		71

Source: Own calculation.

It is noteworthy that nearly a quarter of respondents (22.54%) could not name any wine-producing country from Eastern Europe, and 7.04% of them named countries from other areas of Europe (Austria, France, Italy). The most mentioned countries were Moldova (15.49%), Hungary (12.68%), Georgia and Bulgaria (9.86%). Romania received only 6 mentions (8.45%), 4 from Europe and 2 from

South America. It is surprising that for Romania there were no mentions from North America (where the United States is the largest wine market in the world) and none from Asia (where China is another major wine market).

Question *Q5 – Which of the following Eastern European countries do you know as wine-producing countries?* aimed to evaluate aided awareness regarding the wine-producing countries in Eastern Europe.

Table 2. Wine producing countries from Eastern Europe

Crt. No.	Wine producing countries from Eastern Europe (Aided Awareness)	%	No of responses
1	Bulgaria	77.46%	55
2	Croatia	70.42%	50
3	Georgia	90.14%	64
4	Moldova	92.96%	66
5	Romania	80.28%	57
6	Ukraine	30.99%	22
7	Serbia	25.35%	18
8	Slovenia	53.52%	38
	Total responses	71	

Source: Own calculation.

The top two positions are held by Moldova and Georgia (Table 2), with 66 and 64 responses, respectively. Romania ranks third, with 57 mentions (80.3% of total responses).

Table 3. Respondents' answers about Romania as a wine producing country

Crt. No.	Wine producing countries: Romania (Aided Awareness)	%	No of responses
1	Asia	1.41%	1
2	Australia & New Zeeland	7.04%	5
3	Central America	1.41%	1
4	Europe	46.48%	33
5	Middle East	1.41%	1
6	North America	11.27%	8
7	South America	11.27%	8
	Total responses		57

Source: Own calculation.

Of the 57 mentions of Romania, the majority come from Europe (46.5%), while South America and North America each contributed 11.3%. No responses were recorded from respondents in Africa (Table 3).

Romania is one of the most important wine-producing countries in Europe (ranked 6th in 2023 with 4.6 million hectolitres [17]), and *Q6 - Do you know that Romania is in the Top Ten European countries for wine production*? aimed to identify the level of awareness of this attribute associated with our country. 14 respondents (19.7%) were aware of this attribute of Romania's wine industry (Fig.2).

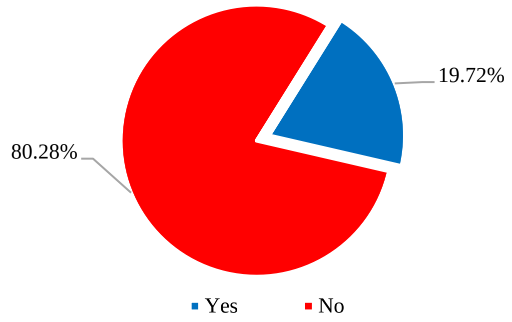

Fig. 2. Do you know that Romania is in the Top Ten European wine producing countries?
Source: Own calculation.

Among those who answered affirmatively to this question, 42.9% are from Europe, 21.4% from North America, and 21.4% from South America, and 14.3% from Australia & New Zealand.

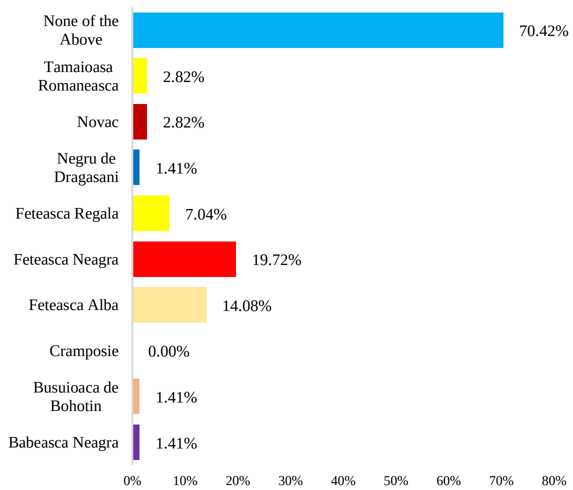

Fig. 3. Aided awareness of Romanian wine grapes
Source: Own calculation.

Another element investigated through *Q7 - Do you know any of the following varieties of Romanian grapes?* was the aided awareness of local grape varieties used in wine production. This question allowed for multiple responses, yet 50 respondents (70.4%) did not recognize any of the most

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important Romanian grape varieties used for winemaking.

Among the recognized varieties, Feteasca Neagră had the highest percentage (19.7%), followed by Feteasca Albă (14.08%) and Feteasca Regală (7.04%) (Fig.3).

In terms of the geography of recognition of native grape varieties, there were 15 responses from Europe (21.1% of total responses), with 7 recognitions for Feteasca Neagră, 5 for Feteasca Albă, 2 for Feteasca Regală, and 1 each for Busuioacă de Bohotin and Tămâioasă Românească. From North America, there were 3 responses (4.2% of total responses), with 2 recognitions for Feteasca Neagră, Feteasca Albă, and Feteasca Regală, and 1 recognition for Novac. From South America, there were 2 responses (2.8% of total responses), with 2 recognitions for Feteasca Albă and 1 each for Băbească Neagră, Feteasca Neagră, Feteasca Regală, Negru de Drăgășani, and Tămâioasă Românească. Additionally, there was 1 response from the Middle East (1.4% of total responses), with 1 recognition for Feteasca Neagră.

The questions *Q8 - Have you consumed a Romanian wine lately (3-6 months)?* and *Q9 - In case of an affirmative answer to Q8, do you remember the brand name of the wine?* were correlated in the sense that it aimed to find out whether respondents had consumed Romanian wine recently (in the last 3-6 months) and, in the case of an affirmative answer, if they could recall the brand name of the wine. In question 8, only 22 respondents (31%) stated that they had consumed Romanian wine during the specified period (with 18 responses from Europe and one each from North America, South America, Australia & New Zealand, and the Middle East). In question 9, out of the 22 who answered affirmatively to the previous question, only 3 (13.6%) could indicate the brand of wine (1 response for Davino, 1 response for Recas, and 1 for Purcari – which is a brand from a producer in Moldova). The mentions for Davino and Recas came from Europe, while the mention for Purcari came from Australia & New Zealand.

Question *Q10 - Please evaluate (not at all agree - totally agree) the following attributes of Romanian wine* aimed to understand the perception of foreign professionals regarding Romanian wine in relation to various attributes related to price, quality relative to price, the use of native grape varieties, and the quality of the distribution of Romanian wines in foreign markets (Fig. 4).

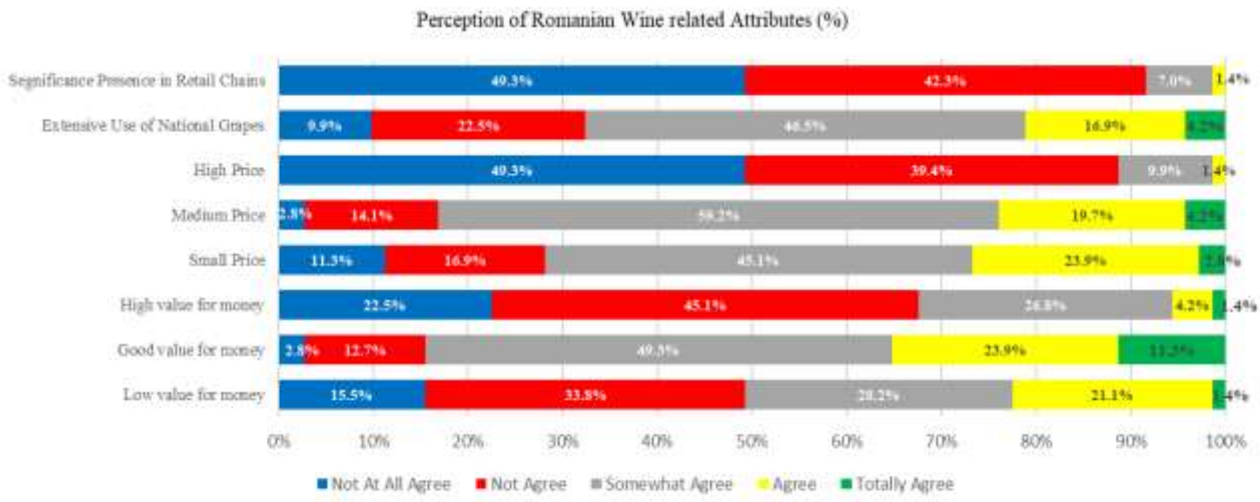

Fig. 4. Perception of Romanian wine related attributes
Source: Own calculation.

49.3% of respondents totally disagree or disagree with the attribute "Low value for money" while only 22.5% totally agree or agree with this attribute. For the attribute "Good value for money", 15.5% of respondents totally disagree or disagree, and

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35.2% totally agree or agree. It is noteworthy that there is a large percentage of undecided respondents ("somewhat agree"), nearly half of the total respondents (49.3%).

In relation to Romanian wine and the attribute "High value for money", 67.6% of respondents totally disagree or disagree with this statement, and 26.8% are undecided.

A particular situation arises with the attribute "Small price", where opinions are polarized (28.2% of respondents totally disagree or disagree, while 26.8% totally agree or agree). For the attribute "Medium price" 59.2% of respondents are practically undecided, while for "High price" 88.7% of respondents totally disagree or disagree with associating this attribute with Romanian wine. Additionally, for the attribute "Extensive use of national grapes," the percentage of undecided respondents is very high (46.5%), and for the attribute "Significant presence in retail chains," there is the highest percentage (91.5%) of those who totally disagree or disagree with associating this attribute with Romanian wine.

Through question *Q11 - Please evaluate (not at all agree - totally agree) the following statements about Romanian wine*, the aim was to understand the perspective of foreign producers regarding Romanian wine in relation to several statements (attributes, benefits and attitudes).

Regarding the first statement, which addresses the optimal price at which Romanian wine is sold in foreign markets, 28.2% of respondents totally agree or agree, but more than half (53.5%) are practically undecided. The situation of undecided respondents is similar for the statement related to the optimal quality of Romanian wine (56.3%), with only 22.5% believing that Romanian wine has optimal quality.

Concerning the statement about distribution ("Easy to find and buy"), 93% of respondents totally disagree or disagree with it. For the statements regarding the benefits associated with consuming Romanian wine ("It accompanies food/meals very well," "It offers moments of relaxation," and "Special sensory experience"), the number of respondents without a clear opinion is predominant.

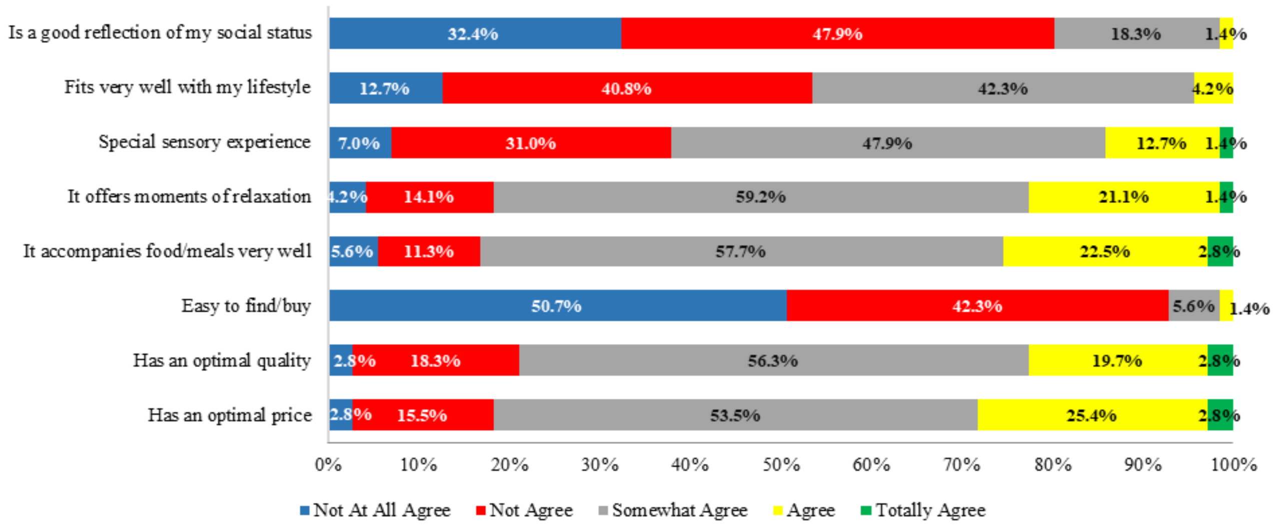

Fig. 5. Evaluation of statements about Romanian wine
Source: Own calculation.

In the case of statements addressing attitudes associated with Romanian wine ("Fits very well with my lifestyle" and "Is a good reflection of my social status"), those who totally disagree or disagree are in the majority: 53.5% and 80.3%, respectively (Fig. 5).

Regarding the general attitude towards Romanian wine (*Q12 - How would you describe your general attitude towards Romanian wine?*), the responses are polarized, with 28.2% of respondents having a favourable or very favourable attitude and 23.9% having an unfavourable or very unfavourable attitude (Fig.6). In this case as well, the percentage of those who do not have a clear, firm attitude is practically the majority (47.9%).

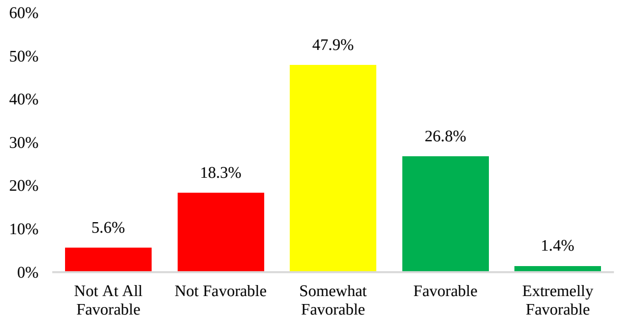

Fig. 6. General attitude towards Romanian wine
Source: Own calculation.

The last question of the questionnaire aimed to understand how strong the respondents' general attitude towards Romanian wine is (*Q13 – How strong is your general attitude towards Romanian wine?*). We sought to evaluate this to understand how challenging it will be to change this attitude in the near future. In this situation, the percentage of those whose attitude ranges from "somewhat strong" to "extremely strong" is very high (85.9%), which suggests that the process of changing this attitude will be rather difficult (Fig.7).

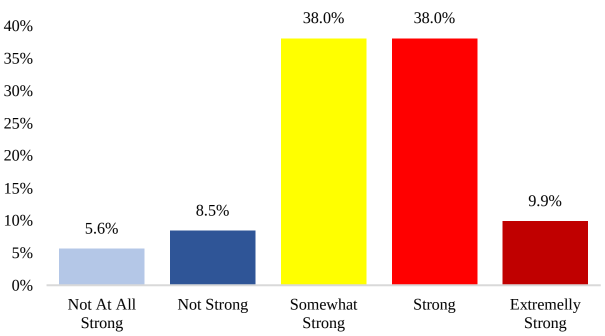

Fig. 7. The strength of general attitude towards Romanian wine
Source: Own calculation.

CONCLUSIONS

This article aims to provide, partial, how Romania is perceived as a wine-producing country by international specialists.

From the perspective of top-of-mind—unaided awareness of Eastern European wine-producing countries, Romania ranks fifth, following Moldova, Hungary, Georgia, and Bulgaria.

In terms of aided awareness, Romania holds the third position among wine-producing countries in Eastern Europe, behind Moldova and Georgia, with nearly half of the awareness coming from Europe and the rest predominantly from South and North America.

The study revealed low awareness of a major attribute associated with Romania as a wine-producing country: our country ranks 6th in Europe in terms of wine production but only 19.7% of respondents are aware of this fact.

Regarding the awareness of indigenous grape varieties used in wine production, 70.4% of those interviewed reported that they did not recognize any of these grape varieties.

Among the recognized varieties, Fetească Neagră, Fetească Albă and Fetească Regală received the most votes. Of those who consumed Romanian wine in the past 3-6 months (31% of respondents), only three could name the respective wine brands.

In the case of other attributes (price, perceived quality, distribution, and the use of local varieties in wine production), as well as benefits and attitudes towards Romanian wine, the perceptions of foreign professionals in the wine world are rather ambiguous and unclear, and when they are firm, they tend to be polarized.

In conclusion, in order to increase the volume and value of exports, Romania's wine industry needs a coherent and consistent marketing and communication program.

One of the first steps would be to create a sectoral brand which would help differentiate and position the wine industry in the international market.

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THE IMPACT OF OIL AND GAS PIPELINES ON AGRICULTURAL ACTIVITY: LITERATURE REVIEW AND BIBLIOMETRIC ANALYSIS

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Abstract

Natural gas infrastructure is still a hot topic for researchers and policymakers in a world where energy transition and supply security are important issues. In addition to being crucial for getting resources to consumer markets, natural gas pipelines also bring up concerns about sustainability, the economy, and the environment. The objective of this study was to investigate the development of research on natural gas infrastructure, identifying the key subjects examined in the specialized literature, the global research collaborations, and the new avenues that have the potential to influence the field's future. Applying bibliometric techniques to the Scopus database, the analysis showed that the research was fragmented in multiple directions. The first path is the technical and operational one, which aims to maximize the transportation of energy resources and increase the efficiency of gas pipelines. Studies that concentrate on energy security policies and the incorporation of natural gas into domestic and global economic strategies represent a second trend, which is represented by economic factors and market rules. A third dimension of research, which has gained momentum recently, concerns the energy transition and reducing the ecological impact of natural gas, in particular by exploring alternative solutions such as green hydrogen and integrating existing infrastructure with new energy technologies. A key result of the study is that, although the impact of gas pipelines on agriculture is significant, this topic is insufficiently explored in the specialized literature. Gas pipelines can affect soil quality, farmland fertility and value, and farmers in affected areas often face land use restrictions and additional costs for soil restoration. As the energy transition becomes a global priority, future research will need to focus not only on making gas transport more efficient and reducing emissions, but also on how this infrastructure interacts with other economic sectors, especially agriculture. Gas pipelines are not only a component of the energy system, but also a factor with significant economic and ecological implications, which must be thoroughly understood in order to be managed effectively. In conclusion, this study highlights that natural gas infrastructure remains a critical topic for the global energy future, but requires a more integrated approach that includes economic, social and environmental aspects.

Key words: *natural gas, sustainable development, economic effects, environmental effects, agriculture*

INTRODUCTION

Energy infrastructure is an essential pillar of economic development, influencing both energy security and the stability of regional markets. Natural gas pipelines play a critical role in ensuring continuous energy flows, facilitating economic integration, reducing dependence on more polluting fuels and promoting a sustainable economy. In the context of decarbonization and the global energy transition, the importance of natural gas infrastructure is analyzed both from the perspective of ensuring energy security and economic and environmental sustainability [1, 7, 28]. Studies show that the development of transnational transport pipelines contributes to price stability and the reduction of supply bottlenecks [9, 30]. Also, the interconnection of natural gas networks allows rapid redistribution of resources in the event of demand fluctuations or unexpected supply interruptions [33, 38]. A concrete example of the importance of these infrastructures is the European Union, where the policy of creating an "energy union" was driven by the need to reduce dependence on foreign imports and increase the diversification of supply sources [2, 11, 22].

The expansion of natural gas infrastructure contributes to economic growth by attracting investment and creating jobs [3, 12, 25]. At the same time, natural gas pipelines reduce energy costs for consumers and industry, facilitating access to more efficient and less polluting energy sources compared to coal or oil [15, 23]. In order to stabilize national economies and preserve competitiveness in global markets, these infrastructures are crucial. Furthermore, in the current energy transition context, natural gas is regarded as an intermediary solution for lowering carbon emissions, enabling the integration of renewable energy sources by bolstering natural gas-based energy production during periods of wind and solar energy fluctuation [5, 8]. An important aspect is the use of existing infrastructure for the transport of renewable natural gases, such as biomethane or green hydrogen, which contributes to reducing the carbon footprint of this sector [24]. In order to create a resilient and sustainable energy system, it is imperative that the current infrastructure be modified. Despite these benefits, the infrastructure for transporting natural gas has numerous drawbacks from an economic and environmental standpoint.

The development of energy infrastructure, especially the expansion of natural gas pipeline networks, has a significant impact on agriculture and agricultural land. One of the most significant economic effects of gas pipelines on farmers is the decrease in crop yields due to physico-chemical changes in the soil. Research has shown that high pipe temperatures reduce soil moisture, thus affecting plant development and leading to significant yield losses [13]. These losses translate into lower incomes for farmers, who are forced to adopt additional measures such as additional irrigation or the use of expensive fertilizers to compensate for soil damage.

The installation of pipelines involves excavation work that destroys the soil structure, which imposes additional costs on farmers in order to restore the fertility of the affected lands. Research from Poland shows that farmers have to bear high costs for fertilization and mechanical land restoration [19]. Gas pipelines impose restrictions on the use of land, which causes a significant depreciation of its value. Farmers who want to sell affected land face difficulties, as investors avoid land subject to restrictions imposed by energy infrastructure [19, 26]. This decrease in land value is a major obstacle for farmers who want to expand their agricultural holdings or obtain financing to modernize their farms. A key aspect of the economic impact is the low level of compensation offered to farmers affected by the construction of gas pipelines. In many cases, gas transportation companies only provide compensation for temporary land use during construction, without considering long-term losses [19, 27].

In addition to direct financial losses, farmers face significant restrictions on land use after pipelines are installed, such as prohibiting the use of heavy machinery for plowing or harvesting above the pipelines or limiting the types of crops that can be planted to avoid damage to the pipeline [29].

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In this context, the paper aimed to investigate the development of research on natural gas infrastructure, identifying the key subjects examined in the specialized literature, the global research collaborations, and the new avenues that have the potential to influence the field's future.

MATERIALS AND METHODS

To carry out the bibliometric analysis related to the impact of natural gas pipelines and energy infrastructure on agriculture, a methodology based on the consultation of the Scopus database, one of the most comprehensive sources of scientific literature, was used. The research was carried out between February 15-18, 2025, the searches being carried out using specific terms of interest, which allowed the extraction of a set of relevant articles. Thus, the expression "Natural gas pipelines" allowed the identification of 26,240 articles, reflecting the breadth of research dedicated to gas transport infrastructure. The term "sustainable development" generated 358 articles, indicating a significant concern over the relationship between energy infrastructure and the principles of sustainable development. In order to analyze the effects of this type of infrastructure on the environment and the economy, the search with the terms "environmental and economic effects" identified 26 articles, which demonstrates a need to deepen this topic in the specialized literature. Regarding the connection between gas pipelines and the agricultural sector, the term "agriculture" returned only 3 articles, which highlights the need to develop research regarding the impact of this infrastructure on agricultural land.

For the analysis and processing of the extracted data, the VOSviewer software was used, a tool specialized in visualizing co-citation networks and relationships between scientific concepts. With its help, the main research directions, the connections between different subfields and the most relevant authors in this field were identified. This method allowed us to create bibliometric maps that highlight the structure of existing research, major thematic clusters and gaps in the specialized literature, thus facilitating a deeper understanding of the subject and providing future directions for research on this important subject.

RESULTS AND DISCUSSIONS

The bibliometric analysis allowed us not only to identify trends in research regarding energy infrastructure and the impact of natural gas pipelines on agriculture, but also to outline an overview of the evolution of this field, facilitating a deeper understanding of the interconnections between energy, the economy and the environment, elements that can contribute to the foundation of coherent sustainable policies (Fig. 1).

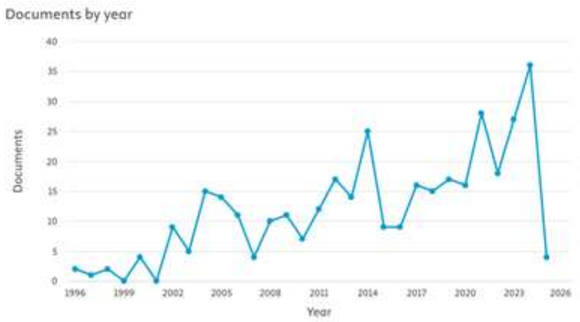

Fig. 1. Evolution of research on energy infrastructure and natural gas pipelines
Source: [32].

Analyzing the research situation in the field, it can be seen that there is a growing interest in studies on energy infrastructure and natural gas pipelines, especially in the last decade (Fig. 2).

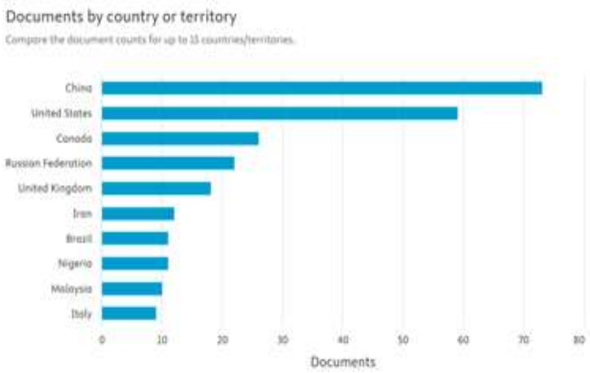

Fig. 2. Distribution of documents regarding energy infrastructure and natural gas pipelines by country
Source: [32].

This trend shows that the development of sustainable energy technologies, the impact on agriculture and the circular economy are becoming increasingly relevant topics in global research.

Bibliometric analysis is a way of highlighting emerging research directions and the evolution of the topic in the context of the energy transition and policies to reduce carbon emissions.

According to the data presented in Figure 2, there is a growing interest in studies on energy infrastructure and natural gas pipelines, especially in the last decade. This trend shows that the development of sustainable energy technologies, the impact on agriculture and the circular economy are becoming increasingly relevant topics in global research.

Romania is on the last places in this ranking, as a result of the fact that this topic was addressed in a single scientific article.

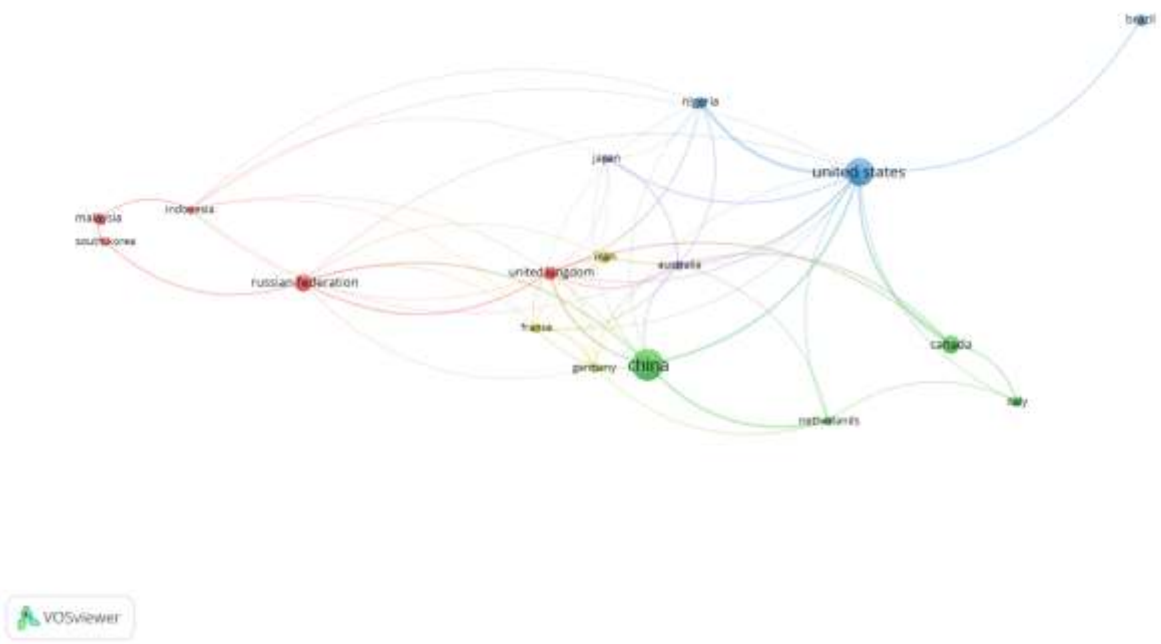

Fig. 3. Global co-authorship network in energy infrastructure research
Source: own processing [34].

The analysis of the relationship between the co-authors and the countries highlights the structure of international collaborations in the field of energy infrastructure that have an essential role in the advancement of scientific research, facilitating the exchange of knowledge, access to resources and the development of innovative technological solutions (Fig. 3).

It can be seen that the U.S. constitutes one of the most important centers of collaboration, having extensive connections with Canada, Nigeria, China and Brazil. This dominant position proves that American researchers are actively involved in international partnerships and that universities and research institutes frequently collaborate with counterparts in other regions of the world. To strengthen this position, collaborations could be expanded with emerging states in Asia and Africa, where energy infrastructure development is booming. Another central actor in this network is China, which has multiple connections with Germany, the United Kingdom, Iran and the Netherlands. This reflects not only an active presence in international research, but also a strategic interest in sustainable energy technologies. Collaborations between China and European states can be intensified through joint projects focused on the energy transition and the development of renewable sources. The Russian Federation also occupies an important place in the co-authorship network, having strong ties with Southeast Asian countries such as Malaysia, Indonesia and South Korea due to the interest related to the expansion of energy infrastructure in the Asian regions and for collaborations in the field of natural gas. Iran and the United Kingdom play intermediary roles in this network, connecting various regions and facilitating the transfer of knowledge between Middle Eastern states and Europe. Their position enables them to serve as intermediaries between researches projects carried out on several continents. Research in this crucial area may be further, in our opinion, by the establishment of international research consortia, which would provide access to European and worldwide funds for collaborative energy initiatives. European nations like Germany, France, and the Netherlands are well-integrated into the network because of their great interest in energy research and connected academic environment. To lessen the ecological impact of energy infrastructure, however, more cooperation with poorer nations could make it easier to transfer technologies and put creative solutions into practice.

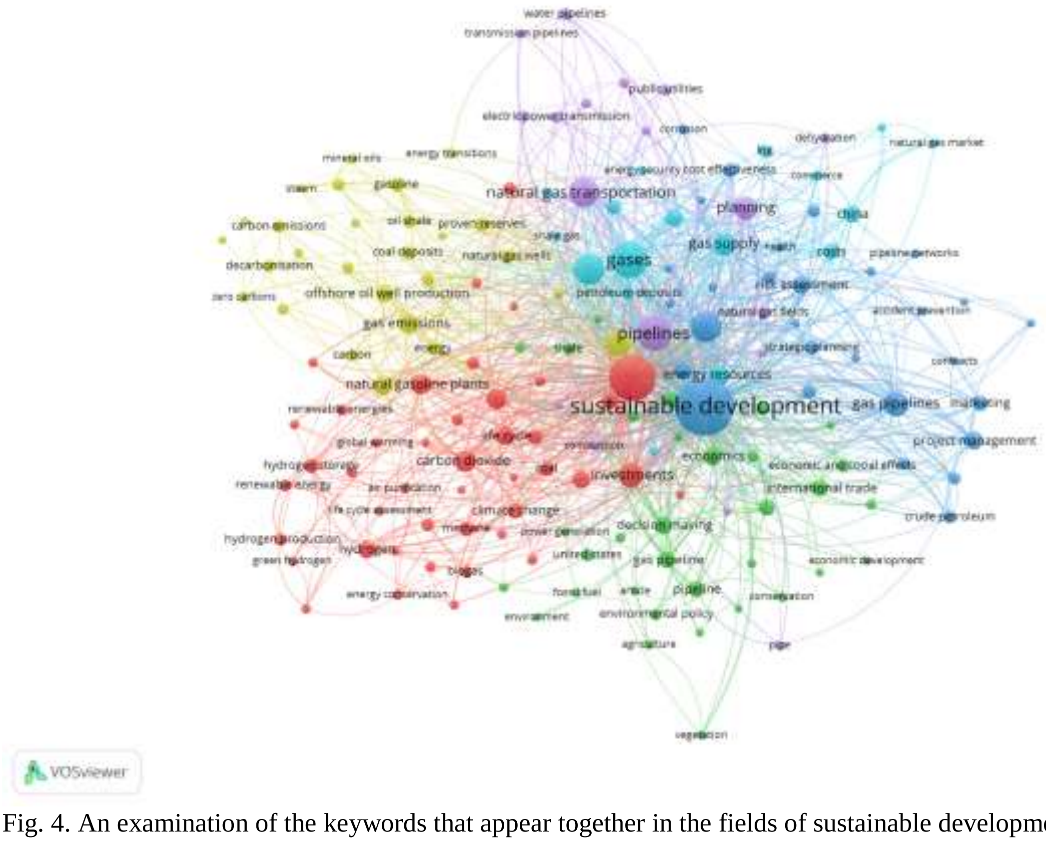

Fig. 4. An examination of the keywords that appear together in the fields of sustainable development and energy infrastructure
Source: own processing [34].

The high correlation between the terms "sustainable development," "pipelines," "energy resources," and "gas supply" suggests that the economic, social, and environmental impacts of energy infrastructure are increasingly being considered when analyzing it (Fig. 4).

The necessity of an integrated strategy to managing natural gas transmission networks is highlighted by the frequent inclusion of elements like risk assessment and strategic planning. The decarbonization and renewable energy cluster is a second significant cluster that includes phrases like "carbon dioxide," "climate change," "hydrogen production," and "renewable energy." This demonstrates that switching to less polluting sources and lowering greenhouse gas emissions are emerging as top research priorities. Additionally, although the integration of hydrogen as a natural gas substitute is a growing topic, it is not yet fully associated with gas pipeline studies, which may suggest areas for further research. In parallel, another cluster is focused on the exploitation of fossil fuel resources, including terms such as "natural gas wells", "coal deposits" and "offshore oil well production". This aspect demonstrates that, despite energy transition efforts, natural gas continues to be an essential component of the global energy market. Researcher interest remains high on extraction efficiency, resource management and pipeline transport optimization. An important dimension of the research is represented by energy planning and infrastructure, grouped in a cluster containing terms such as "public utilities", "electric power transmission" and "pipeline networks". This highlights the strong link between natural gas transmission networks, energy security and their integration into electricity and water supply systems.

In terms of economic and environmental impact, related terms such as "economic development", "environmental policy", "agriculture" and "conservation" emphasize the importance of analyzing the effects of gas pipelines on agricultural land, ecosystems and local communities. However, the weaker connections between these concepts show that this direction of research is still insufficiently explored, which opens up opportunities for in-depth studies on the relationship between energy infrastructure and the sustainability of land used for agriculture (Fig. 5).

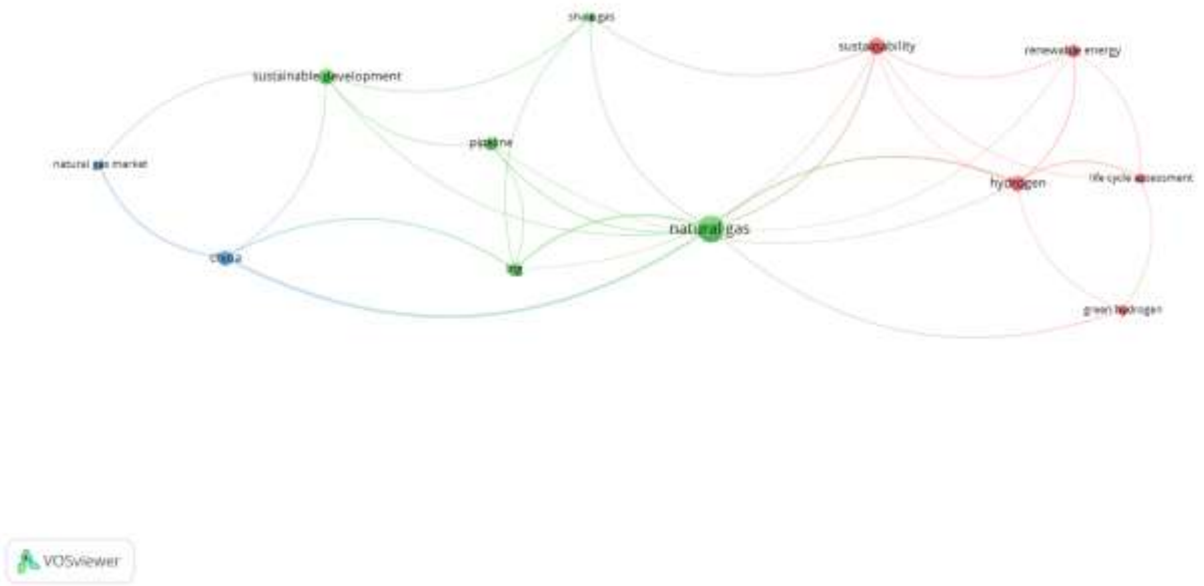

Fig. 5. Examination of key words' co-occurrences and authors in the context of sustainable development and energy infrastructure
Source: own processing [34].

From the analysis of the relationship between the co-occurrence and the authors of the keywords, it is found that a first essential aspect observed is the central position of the term "natural gas", which dominates the thematic network and is directly correlated with fundamental concepts such as "pipelines", "LNG" (liquefied natural gas) and "shale gas". This connection indicates that the literature places particular emphasis on natural gas transport and distribution, reflecting concerns about infrastructure, energy efficiency and accessibility in global markets. Moreover, the link between "natural gas" and "sustainable development" demonstrates that recent studies analyze natural gas from a sustainability perspective, considering both economic and environmental implications. The "natural gas market" represents another significant cluster, and its strong relationship to "China" suggests that scholars are becoming more interested in the local natural gas market's development. There has been a lot of research on energy policy, infrastructure investments, and the effects of natural gas on China's energy security because the country is one of the biggest importers and consumers of natural gas.

In parallel, the report also highlights the decrease of carbon emissions and the shift to renewable energy sources as areas of attention. Thus, the terms "sustainability", "hydrogen" and "renewable energy" form a distinct cluster, reflecting the global trend to explore cleaner alternatives to fossil fuels. Interestingly, "green hydrogen" is a well-connected concept in this network, suggesting an increased interest in green hydrogen as a viable solution in the energy transition. Also, the presence of the term "life cycle assessment" in this cluster indicates that recent studies pay more attention to the life cycle assessment of natural gas and hydrogen, analyzing their environmental impact and economic feasibility.

The analysis also highlights a close connection between natural gas infrastructure and sustainable development, as a result of which current research is no longer limited to the technical and economic aspects of gas transport, but also includes dimensions related to environmental policies, resource conservation and the impact on ecosystems

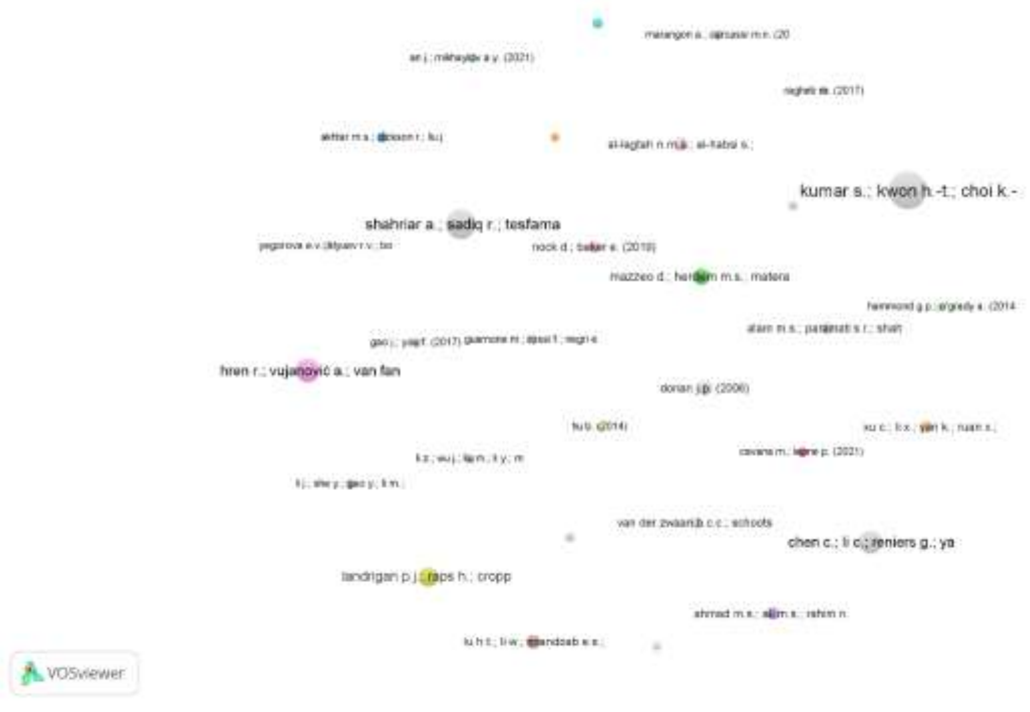

Fig. 6. Analysis of the citation network of documents from the specialized literature on energy infrastructure and sustainable development
Source: own processing [34].

A first aspect observed is the distribution of authors according to the influence of their works (Fig. 6). Names like Shahriar A., Sadiq R. [31], Kumar S. and Kwon H.-T. [20] they have a high number of citations and, implicitly, a significant influence on the evolution of the field. Similarly, authors Hammond G.P. and O'Grady A. (2014) [14] are placed in central positions, due to the fact that their works were frequently used as references in subsequent studies. Also, the connections between the authors demonstrate the existence of complementary research directions, with authors grouped in clusters depending on the topic addressed. For example, Chen C., Li C. and Reniers G. [6] are associated with economic and management aspects of gas infrastructure, while Hren R., Vujanović A. and Van Fan [16] are related to technical analysis and sustainability. This structure shows that the literature is fragmented into distinct subfields, but which interact with each other through common citations and references.

Another important aspect of the analysis is the identification of seminal and emerging works. Older researches, such as Dorian J.P. (2006) [10] and Hu B. (2014) [17], have a high number of citations, having an essential role in establishing some key concepts and methodologies used in subsequent research. Instead, more recent works such as Cavana M. and Leone P. (2021) [4] have opened up new research directions and emerging trends.

A dynamic ecosystem is thus reflected in the citation network, where new contributions are progressively incorporated into the body of existing literature and previous research serves as the basis for current investigations.

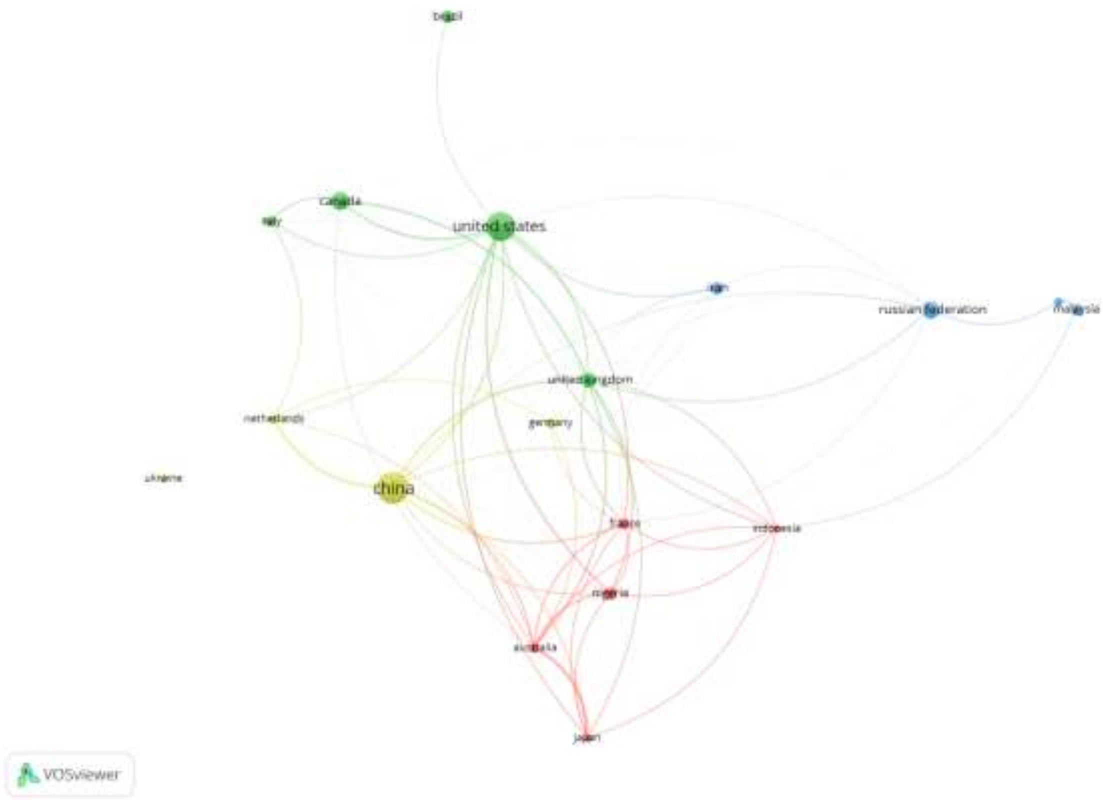

Fig. 7. An examination of the connection between countries and co-citations
Source: own processing [34].

A complex web of scholarly impact characterizes research on energy infrastructure in the context of globalization and the energy transition. The most cited writers establish their status based on how frequently their work is cited in later studies.

Figure 7 sheds light on the primary research centers by examining co-citations, identifying the nations that have the most effect on the literature and the connections between them.

The dominance of the United States and China in the co-citation network is the first important factor. These countries are the main hubs for science and have a significant impact on the development of energy infrastructure both theoretically and practically. The United States is closely associated with Canada, the United Kingdom, and Brazil. However, China's close ties to the Netherlands, Germany, and France show a propensity for cooperation with Europe, particularly in the areas of energy laws and gas transportation technologies.

The distribution of theme clusters suggests that there are multiple separate but related lines of inquiry. Because they are concerned about managing energy resources in an economical and ecologically responsible way, the United States, Canada, and the United Kingdom are mostly focused on energy policy, economics, and sustainability. To maintain a global balance between supply and demand, China, Germany, and the Netherlands, on the other hand, are increasingly concentrated on gas transportation technologies and energy infrastructure optimization.

Another important cluster, made up of Japan, Australia, Nigeria and Indonesia, addresses the environmental impact of energy infrastructure, focusing on climate change, the energy transition and the development of renewable sources, relevant as it reflects increasing pressure on governments and industry to reduce the carbon footprint of natural gas transport. In parallel, a group of countries such as Russia, Iran and Malaysia are more focused on issues related to energy security and natural gas geopolitics, given their major role in the export of energy resources.

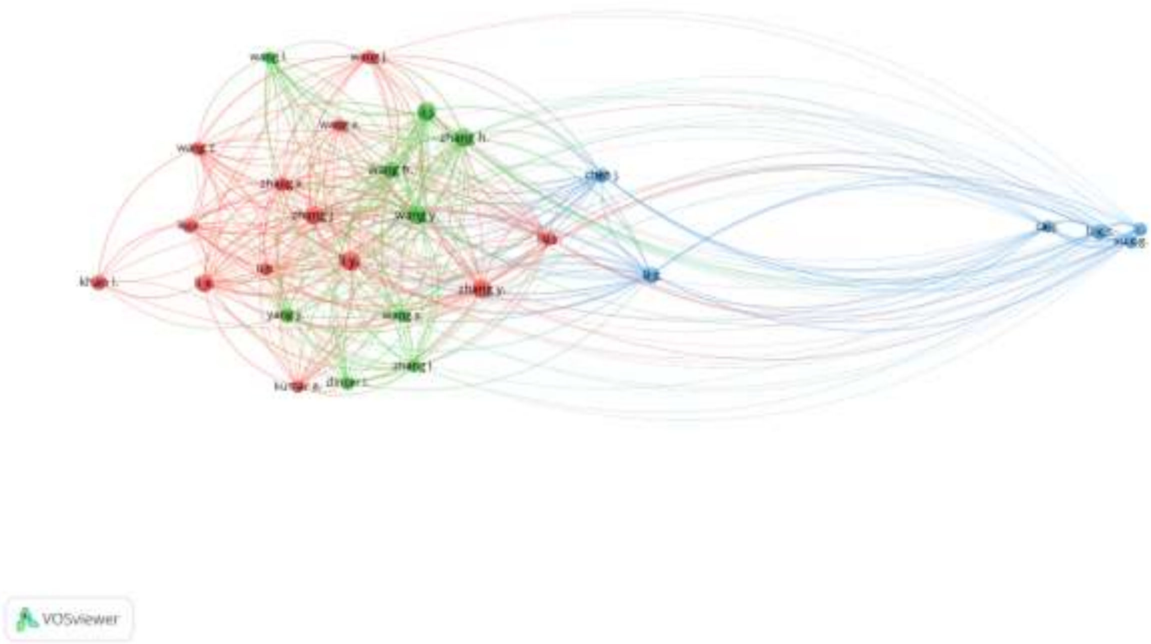

Fig. 8. Analysis of the relationship between co-citations and cited authors in the field of energy infrastructure and sustainable development
Source: own processing [34].

Figure 8 shows a well-defined structure, where authors organize themselves into three main clusters, each representing a distinct research direction. The red cluster, where we find authors such as Khan I., Liu J. and Zhang X. [18], reflects a research focus on technical and operational aspects of natural gas infrastructure, such as optimization of transmission networks and distribution efficiency. The green cluster, dominated by names such as Zhang Y., Wang H. and Liu L. [37], is more oriented towards energy economy and sustainability, analyzing the impact of infrastructure on global development and public policies. In parallel, the blue cluster, where authors such as Xu G., Cai J. and Li Z. [36] are present, indicates an interdisciplinary approach, with research that questions the role of natural gas in the energy transition and their integration into the renewable energy mix.

A distinctive feature of this network is the existence of a dense central core, where authors from the red and green clusters are frequently cited together.

Tabelul 1. Analysis of the articles regarding the impact of the natural gas pipelines on agriculture

Authors and year of publication	Title	Purpose	Results obtained
Landrigan, P. J., Raps, H., Cropper, M., Bald, C., Brunner, M., Canonizado, E. M., ... & Dunlop, S. (2023) [21]	The Minderoo-Monaco Commission on plastics and human health	The purpose of this study is to analyze the impact of natural gas transportation on agriculture, highlighting the main effects that energy infrastructure has on agricultural land and rural ecosystems. In this context, the research explores how the construction and operation of gas pipelines influence soil fertility, access to water resources and agricultural productivity	Studiul a evidențiat că The transportation of natural gas has a significant negative impact on agriculture, affecting soil fertility, access to water and land use through soil compaction, erosion, contamination and imposing restrictions on agricultural activities. It was also found that, although these effects are obvious and relevant from an economic and ecological point of view, the specialized literature has not paid enough attention to this topic, indicating the need for further research to quantify the long-term impact and identify mitigation solutions. [21].
Walker, B. L., Neubaum, M. A., Goforth, S. R., & Flenner, M. M. (2020). [35].	Assessing habitat loss and alteration brought on by recent energy infrastructure development in a remote, outlying greater sage-grouse population	This study set out to measure the amount of habitat loss and alteration that an isolated Greater Sage-Grouse (GrSG) population in the western United States—more especially, Colorado—has experienced as a result of the development of energy infrastructure. Evaluating how highways, natural gas pipelines, and other energy infrastructure affect ecosystems and land cover was the main goal of the study	The research indicates that the growth of energy infrastructure, such as natural gas pipelines, is significantly influencing natural habitats and farms, which in turn impacts the species that rely on these ecosystems. Even while land reclamation is being done, it is not very effective, and little is known about how it will affect agriculture and biodiversity in the long run. According to these findings, more stringent energy infrastructure impact management regulations are required to stop additional habitat loss and to safeguard the environment and local economies in impacted areas [35]

Source: own processing.

This is due to the fact that their works serve as fundamental references for numerous subsequent researches, having a significant impact on the development of the field.

In contrast, the authors in the blue cluster present a more dispersed network, having a greater influence in interdisciplinary areas and in studies aimed at the integration of natural gas into new energy policies.

The analysis of this co-citation network also highlights a significant presence of researchers from Asia, especially China, which reflects the growing involvement of this region in the development and modernization of energy infrastructure.

Next, we also analyzed the articles on the impact of natural gas transport on agriculture, confirming that the number of studies is surprisingly low, although the effects on agricultural land are significant. Most existing research focuses on the technical aspects of infrastructure, energy efficiency and impact on biodiversity, and the issues of soil compaction, fertility loss and restrictions on farmers are rarely addressed in detail (Table 1).

Studies on energy infrastructure prioritize grid optimization and emissions reduction over the impact on agriculture. Also, the effects on agricultural land are difficult to quantify in the long term, requiring long monitoring and interdisciplinary studies, which discourages extensive research in this field.

In this regard, it is imperative that future research focus more on the long-term effects of gas pipelines on agriculture, incorporating multidisciplinary studies that examine both the economic impacts on farmers and the physico-chemical changes to the soil, so that decisions regarding the expansion of energy infrastructure are founded on a thorough evaluation of the costs and benefits.

CONCLUSIONS

As the world's energy revolution accelerates, natural gas pipelines play an increasingly complicated role by tying together sustainability, energy security, and economic factors. These infrastructures are much more than just ways to move resources; they also serve to maintain delicate economic equilibrium, impact geopolitical relations, and determine the direction of energy on a global scale.

The examination of scientific studies showed that natural gas infrastructure is a complex area with entwined technical, financial, and sustainability elements. Despite the fact that a great deal of research has been done on the effectiveness of transportation networks, energy flow optimization, and natural gas integration in the energy transition, the effects on agriculture have not received enough attention. Despite the fact that the effects on agricultural land are significant – including soil compaction, erosion, restrictions on farmers and decreased land values – the number of studies analyzing these issues is few. This gap in research can be explained both by the difficulty of quantifying long-term impact and by the prioritization of other topics of interest by research funders.

This bibliometric analysis was not just a theoretical exercise, but a research that aimed to provide essential insight for governments, investors and researchers. The results obtained can contribute to the shaping of energy policies, providing a sound scientific basis for decisions on infrastructure investments. At the same time, identifying the most influential research directions facilitates the understanding of technologies and strategies with the greatest development potential. Last but not least, this report helps policymakers and academics create new academic and industrial relationships by giving them a comprehensive picture of the key trends and potential for international collaboration.

In this context, future research must focus not only on optimizing gas transport and reducing ecological impact, but also on how this infrastructure influences agricultural land and the rural economy. Given the interdependence between energy infrastructure and other economic sectors, a more integrated and interdisciplinary approach is essential so that infrastructure development is compatible with sustainability goals and the protection of natural resources.

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THE IMPACT OF IMPLEMENTING DIGITALIZATION IN THE FIELD OF INTERNAL AUDIT IN THE CONTEXT OF THE INCREASING COMPLEXITY OF THE SOCIO-ECONOMIC ENVIRONMENT IN THE AGRICULTURAL FIELD

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Abstract

The article analyzes how the use of information technologies to analyze internal audit information can generate added value for agricultural companies. With the help of audit tests performed using audit applications (risk alerts, support for different data formats, customized forms, verification of quantitative or qualitative elements), audit specialists will contribute to the development of governance systems of agricultural companies in the sense that, by digitizing reports, they will have the possibility to analyze recommendations, track the flow of documents and the tools used by the audit team. The research method chosen was the use of a questionnaire consisting of 12 questions/items, addressed to internal auditors working the level of companies whose main activity is agriculture. Through the research activity undertaken, the need for internal audit to become a digitalized work tool was emphasized, which would provide stakeholders with documents in the form of reports that converge with the principles of participatory management, risk management, and governance, which would constitute the premises for an investigative audit.

Key words**:** *risk, performance, audit, control, management*

INTRODUCTION

The acceleration of the development of new information technologies in recent years has exceeded, in some areas, even the most optimistic forecasts. The analysis of articles and specialized publications on internal audit shows a weak connection with the technological component specialized in software programs specific to audit and internal control applicable to companies in the agricultural field [15] [3] [5] [6].

We believe that information technologies contribute greatly to increasing the reliability of the audit in the performance management of companies operating in the agricultural field, which requires better professional training of auditors in increasing digital skills and the use of software packages [14]. At the same time, the use of artificial intelligence supports agricultural companies in providing agricultural economic goods to support citizens and increase their level of well-being following consumption. Machine learning empowers current tools to learn from past experiences, analyze patterns and provide assistance in obtaining maximum performance under given resource conditions. Also, digitalized audit systems have the role of reducing systemic risks that can be generated by redundancy, but also by errors in agricultural company reporting in areas such as accounting, budgeting, human resources or internal managerial control [10].

Most studies based on the digitalization of audit techniques and tools have identified the primary purpose of using new technologies as risk reduction [7] [13].

However, it has not been possible to outline an audit model that uses exclusively digital means and whose application would provide auditors with adequate digital tools in formulating audit conclusions that would incorporate recommendations by fulfilling the specific factors of agricultural company management.

The purpose of the article is to emphasize the need for resource management using automated means of attracting and analyzing audit data within the audit trail, in order to achieve the main objectives of the company in the agricultural field, in conditions of efficiency, effectiveness and economy, principles that are convergent with the philosophy of public internal audit.

MATERIALS AND METHODS

In order to highlight the positive effects of the internal audit digitalization process [1] in agricultural companies, the research is based on three aspects relevant to the research result, such as: governance of agricultural companies, information technology for structuring the elements analyzed in audit reports in the form of recommendations that exclusively target the process of making own economic resources more efficient and attracted to agricultural management, the risks associated with the internal audit system [9].

Within the proposed purpose, the following research objectives were established:

-identifying auditable areas exposed to a high degree of risk;

-determining the impact of information technology in the agricultural sector;

-identification of weaknesses within the audit activity and highlighted in the audit reports;

-emphasizing the need for training internal auditors in the field of information technology and digitalization.

The research aims to find a way to formulate audit recommendations from an informational perspective, which would allow for the interoperability of data and accounting, budgetary, and managerial systems to facilitate the managerial decision-making process under minimal risk conditions. [4].

At the same time, the research focuses on the use of digital technologies [8] in order to better utilize resources and increase the economy, efficiency and effectiveness of the use of public funds within agricultural companies.

Within the research, the objectives aim to develop and build a statistical model whose variables establish a coherence of deterministic relationships between the agricultural company, the legislation and good practices specific to the audit field and the principles of internal audit, using a statistical population of 230 people who hold the position of internal auditor within agricultural companies.

A market research on the digitalization of internal audit was carried out using the questionnaire as a working tool. The general purpose of the questionnaire was to disseminate opinions and to know the possible reactions of internal auditors regarding the digitalization of internal audit at the level of companies in the agricultural field.

The research method chosen was the use of a questionnaire consisting of 12 questions, addressed to internal auditors working at the level of companies in the agricultural field.

The administration method used was a field survey, and the technique applied was the structured interview. The questionnaire was sent out and the information was collected during the period October - November 2024. The analyzed data are both quantitative and qualitative.

Summary of the results recorded:

-138 internal auditors responded affirmatively to the invitation to complete the Questionnaire on the impact of implementing digitalization in internal audit sphere;

-84% of respondents believe that the budgetary area is among the significant risk factors in agricultural companies;

-92% of respondents believe that the digitalization of economic processes, and implicitly of internal audit, would reduce risk at the level of an agricultural entity, a fact associated with the reduction of the general level of unitary expenses;

-70% of respondents believe that legislative predictability in the field of agriculture, especially the fiscal sphere, constitutes an essential factor in exploiting market opportunities;

-80% of internal auditors believe that a set of tools would be beneficial to support the audit activity of sensitive areas (example: additional resources in the form of a guide to good practices in the field).

RESULTS AND DISCUSSIONS

Based on the documented analysis, 12 questions were proposed for interviewing, which were answered by 230 people.

The study establishes an association between a continuous variable (dependent variable) identified as "knowledge in implementing the concept of digitalization of internal audit in Romania" and discrete variables (independent variables, factors) identified as behavior regarding the attitude towards the principles of internal audit (attitude towards risk, transparency of information, internal audit methods, efficiency, and effectiveness).

In the 12 questions presented in Table 1, question 1 was considered the dependent variable.

Table 1. Centralizer of questions for validating research objectives

Items/ Variables	Statistical results
1. Do you have knowledge about the implementation of the digitalization concept of internal audit in Romania?	Mean: 1.6304Median: 2.00 Mode: 2.00 Sample Variance: 0.234 Standard Error: 0.03190 Skewness: -0.544 Kurtosis:-0.544
2. Do you believe that the implementation of digitalization in certain fields of activity could lead to the efficiency, effectiveness, and transparency of the expenses of public entities?	Mean: 1.2739Median: 1.00 Mode: 1.00 Sample Variance: 0.2 Standard Error: 0.44694 Skewness: 1.021 Kurtosis:- 0.976
3. Select the first three auditable areas for which you consider that the risk factor often reaches a significant level	Mean: 4.1739Median: 4.00 Mode: 7.00 Sample Variance: 4.948 Standard Error: 0.146767 Skewness: 0.021 Kurtosis:- 1.309
4. Do you believe that digitalization could lead to efficiency, effectiveness, and transparency of public entity spending?	Mean: 1.2957Median: 1.00 Mode: 1.00 Sample Variance: 0.209 Standard Error: 0.03016 Skewness: 1.021 Kurtosis:- 1.198
5. To what extent do you believe that the implementation of an information technology system could influence the activity of the entity in which you operate, based on a scale from 1 to 5 (1 – low impact, 5 – high impact)?	Mean: 2.5304 Median: 3.00 Mode: 1.00 Sample Variance: 0.966 Standard Error: 0.06482 Skewness: 0.554 Kurtosis: 0.535
6. Do you find a set of digital tools useful to support your audit work?	Mean: 1.5391 Median: 2.00Mode: 2.00 Sample Variance: 0.250 Standard Error: 0.03294 Skewness: -0.158 Kurtosis:- 1.992
7. Documentation and record keeping is an essential step in the audit process. Do you consider that the use of digital technologies in audit techniques and tools could generate transparency in the audit process?	Mean: 1.4609 Median: 1.00Mode: 1.00 Sample Variance: 0.250 Standard Error: 0.03294 Skewness: 0.158 Kurtosis:- 1.992
8. Can internal audit activity be made more efficient through cooperation with other institutions with a control role?	Mean: 1.1565 Median: 1.00 Mode: 1.00 Sample Variance: 0.133 Standard Error: 0.02401 Skewness: 1.903 Kurtosis:- 1.636
9. The institution in which you undertake your activity falls into the category	Mean: 1.2348 Median: 1.00 Mode: 1.00 Sample Variance: 0.180 Standard Error: 0.44694 Skewness: 1.260 Kurtosis:- 0.417
10. The internal public audit structure within your institution is defined as:	Mean: 1.1043 Median: 1.00 Mode: 1.00 Sample Variance: 0.094 Standard Error: 0.02020 Skewness: 2.605 Kurtosis: 4.830
11. In which auditable areas did you undertake assurance missions during 2024?	Mean: 1.5609 Median: 1.00Mode: 1.00 Sample Variance: 0.579 Standard Error: 0.05018 Skewness: 0.932 Kurtosis:- 0.652
12. What is the degree of implementation of the recommendations made during the audit mission within your entity?	Mean: 3.3391 Median: 1.00Mode: 1.00 Sample Variance: 7.692 Standard Error: 0.18288 Skewness: 0.495 Kurtosis:- 1.659

Source: Self-representation based on the 138 validated questionnaires.

The dependent variable results from the interpretation of statistical data and this

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emerged that the hypothesis is validated; the digitalization of audit methods produces positive effects on the general management of the company in the agricultural field, with a significant impact on improving risk management within companies.

The study requires an analysis tool that identifies the interaction of the two factors: the dependent variable and the discrete, independent variables, based on a bifactorial analysis of variance by decomposing the total variation into residual variation.

The statistical interpretation of the results modeled using the SPSS program [17] is shown in Table 2a, 2b, 2c.

Table 2a Case processing summary

Case Processing Summary		
	N	Percent
Included	230	98.7%
Excluded	3	1.3%
Total	233	100.0%

Source: Self-representation based on Statistical Models

Table 2b. Target and dependent variable Q1/Item 1

Target	**Dependent Variable Q1/Item 1**
Automatic data preparation active	
Model selection method	Before starting a new model
New model knowledge criterion	-767.972

Source: Self-representation based on Statistical Models

The model considers statistics that are based on cases with valid data for all variables used, as presented in Table 3. The information criteria admit the complete probability function of the proposed model, with an accuracy of 86%. This aspect shows the fact that the digitalization of the audit is required, which could lead to the efficiency, effectiveness, and transparency of agricultural company expenses, and the current internal audit structure has the necessary resources to support the implementation of the activities due to be undertaken in this regard.

Table 2c. Goodness of Fit

Goodness of Fit[a]			
	Value	df	Value/df
Deviance	75.592	229	0.330
Scaled Deviance	230.000	229	
Pearson Chi-Square	75.592	229	0.330
Scaled Pearson Chi-Square	230.000	229	
Log Likelihood[b]	-105.301		
Akaike's Information Criterion (AIC)	214.603		
Finite Sample Corrected AIC (AICC)	214.656		
Bayesian Information Criterion (BIC)	221.479		
Consistent AIC (CAIC)	223.479		
Dependent Variable: Q1 Model: (Intercept)			
Information criteria in a smaller form are better.			
The full likelihood function is displayed and used in information criteria.			

Source: Self-representation based on Statistical Models

Tabel 3. Model checking

Tests of Model Effects			
	Type III		
Source	Wald Chi-Square	df	Sig.
(Intercept)	277.485	1	0.000
Dependent Variable: Q1 Model: (Intercept), offset = Q12			

Source: Self-representation based on Statistical Models

Tabel 3a Parameter estimates

Parameter Estimates										
			95% Wald Confidence Interval		Hypothesis Test				95% Wald Confidence Interval for Exp(B)	
Parameter	B	Std. Error	Lower	Upper	Wald Chi-Square	df	Sig.	Exp (B)	Lower	Upper
(Intercept)	-2.780	0.1669	-3.107	-2.453	277.485	1	0.000	0.062	0.045	0.086
(Scale)	9.998[a]	0.9323	8.328	12.003						
Dependent Variable: Q1 Model: (Intercept), offset = Q12										
a. Maximum likelihood estimate.										

Source: Self-representation based on Statistical Models.

Tabel 3b Model summary

Model Summary		
Target		Q1
Probability Distribution		Normal
Link Function		Identity
Information Criterion	Akaike Corrected	324.726
	Bayesian	328.142
Information criteria are based on the -2 log likelihood (322,709) and are used to compare models. Models with smaller information criterion values fit better.		

Source: Self-representation based on Statistical Models.

Tabel 3c Residual effect

Residual Effect						
					95% Confidence Interval	
Residual Effect	Estimate	Std. Error	Z	Sig.	Lower	Upper
Variance	0.234	0.022	10.700	0.000	0.195	0.281
Covariance Structure: Scaled Identity Subject Specification: (None)						

Source: Self-representation based on Statistical Models.

The implementation of digitalization would contribute decisively to reducing risk by spreading it across agricultural companies, in the sense of establishing risk factors and identifying activities, as can be seen from Table 3, 3a, 3b, 3c, which can generate behaviors that minimize the occurrence of the event that would produce the risk. The research result reveals that independent variables are a factor that influences the impact of risks associated with activities carried out at the company level. In this sense, the increase in the impact of independent variables determines a high level of risks associated with activities that are the subject of internal audit (by influencing the impact), which is why it is necessary to allocate a larger amount of time for the audit, since areas that present risks are usually audited annually. Therefore, as the impact of independent variables increases, the use of digital technologies to reduce the level of vulnerability should increase. This fact is decisive for achieving the dimensioning of the audit activity, implicitly the audit scope.

The research reveals the role of digitization and computerization of audit systems in formulating solutions for the management of agricultural companies regarding efficiency, economy and the harmonization of approaches for the purpose of formulating unitary recommendations, with a high level of traceability to the area of implementation of the recommendations. Thus, by auditing the agricultural sector, the aim is to identify the specificity, vulnerabilities and deficiencies of the system in order to remedy them by providing digitalized audit services, in order to identify, in the shortest possible time, vulnerabilities generated by factors such as regulation, market fluctuations, prices, competition, intrinsic factors such as soil, water, climate, pests. The questionnaire shows the impact of implementing digitalization in the field of internal audit within agricultural companies.

CONCLUSIONS

Following the digitalization of audit techniques, as well as the recommendations of audit missions, the management of agricultural companies will have various tools to maximize results, with an effect in terms of competitiveness and creation of added value, respectively well-being at the level of the branch of the economy.

By auditing organizational processes of strategic importance (e.g. financial-accounting, administrative, human resources) under an integrated vision with the managerial activity, a general picture, an overview of the institution can be formed. For these reasons, the internal audit must be a exclusive, complex and impersonal. In the opinion of the study, internal audit will be strongly influenced by technology, identifying the premises for a methodological and approach change at the level of data collected and analyzed, identification of causes that may generate the problem, formulation of recommendations that will give companies in the agricultural field premises for implementing the principles of performance management. To increase the effectiveness of audit missions and performance within audit missions, it is necessary to use multi-device means complementary to artificial intelligence systems that generate rapid advantages for the exercise of audit missions.

Once implemented, this model facilitates the activity of internal public audit, streamlines the activities of internal auditors and saves resources of companies in the agricultural sector, using artificial intelligence systems. The role of artificial intelligence is to alleviate the burden of laborious manual processes and to significantly simplify work processes. The ability to quickly evaluate massive data sets not only frees professionals for more valuable tasks, but also allows them to perform their work better. The risk estimation process becomes much more accurate as the amount of data analyzed increases [2]. Larger data sets mean more discrepancies, and auditors must examine them to determine whether or not there are deficiencies in the audit system. While the manual burden on auditors can be reduced, audit professionals can focus on generating strategic insights at the management level. In the process, auditors move from a purely assurance-based role to one in which they become key consultants for the development of agricultural companies [11]. Agricultural companies must offer auditors the chance to work with advanced technologies, thus developing human capital and, at the same time, providing the chance to create complex consulting and management assistance services. Reducing the burden of manual processes and offering staff the opportunity to exercise strategic thinking and analysis will improve the audit process.

At the same time, by developing IT systems at the audit mission level, methods of interactivity can be generated in adjacent systems, such as the internal managerial control system. The use of IT systems provides the premises for performance through a common approach to procedures, standards, contractual clauses, attracting providers of complex integrated services for the professionalization of the system. As a result of the research, we can appreciate that internal public audit, through the specific activities and tools used in carrying out audit missions, creates a mechanism for evaluating all activities in an agricultural company, while also being a promoter of the quality of consulting services, included finance and structural funds [12], [16].

The digitalization/computerization of internal audit, as appreciated by over 80% of the auditors included in this study, will primarily impact on increasing the degree of efficiency and effectiveness, but also on the reliability of this process, in the context of technological development and the increasing complexity of organizational processes, in organizations' attempt to adapt to changes in the external environment.

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EVALUATION OF HONEY QUALITY: COMPARISON OF THE PHYSICO-CHEMICAL COMPOSITION INITIALLY AND AFTER TWO YEARS OF STORAGE

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Abstract

The study presents the evaluation of the quality of honey according to its physico-chemical composition, both at the time of harvesting and after two years of storage. Important parameters such as sugar content, moisture, pH, enzyme activity and other characteristics are measured and compared to determine whether and how storage influences these properties. The results of the study may provide valuable information for the beekeeping industry and consumers, highlighting the impact of long-term storage on honey quality and safety.

Key words**:** *honey, storage, quality, physicochemical composition, analysis*

INTRODUCTION

Bee honey is a natural product that has been known and used for thousands of years for its exceptional nutritional and therapeutic properties. Chemically, honey is a complex mixture of sugars, water, enzymes, organic acids, amino acids, vitamins and minerals, together with several bioactive compounds with antimicrobial and antioxidant properties. Thanks to this unique composition, honey has remarkable stability and can be stored for extended periods of time without significant deterioration [1, 2, 3, 7]. However, optimal storage conditions play a crucial role in maintaining its physic-chemical and biological properties. The storage of bee honey involves factors such as temperature, humidity and exposure to light, which can influence crystallization, fermentation and degradation of active compounds. Research shows that honey has inherent antimicrobial activity due to its low water content and high acidity, but prolonged exposure to unsuitable conditions can lead to degradation of enzymes and changes in taste, colour and texture [8, 9, 10]. Thus, understanding the factors that influence the stability of honey is essential to ensure the long-term preservation of its nutritional and therapeutic qualities [4, 5, 6].

The aim of this work is to analyse the quality of honey before and two years after storage, studying the impact of environmental factors on the stability of its composition and providing practical solutions for efficient storage [17, 18, 20].

MATERIALS AND METHODS

The beehive where the flower nectar was collected is located in Cisnădioara, Sibiu County. The honey is decrystallized and prepared for sale in the laboratory at 117 A, Valea Argintului Street. In addition to the stationary beehive in the village, the farm also has a trailer pavilion with about 120 hives. The breed used is *Apis melifera carpatica Foti*, 1965. We used six varieties (linden, manna, acacia and hawthorn, polyflower and rapeseed) from 2018-2019 and three others (linden, acacia, polyflower) from 2021 for laboratory analysis.

The analyses were repeated after two years of storage.

Electrical conductivity measures the ability of honey to conduct electric current and depends on the concentration of minerals, organic acids and ionic compounds present in honey [11, 12, 13, 14, 15, 16].

Steps to determine the electrical conductivity of honey:

A. Preparation of the test solution

A solution of honey dissolved in distilled water was prepared. The standard proportion is 20% honey in water, which means that 20 g of honey is dissolved in 100 ml of distilled water. The solution must be thoroughly homogenized to avoid any inhomogeneous particles that could affect the measurement.

B. Calibration of the conductometer

A conductometer is a device used to measure the electrical conductivity of a solution. Before measuring the honey solution, the conductometer must be calibrated using standard solutions with known conductivity values. This step is essential to obtain accurate measurements.

C. Conductivity measurement

After calibration, the conductometer electrode is placed in the honey solution. The electrical conductivity measurement is usually made at a standard temperature of 20°C. If the solution temperature differs, a correction factor must be applied to adjust the conductivity value [11,12, 13, 14, 15, 16].

D. Conductivity calculation

Conductivity is measured in microsiemens per centimeter (µS/cm). The value read directly from the meter is the conductivity of the honey solution.

Steps to determine the pH of honey:

Determining Honey pH

1. Prepared a Honey Solution

Accurately weighing 10 grams of honey, Dissolved in 100 ml of distilled water. Distilled water serves to prevent impurities from affecting the pH measurement. I Stirred the solution thoroughly to ensure us that it's evenly mixed.

2. Calibrating the pH meter

Before measuring the honey solution's pH, We calibrated the pH meter using standard buffer solutions. This ensures accurate readings pH meter, a device that must be calibrated before use. Calibration is carried out using buffer solutions of known pH (usually solutions of pH 4, 7 and 9) so that accurate and precise measurements are obtained.

3. pH measurement

After calibration, place the pH meter electrode in the diluted honey solution. It is important that the electrode is clean and completely immersed in the solution, without touching the edges of the measuring vessel.

The temperature of the solution may influence the result, so measurements are usually made at room temperature (20-25°C), or corrections are applied if the temperature differs.

Procedure for determining the alkalinity of honey

The determination of alkalinity is usually done by an acid-base titration method, using a strong acid (such as hydrochloric acid) to neutralize the alkaline substances in the honey [11, 12, 13, 14, 15, 16].

Dissolve a specific amount of honey 5 g in a specific volume of distilled water (about 50 ml). We used distilled water so as not to influence the result. To facilitate visualization of the neutralization point, we added a pH indicator such as phenolphthalein.

This will change the color of the solution when all the alkali in the honey has been neutralized by the acid.

I gradually added a standardized acid solution, usually hydrochloric acid (HCl), until the solution changes color, thus signalling the equivalence point, the point at which all the alkaline substances in the honey have been neutralized.

The volume of acid needed to neutralize the honey solution is used to calculate alkalinity. This is expressed in milliequivalents of acid per kilogram of honey (meq/kg).

RESULTS AND DISCUSSIONS

A. The acid value of honey is a very important parameter that provides essential information about the quality and freshness of honey.

Here are some key aspects that highlight the importance of this index:

1. Freshness and honey quality indicator

The acidity of honey can increase with time and the fermentation process caused by micro-organisms.

Fresh honey has a relatively low acidity, whereas old or fermented honey will have a higher acidity. Thus, the acid value is a direct indicator of the freshness of honey.

2. Fermentation process control

If honey contains high levels of water and yeasts, it can start to ferment. During fermentation, the acidity of honey increases due to the production of organic acids (such as acetic acid).

A high acid number may suggest that honey has started to ferment, affecting both the taste and the safety of the product.

3. Counterfeiting and tampering detection

Low-quality honey that has been adulterated or mixed with other products may have a different acid value than pure honey.

By monitoring this parameter, it can be detected whether the honey has been diluted or chemically altered.

4. Conservation potential determination

Low acidity indicates that honey can be stored for a longer period of time without losing quality.

Conversely, high acidity may signal a shorter shelf life and the need for additional preservation measures.

5. The correlation with floral composition

The acidity of honey is influenced by its floral origin. Honey made from different flowers will have different pH levels because the nectar and pollen have varying acidity.

This parameter can be used to identify the floral source and hence the type of honey, providing a guarantee of authenticity.

6. Influence on taste and flavor

The acidity of honey contributes significantly to the taste and flavor of the final product. Honey with low acidity has a smoother and more balanced taste, while high acidity can impart a sharper and sometimes unpleasant taste. Thus acidity is essential for the organoleptic evaluation of honey.

In general, the acid value of good quality honey should be below 50 milliequivalents of acid per kilogram (meq/kg) according to international standards.

Exceeding this threshold may indicate that the honey is of inferior quality or has been stored under inappropriate conditions Table 1.

Photo 1 provides information about the laboratory tools used for making the chemical analysis of honey.

Table 1. Determination of acidity index

Honey type	Year	Quantity (g)	Titration NaOH (ml)	
Linden	2018	11.07	21.72	30.52
Manna	2018	10.79	35.54	37.42
Acacia	2019	10.34	13.82	34.46
Acacia and Hawthorn	2018	10.08	13.82	17.72
Polyflower	2019	10.84	29.61	12.80
Rapeseed	2018	10.04	9.87	17.72
Acacia	2021	11.37	-	15.75
Linden	2021	11.75	-	22.64
Polyflower	2021	10.30	-	41.35

Source: Own results.

The acid value of honey is an essential parameter in assessing the quality, freshness and authenticity of honey. It helps to detect the fermentation process, check the quality of the product and ensure optimal taste and flavor, thus guaranteeing consumer safety and satisfaction.

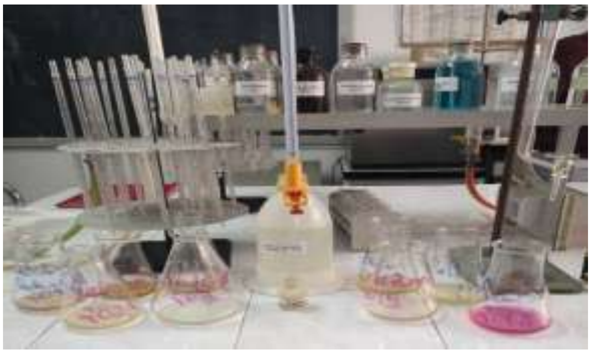

Photo 1. Honey acidity analysis, glassware, reagents and honey assortments
Source: original.

Our research found that four honey varieties — acacia and hawthorn, acacia, manna, and linden — became more acidic over time.
We also identified a decrease in the acidity of rapeseed and polyflower honey (Fig. 1).

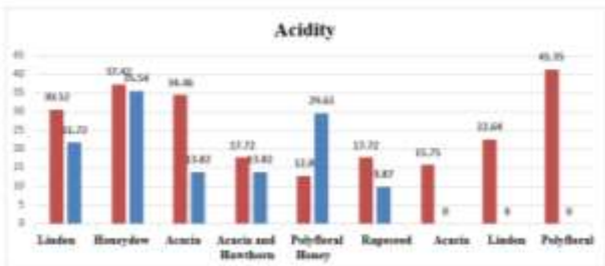

Fig. 1. Graphical representation of the values obtained after the determination of acidity
Source: original.

B. Determination of electrical conductivity of honey is an important method used to assess the purity and composition of honey, as it is an indicator of the floral source and possible contamination or unauthorized additions.

Honey derived from flower nectar typically exhibits low electrical conductivity, generally measuring less than 0.8 mS/cm.

It comes mainly from flower nectar and has a lower mineral content.

Manna honey (forest honey): has a higher electrical conductivity, usually above 0.8 mS/cm, due to its higher concentration of minerals and salts.

This comes from the excretions of insects that feed on plant sap.

Other honeys: The electrical conductivity of honey is influenced by a variety of factors, including the type of honey, the soil conditions where the nectar-producing plants grow, and the surrounding environment.

Measuring honey's conductivity is important because it helps us:

(i)Pinpoint the honey's origin: Conductivity acts like a fingerprint, providing clues about the types of flowers or plants used to produce the honey. This information can be used to verify the honey's source and ensure its authenticity.

For example, blossom honey and manna honey can be clearly differentiated by this test.

(ii)**Purity and quality evaluation**: Increased conductivity may indicate the presence of additional minerals that are not specific to natural honey, suggesting possible contamination or added substances.

(iii)**Determining geographical origin**: The mineral content of honey varies according to geographical region. Determination of conductivity can help to establish the regional origin of the product.

(iv)**Detection of counterfeit:** Abnormal conductivity may indicate that honey has been counterfeited or mixed with syrups or other synthetic products.

The determination of electrical conductivity is an essential parameter in the analysis of honey, providing valuable information about its composition and authenticity.

The method is fast, accurate and non-invasive, contributing to the correct classification of honey and ensuring a high quality standard. Regulations: STAS 784/3-2009 in Romania and 1151/2012 Europe [19].

Table 2. Determination of electrical conductivity

Honey type	Year	Electrical conductivity µS· cm-1	
Linden	2018	1.78	1.69
Manna	2018	1.29	1.67
Acacia	2019	0.80	1.73
Acacia and Hawthorn	2018	1.15	1.75
Polyflower	2019	1.38	1.63
Rapeseed	2018	0.61	1.79
Acacia	2021	-	1.72
Linden	2021	-	1.71
Polyflower	2021	-	1.67

Source: original.

The electrical conductance of honey analyzed in 2020 has values between 0.61 and 1.78 µS· cm-1;

The electrical conductance of honey analyzed in the year 2022 has values between 1.63 and 1.79 µS· cm-1.

Here it is easily observed that the electrical conductivity of honey assortments after storage for two years is higher (Fig. 2).

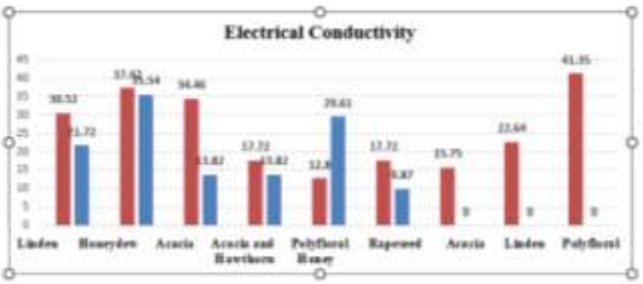

Fig. 2. Graphical representation of the values obtained after determining the conductivity of honey
Source: original.

C. Determining the acidity of honey, measured by its pH, is crucial for understanding its quality and properties. This acidity comes from natural components like organic acids, particularly gluconic acid.

The acidity of honey plays an important role in its microbiological stability and in preventing fermentation, and also contributes to its unique taste.

The pH meter will display a numerical value representing the pH of the honey solution (Fig. 3).

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Vol. 25, Issue 1, 2025
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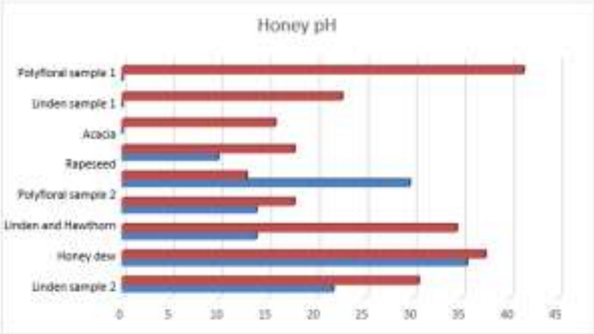

Fig. 3. Honey pH by type
Source: Original.

Honey is naturally acidic, typically with a pH between 3.2 and 4.5. Knowing the pH of honey is important because it can tell us about its freshness and overall quality.

(i) **Fresh honey** tends to have a specific pH, and any changes in that pH might suggest that it's not as fresh as it should be.

A higher acidity may suggest the presence of ongoing fermentation processes, while a lower pH indicates that the honey is less prone to fermentation and bacterial growth. Low pH also contributes to its microbiological stability.

(ii)Determining floral origin

The type of honey influences its pH level. Blossom honey and honeydew honey, for instance, have different amounts of organic acids and minerals, leading to variations in pH. Honeydew honey, with its higher mineral content, tends to be less acidic than blossom honey.

(iii) This **difference in acidity** affects the taste of honey. Honey with a lower pH has a sharper, more tart flavor, while honey with a higher pH tastes milder and sweeter.

Therefore, pH can affect the perception of honey flavor.

(iv)Indicator of degradation processes - If the pH of the honey is higher than typical values, this may indicate fermentation in progress or degradation of the product due to improper storage conditions.

Such a product may present an increased risk of microbiological spoilage and is not recommended for consumption.

The determination of the pH of bee honey is essential to assess its acidity and stability, helping to ensure product quality.

pH also plays an important role in the taste of honey and can be a key factor in identifying the type of honey and its floral source.

Legislation: SR 784-3:2009, 2009 in Romania and 1151/2012 in Europe.

Table 3. Determination of pH

Honey type	**Year**	**pH-ul**	
Linded	2018	5.11	4.37
Manna	2018	4.65	4.07
Acacia	2019	4.90	3.84
Acacia and Hawthorn	2018	5.47	4.30
Polyflower	2019	4.30	4.06
Rapeseed	2018	5.94	4.18
Acacia	2021	-	3.91
Linded	2021	-	3.93
Polyfloral	2021	-	4.03

Source: original.

A difference can be seen between the results in 2020 and 2022 two years after storage. After two years of storage of the honey samples a decrease in pH units can easily be observed.

D. The determination of the alkalinity of honey is a method used in the chemical analysis of this natural product to measure its ability to neutralize acids.

The importance of determining the alkalinity of honey

(i)Indicator of floral and geographical source:

The alkalinity of honey provides information about its content of alkaline substances (especially minerals), which may originate either from the natural composition of honey or from contamination or adulteration.

Figure 4 presents the values of total alkalinity by honey type.

The alkalinity of honey varies according to its floral source and the geographical environment in which the bees were collected. For example, honey from certain regions with mineral-rich soils may have a higher alkalinity. In contrast, floral honey, which comes from the nectar of flowers, usually has a lower alkalinity than honeydew honey, which comes from tree sap.

(ii)Verification of purity and quality: The alkalinity of honey can be a useful parameter to identify contamination or adulteration. An abnormal alkalinity value could suggest the addition of unapproved substances or exposure to improper storage conditions.

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(iii)Evaluation of the production process: Abnormal alkalinity levels may indicate m mishandling of the honey, including overheating, which can change the chemical composition of the honey, leading to deterioration in the quality of the product.

(iv)Determination of chemical stability: Too high or too low a level of alkalinity can influence the long-term stability of honey, affecting both taste and microbiological properties.

1. *Flower honey*: The alkalinity of floral honey is generally low, due to its lower content of minerals and alkaline compounds. It typically ranges between 0 and 1 meq/kg.

2. *Manna honey:* On the other hand, manna honey has a higher alkalinity due to the higher concentration of minerals and salts. Typical values for peanut honey are higher than 1 meq/kg.

3. *Deviation from normal values:* Abnormally high alkalinity may suggest the presence of contaminants or chemical changes during honey processing (e.g., excessive heating or the addition of additives). A very low alkalinity could indicate poor quality honey or possible dilution.

Honey from different flowers can have different levels of alkalinity, depending on the mineral composition of the nectar and pollen.

Apple honey usually has a higher alkalinity due to its plant source and higher mineral content.

Improper handling, such as heating the honey at high temperatures, can affect its chemical composition, changing its alkalinity. Determining the alkalinity of honey is a useful test for assessing the composition and quality of honey. Alkalinity can provide important information about the floral source, purity and potential contamination of the product. This is a simple and effective quality control method that helps to maintain high standards in honey production.

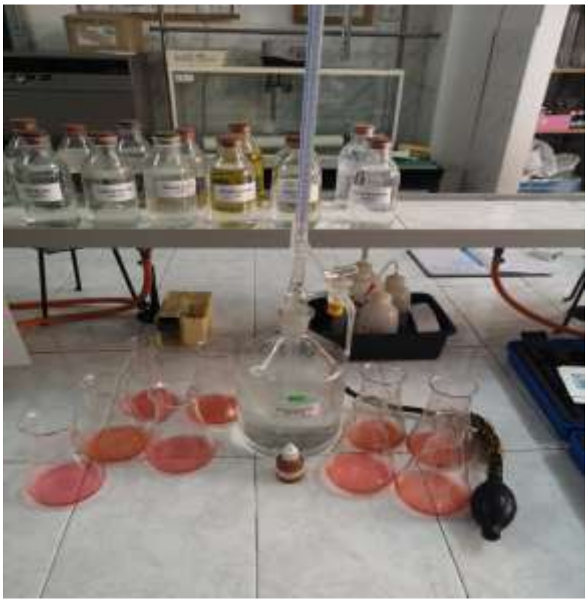

Photo 2. Honey alkalinity analysis, glassware, reagents and honey assortments
Source: original.

Comparing the results of alkalinity determination of bee honey between the years 2020 and 2022, we can observe:

-an increase in total alkalinity in honey from linden, acacia, acacia and hawthorn and polyflorous honey;

-a decrease in the total alkalinity of honey.

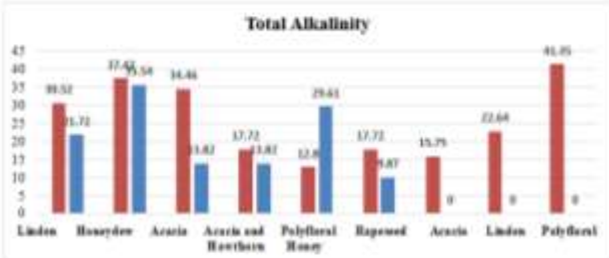

Fig. 4. Total alkalinity by honey type
Source: Original.

E. The water content of honey is an essential parameter for determining its quality and stability over time.

Too much water can lead to fermentation, affecting the flavor, texture and nutritional value of honey. In general, quality honey has a water content of around 16-18%. Accurate analysis is necessary to ensure these standards.

Why is it Important to Know the Water Content of Honey?

(i)To avoid spoilage: If honey contains too much water (above 18%), it can ferment. This happens because yeasts that thrive in sugary environments can grow and produce alcohol and carbon dioxide.

(ii)To ensure long-lasting quality: Honey with lower water content is more stable and can be stored for longer periods without spoiling or changing its texture and flavor.

(iii)To maintain high quality and value: Honey with a lower water content generally has a better texture and taste, making it more desirable and valuable.

What Factors Affect the Water Content of Honey?

(I'll need more information to answer this part! Factors that influence water content in honey include things like the nectar source, beekeeping practices, climate, and processing methods.)

Air humidity: During extraction and storage, honey can absorb moisture from the air. It is therefore recommended that honey is stored in dry, well-ventilated rooms.

Flower type: Different types of honey can have varying water contents depending on the source of the flower from which bees collect nectar.

The moment of honey collection from the combs. If honey is collected too early from the combs, it may contain more water than optimal.

In conclusion, determining the water content in honey is crucial to ensure the quality, safety and stability of this product.

Modern methods, such as refractometry and oven dehydration, provide accurate solutions for this process, helping to maintain high standards in honey production and marketing.

Regulations: STAS SR 784-3: 2009 in Romania and 1151/2012 in Europe.

Table 4 presents the determination of water content by honey type.

Table 4. Determination of water content in honey

Honey type	Year	Refractive index	Water (%)	Dried substance	Density
Linden	2018	1.4896	19.1%	80.9 %	1.4885
Manna	2018	1.4910	17.6%	82.4 %	1.4296
Acacia	2019	1.4785	23.4%	76.6 %	1.3946
Acacia and Hawthorn	2018	1.4873	20.1%	74.6 %	1.4580
Polyfloral	2019	1.4915	16.8%	83.2 %	1.4310
Rapeseed	2018	1.4920	18.9%	81.1 %	1.4930
Determination of water content					
Honey type	**Year**	**Refractive Index**	**Water (%)**	**Dried substance**	**Density**
Linden	2018	1.4896	19.1%	80.9 %	1.4885
Manna	2018	1.4910	17.6%	82.4 %	1.4296
Acacia	2019	1.4785	23.4%	76.6 %	1.3946
Acacia and Hawthorn	2018	1.4873	20.1%	74.6 %	1.4580
Polyfloral	2019	1.4915	16.8%	83.2 %	1.4310
Rapeseed	2018	1.4920	18.9%	81.1 %	1.4930
Acacia	2021	1.4885	19.2%	80.8%	1.4226
Linden	2021	1.4865	20.0%	80%	1.4170
Poliyfloral	2021	1.4925	17.6	82.4%	1.4334

Source: original.

CONCLUSIONS

This study is a rigorous evaluation of honey quality after a two-year storage period. The research was carried out on nine varieties of honey harvested from the Cisnădioara apiary and subjected to detailed physic-chemical analysis to assess changes in their composition. The nutritional value of the honey, mainly due to its high sugar content (70-80%), classifies it as a high energy food. In addition, the presence of vitamins, which come exclusively from the pollen and nectar of beekeeping plants, contributes to its quality. In this research, honey varieties were re-evaluated after two years of storage under controlled conditions, without exposure to moisture and light, in sealed containers, to observe whether and to what extent the physic-chemical composition was affected. The results showed changes in some parameters such as pH, acidity, alkalinity, conductivity and water content, but the organoleptic properties and water and dry matter content remained stable. These findings confirm that all assortments analysed are natural, with no added additives or sweeteners, retaining their authenticity even after two years of storage.

For not losing its quality and healing properties, honey must be preserved on a shelf in well-sealed glass jars, in a dark and dry place or with maximum 60% humidity, a cold room with a temperature of +20 degrees and also well ventilated and without any fungi. and molds.

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THE INFLUENCE OF THE CASTRATION METHOD AND THE WEIGHT BEFORE SLAUGHTER ON THE INDICATORS OF THE MEAT CUTS OF PIG CARCASSES

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Abstract

The aim of the article was to investigate the dependence of the slaughter characteristics of boars and the method of their castration on the weight before slaughter. To carry out the experiment, 30 surgically and 30 immunocastrated male pigs weighing 100, 110 and 120 kg were taken and reared under the same conditions in an industrial pig complex. After completion, the pigs were slaughtered and the carcasses were cut into cuts. The weight and content of the cuts were examined separately in the shoulder-scapular third, back-loin third and pelvis-femoral third of all groups of experimental pigs. According to the experimental results, the influence of the castration method on the weight and content of meat cuts, bacon pieces and bones in the shoulder-scapular third was found to be in favour of the immunocastrated boars. The weight and content of meat pieces in the posterior lumbar third were the same in surgically and immunocastrated boars, with the exception of bones. Meat pieces, bacon and bones in the pelvic femoral third of the pelvis did not differ between surgically and immunocastrated male pigs. Increasing the weight before slaughter from 100 to 120 kg had a positive effect on the weight and meat piece content of the piglets in both castration methods.

Key words: *meat cuts, pig carcass, lard, loin, belly*

INTRODUCTION

Immunological castration of boars is already widely used in pig farming, but its use is not yet as widespread as surgical castration [33, 42]. In addition to the influence of factors such as feeding factor [31, 32], genotype [29], pre-slaughter weight [43], transport conditions

[34] and pre-slaughter pig treatment [15], the method of castration is another factor influencing the quality of pork. The main purpose of pig castration is to eliminate the unpleasant "boar smell". It is known that the unpleasant smell of pork derived from wild boar can be minimised by reducing the concentrations of androstenone and skatol compounds in the fat and muscle tissue. Usually, the elimination of thissmell is achieved by castration [6] or without castration using methods of genetic selection, the addition of special feed additives and technological aspects of rearing and fattening [38]. However, it is known that the most common methods of eliminating "boar smell" worldwide are surgical castration with or without anaesthesia and analgesia, and immunological castration [40]. Raising pigs without castration is common in the UK, Ireland, Spain and Portugal. In the Netherlands, 80% of boars are reared without castration and 20% are castrated. Nineteen other countries in Central and Western Europe castrate about 80% of their pig population [17]. On average, the proportion of surgically castrated pigs in EU countries was 97.3% and the proportion immunocastrated was 2.7% [18]. However, it has been reported that surgical castration of boars in the European Union was performed with anaesthesia in 5%, with analgesia in 41% and without anaesthesia or analgesia in 54% [2]. Given the significant prevalence of surgical castration in the European Union, a strong initiative to end it has long been growing in society [8]. Surgical castration of male piglets without analgesia or anaesthesia is considered welfare-relevant and humane, and animal welfare would improve if it were performed with analgesia [44]. However, there is evidence that general or local anaesthesia during surgical castration in pigs causes additional health problems later on [10]. An alternative is therefore immunological castration [11, 21], which consists of two inoculations against gonadotropin-releasing hormone (GnRH) and uses the pig's immune system to achieve an effect at the level of surgical castration. It makes it possible to solve the problem of "boar smell" by minimising pain and aggressive [5] and sexual behaviour [11] characteristic of boars reared without castration.

Most farmers are very sceptical about immunocastration, although its effectiveness has been scientifically proven. Among consumers, three main factors influence the spread and acceptance of immunocastration in society. In particular, sensitivity to animal welfare and the high quality of pork without the "boar smell" contribute to the spread of immunocastration. But the question of the safety of pork from immunocastrated male animals is a cause for concern [28]. Farmers' fears about the widespread introduction of immunocastration are not unfounded, as not all pigs respond equally to the introduction of the vaccine. Some animals do not respond to the vaccine (so-called "non-responders") due to poor immunological response or technically incorrect vaccination [26]. The number of such pigs in the total population is 1-3%. Immunocastration reliably prevents the occurrence of "boar smell" only if farmers follow the manufacturer's recommendations for vaccination methods and dates [49]. Consumers generally rate the smell of meat and fat samples from immunocastrated boars better than those from surgically castrated boars [40]. Studies show that immunocastration of pigs improves some growth indicators and the quality of pig carcasses and meat [13]. Similar published data describe that the method of castration had no effect on the weight of major carcass cuts, with the exception of higher breast weight, leg content and weight in immunocastrated compared to surgically castrated pigs [3].

Immunocastrated pigs show intense fat deposition and consequently an increase in fat weight after immunisation [39], which leads to fattening the pigs to a higher weight before slaughter, which also affects the indicators of their carcasses [41]. At the same time, when the slaughter weight increases from 100 to 140 kg, the relative proportion of all meat parts in the carcasses decreases from 55.9 to 51.0% and the proportion of bacon increases from 27.4 to 33.5%. The content of high quality meat parts in carcasses decreases to 42.1%, which has a significant impact on the quality and price of pork [47]. An important reserve for increasing pork production is the higher weight of animals before slaughter. However, the question of the optimal weight condition of pigs for slaughter remains unresolved. Research has shown that fattening pigs to a high weight (120-130 kg) leads to an increase in feed costs per unit of growth and an increase in production costs. Slaughtering pigs at a lower weight helps to reduce feed costs and increase carcass production [7]. Published data indicate a significant increase in average daily gain after the second vaccination in immunocastrated pigs [30], resulting in a rapid increase in carcass fat content [16]. To curb the excessive fat content of carcasses from immunocastrated boars, some researchers attempted to restrict feeding. However, this had no significant effect on fat deposition and carcass leanness [14]. The result of such restriction of feeding of immunocastrates was only an increase in aggressiveness of the boars during fattening [45] or before slaughter [4]. However, there is a report of an effect of immunocastration resulting in lower carcass fat content compared to surgically castrated pigs [36, 22]. In addition, some researchers indicate that the castration method has no effect on the weight and percentage of carcass meat, except for the index of fat thickness in immunocastrated pigs, which was higher than in surgically castrated animals [35]. As stated in recent scientific works, the weight of the rear part of the carcass depended on 74.5% of the pre-slaughter weight and 6.07% on the castration method, and the weight of the loin depended on 39.7% on the pre-slaughter weight of pigs, on 5.78% on the method castration and by 9.46% depended on the interaction of the factors of castration method and pre-slaughter weight [1]. In addition, the relationship between pre-slaughter weight and androstenone content was demonstrated. It was found that with increasing live weight, androstenone levels increase from 0.60 $\mu g\ g^{-1}$ in 105-kilogramme boars to 1.02 $\mu g\ g^{-1}$ in 130-kilogramme animals [19].

Thus, both the castration method and the weight before slaughter influence the weight of the meat parts of the carcass. The use of the method of immunocastration of pigs accelerates their growth, leading to an increase in weight before slaughter, which probably increases the influence of this factor on the weight indicators of large-piece semi-finished products. The study of the dependence of the slaughter performance of pigs on the influence of the castration method at different weights before slaughter is of high relevance, since immunocastration is an alternative veterinary method that is still gaining widespread use among pork producers. The purpose of the experiment is to evaluate how immunocastration, surgical castration and mass before slaughter affected the slaughter characteristics in three parts of pig carcasses.

MATERIALS AND METHODS

Hybrid boars of F_1 sows (Irish Landrace × Yorkshire) and Max-Gro terminal boars were used to study the influence of castration method and weight before slaughter on the weight and percentage of meat cuts. The pigs were kept in Globinsky Pig Complex LLC, Poltava region, Ukraine.

Two hundred boars were selected to participate in the experiment. After the boars were born, two heads were taken from the nest by a sow with the same physiological development and weight. One of the two pigs removed from the sow was marked with a red plastic indicator and the other with a blue plastic indicator, which also bore an individual number.

One hundred boars with red indicators were surgically castrated on the second day of life. The other hundred analogues with blue indicators remained "intact" as they underwent immunological castration. For immunological castration, the vaccine Improvak was used, which was injected intramuscularly in a volume of 2 ml into the uncastrated piglets at 77 days of age and again at 125 days of age.

During fattening, 50 pigs were kept under technologically identical conditions in pens with an area of 40 m^2, the floor of which was completely slit and made of concrete. Feeding was 10 times a day with liquid complete feed mixtures, which had a ratio of dry feed to liquid portion of 1 : 3. The diet comprised feed produced at the Weda feed farm (Dammann & Westerkamp GmbH, Austria) on the premises of the pig complex, containing: wheat grain 35.6%, maize grain kibbled 19.2%, soybean seed meal solvent extracted 13.6%, sorghum grain 11.8%, cereals, screenings 10.2%, sunflower seed meal mechanically extracted 8.6%, wheat bran 1.0%.

The nutritional value of the feed contained the necessary micro and macro elements and vitamins required for normal fattening of pigs between 30 and 120 kg (Table 1).

Table 1. Nutritional value of feed for fattening

Indicator	Value
Protein content,%	18.5
Lysine content,%	1.0
Oil content,%	2.9
Fiber content,%	4.4
Calcium content,%	0.62
Assimilable phosphorus content,%	0.28
Total phosphorus content,%	0.59
Vitamin A content, IU kg^{-1}	10,000
Vitamin D content, IU kg^{-1}	2,000
Vitamin E content, IU kg^{-1}	100
Biotin content, µg kg^{-1}	100
Assimilable energy, MJ kg^{-1}	13.63

Source: own calculations.

The pigs were marked with a spray on the back skin after weighing, which divided them into 3 groups of 30 pigs each weighing 100, 110 and 120 kg (for surgically castrated) and into 3 groups of 30 pigs each weighing 100, 110 and 120 kg (for immunologically castrated). Based on Globinsky Meat Factory LLC, Poltava region, Ukraine, the animals in each group were re-weighed after a 24-hour starvation period and slaughtered according to ISO 23781:2021 [24]. After slaughter, the carcasses were weighed and then chilled at a temperature of 2 to -4 oC for 24 hours. At the end of the chilling period, the carcasses were divided into three anatomical parts: cervical-scapular, dorsal-lumbar and pelvic-femoral. Each anatomical part was cut into pieces of meat, bacon, bone and skin using generally accepted methods according to ISO 3100-1 [25]. During the experiment, the slaughter qualities of the boars were examined, including the weight and the content of the most valuable large pieces in the three specified parts of the carcass.

The statistical analysis of the experimental data series included the estimation of the mean value of the indicator, the determination of the error of the standard value and the determination of the standard deviation. The significance level of the discrepancy ($p \leq 0.01$) of the slaughter indicator values was determined using Student's t-test. All statistical analyses and calculations were performed in Microsoft Office Excel 2010.

European legislation on the humane treatment of experimental animals was taken as the basis for setting up the experiment to avoid the suffering of pigs [12].

RESULTS AND DISCUSSIONS

Examination of the slaughter qualities of the shoulder-scapular part of the carcass revealed a 4.80 kg or 21.05% higher weight ($p < 0.01$) in surgically castrated boars weighing 120 kg before slaughter compared to 100 kg in surgically castrated boars. Neck meat weight was 0.80 kg or 19.51% higher in surgically castrated boars weighing 120 kg compared to boars weighing 100 kg ($p < 0.001$) and 0.70 kg or 16.67% higher compared to boars weighing 110 kg ($p < 0.001$). The neck bone of surgically castrated pigs was significantly heavier at 120 kg, both compared to 100 kg boars by 0.50 kg or 25.00% ($p < 0.001$) and compared to 110 kg boars by 0.30 kg or 13.64% ($p < 0.01$). The value of the neck index in surgically castrated pigs was highest in heavy pigs (120 kg) compared to light pigs (100 kg) by 0.10 kg or 6.67% ($p < 0.05$). In 120 kg surgically castrated pigs, shoulder bone weight was 0.40 kg or 23.53% higher than in 100 kg pigs ($p < 0.05$), although no significant difference was found in shoulder blade meat weight between the groups. In 120 kg surgically castrated pigs, the value of the indicator for lard with shoulder exceeded the same indicator in 100 kg pigs by 0.50 kg or 29.41% ($p < 0.01$) and by 0.40 kg or 22.22% in 110 kg analogues ($p < 0.01$). Lard with skin was also 0.60 kg or 13.96% heavier in 120 kg surgical castrates than in 100 kg animals. No significant difference was found between surgically castrated boars weighing 100, 110 and 120 kg for other indicators of meat weight in the shoulder-scapular third of the carcass (Table 2).

The weight of the scapular part of heavyweight pigs was higher than that of light (100 kg) counterparts by 4.70 kg or 20.26% ($p < 0.05$). Also, the weight of the neck of pigs with 120 kg of pre-slaughter weight was probably higher than that of lighter peers by 0.60 kg or 13.95 ($p<0.05$). Immunocastrated pigs slaughtered at 120 kg were superior to both 100 kg and 110 kg animals in terms of neck bone weight by 0.60 kg or 31.58% ($p <0.001$). The output of neck single grade pork in immunocastrates weighing 120 kg was higher than in their peers slaughtered at 100 and 110 kg, relative to each group.

Table 2. Weight of large-piece semi-finished products in the shoulder-scapular third of the carcass, n=30

Pre-slaughter weight, kg	**100 kg**	**110 kg**	**120 kg**
Indicator	**Surgically castrated**		
Weight of the shoulder-scapular third, kg	22.8 ± 1.25^{aA}	24.5 ± 1.10^{bA}	27.6 ± 1.01^{bA}
Neck with bone, kg	7.6 ± 0.55^{aA}	7.9 ± 0.43^{aA}	9.1 ± 0.75^{aA}
Neck meat, kg	4.1 ± 0.12^{aA}	4.2 ± 0.09^{aA}	4.9 ± 0.13^{bA}
Neck bone, kg	2.0 ± 0.09^{aA}	2.2 ± 0.08^{aB}	2.5 ± 0.06^{bA}
Neck single grade pork, kg	1.4 ± 0.04^{aA}	1.5 ± 0.04^{abA}	1.6 ± 0.05^{bA}
Shoulder blade meat, kg	7.9 ± 0.51^{aA}	8.4 ± 0.63^{aA}	9.5 ± 0.72^{aA}
Shoulder bone, kg	1.7 ± 0.13^{aA}	1.9 ± 0.11^{abA}	2.1 ± 0.12^{bA}
Shoulder single grade pork, kg	1.7 ± 0.15^{aA}	1.8 ± 0.10^{aA}	2.0 ± 0.06^{bA}
Lard with skin, kg	3.9 ± 0.29^{aA}	4.3 ± 0.33^{abA}	4.9 ± 0.21^{bB}
Indicator	**Immuno castrated**		
Weight of the shoulder-scapular third, kg	23.2 ± 1.13^{aA}	24.8 ± 1.39^{abA}	27.9 ± 1.44^{bA}
Neck with bone, kg	8.0 ± 0.84^{aA}	8.1 ± 1.10^{aA}	9.5 ± 0.95^{aA}
Neck meat, kg	4.3 ± 0.13^{aA}	4.4 ± 0.18^{abA}	4.9 ± 0.20^{bA}
Neck bone, kg	1.9 ± 0.07^{aA}	1.9 ± 0.08^{aA}	2.5 ± 0.10^{bA}
Neck single grade pork, kg	1.7 ± 0.04^{aB}	1.7 ± 0.06^{aB}	2.0 ± 0.05^{bB}
Shoulder blade meat, kg	8.2 ± 0.65^{aA}	8.8 ± 0.50^{abA}	10.1 ± 0.43^{bA}
Shoulder bone, kg	1.8 ± 0.14^{aA}	1.9 ± 0.09^{abA}	2.6 ± 0.05^{bB}
Shoulder single grade pork, kg	1.8 ± 0.11^{aA}	2.1 ± 0.09^{bB}	2.1 ± 0.12^{abA}
Lard with skin, kg	3.8 ± 0.22^{aA}	3.7 ± 0.18^{aA}	3.9 ± 0.16^{aA}

Different lowercase letters (a, b) indicate statistical difference different weight categories of one method of castration (lines) at the level of $P <0.05$. Different capital letters (A, B, C, D) indicate statistical difference between different methods of castration of the same weight category (columns)at the level of $P <0.05$
Source: own calculations.

The shoulder meat of immunocastrates was also 1.90 kg or 23.17% heavier in 120 kg boars than in their 110 kg counterparts ($p <0.05$). Heavy immunocastrates (120 kg) had a higher shoulder bone weight of 0.80 kg or 44.44% ($p <0.001$) than light immunocastrates (100 kg) and 0.70 kg or 36.84% higher ($p <0.001$) than immunocastrates with average pre-slaughter weight (110 kg). Single-grade pork from the shoulder was 0.30 kg or 16.67% heavier in immunocastrated boars of 110 kg than in immunocastrated boars of 100 kg ($p <0.05$). Statistically significant differences between the weights of other cuts of meat were not found in immunocastrated pigs regardless of weight.

It was found that the weight of the neck bone in surgically castrated boars of 110 kg was 0.30 kg or 13.64% ($p <0.05$) higher than in immunocastrated boars of 110 kg, and in surgically and immunocastrated boars of 100 and 120 kg the difference was not present according to this indicator. Both the weight of pork of the same grade and the weight of the humerus were significantly higher in pigs that were immunocastrated at pre-slaughter weight of 100, 110 and 120 kg, except for light and medium weight pigs. The weight of pig shoulder with skin was 0.30 kg or 16.67% higher in immunocastrates weighing 110 kg compared to surgical castrates weighing 110 kg ($p <0.05$), while there was no difference in the value of this indicator in piglets of both castration methods in the 100 and 120 kg weight classes. The weight of lard with skin was 1.0 kg or 20.41% higher in surgically castrated pigs weighing 120 kg than in immunocastrated pigs weighing 120 kg ($p < 0.01$). For carcasses of boars weighing 100 and 110 kg for both castration methods, this indicator did not show statistically significant differences.

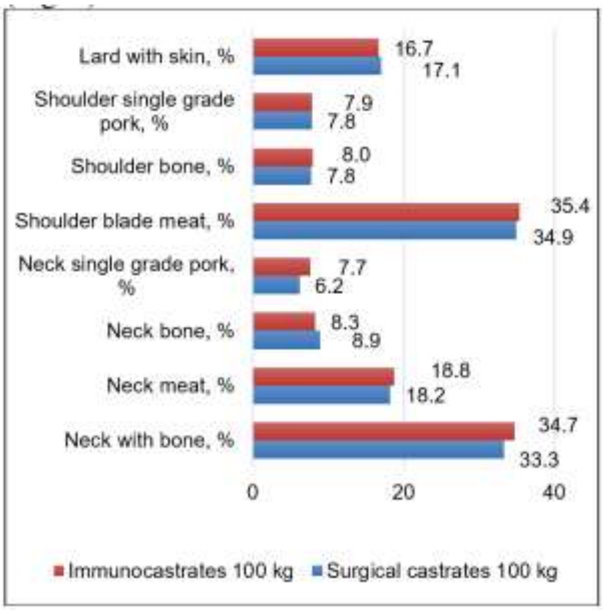

Fig. 1. The content of meat cuts in the shoulder-scapular third of the carcass of 100 kg pigs
Source: own calculations.

In lightweight pigs of 100 kg, the share of single-type necks was higher by 1.5% in immunocastrated compared to analogs that underwent surgical castration (Fig. 1).
Estimation of the share of cuttings of large-sized semi-finished products in the shoulder-scapular third of the carcass of 110 kg male pigs revealed a 1.5% and 1.0% higher content of shoulder single grade pork and neck single grade pork in immunocastrates and a 1.2% higher content of neck bone in surgical castrates (Fig. 2).
Heavyweight surgical castrates had a higher meat chunk content in the shoulder compared to surgically castrated counterparts by 1.6% shoulder meat and 1.2% neck pork of the same type.
At the same time, surgically castrated piglets had a higher lard with skin content of 3.7% in this part of the carcass (Fig. 3).

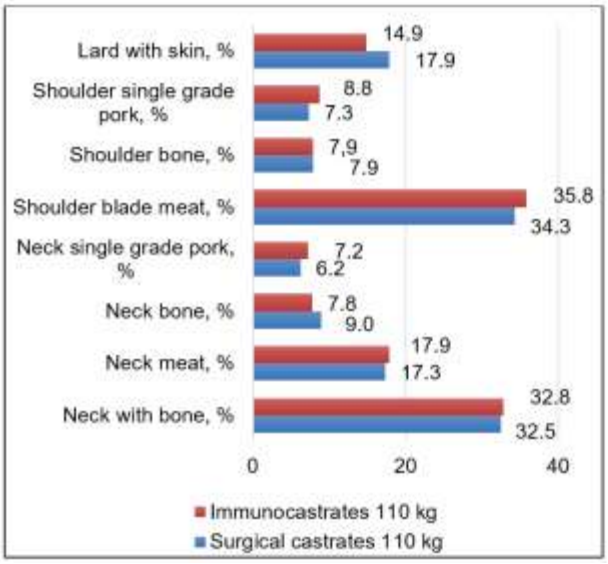

Fig. 2. The content of meat cuts in the shoulder-scapular third of the carcass of 110 kg pigs
Source: own calculations.

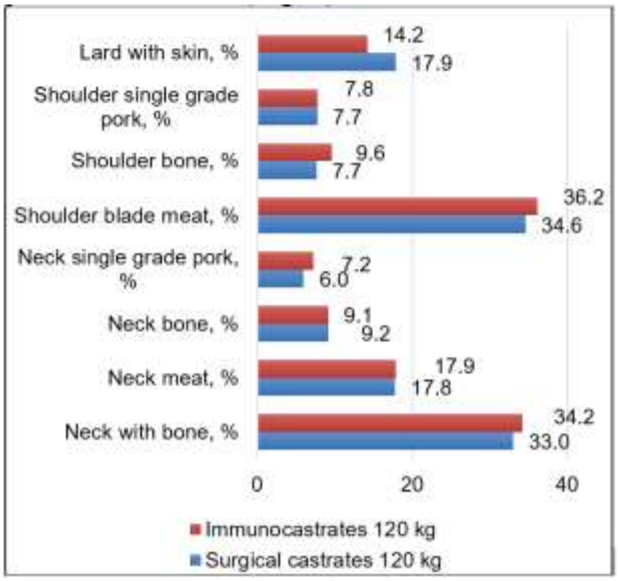

Fig. 3. The content of meat cuts in the shoulder-scapular third of the carcass of 120 kg pigs
Source: own calculations.

In surgically castrated pigs, the weight of the back- lumbar third of the carcass was 6.10 kg or 25.52% ($p < 0.05$) higher in 120 kg pigs compared to 100 kg pigs and 4.30 kg or 16.73% ($p < 0.05$) higher compared to 110 kg pigs (Table 3). In the 120 kg surgically castrated animals, the loin bone-in was also 2.6 kg or 23.64% heavier ($p < 0.05$) than in the 100 kg animals. Belly bone-in was also 3.6 kg or 28.13% heavier in heavy (120 kg) surgically castrated animals compared to light (100 kg) animals ($p < 0.05$). Lumbar bone of loin weight was 0.2 kg or 9.52% higher in 120 kg surgically castrated pigs compared to 100 kg pigs (p <0.01). Heavy surgical castrates outnumbered their lighter counterparts by 3.3 kg or 30.28% in abdominal weight, as well as peers with an average weight of 2.3 kg or 19.33%.

Table 3. Weight of meat cuts in the back-lumbar third of the carcass, n=30

Pre-slaughter weight, kg	**100 kg**	**110 kg**	**120 kg**
Indicator	**Surgically castrated**		
Weight of back-lumbar third, kg	$23.9±1.74^{aA}$	$25.7±1.43^{aA}$	$30.0±1.32^{Ba}$
Loin bone-in, kg	$11.0±0.81^{aA}$	$11.7±0.75^{abA}$	$13.6±0.77^{Ba}$
Belly bone-in, kg	$12.8±1.03^{aA}$	$14.0±1.10^{abA}$	$16.4±1.12^{Ba}$
Eye of loin, kg	$5.5±0.31^{aA}$	$5.7±0.29^{aA}$	$6.3±0.93^{Aa}$
Bone of loin, kg	$2.1±0.03^{aA}$	$2.2±0.05^{abA}$	$2.3±0.05^{Ba}$
Belly, kg	$10.9±0.98^{aA}$	$11.9±0.68^{aA}$	$14.2±0.61^{Ba}$
Bone of belly, kg	$1.9±0.04^{aA}$	$2.0±0.05^{aA}$	$2.0±0.05^{Aa}$
Single grade meat, kg	$0.3±0.01^{aA}$	$0.3±0.01^{aA}$	$0.4±0.02^{Ba}$
Spine lard with skin, kg	$3.0±0.52^{aA}$	$3.5±0.48^{abA}$	$4.6±0.40^{Ba}$
Indicator	**Immuno castrated**		
Weight of back-lumbar third, kg	$23.6±1.55^{aA}$	$25.9±1.33^{abA}$	$29.6±1.26^{Ba}$
Loin bone-in, kg	$10.8±0.82^{aA}$	$11.9±0.91^{abA}$	$14.0±1.11^{Ba}$
Belly bone-in, kg	$12.7±1.09^{aA}$	$13.9±1.13^{aA}$	$15.5±1.03^{Aa}$
Eye of loin, kg	$5.4±0.80^{aA}$	$5.8±0.55^{aA}$	$6.6±0.99^{Aa}$
Bone of loin, kg	$2.2±0.04^{aA}$	$2.3±0.06^{aA}$	$2.6±0.05^{Bb}$
Belly, kg	$10.7±0.57^{aA}$	$11.9±0.81^{abA}$	$13.3±0.76^{Ba}$
Bone of belly, kg	$2.0±0.06^{aA}$	$2.0±0.05^{aA}$	$2.2±0.06^{b*B}$
Single grade meat, kg	$0.3±0.01^{aA}$	$0.3±0.01^{aA}$	$0.4±0.01^{Ba}$
Spine lard with skin, kg	$2.9±0.30^{aA}$	$3.4±0.24^{aA}$	$4.3±0.38^{Ba}$

Different lowercase letters (a, b) indicate statistical difference different weight categories of one method of castration (lines) at the level of P <0.05. No the same capital letters indicate statistical difference between different columns at P <0.05
Source: own calculations.

The weight of single-grade meat in the back-lumbar third of the carcass was significantly higher in 120 kg surgically castrated male pigs and equally exceeded the value of this indicator in 100 and 110 kg pigs by 0.1 kg or 33.33% (p <0.001). Similarly, the weight of spine lard with skin was 1.6 kg or 53.33% higher in surgically castrated boars weighing 120 kg than in 100 pigs (p <0.05).
The weight of the back- lumbar third of the carcass in immunocastrated boars was 6.0 kg or 25.42% higher in animals weighing 120 kg compared to lighter conspecifics weighing 100 kg (p <0.01). It was found that the weight of the loin bone-in was also 3.2 kg or 29.63% higher in 120 kg immunocastrated boars compared to 100 kg animals (p <0.05). The weight of the loin bone was 0.4 kg or 18.18% (p <0.001) and 0.3 kg or 13.04% (p <0.01) higher in 120 kg immunocastrated boars compared to 100 and 110 kg animals, respectively.
Belly weight was 2.6 kg or 24.3% higher in heavy (120 kg) immunocastrated male pigs compared to light (100 kg) pigs (p <0.05). Bone of belly weight was also 0.20 kg or 10.00% (p <0.05) higher in 120 kg immunocastrated male pigs compared to 100 and 110 kg pigs. The weight of single-grade meat from the back- lumbar third of the carcass was 0.1 kg or 33.33% higher in 120 kg immunocastrated piglets compared to 100 and 110 kg conspecifics (p <0.001). A higher weight of spine lard with skin was observed in 120 kg immunocastrated pigs compared to their pre-slaughter counterparts weighing 100 kg, by 1.4 kg or 48.28% (p <0.01).
Heavyweight immunologically castrated males had a higher weight of loin bone in the back third of the carcass compared to peers who underwent surgical castration by 0.3 kg or by 13.04%. Bone of belly weight was 0.20 kg or 10.00% higher in 120 kg immunocastrated boars than in 120 kg surgically castrated boars (p <0.05). Pigs of different weight categories did not differ in the slaughter qualities of the back third of the carcass.

Also, leggy males, which were castrated by different methods, did not have differences in the indicators of meat offcuts in the rear third of the carcass (Fig. 4).

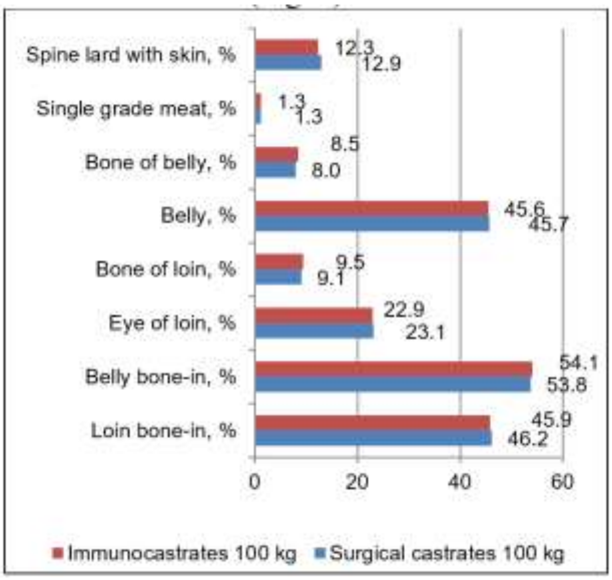

Fig. 4. The content of meat cuts in the back-lumbar third of the carcass of 100 kg pigs
Source: own calculations.

After both surgical and immunological castration of 110 kg pigs, statistically equal values were determined for the indicator content of the meat pieces from the back-lumbar part of the carcass (Fig. 5).

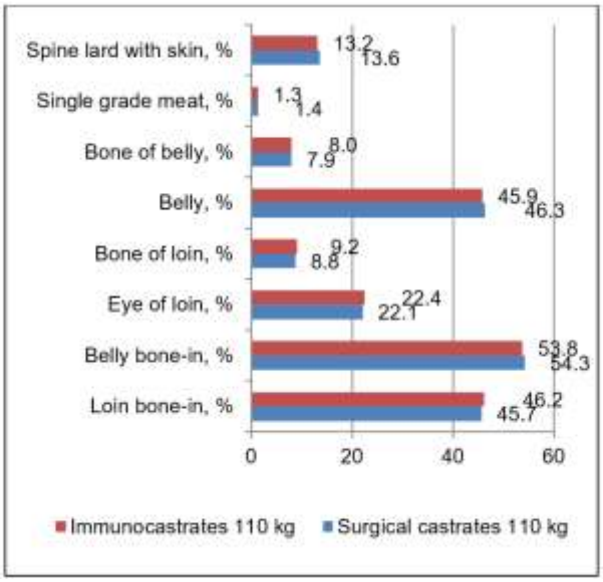

Fig. 5. The content of meat cuts in the back-lumbar third of the carcass of 110 kg pigs
Source: own calculations.

Immunocastrated pigs weighing 120 kg before slaughter had 0.6% and 1.2% higher content bone of belly and bone of loin compared to surgically castrated pigs, while there was no difference in the content of the other components in the back- lumbar third of the pig carcasses of this weight group (Fig. 6).

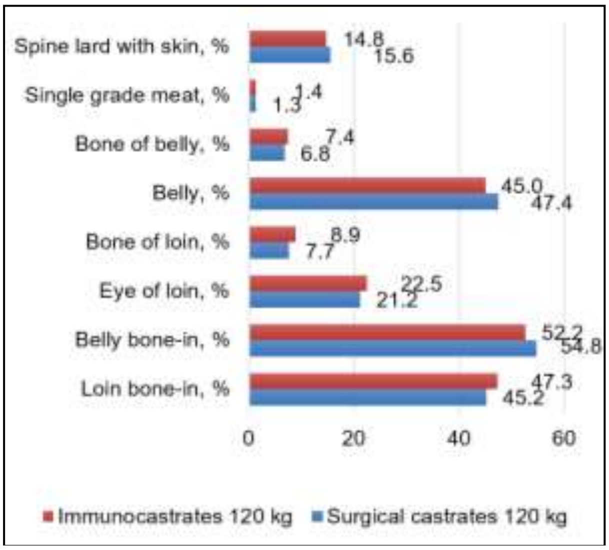

Fig. 6. The content of meat cuts in the back-lumbar third of the carcass of 120 kg pigs
Source: own calculations.

The weight of the pelvic-femoral third was 5.3 kg or 21.81% higher in surgically castrated boars in the heavy pig group (120 kg) than in their counterparts weighing 100 kg ($p <0.05$).
Immunocastrated piglets weighing 120 kg differed by the greatest leg weight by 3.0 kg or 18.52% ($p <0.01$) compared to their pre-slaughter counterparts weighing 100 kg (Table 4). The remaining cuts of meat from surgically castrated boars did not differ in weight between 100, 110 and 120 kg pigs.
The weight of the pelvic-femoral third in immunocastrated pigs was 5.1 kg or 20.90% higher in heavy boars (120 kg) than in light conspecifics (100 kg) ($p <0.05$).
Similarly, for boneless leg weight, the 120 kg immunocastrates were superior to the 100 kg and 110 kg analogues in leg boneless weight by 4.0 kg or 25.81% ($p <0.001$) and 2.5 kg or 14.71% ($p <0.05$), respectively.
It was established that the bone of leg was heavier in immunocastrates weighing 120 kg before slaughter compared to peers weighing 100 kg before slaughter ($p <0.05$).
Immunocastrated pigs, regardless of their weight, had the same large meat offcuts from the rear third. The weight of meat offcuts in

the hindquarters of pigs subjected to different methods of castration also did not differ. And the content of meat offal had no statistically significant difference in light-weight, medium-weight and heavy-weight pigs. (Fig. 7, 8, 9).

Table 4. Weight of meat cuts in the pelvic-femoral third of the carcass, n=30

Pre-slaughter weight, kg	**100 kg**	**110 kg**	**120 kg**
Indicator	**Surgically castrated**		
Weight of pelvic-femoral third, kg	24.3 ± 1.48^{aA}	26.7 ± 1.12^{abA}	29.6 ± 1.41^{Ba}
Leg boneless, kg	16.2 ± 0.77^{aA}	17.4 ± 0.64^{abA}	19.2 ± 0.65^{Ba}
Bone of leg, kg	2.2 ± 0.14^{aA}	2.4 ± 0.15^{aA}	2.6 ± 0.14^{Aa}
Tail, kg	0.3 ± 0.01^{aA}	0.3 ± 0.01^{aA}	0.3 ± 0.01^{Aa}
Single grade pork, kg	1.2 ± 0.08^{aA}	1.3 ± 0.07^{aA}	1.4 ± 0.08^{Aa}
Fat pork with skin, kg	4.2 ± 0.56^{aA}	5.2 ± 0.42^{aA}	5.7 ± 0.53^{Aa}
Indicator	**Immuno castrated**		
Weight of pelvic-femoral third, kg	24.4 ± 1.35^{aA}	26.2 ± 1.22^{abA}	29.5 ± 1.32^{Ba}
Leg boneless, kg	15.5 ± 0.66^{aA}	17.0 ± 0.80^{aA}	19.5 ± 0.73^{Ba}
Bone of leg, kg	2.4 ± 0.12^{aA}	2.5 ± 0.13^{abA}	2.8 ± 0.12^{Ba}
Tail, kg	0.3 ± 0.01^{aA}	0.3 ± 0.01^{aA}	0.3 ± 0.01^{Aa}
Single grade pork, kg	1.4 ± 0.09^{aA}	1.5 ± 0.09^{aA}	1.5 ± 0.07^{Aa}
Fat pork with skin, kg	4.6 ± 0.49^{aA}	4.9 ± 0.33^{aA}	5.2 ± 0.32^{Aa}

Different lowercase letters (a, b) indicate statistical difference different weight categories of one method of castration (lines) at the level of P <0.05. Different capital letters (A, B, C, D) indicate statistical difference between different methods of castration of the same weight category (columns)at the level of P <0.05
Source: own calculations.

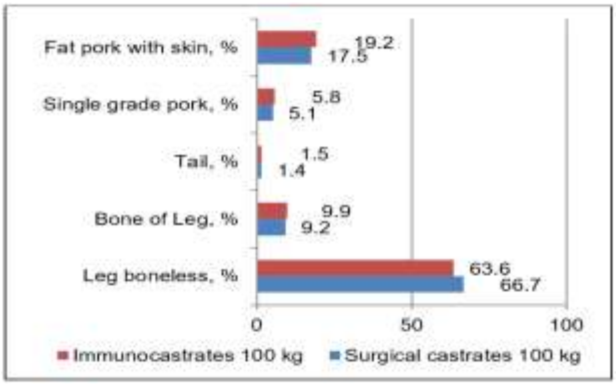

Fig. 7. The content of meat cuts in the pelvic-femoral third of the carcass of 100 kg pigs
Source: own calculations.

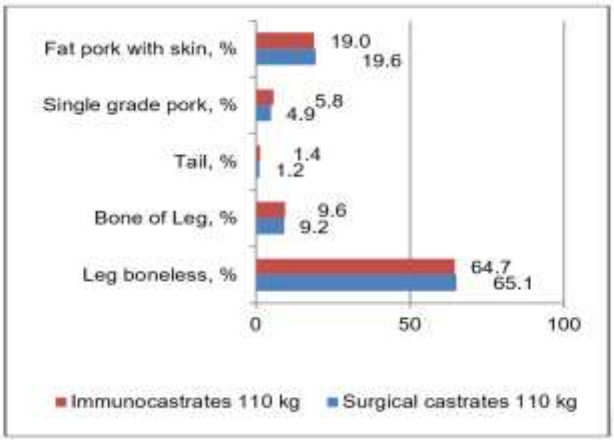

Fig. 8. The content of meat cuts in the pelvic-femoral third of the carcass of 110 kg pigs
Source: own calculations.

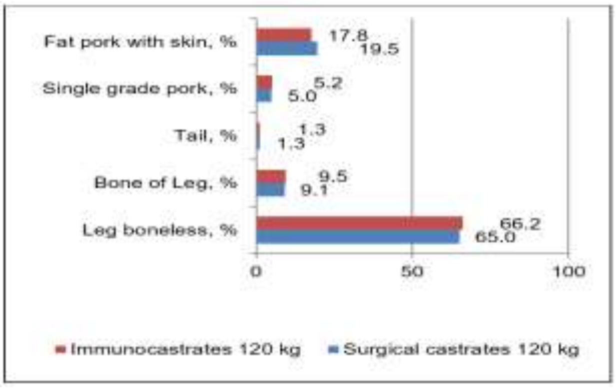

Fig. 9. The content of meat cuts in the pelvic-femoral third of the carcass of 120 kg pigs
Source: own calculations.

Similar to conclusions [1] about the influence of mass before slaughter on the weight of the back third of the carcass by 74.4% and on the weight of the loin, we obtained similar results of the influence of the factor characteristic on the studied slaughter qualities of the carcass. Also similar to the reports of similar studies about the different mass of the rear third of the carcass by 21.8% and by 20.0% in light-weight and heavy-weight pigs, both in immunologically castrated males and in surgically castrated ones, we reached similar results in our experiment. However, in our experiment, no dependence was found between the pre-slaughter weight and the loin portion, which contradicts the reports on its possible existence [27] at the level of 0.7% for the specified part of the meat cut, but agrees with another opinion [46] on the absence of such an effect not only on the weight of the loin but also on the weight of the neck meat, with which, however, our results do not agree. In contrast to the published manuscript [3], which reported the influence of castration method on carcass weight and percentage of belly meat, we also found no correlation between castration method and indicators of weight and percentage of belly meat. However, in our study, slaughter weight reliably influenced this indicator only in surgically castrated pigs.

The statement [3, 16, 35, 39] about more intense fat deposition and consequently an increase in lard weight after immunisation was not confirmed in our experiment. Instead of what was said [37] about the lack of influence of the castration method on slaughter qualities, we found a higher mass of fat in the shoulder part of the carcass in heavy-weight surgically castrated males compared to counterparts that underwent immunological castration, which is positively correlated with the results of the experiment [22, 36]. However, similar to the findings [47] on the increase in lard weight when increasing the pre-slaughter weight of boars from 100 to 140 kg, we found a similar increase in lard weight when increasing the pre-slaughter weight from 100 to 120 kg, but exclusively in the shoulder-scapular part of the carcass in surgically castrated pigs as well as in immunocastrated male pigs and in the back-lumbar part of the carcass in immunologically castrated pigs. We had somewhat contrary data in contrast to the publications [35, 37], which talked about the lack of influence of the castration method on the weight and proportion of carcass meat parts, as we found a reliable influence of the castration method on the weight and proportion of neck single grade pork, shoulder single grade pork and shoulder blade meat in surgically and immunocastrated boars.

Previously published scientific papers [9] have also pointed out that there is no reliable dependence between castration method and the weight of the neck bones, shoulder bones, bones of loin and bones of belly in the carcass, but we found that both castration method and pre-slaughter weight were reliably related to these indicators. Thus, in our experiment, neck bones were found to be heavier in surgically castrated boars and the bones of loin and abdominal bones were heavier in immunocastrated boars, which is consistent with the conclusions of other authors [20, 23] who also identified heavier bones in immunocastrates.

Considering the report [48] on the absence of any influence of castration method on pig carcass parameters, we can state the opposite, that there was an influence, but it was selective and not complete. The influence of the castration method in boars was reflected to a greater extent on the front and middle parts of the carcass than on the rear.

CONCLUSIONS

Immunocastrated pigs showed an advantage in terms of mass and proportion of neck, scapula and scapular meat relative to surgically castrated counterparts. But males that were castrated surgically had a higher content of bones in the third of the shoulder and fat and skin.

Immunocastrates also had greater vagus and posterior third lumbar and abdominal bone content than surgically castrated counterparts. The meat cuts in the pelvic-femoral thirds of the carcass showed no significant difference in weight and content in boars with surgical and immunological castration methods. Taking into account the influence of weight before slaughter, it was found that the weight and content of most meat cuts in the three parts of the carcass of 120 kg boars outweighed their lighter 100 and 110 kg counterparts for both castration methods. Therefore, immunocastration of boars ensured a greater weight of meat pieces. The combination of immunocastration and an increase in the slaughter weight of boars up to 120 kg made it possible to obtain more meat cuts compared to surgically castrated boars of the same weight.

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PRECISION LIVESTOCK FARMING AND ITS ROLE FOR ASSURING A SUSTAINABLE CATTLE MANAGEMENT- A STUDY CASE ON CONNECTED COW

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Abstract

Precision Livestock Farming (PLF) has emerged to help animal husbandry to become more efficient and sustainable. In this context, the goal of this research study is to describe "Connected Cow" as a groundbreaking evolution moment in cattle management, because PLF technologies are destined to revolutionize traditional practices. For setting up this work, a large range of research studies, technical reports, and industry case studies published between 2010 and 2023 have been used, been carefully selected, logically structured and assessed in a critical manner. The results proved that by utilizing IoT devices, sensors, and data analytics, the connected cow framework enables real-time monitoring of health, behavior, feeding patterns, reproduction, and production. This approach allows for data-driven management decisions, enhancing productivity, improving animal welfare, and reducing environmental impact. This paper delves into the connected cow's role in shifting cattle management paradigms, offering insights into its operational benefits and challenges, including data integration, cost barriers, and technology adoption. Future advancements in AI and machine learning are also discussed as enablers of predictive and adaptive management solutions. By emphasizing the integration of connectivity and management, the connected cow highlights a transformative path toward sustainable, efficient, and welfare-focused livestock farming.

Key words**:** *connected cow, precision livestock farming, IoT, cattle management*

INTRODUCTION

A number of technologies have changed the way that dairy farming is practiced and managed. This includes the use of artificial insemination, mass production of high-quality silages, mechanization of milking, but most importantly, the ability to provide large amounts of highly digestible diets to high-producing cows [25, 13]. These and other mechanistic approaches have arguably contributed to the magnitude of production we observe today for high-yielding cows. Widespread implementation of suboptimal periodic events has gone uncontested, however. Generic approaches that treat animal groups or the herd as a whole can have deleterious effects on animals within that group that are overlooked.

The era of digital transformation of farm management has begun and AI applications have started to be used on a large scale with a beneficial impact on the sustainability in agriculture [10, 27, 28, 33].

The AI tools have a beneficial role for a better understanding of animal function and perception of animal welfare in management systems [3]. There is public concern regarding many aspects of farm animal welfare, including restraint, mutilation, confinement, sensory deprivation, chronic boredom, and fear that is only alleviated by the illusion of control. Efficient technological advancements at the farm level have been well adopted and increased efficiency. These are of clear importance from a sustainability perspective. Increasing societal pressure on the human-animal relationship and other animal welfare concerns influences consumer demands [23,18].

Currently, we observe a societal transition to more interest in animal welfare, including how dairy cows are managed. From a philanthropic viewpoint, an ideal farm would produce without regard for economics, but from an economic viewpoint, an ideal farm would be low cost, highly productive, and economically stable [23]. Although factors besides welfare and efficiency are important in many modern dairy farms, they are essentially what are needed for contemporary society. Unfortunately, although more precise technologies are developed that may change the landscape of precision livestock farming and automated assessment of health and welfare, many are not realized or steadily adopted [18, 34].

In this context, the paper aimed to approach Precision Livestock Farming (PLF) in cattle management describing and emphasizing how IoT devices, sensors, and data analytics, the connected cow framework assure the monitoring of health, behavior, feeding, reproduction, production and many other aspects related to economic efficiency and profitability which contribute to the development of sustainability in cattle farms.

MATERIALS AND METHODS

This paper follows a systematic review methodology to analyze and synthesize the current state of knowledge on the "connected cow" and its role in Precision Livestock Farming (PLF) (Figure 1).

The review process was conducted in four stages: (1) defining the research scope, (2) identifying relevant literature, (3) applying inclusion and exclusion criteria, and (4) synthesizing the findings.

The scope of the systematic review was defined to include research studies, technical reports, and industry case studies published between 2010 and 2023 that focus on IoT technologies, data analytics, and their applications in cattle management.

The primary objectives of the review were to:
(i) analyze the key components of the connected cow framework,
(ii) evaluate its operational benefits and challenges, and
(iii) explore future advancements in AI and machine learning for predictive livestock management.

A comprehensive search was conducted across multiple scientific databases, including: Scopus, Web of Science, PubMed (for studies related to animal health and welfare), IEEE Xplore (for IoT and data analytics technologies), Agricultural & Environmental Science Collection. The keywords and Boolean operators used in the search included: "connected cow" OR "precision livestock farming" or "IoT in cattle management" "smart farming" and "cattle", "livestock sensors" and "data analytics", "real-time monitoring" and "animal welfare".

The search was supplemented by a manual review of references cited in key scientific journals and reports, as well as consultation with industry white papers and government publications. To ensure relevance and quality, specific inclusion and exclusion criteria were applied to filter the retrieved studies. Inclusion

Criteria included: Peer-reviewed articles, conference proceedings, and technical reports published in English between 2010 and 2023.

Studies focusing on IoT, sensors, and data analytics for cattle management, research discussing the operational benefits, challenges, or future trends of PLF technologies. Exclusion criteria included: Articles unrelated to cattle or livestock farming, studies focusing solely on other livestock species (e.g., poultry or swine),

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Publications with insufficient technical detail or methodology. Data were extracted from the selected studies using a structured framework.

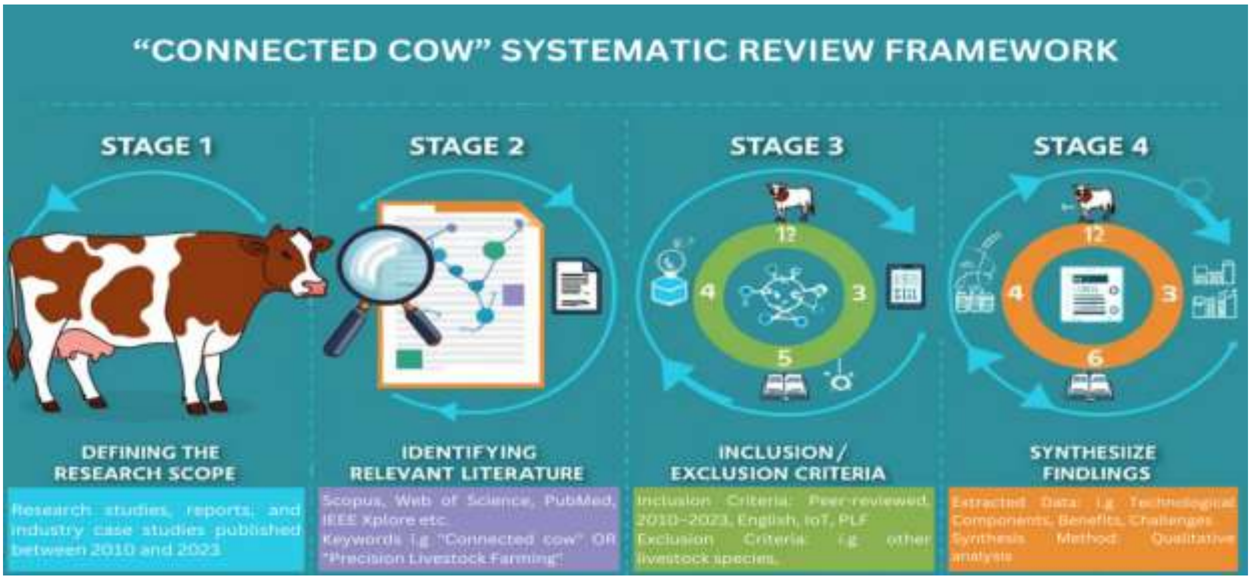

Fig. 1. Flow chart methodology used in thestudy.
Source: Author's own creation.

Key parameters recorded included technological components (i.g Types of IoT devices, sensors, and data analytics platforms discussed), operational benefits (i.g Metrics such as productivity gains, health monitoring improvements, and environmental outcomes), challenges (i.g. barriers to adoption, including cost, data integration, and farmer training), future opportunities (i.g Advancements in AI, machine learning, and predictive analytics). The extracted data were synthesized qualitatively to identify recurring themes and knowledge gaps.

To assess the methodological rigor of the included studies, each article was evaluated using the following criteria: clarity of objectives and methodology; relevance of results to the connected cow framework; robustness of data collection and analysis methods; peer-reviewed status of the publication; studies meeting at least 75% of these quality indicators were included in the final synthesis.

RESULTS AND DISCUSSIONS

This section presents and discusses the findings from the systematic review, organized into key themes: the evolution of cattle management, the concept of the connected cow, its operational benefits, and its transformative role in livestock farming. By tracing the progression of cattle management practices, we contextualize the significance of the connected cow within the broader framework of Precision Livestock Farming (PLF). The operational benefits, challenges, and implications of this technological shift are critically examined, along with insights into the paradigm shifts it drives in sustainable cattle farming.

Evolution of cattle management

On the Indian subcontinent, evidence of dairy cow management survives, inscribed in Harappan seals dating back to around 3300 B.C. or over 5000 years ago. This historical record attests that animals have been bred selectively worldwide for specific purposes, illustrating the close relationship and mutual dependency of humans with their cattle through generations [36]. This evolving relationship has fostered the rise of livestock farming, inadvertently shifting selected traits, such as hardiness, fertility, or milk and meat production to satisfy multiple human needs. Initially, on the extensive farm, farmers developed low-density mobility management systems for cattle in search of pastures and other natural resources, a lifestyle that has survived unchanged in some corners of the world and was once essential for many trade routes. Enclosure systems allowed animals to move and graze freely without the risk of wolves and other predators becoming a challenge. The Roman author described how in southern Italy farmers moved their agricultural estate from winter to summer pastures [16, 14].

Traditional cattle management has relied on labor-intensive practices and empirical knowledge passed down through generations. Monitoring livestock health, reproduction, and feeding patterns was conducted through manual observation, often leading to delayed responses to health or productivity issues. While effective in smaller-scale farming, these methods struggled to meet the demands of modern, large-scale operations [24] (Fig.2).

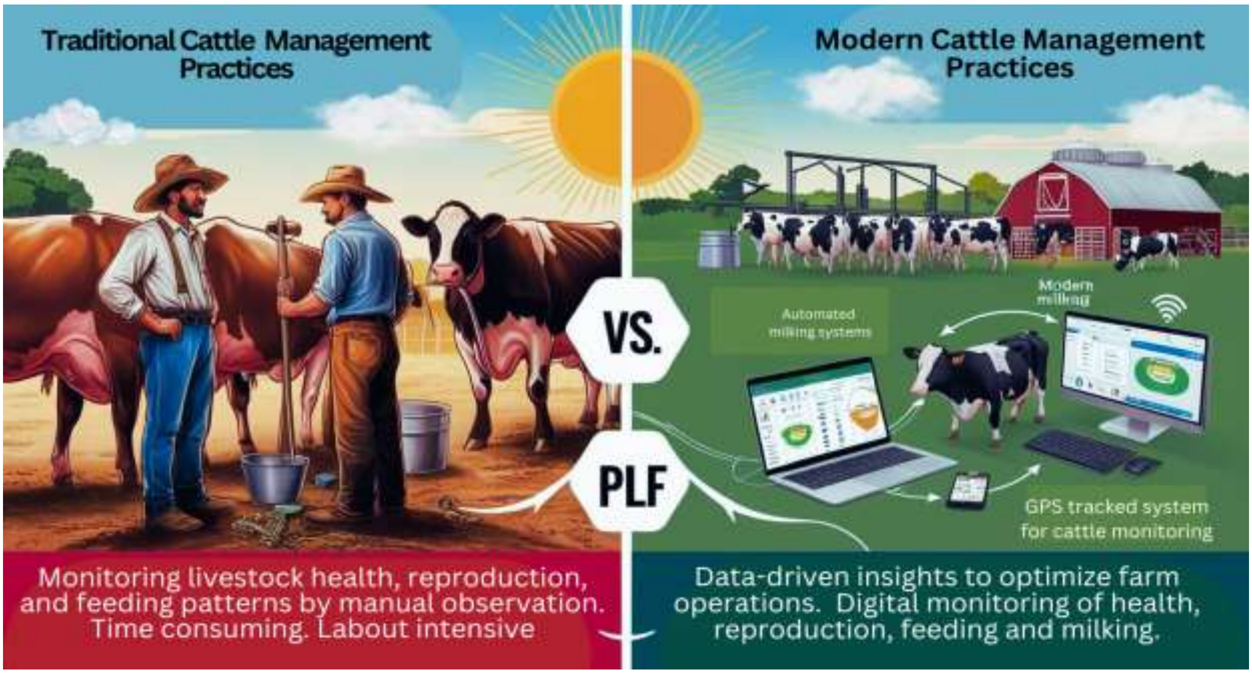

Fig. 2 Traditional cattle management practices vs. Moderna Cattle Management Practices based on Precision Livestock Farming (PLF)
Source: Author's own creation.

The concept of the "Connected Cow"

Today's conscientious consumer is increasingly focused on knowing about the products they're buying after witnessing many cases of lax regulation in consumer goods. It's no wonder so many people are demanding a higher standard as consumers [1, 30]. Yet much of the food produced in the world today comes from animals that are not fully tracked or managed using current technology to reach these higher standards.

It's hard to rectify the information age with a person's desire to know more about where their red meat or dairy products are coming from if no one knows where the cow has been [30, 17, 9, 19, 12].

The connected cow represents integrated system where individual cattle are equipped with IoT devices and sensors to collect data on health, behavior, feeding patterns, and reproductive status. These components work in tandem with cloud-based platforms, enabling farmers to access actionable insights via smartphones or computers [5, 31].

IoT devices such as wearable collars, ear tags, and rumen sensors serve as the backbone of the connected cow system (Fig. 3). These devices collect critical data points, including body temperature, activity levels, and feed intake. Advanced sensors can even detect early signs of illness or stress, prompting timely intervention and reducing the need for antibiotics or other reactive measures [20].

The data generated by IoT devices is processed using cloud computing and advanced analytics tools. Real-time dashboards and predictive algorithms allow farmers to monitor herd health, identify estrus cycles for improved breeding, and optimize feed efficiency. Machine learning algorithms are increasingly being utilized to detect patterns and predict potential health or productivity issues before they occur [4, 35, 29, 2]. Connected cow systems contribute to higher productivity by enabling precise monitoring of feeding and reproduction. For example, optimized feed intake monitoring reduces waste and ensures optimal nutrition, leading to higher milk yields and faster growth rates [35, 2]. Moreover, early detection of reproductive cycles allows for targeted breeding, improving reproductive efficiency [4].

Fig. 3 Precision livestock tools used within the "Connected Cow" Framework
Source: Author's own creation.

Real-time monitoring promotes animal welfare by enabling farmers to address health concerns at their earliest stages. Sensors can detect subtle changes in behavior or physiology that may indicate stress or illness, allowing for prompt intervention. By reducing the need for reactive treatments, the connected cow fosters a preventive approach to health management [32].

Efficient resource management enabled by connected cow systems helps minimize the environmental footprint of cattle farming. By optimizing feed conversion ratios and reducing methane emissions through better herd health, farmers can contribute to sustainable livestock production. Additionally, reduced reliance on antibiotics and other treatments aligns with global efforts to combat antimicrobial resistance [11, 26].

The economic impact of Precision Livestock Farming (PLF) in dairy farms

Precision Livestock Farming (PLF) significantly enhances the economic efficiency and sustainability of dairy farms by optimizing resource use, increasing productivity, and boosting profitability. The usage of land, animal shelters, herds, crops, materials, and labor may all be optimized with the implementation of PLF technologies. By automating processes such as feeding and milking, automated systems lower the amount of feed that is wasted, improve the management of animal health, and reduce the amount of work that is required. Consequently, this results in improved resource allocation and cost reductions.

Forage production and feed quality may also be improved through advanced monitoring tools. This, in turn, boosts milk production and quality, meeting higher standards and improving traceability. Better herd health management through PLF reduces veterinary costs and improves reproductive performance, further contributing to increased productivity.

By lowering production costs per animal and reducing the cost of milk per kilogram, PLF promotes economic sustainability. Higher revenues are generated from improved milk quality, increased calf sales, and higher gross output per cow. Financial performance indicators such as total profit, profit margins, and profit per cow or per liter of milk are significantly improved through efficient resource allocation and production optimization.

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Role in shifting cattle management paradigms

The concept involved in the connected cow framework means a major shift from clarification methods and reactive solutions to preventive and predictive methods [7]. Apart from the conventional rearing systems, the adoption of PLF technologies is of particularly importance for organic dairy systems, where the focus is on sustainable practices and minimizing environmental impact. Technologies such as real-time pasture monitoring, non-invasive health tracking, and automated manure management help organic farms maintain compliance with strict standards while improving productivity and profitability. For example, pasture management tools may help farmers to ensure optimal grazing without overuse, preserving soil health. Reducing the reliance on antibiotics and supporting of organic certification may be supported by the implementation of Non-invasive monitoring systems that allow for early disease detection.

Manure management technologies could contribute to the optimization of nutrient recycling, reducing environmental footprint and supporting sustainable farming practices.

The risks related to the implementation of PLF

PLF fosters sustainable cattle management by integrating technological advancements that not only reduce costs but also enhance profitability, paving the way for a more efficient and economically viable dairy farming industry. Yet, the widespread implementation of this framework is challenging, with data merging, equipment costs, and digital literacy of farmers being the primary barriers [21, 22, 6, 15]. Operating within the connected cow framework requires a team that includes technologists to address these challenges, while farming experts and policymakers play a vital role in overcoming these obstacles.

One significant risk is the high cost of integrating advanced technologies into farms, which creates financial strain, especially for smaller operations. The limited access to PLF tools based on farm size and available resources can exacerbate inequality among farmers, leaving many unable to adopt these innovations.

In large-scale farms, the reliance on fully integrated and automated systems poses another critical risk. A system failure could have devastating consequences, halting operations and causing significant economic losses. Furthermore, the use of intrusive tags and monitoring devices could impact animal welfare, raising ethical concerns and potentially influencing public perception.

As PLF expands, the close relationship between food security and animal welfare becomes more apparent. The improper implementation of PLF could jeopardize this balance, making it vital to ensure that sustainability goals do not compromise the welfare of livestock or the resilience of food systems.

CONCLUSIONS

The "connected cow" concept demonstrates that the cattle industry is capable of using technology in ways that dramatically change cattle operations and management in the PLF era. With the use of IoT devices, data analytics and real-time monitoring, this approach optimizes production and efficiency, promotes proper treatment of animals and minimizes negative effects on the environment. However, there is still a significant way to go for deep market penetration, some of which entails costs, data interface, and farmer education. The on-going development of artificial intelligence and machine learning will lead to the discovery of new forms of predictive and adaptive management that can likely enhance the productivity of herds. Thus, the concept of a connected cow is an evolving one, and it is the way to achieve the ever-increasingly more efficient, sustainable, and welfare-friendly form of livestock farming that can begin a new chapter in the agricultural history.

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QUANTIFICATION OF DOMESTIC WATER USE FOR ESTIMATING IRRIGATION WATER AVAILABILITY OF SMALL RESERVOIRS IN NORTHERN GHANA

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Abstract

In Sub-Saharan Africa, small reservoirs that collect unused surface water have a high potential to improve agricultural productivity if developed. However, since water from small reservoirs is used for multiple purposes, allocating water for domestic use is crucial and needs to be prioritized over irrigation water in irrigation planning from small reservoirs. Thus, this study quantifies the water used at home in some rural communities in northern Ghana to develop an estimation method of water availability for irrigation development in small reservoirs. The applied methods are questionnaire-based interviews and measuring containers installed with a sensor logger to obtain long-term data. The measurement period was two years and nine months, from June 2017 to March 2020. The results clarified the general water use situation and seasonal differences in household water use. Further, an equation to estimate the domestic water demand is proposed with a value of 30 L per person per day as a guideline for the amount to be secured as household water in irrigation planning from small reservoirs.

Key words: *household water, dugout, livestock, irrigation plan, productive water use*

INTRODUCTION

Among the various irrigation facilities, reservoirs that can store water throughout the year in climate zones with irregular rainfall patterns are gaining attention. Along with ongoing climate change, reservoirs are crucial for maintaining production resilience. It is estimated that the construction of small reservoirs can almost double the production of cereals in Africa, even if the reservoir capacity ratio is as small as one [19]. Considerable potential for profitable smallholder irrigation expansion in Sub-Saharan Africa has been revealed, and the potential for area expansion by small reservoirs has been estimated at 22 million ha [21], [22]. Water resources are sufficient to farm all potential cultivable areas in some countries, including Ghana, even when rain-fed and irrigated systems are fully operational [1]. However, water resources in Sub-Saharan Africa have not yet been developed to meet their potential [22]. In Sub-Saharan Africa, small reservoirs that collect unused surface water have a high potential to improve agricultural productivity if developed.

In Ghana, small reservoir development in rural areas is essential to rural development. Many studies have been conducted to evaluate the potential of small reservoirs and assess their effectiveness. Kawachi et al. [8] described a prototype reservoir's design and construction practices in Ghana. A manual was developed to install a pair-pond system for supplementary irrigation in the Northern Region of Ghana [10]. An assessment of small reservoirs found that despite economic incentives, the perceived patronage of irrigation in most dams was low, and the organized management and operations of small reservoirs were poor [2]. Water users require a more substantial educational support for water management [13]. In these circumstances, the government of Ghana promotes the development of small reservoirs through various projects such as the "One Village, One Dam initiative," which aims to provide all-year water availability for smallholder farmers, focusing on northern Ghana. However, criticism has arisen as reservoirs are underutilized for irrigation, and some do not meet the expectations of the beneficiaries [3].

A critical shortcoming of the small reservoir for irrigation development in northern Ghana is the lack of a concept for water allocation among various uses [14]. Reservoir water is used for multiple purposes [11], [5], [9], and domestic water should be prioritized over irrigation water [4]. Domestic water should be secured separately from irrigation water to avoid conflict between water use, and it must be estimated before small reservoir irrigation development is designed.

Domestic water estimation is difficult because limited data are available. The World Health Organization (WHO) [20] stated that a minimum volume of 7.5 L per capita per day will provide sufficient water for hydration and incorporation into food for most people under most conditions. However, this figure excludes activities such as bathing and laundry. Thomson et al. [18] determined the mean daily domestic water per capita used by piped and un-piped households in rural and urban areas, focusing on all domestic water-related activities, which varied from approximately 20 to 70 L, through interviews and direct measurements in East Africa. It has also been reported that domestic water volume primarily depends on access, which is determined by distance or collection time. The likely quantity of water collected per capita is often less than 5 L per day if the distance is more than 1,000 m or the total collection time is over 30 min, and unlikely to exceed 20 L per day if the distance is between 100–1,000 m or the collection time is 5–30 min [20], [7]. Another study reported that the average per capita daily use is approximately 10 L, with considerable variation, according to a literature review [16]. However, updated information on household consumption in Ghana is far more limited. Furthermore, most studies relied on interviews, observation, or measurement by unspecified methods [15] [17] due to the difficulty of accurately measuring for an extended period.

Thus, this study quantifies the water used at home in some rural communities in northern Ghana by using measuring containers installed with a sensor logger to obtain long-term data and develop an estimation method for the water availability of small reservoirs for irrigation development.

MATERIALS AND METHODS

Definition of domestic water

This study defines domestic water as water used for household activities that can be differentiated into four categories: i) consumption (drinking and cooking), ii) hygiene (bathing, washing, and cleaning), iii) amenity use (watering lawns, car-washing, and other non-essential tasks), and iv) productive use (watering livestock and kitchen gardens and beer-brewing) [18]. In rural Ghana, some domestic water is used at home, while others are used outside. In this paper, we refer to the water used at home "household water," which is mainly collected by women and is stored at home for their activities.

Site description

The study was conducted in three villages, Nwogu, Kpilo, and Mbanayili, in the Kumbungu District, Northern Region. They are located in the Savannah climate zone, which has one rainy season and a long dry season from November to March. Rain-fed cultivation and livestock raising are common in Kumbungu District. Each of the three villages has a small reservoir called a dugout. Dugout usually serves one to two villages and is said to be installed primarily for domestic use and livestock, with limited use for irrigation [12].

Access to public taps is limited in Kumbungu District, and residents depend on open water sources, including dugouts. The statistics [6] show that 19.9% of households drink water from public taps or standpipes. In comparison, 27.6% mainly drink from dugouts or dams. For other domestic use, 15.3% is from public taps or standpipes, and 32.3% is from dugouts or dams [6].

Women collect household water from these sources [21], by walking from a water source to their house carrying water on their heads. The collected water is stored in various containers at home.

Interview survey

Questionnaire-based interviews were conducted in 2014 to gather an overview of domestic water use by the residents of the three villages. The questionnaire consisted of i) household water use by women, ii) animal water use during the dry season, and iii) agricultural water use during the dry season. The questionnaire excluded uncommon practices such as household water use by men or amenity water use.

Eighteen households were selected based on recommendations from village contacts. Eighteen men who were the heads of households and 18 women who were the wives of the heads of households were interviewed separately.

Measurement of household water use

The volume of water use at home was measured using measuring containers installed in eight households in Nwogu and Kpilo. The duration was two years and nine months, from June 2017 to March 2020. The measuring containers had a radius of 0.3 m and a height of 1.0 m, and a water level logger (HOBO U20L) was installed at the bottom. The water level loggers recorded the hourly absolute pressure and temperature, which were converted to water depth using the temperature and independently measured air pressure. An increase in water depth greater than 0.02 m was considered as a water level rise because the water level sensors had a measurement accuracy of ±1 cm. The water level rise was converted into volume added to the containers.

In addition to the measurements, the number and size of other water containers at home were measured with measuring tape. Demographic information about the households was confirmed, and specific purposes of water use from the measuring containers were obtained through interviews conducted on women in each family.

In addition, daily rainfall data were obtained from the meteorological station in Tamale, the capital city of the Northern Region, during the measuring period.

Data analysis

The collected and measured data were analyzed using the Excel add-in software (Excel multivariate analysis ver.8 by ESUMI) to explore the factors that affect the amount of water used at home.

RESULTS AND DISCUSSIONS

Overview of domestic water use

The women's interview results on household water use revealed that the water stored at home was used for consumption, hygiene, and in the productive categories (Table 1). Dugout and tap water were used almost in the same manner, except for one woman who used tap water only for drinking. Tap water use was slightly less rated for bathing than dugout water use.

Table 1. Number of respondents who used water in each subcategory

Subcategory of domestic water use	Use water from a dugout	Using tap water
Drinking	18	18
Cooking	18	17
Laundry	18	17
Cleaning	18	17
Bathing	18	14
Rice parboiling	7	5
Shea butter making	15	14
Others	1 (brick making)	1 (brick making)

Source: Results of the survey.

It is noted that productive water use for shea butter and rice parboiling is common among women, as 15 out of 18 women (83%) performed shea butter making or rice parboiling.

Productive water use is recognized as the most water-consuming domestic water use by those who make shea butter or parboiled rice (Table 2).

The interview results for men and women revealed variations in animal watering. Most respondents took their animals to a nearby dugout or allowed them to go alone, while others gave water at home fetched from a dugout or tap (Table 3). It also shows that men are the primary users of livestock water.

Table 2. Productive water use by women

Respondent	Rice parboiling	Shea butter making	Most water-consuming activity
KF1	-	-	Bathing
KF2	-	*	Shea butter making
KF3	-	*	Shea butter making
KF4	-	*	Shea butter making
KF5	-	*	Shea butter making
KF6	*	*	Shea butter making
M1F	*	*	Shea butter making
MF2	-	*	Shea butter making
MF3	*	*	Shea butter making
MF4	-	-	Bathing
MF5	*	*	Rice parboiling
MF6	*	*	Shea butter making
NF1	-	*	Shea butter making
NF2	-	*	Shea butter making
NF3	*	*	Shea butter making
NF4	-	*	Shea butter making
NF5	*	*	Shea butter making
NF6	-	-	Laundry

* : yes, -: no
K, M, and N denote each studied site, and F denotes women in the respondents' column.
Source: Results of the survey.

All men interviewed used water for livestock drinking, while only five women used it to rear cattle, sheep, and goats.

Men are more likely to use water for agriculture than women. Seventy-eight percent (78%) of men use dugout water for agriculture during the dry season. The crops cultivated under irrigation include chili peppers, amaranthus, tomatoes, other vegetables, and nursery trees. In contrast, only one woman uses dugout water to grow okra, amaranthus, and nalta jute, while another fetches water from dugout to irrigate her husband's crops fields.

Quantity of household water use

The obtained data on the total volume of water added to the measuring container was multiplied by the equivalent number of water containers at home and then divided by the number of measuring days and number of household members at home to give the daily volume of household water per person (Table 4).

The calculated daily water uses per person varied from 3.8 L to 20.2 L among households. The average water consumptions of the two villages are 14.3 L for Nwogu households and 7.4 L for Kpilo households. The distance to the village dugout may cause discrepancies in the village averages because the distance to the village dugout is 800 m for Nwogu households and 1,400 m for Kpilo. This result is consistent with those of previous studies [20] [7], which reported the effect of water collection distance on the amount of water use.

The seasonal variation in water use was observed by the monthly average of the daily volume of water used per person and the monthly precipitation during the study period (Fig. 1). On average, 12.43 L per day per capita was consumed in the dry season and 5.75 L in the rainy season, taking months with more than 100 mm/month of precipitation as the rainy season and months with no rain as the dry season, with a significant difference ($t(7) = 3.93$, $p=0.0057$). Previous studies have reported conflicting results on seasonal differences in water use [16, 17]. The results of the present study support the idea that people consume more water during the dry season because of the vital necessity for hydration and their higher dependence on water stored at home.

The daily water use per person in the three households was less than or equal to 7.5 L, the minimum volume required to provide sufficient water for hydration and incorporation into food for most people under most conditions [12]. These small values may be caused by differences in the water use by the measuring container. For example, the calculation results could be underestimated if laundry was frequently performed at the dugout site. Given this uncertainty, the measurement results indicate households' water consumption capability.

Correlation between household water volume and various factors

A Spearman's rank correlation test was conducted to determine the relationship between the daily volume of household water use and the quantitative variables: the rate of children in a family, the number of housewives, and the amount of livestock watered from the measuring containers. As a result, no significant correlation was observed with the data obtained in this study (Table 5). Furthermore, the correlation ratio was calculated between the qualitative variables, the presence or absence of activities with water from the measuring containers, and the daily water volume used at home (Table 6).

Table 3. Livestock watering during the dry season

Respondent	Choice of dugout	Reason for the choice	Animal kinds
KM1	Kpilo dugout	The dugout is close	Sheep, goats
KM2	Kpilo dugout, tap water	The dugout is a community-owned and close	Sheep, goats
KM3	Kpilo dugout (fetching)	Fetch water to prevent loss of animals	Sheep, goats
KM4	Tap water (fetching)	Na	Cattle, Sheep
KM5	Kpilo dugout (fetching)	Have no child to lead animals to the dugout	Sheep, goats
KM6	Tap water and Kpilo dugout	Use dugout water when the tap is not functioning	Sheep, goats
MM1	Mbanayili dugout	The dugout is a community-owned	Cattle, sheep and goats
MM2	Any dugout accessible to animals	Animals choose	Sheep, goats
MM3	Mbanayili dugout and at home	Animals choose	Sheep, goats
MM4	Give water at home	Dugouts are far	Cattle, sheep and goats
MM5	Mbanayili dugout	The dugout is a community-owned	Sheep, goats
MM6	Nwogu and Mbanayili dugout	Animal chose	Sheep, goats
NM1	Nwogu dugout	The dugout is close	Cattle, Sheep
NM2	Nwogu dugout	The dugout is close	Sheep, goats
NM3	Nwogu dugout	The dugout is close	Sheep, goats
NM4	Nwogu dugout	The dugout is close	Cattle, sheep, and goats
NM5	Nwogu dugout	The dugout is a community-owned	Cattle, goats
NM6	Any dugout accessible to animals	Animal chose	Goats
KF4	Bira dugout (the place is unknown)	Na	Sheep
KF5	Na	Na	Sheep
KF6	Kpilo dugout	Na	Goats
MF1	Kpilo dugout	Na	Sheep
MF2	Mbanayili dugout	Animals or children who lead them choose	Sheep, goats

K, M, and N denote each studied site; M for men, and F for women, respectively, in the respondent's column.
Source: Results of the survey.

Table 4. Daily household water consumption per person

	N1	N2	N3	N4	K1	K2	K3	K4
Total volume of water added (m^3)	102.10	72.60	57.36	78.39	23.97	17.03	34.77	30.28
Total number of measurement days	1006.5	1006.5	1006.5	1006.5	828.6	1006.5	1006.5	1006.5
Number of water containers at home (equivalent to the measuring containers)	2.5	2.8	2.5	2.8	2.8	3.8	2	2.8
Number of household members	20	10	19	13	11	17	7	10
Number of children among household members	9	4	7	5	2	3	3	4
Daily water consumption per person (L per day)	12.7	20.2	7.5	16.8	7.4	3.8	9.9	8.4
Watered livestock from the measuring container	5	7	6	3	4	5	1	0
Water use from the container								
Drinking	*		*		*	*	*	*
Cooking	*	*	*	*	*	*	*	*
bathing		*	*	*	*		*	*
cleaning		*			*	*	*	*
laundry	*	*			*		*	*
shea butter		*	*					*
parboiling	*	*	*		*			*

The N-number indicates households in Nwogu, and the K-number indicates households in Kpilo.
Source: Results of the survey.

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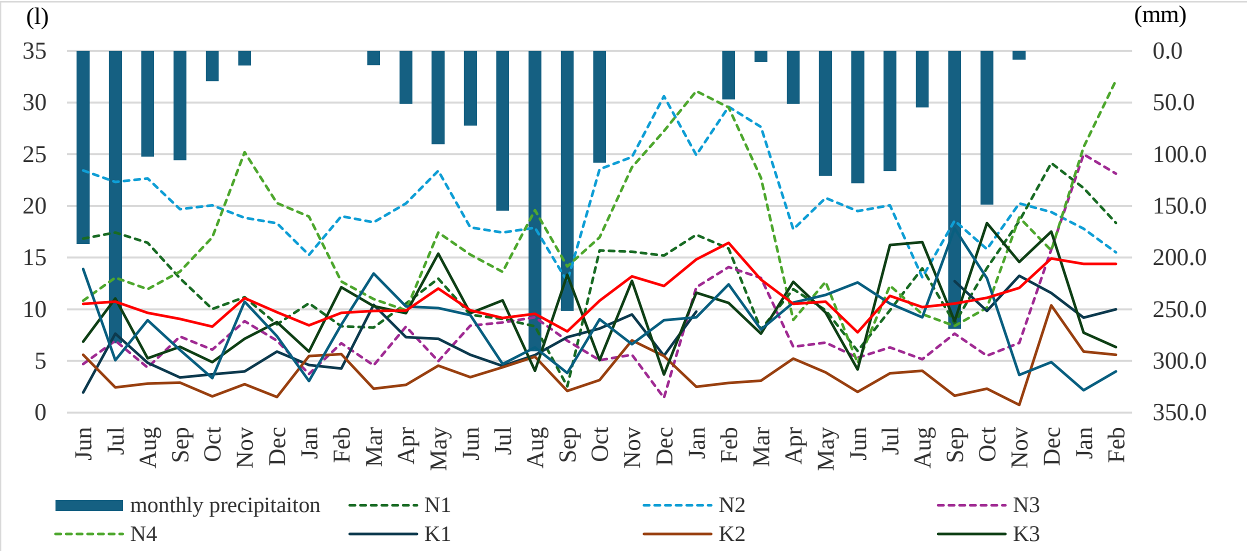

Fig. 1. Monthly average daily water volume per person and monthly precipitation from June 2017 to February 2020 in Tamale
Source: Results of the survey

Table 5. Correlation coefficients between the daily water volume per person and the quantitative variables

Variables	Correlation coefficient	*p*-value
Rate of children in the family	0.687	0.060
Number of housewives	-0.546	0.162
Amount of livestock water supplies at home	0.108	0.799

Source: Results of the survey.

Table 6. Correlation ratio between daily water volume per person and qualitative variables

Variables	Correlation ratio
Drinking	0.760**
Laundry	0.022
Cleaning	0.052
Bathing	0.019
Rice processing	0.082
Shea butter	0.123

***p* < .01
Source: Results of the survey.

The presence of productive activities was not correlated with water volume. This indicates the risk of depending on a recall survey because the interview showed that most women think productive water use is the most water-consuming activity. High water fetching load during productive activities may be linked to the perception that more water is being used than is the case.

The absence of drinking water from the container and the daily water volume were strongly correlated, with a correlation ratio = 0.760 and p-value = 0.005. In this case, less water is used when drinking water is taken from a measuring container. One possible explanation is that women who use more water tend to keep drinking water separately for hygiene. In future studies, measuring all water containers at home is recommended to avoid the risk of uneven water use.

Estimation of water availability in small reservoirs for irrigation development

The quantity of water available for irrigation development from a reservoir is given by equation (1) because domestic water should be prioritized over irrigation water [4].

$$V_{irrigation} = V_{reservoir} - V_{domestic}, \quad (1)$$

where: $V_{irrigation}$ is the irrigation volume, $V_{reservoir}$ is the reservoir water volume, and $V_{domestic}$ is the domestic water demand.

According to the interview results, domestic water can be divided into household water use at home, livestock water use at reservoirs, existing agricultural water use, and other water uses such as brick-making [2, 16] and laundry at reservoirs, as equation (2):

$$V_{domestic} = U_{house} + U_{livestock} + U_{agric} + U_{other}, \quad (2)$$

where U_{house} is household water use at home, $U_{livestock}$ is livestock water use at reservoirs, U_{agric} is existing agricultural water use, and U_{other} is other water uses.

Equation (2) makes it easier to proceed with further quantification than dividing domestic water use according to categories in [18] because equation (2) 's item corresponds to the leading water user group with the gender specified.

This study explored the factors that determine water use volume, but no significant factors were identified. Thus, estimating household water use based on the presence or absence of activities is inappropriate based on currently available data. The small sample size and the survey design, which assumes that all water is used in the same way as the measuring containers, limit the analysis of the relationship between water use and the amount of water. Further investigations of water use by the whole household with additional samples may provide a clearer picture of water use in the study area.

However, because domestic water is essential to daily life, irrigation plans must secure it. Therefore, it is proposed to use 30 L per person per day as a guideline for the amount to be secured as household water U_{house} in irrigation planning from small reservoirs. The figure is the largest among the figures from the measurement (Fig. 1), indicating households' consumption capabilities. Together with $U_{\mathrm{livestock}}$ and U_{agric}, applying existing studies on unit water requirements and the number of targeted animals or cultivated areas and other water use, if necessary, V_{domestic} and $V_{\mathrm{irrigation}}$ can be estimated.

CONCLUSIONS

This study employed a questionnaire-based interview and a new method of estimating household water use in rural areas: the measuring containers with sensor loggers to record the hourly water level changes in the containers in rural households. The interview results clarified the study area's general water use situation: most women perform productive activities, which they recognize as the most water-intensive; animal water use is common among men and women, and agricultural water use is common among men. The analysis of measured household water use provided insight into domestic activities and their water use: household water shows seasonal differences, the presence of productive activities does not affect the total household water volume, and the number of animals given water at home does not, either. The limitation of using a single measuring container at home is discussed, and the measurement of all containers at home is proposed for future study. Further, an equation to estimate the domestic water demand is proposed with a value of 30 L per person per day as a guideline for the amount to be secured as household water in irrigation planning from small reservoirs. This equation and the value can be used to estimate the domestic water demand and the water volume for irrigation from a multi-purpose reservoir, together with data on water for livestock and agriculture.

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LIVELIHOOD ACTIVITIES AND DETERMINANTS OF ADOPTION OF CLIMATE CHANGE ADAPTATION STRATEGIES AMONG FARMING HOUSEHOLDS IN OYO STATE, NIGERIA

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Abstract

Study gaps still exist despite the growing number of climate change and adaptation studies. Earlier studies frequently focus on the adaptation strategies used, but they need more understanding of the institutional and socioeconomic factors affecting these choices. Furthermore, although livelihood activities diversification is acknowledged as a coping strategy against climate shocks, more is needed to know about the direct relationship between livelihood activities and adopting adaptation strategies. This study examined livelihood activities and the determinants of adopting climate change adaptation strategies among farming households in Oyo State, Nigeria. A multi-stage sampling technique was used to select 120 farming households. Data collection was done with the aid of a questionnaire designed to meet the objectives of the study. Analysis of socioeconomic characteristics and choices of adaptation strategies was done using percentages. In contrast, a binary logistic regression model was used to establish the factors influencing the likelihood of adopting adaptation strategies. The result from the study indicated that the majority (94.1%) of the household heads were between 60 years of age and below, with an average household head being 48.5 years and more than half (60%) male. Adjustment of farming operation time was adopted by the majority (84.4%) of the farmers. The binary logistic regression model highlighted that the likelihood of adopting adaptation strategies by farming households included the household heads' age (β= 0.413), sex (β= 0.210), household size (β= 0.144), farm income (β= 0.454), access to credit (β= 0.147), membership of cooperative (β= 0.344), access to weather information (β= 0.165) and crop farming as a livelihood activity (β= 0.013). This study recommends that an adequate and timely supply of weather and climate change information be provided to the farmers and regular credit access, as this is crucial for improved adoption of climate change adaptation strategies.

Key words**:** *adaptation strategies, climate change, farming households*

INTRODUCTION

Given its significant contribution to the National Gross Domestic Product, agriculture plays a crucial role in the economies of West African nations. In addition to employing almost 70% of the rural population, it generated 500 billion USD in 2023, representing 25% of the National GDP. In spite of its contribution to the economy, the sector still needs to be developed primarily due to low levels of mechanization, poor infrastructure and vulnerability to climate change [10].

Globally, agricultural systems face severe problems due to climate change [9]. The livelihoods and well-being of farming households are at risk due to its detrimental effects on food security, water availability and natural resources, especially in vulnerable areas like Nigeria, where a large percentage of the population derive their living from agriculture [13].

Alabi et al. [2] in Osun State and Ogunjimi and Ikefusi [15] in Kogi State examined the various adaptation techniques and factors that influence the selection of adaptation techniques to lessen the adverse effects of climate change on arable crop production in Nigeria.

Furthermore, different regions of the world experience the effects of climate change in different ways, with developing countries bearing the brunt of these effects due to their lack of resources, technology, and capacity for environmental adaptation [3].

Nigeria is among the nations negatively impacted by climate change, mainly affecting its agricultural activities. Agriculture represents a major means of sustenance in the study area and the farmers are already managing with the effect of climate change as well as associated issues such as erratic rainfall patterns, temperature fluctuations, droughts and declining soil fertility [22]. Since the predicted temperatures and rainfall levels can no longer be relied upon, these erratic weather patterns can make it challenging to grow and maintain crops in areas that depend on farming as a means of livelihood [12]. Furthermore, farming households are more vulnerable due to these changes because they frequently need more institutional financial and technical assistance to appropriately respond to climate change effects.

Crop diversification, better irrigation techniques, and soil conservation are some climate change adaptation strategies advocated to lessen these difficulties [16]. Nevertheless, the adoption of these strategies and other institutional factors by farming households in Oyo State is still shallow. Socioeconomic characteristics, including age, income, education and access to financial services, influence the decision to implement adaptive measures. Additionally, farming households' means of subsistence further influence their adaptability. Many households participate in various income-generating activities as a coping strategy against climate-related shocks [17]. Nevertheless, it is unclear how much these livelihood pursuits affect adopting climate adaptation measures. Designing focused interventions that improve resilience and sustainability requires a deeper comprehension of the relationship between livelihood activities and the determinants of choices of adaptation.

Additionally, the majority of studies must concentrate on the ways in which institutional support such as credit availability and membership in cooperative societies can boost adoption choices. To fully understand the elements influencing farming households' adaptation to climate change, these gaps must be filled. This will support the development of policies and programs that would help farming households in Oyo State adopt workable strategies for adapting to climate change.

In order to better understand how agricultural households in the study area are using climate change adaptation techniques, this study looks at these objectives. Description of the socioeconomic characteristics of the farming households, identification of the various livelihood activities, examination of the different adaptation strategies employed by farming households, and analysing the factors influencing farmers' adoption of climate change adaptation strategies.

MATERIALS AND METHODS

Area of study

The study was carried out in Lagelu Local Government Area, Oyo State. Farming households in the study area were the respondents for the study. They are notably known for their extensive engagement in crop production activities such as growing of cassava, yam, cocoyam, vegetables, cocoa, kolanut, groundnut and melon. With coordinates of 8 00'N and 4 00'E, Oyo State is an inland state in the Southwest. Kwara State borders Oyo State on the North, Ogun State borders it on the South, the Republic of Benin borders it on the West and Osun State borders it on the Southeast. In 2022, its population is estimated to be 216,783,400 [20].

Sampling procedure

A multistage sampling process is used to choose farmers (heads of farming households) in the area of study. In stage 1, seven wards were randomly selected from the 14 wards in the study area. In stage 2, two (2) villages were randomly chosen from each of the seven wards to give a total of 14 villages. In stage three, 120 farming households were selected across the 14 villages based on a proportionate selection to size. This occurred due to an unequal distribution of farming households across the 14 villages. Minimum of eight (8) farming households. Primary data was collected with the aid of a well-designed questionnaire to meet the objectives of the study.

Analytical technique

Descriptive statistics such as frequencies, percentages and means were used to describe the farming households' socioeconomic characteristics, engagement in livelihood activities and the various adaptation strategies employed to cope with climate change. Logit regression was use to examine the determinants of adoption of climate change adaptation strategies among the farming households

Factors influencing adoption of climate change adaptation strategies among the farming households

Logit Regression

The determinants of adoption of climate change adaptation strategies among farming households in the study area was examined using a logistic regression model. The dependent variable (Y) in this binary choice model is dichotomous. The model was chosen because the probability estimate lies between a range of 0 and 1 The dependent variable takes the value of 1 if the farmer adapts to climate change by adopting any of the strategy and zero if otherwise. Also, they do not exhibit linear relationship with the explanatory (independent variables) but rather depend on the cumulative logistic distribution function expressed as:

P_i = Prob {Y = 1/X} = 1/1+e-z ....(1)

For easy interpretation,

$z_i = \alpha + \beta_1X_1 + \beta_2X_2 \ldots . \beta_nX_n$. ....(2)

Equation 2 can be stated in its odd ratio form as:

The log of odds ratio or the logit =
$Ln (P_i /1-P_i) = \alpha + \beta_1X_1 + \beta_2X_2 \ldots . B_nX_n$...(3)

where:
P_i = Probability of adopting climate change adaptation strategies.
β_i = parameters of the independent variables,
i = indexes of the households' observations.

To get the value of z_i, the probability of observing the sample among the respondents must be formed through the introduction of a dichotomous dependent variable Y_i such that Y is equals 1 if the respondent is adopting climate change adaptation strategy and 0 if otherwise. Maximum likelihood estimation (MLE) technique was used in the estimation of the model.

The model is explicitly written as:
Y = Respondents adoption of climate change adaptation strategies (climate change adaptation strategies adoption = 1; 0 otherwise)
X_1 = Household head age in years
X_2 = Household head marital status (married = 1; 0 otherwise)
X_3 = Household head sex (male-headed household = 1; 0 otherwise)
X_4 = Household size (number)
X_5 = Household head educational status (educated = 1; 0 otherwise)
X_6 = Monthly farm income (naira)
X_7 = Farming experience (years)
X_8 = Farm size (hectares)
X_9 = Access to credit (beneficiary = 1; 0 otherwise)
X_{10} = Land ownership (owned = 1; 0 otherwise)
X_{11} = Membership of cooperative societies (member = 1; 0 otherwise)
X_{12} = Access to weather information (access = 1; 0 otherwise)
X_{13} = Crop farming is a livelihood activity (yes = 1; 0 otherwise)
X_{14} = Livestock farming is a livelihood activity (yes= 1; 0 otherwise)
X_{15} = Trading is a livelihood activity (yes= 1; 0 otherwise)

RESULTS AND DISCUSSIONS

Socio-economic characteristics of farming households

Farming households' socioeconomic characteristics are shown in Table 1. The majority (94.1%) of the household heads were between 60 and below, with an average household head being 48.5 years. This suggests that a significant portion of the farmers are still in their ideal years for economic productivity and hence, are young. According to the results in the table, just 40% of the respondents were female, with a more significant proportion (60%) being male. This suggests that farming is a male-dominated activity, which is consistent with Oke et al.'s findings in 2022 [18].

A higher proportion (41.7%) of the household heads had primary education, a smaller percentage (15%) had tertiary education and 25% and 18.3% had secondary and non-formal education, respectively. This suggests that a larger portion of the household heads had some kind of education, which might have influenced their choice to embrace a strategy for adapting to climate change. Marital status showed that the majority (69.2%) of agricultural households in the study area were headed by married individuals. Considering that marriage is seen by society as a commitment and a responsibility, this showed that the majority of the respondents are accountable. Household size distribution showed that more than half (51.7%) of the households have 5-8 people in their households. The average household size was 5 people.

According to the study, the majority (47.5%) of the respondents had farming experience between 11 and 20 years, while a little (19.2%) had farming experience above 20 years. The average farmer had a farming experience of 14.8 years. Most (65.8%) of the farming households earned less than ₦100,000 monthly from their farming activities, with very few (3.3%) earning above ₦200,000. In addition, less than one-third earned between ₦100,000 and ₦200,000 monthly. The average monthly income among the farming households was ₦85,916.67.

Majority (94.2%) of the farmers are smallholders, as indicated by the fact that most of them owned between 1 and 5 hectares and only 5% had between 6 and 10 hectares. In terms of belonging to a cooperative society, the majority of respondents (89.2%) are cooperative society members, while very few (10.8%) are non-members. Many (84.2%) of farming households can access farm credit, while less than one-quarter (15.8%) cannot. It can also be seen from the table that there is a limited access to information on weather among the farming households going with the fact that a large number (85%) do not access weather information whereas just very few (15%) having access to information on weather.

Table 1. The socio-economic characteristics of farming households

Characteristics	Frequency	Percentage	Mean
Age (years)			
≤ 30	10	8.3	
31 – 40	45	37.5	
41 – 50	33	27.5	
51 – 60	25	20.8	
Above 60	7	5.8	48.5
Sex			
Male	72	60.0	
Female	48	40.0	
Educational level			
Non-formal	30	25.0	
Primary	50	41.7	
Secondary	22	18.3	
Tertiary	18	15.0	
Marital status			
Married	83	69.2	
Single	6	5.0	
Widow	22	18.3	
Divorced	9	7.5	
Household size (number)			
1 – 4	55	45.8	
5 – 8	62	51.7	
9 and above	3	2.5	5
Farming experience (years)			
1 – 10	40	33.3	
11 – 20	57	47.5	
21 – above	23	19.2	14.8
Monthly farm income (naira)			
< 100,000	79	65.8	
100,000 – 200,000	37	30.8	
> 200,000	4	3.3	85,916.67
Farm size (hectares)			
1 – 5	113	94.2	
6 – 10	6	5.0	
Above 10	1	0.8	2.7
Membership of cooperative society			
Yes	107	89.2	
No	13	10.8	
Access to credit			
Yes	101	84.2	
No	19	15.8	
Access to weather information			
Yes	18	15.0	
No	102	85.0	
Adoption of climate change adaptation strategies			
Yes	118	98.3	
No	2	1.7	

Source: Computed from Field Survey, 2023.

Furthermore, according to the result in Table 1, most (98.3%) of the respondents agree to be currently implementing at least one climate change adaptation strategy, while very few (1.7%) did not. This may be because most of the respondents are educated.

Livelihood activities among farming households

According to Gebru and Beyene [7], livelihood choices made by people are based on the level of their household assets or the availability of infrastructure in their community. Table 2 shows the frequency distribution of the farming households based on their primary occupation, as the majority of the farming households had numerous choices of livelihood. Crop production serves the main livelihood source as it is engaged in by the majority (77.8%). Also, very few (22.5%) were involved in livestock farming. Furthermore, a large number (65.7%) of the households engaged in trading as their source of livelihood. These findings conform to the earlier studies of [17, 1, 14], which stated that most rural households in Nigeria engage in multiple livelihood activities such as trading, small-scale business enterprises and processing of agricultural goods and arts and craft in order to supplement earning from farming.

Table 2. Distribution of farming households according to livelihood activities

Livelihood activities	Percentage*
Crop farmers	77.8
Livestock farmers	22.5
Trading	65.7

* implies multiple responses
Source: Computed from Field Survey, 2023.

Adaptation strategies for climate change

It is evident that the farmers in the area of study are informed of climate change and have taken a number of adaptation strategies to counteract the risks it poses to agricultural production. The various methods of adaptation employed by farmers in the study's location are displayed in Table 3. According to the table's results, 69.5% of respondents diversified their agricultural pursuits and 85.6% modified their operation time to favour greater output and returns. Nonetheless, 44.1% of farmers develop innovative solutions as part of their adaptation plans, while 51.7% step up irrigation operations. More so, 32.2%, 25.4% and 16.9% of the farming households adopted temporary migration to new sites, decreased the use of agricultural inputs and forests and restored damaged ecosystems, respectively. Only 1.7% of farming households do not use an adaptation strategy. The majority of farmers that adopted adaptation measures tended to combine different adaptation tactics, according to the multiple replies that were recorded. The outcome is consistent with previous reports of [4] that farmers employ a variety of adaptive measures.

Table 3. Adaptation strategies for climate change among farming households

Climate change adaptation strategies	%*	Rank
1.Farming operation time adjustment	85.6	1st
2.Agricultural activities diversification.	69.5	2nd
3.Irrigation intensification	51.7	3rd
4.Innovative solutions investigation and development	44.1	4th
5.Temporary migration to new sites	32.2	5th
6.Agricultural inputs usage decrease	25.4	6th
7.Damaged ecosystem restoration and forest replanting	16.9	7th
8.No strategy adopted at all	1.7	8th

* implies multiple responses
Source: Computed from Field Survey, 2023.

Factors influencing climate change adaptation strategies among farming households

The factors influencing farming households' decision to adopt climate change adaptation strategy was determined using a binary logistic regression. The model fits the data at ($p<0.001$) as indicated by the chi-square goodness of fit statistic (73.27). The goodness of fit demonstrated that the variables captured in this study were valid in explaining the factors determining a farmer's likelihood to adopt any adaptation strategy in tackling the climate change effect in the study's location. In addition, the pseudo R^2 value of (0.6839) shows that about 68% of the outcome (likelihood of adapting an adaptation strategy) can be determined by the selected independent variables captured in the model. Age, sex, household size, farm income, access to credit, membership of cooperatives and weather information access had a significant effect on the decision to adopt any adaptation strategies to mitigate climate change (Table 4).

Table 4. Logistic regression result of the factors influencing climate change adaptation strategies among farming households

Variables	Estimated B values	Standard error	z – value	p>|z|
Age	0.413	0.200	2.07**	0.001
Marital status	-0.461	0.719	0.64	0.522
Sex	0.210	0.040	5.25***	0.000
Household size	0.144	0.080	1.80*	0.046
Educational level	0.982	1.170	0.84	0.404
Farm income	0.454	0.112	4.05***	0.001
Farming experience	-0.098	0.122	0.80	0.423
Farm size	-0.756	1.114	0.68	0.498
Credit access	0.147	0.038	3.87***	0.002
Land ownership status	-0.942	1.541	0.61	0.541
Cooperative membership	0.344	0.091	3.78***	0.001
Access to weather information	0.165	0.019	8.68***	0.000
Crop farming is a livelihood activity	0.013	0.005	2.60***	0.000
Livestock farming is a livelihood activity	0.318	1.589	0.20	0.917
Trading as a livelihood activity	1.498	1.654	0.91	0.876
Constant	0.769	0.196	3.92	0.000
Log likelihood function	-100.552			
Chi^2 of Likelihood Ratio test (df = 15)	73.27			
Pseudo R^2	0.6839			
$Pro>chi^2$	0.000			
Number of observations	120			

Source: Computed from Field Survey, 2023
***, **, * implies Significance at p<0.01, p<0.05 and p< 0.10 levels respectively

The findings showed a strong and positive relationship between the farmer's age and the strategies they choose to adapt to climate change. This indicates that household heads are more willing to implement adaptation strategies as they get older, which is consistent with previous result of [5], which found a positive correlation between age and climate change adaptation.
Adopting a strategy to adapt to climate change was positively correlated with the sex coefficient, which was significant at 1%. This means that as you move from male to female, more male-headed households are more likely to choose an adaptation strategy than female-headed households. This result is consistent with [5], who found that male-headed families are more able to take risks and learn about new technology than female-headed households. In contrast, [8] found that households headed by females are more likely to implement climate change adaptation measures.
Strategies for adapting to climate change have a positive relationship with farm income, which is significant at 1%. This suggests that the possibility of using climate change adaptation techniques increases as farm income increases.
This conclusion confirms the findings of [5], who discovered that farming households with high farm income are more likely to implement climate change adaptation strategies.
Access to credit, which was significant at 1% has a positive relationship with adopting climate change adaptation strategies.
This suggests that when farming households secure more credit, the likelihood of implementing adaptive measures increases. The outcome unequivocally demonstrates the value of financing availability in easing farmers' financial barriers to agricultural technology investment.
This is consistent with the earlier investigations of [6] and [19], who found that more credit accessibility raises the likelihood of implementing adaptation measures. Adopting ways to adapt to climate change is

positively associated with cooperative membership, which is significant at 1%.

This suggests that embracing climate change adaptation solutions is more likely when one is a part of a cooperative society.

This finding is consistent with that of [5] and [11], who claimed that association membership raises farmers' awareness of coping mechanisms for the consequences of climate change.

When deciding whether to put climate change adaptation techniques into practice, access to weather information has a positive coefficient and was significant at the 1% level. This is consistent with the previous findings of [7] and [21], who also observed comparable outcomes.

Cultivation of crops as a source of livelihood was likewise important and had a positive effect at 1% significance level on the choice to adopt climate change adaptation measures.

This suggests that households involved in crop farming are more likely to use strategies for adapting to climate change than households involved in raising livestock or buying and selling activities.

This implies that crop cultivation is more affected by climate change than other sources of livelihood.

The table also showed that the likelihood of farming households implementing climate change adaptation measures is not significantly impacted by other factors, including marital status, educational attainment, experience in farming, size of the farmland and land ownership status.

CONCLUSIONS

While just 22.5% of farming households are engaged in the production of livestock, a sizable number (77.8%) are engaged in raising crops. Furthermore, only 1.7% of agricultural households did not adopt any climate change adaptation strategy, whereas the majority (98.3%) did. According to the study's findings on climate change adaptation strategies, 69.5% of the farming households varied their agricultural pursuits and 85.6% of them modified their operating hours to favour greater output and returns. Nonetheless, as part of their adaptation plans, 44.1% of the farmers create creative solutions, while 51.7% of the farmers step up irrigation operations. Furthermore, 32.2%, 25.4%, and 16.9% of the farming households, respectively, migrated temporarily to new locations, reduced their use of forests and agricultural inputs and repaired damaged ecosystems. According to the results of the logistic model, age, sex, household size, farm income, access to credit, cooperative membership and access to information on weather all have a significant impact on the likelihood that farming households in the study area will implement any climate change adaptation strategies.

Female farmers should be adequately equipped and trained to adopt adaptation strategies. Older farmers should be trained and encouraged to implement adaptation strategies. Farmers should try to join cooperative societies. Government policies should be restructured to properly address the needs of farming households to safeguard them from the effects of climate change by helping them with timely access to weather information. Government and private lending institutions should make credit readily available to farmers for better farming practices.

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EFFECT OF INFRASTRUCTURE DEVELOPMENT ON THE EXPANSION OF TOURISM BUSINESSES IN AGODI GARDENS IBADAN OYO STATE, NIGERIA

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Abstract

This study investigates how infrastructure development influences the expansion of tourism businesses in Nigeria using several regression analyses on data from 270 respondents. The study found that the security infrastructure positively and significantly influences the increase in tourism, with a coefficient of 0.496 and a t-value of 5.794 (p = 0.000). The communication infrastructure showed a negative influence with a coefficient of -0.275 and a t-value of -3.309 (p = 0.001). Utility infrastructure equally negatively affected tourism growth with a coefficient of -0. 201 and a t-value of -3.064 (p = 0.002). Furthermore, the study found a negative correlation between utility infrastructure and tourism growth, with a coefficient of -0.110 and a t-value of -2.252 (p = 0.032). The study ends with several suggestions: investing in better security infrastructure to increase safety, modernising communication systems to improve accessibility, addressing utility shortcomings by guaranteeing consistent energy and water supply, and strengthening financial infrastructure by improving credit access and reducing interest rates. These recommendations attempt to fix the infrastructure problems, thereby promoting the expansion of Nigerian travel agencies.

Key words: *infrastructure development, tourism expansion, businesses, Nigeria*

INTRODUCTION

People are increasingly realizing how important tourism is to the global economy and how much it can drive social development. Infrastructure development is heavily dependent on improving tourism experiences and ensuring continuous development. This research investigates the importance of infrastructure development in tourism, specifically referencing worldwide trends and Nigerian-specific observations. Infrastructure building is absolutely essential for global travel business expansion. Developing infrastructure spanning transportation networks, hotel facilities, communication systems, and utility services can help to draw visitors and enhance their experiences. Highways, railroads, and airports, among other efficient means of mobility, help visitors simply move to and from different points. Furthermore, contemporary infrastructure enhances the safety and comfort of travel, therefore affecting visitor satisfaction and return trips [13].

Furthermore, better infrastructure helps to diversify the tourism offerings. Creating cultural centres, museums, and entertainment venues, for instance, gives guests more options of activities, thereby extending their stay and increasing the tourism revenue. Important in the digitisation of tourism services as well is the integration of information and communication technology (ICT) into travel infrastructure, enabling more effective marketing and management of tourist destinations [3].

Sustainable infrastructure is another critical factor because it guarantees that the increase in tourism does not compromise environmental integrity. To help the long-term survival of tourism destinations, the Global Sustainable Tourism Council (GSTC) underlines the need for creating infrastructure that lowers negative environmental effects, such as pollution and resource depletion [6]. Infrastructure development is particularly critical given Nigeria's outstanding cultural and ecological legacy, which has outstanding tourism potential. Infrastructural development is especially important in that nation. However, poor infrastructure has significantly hampered the realisation of this promise. Unlocking Nigeria's tourism potential and positioning the country as a competitive tourist destination in Africa depends on improvements in utilities, housing, and transportation, as well as in infrastructure. Connecting tourism spots across Nigeria's several areas depend on the state of transportation infrastructure such as road networks, airports, seaports, among other things. Often, poor road conditions and restricted air connectivity have made it difficult for visitors to reach isolated but naturally significant areas [2]. Improving these infrastructure aspects will help to greatly increase visitor experience and access. Furthermore, the support of tourism operations in Nigeria depends on the evolution of utilities, including electricity, water supply, and telecommunications. Many tourist locations experience frequent power outages and insufficient water supplies, which lowers the quality of the services provided and therefore affects the overall visitor experience [5]. Improving tourism service delivery depends on addressing these infrastructure issues.

Investment in digital infrastructure is also required to modernise Nigeria's tourism sector. ICT's application in tourism marketing and management can raise the global awareness of Nigerian tourist locations, draw more guests, and enhance sectoral operational effectiveness[9].

We cannot overestimate the importance of infrastructure improvement for travel. Globally, infrastructure is the backbone of the travel sector since it makes it possible to provide services with efficiency and sustainability. Unlocking Nigeria's tourism potential and promoting economic development depend on addressing infrastructure gaps. Thus, the sustainable growth of tourism in Nigeria depends on calculated investment in security, utilities, and digital infrastructure.

Hypotheses

H01: Security infrastructure has no significant effect on the expansion of tourism businesses in Agodi Gardens, Ibadan.

H02: Communication infrastructure has no significant effect on the expansion of tourism businesses in Agodi Gardens, Ibadan.

H03: Utility infrastructure has no significant effect on the expansion of tourism businesses in Agodi Gardens, Ibadan.

H04: Financial infrastructure has no significant effect on the expansion of tourism businesses in Agodi Gardens, Ibadan.

Problem statement

Although economic development depends on tourism, its spread usually depends on enough infrastructure. Agodi Gardens in Ibadan, Oyo State, has enormous potential as a major tourist destination.

The gardens sit on 150 acres of land. At the beginning, Agodi Gardens were named **Agodi Zoological and Botanical Gardens and were** created in 1967. In 1980, the garden was destroyed by the Ogunpa flood disaster when most of the animals were swept away by the raging water. In 2012, The Oyo State Government started to renovate the gardens which were reopened in 2014.

It was founded as a biological and recreational centre as well as a source of educational services both for inhabitants and visitors who want to spend time, learn about and enjoy admiring the nature in the garden and animals. It is a reference meeting point for botanists, zoologists, environmentalists, naturalists and users of medicinal plants. It was created as a gene pool and biodiversity complex and amusement park.

Its recovery after more floods transformed the gardens into a modern theme park and zoological garden [12, 8,10].

However, infrastructure in this garden is very important for the expansion of tourism-related companies.

In this field, current research does not thoroughly investigate the link between infrastructure development and corporate expansion. By looking at how infrastructure affects the expansion and sustainability of tourism companies in Agodi Gardens, this study seeks to close this gap. The results aim to provide stakeholders and legislators with practical information so they can improve tourism growth in this and related areas.

Literature review

Theoretical framework

Simon Kuznets's substantially developed Economic Development Theory from the 1950s offers a basic framework for appreciating the part infrastructure plays in economic development. According to Kuznets' thesis, promoting economic development depends critically on infrastructure enhancements, including changes in utilities, transportation, and communication networks. These gains in efficiency, reduced transaction costs, and investment attraction all contribute to economic growth.

This theory is quite relevant regarding tourism. It suggests that investments in infrastructure directly affect the growth of tourist businesses by increasing the attractiveness of tourism locations, enhancing access to destinations, and boosting the quality of services. Better utilities and communication infrastructure, for example, can improve the visitor experience; better transport systems can help encourage easier movement to and within tourist destinations. Using Kuznets' Economic Development Theory, researchers can explore how infrastructure development contributes to the growth and success of tourism companies, providing insights into how targeted investments can stimulate economic activity and sustainable development within the sector.

Empirical review

Michael Porter (2015) [11] conducted research in Switzerland, looking at a sample of three hundred travel agencies to see how contemporary infrastructure might affect travel growth. The results revealed that by increasing access and operational efficiency, Switzerland's highly developed communication and transport systems significantly helped tourism businesses grow. Porter's studies showed how contemporary infrastructure investments help to maintain the competitiveness of tourism companies in developed economies.

In 2016, [4] investigated how infrastructure construction influences the expansion of Taiwanese tourism businesses. The study concentrated on how better infrastructure might affect the growth and operations of 250 travel agencies spread over different areas of Taiwan. [4] studies indicate that improved transport infrastructure, particularly the construction of high-speed rail and improved road networks, significantly contributed to the growth of tourist businesses by increasing visitor accessibility and reducing trip times. The study also showed that improved utility infrastructure—including consistent electricity and water supply—significantly influences the quality of services provided by these businesses.

Because [4] empirical studies demonstrate a clear link between tourism business expansion and infrastructure development, they are important. It provides a useful foundation for legislators seeking to increase tourism through infrastructure upgrades because it demonstrates how focused infrastructure investments can result in significant gains in company performance within the tourism sector.

[7] conducted research in India looking at how infrastructure development affects the travel industry. Using a sample size of 400 travel-related companies, [7] found that changes in road networks, utilities, and telecommunications significantly influenced the growth of tourist businesses. The study underlined the need for focused infrastructure projects in underdeveloped nations to release the potential of the tourism sector, usually hampered by poor amenities.

[1] examined how infrastructural development affected Lagos State's tourism industry in Nigeria. According to [1], from a sample of 200 travel companies, inadequate infrastructure—especially in utilities and transportation—has hampered the expansion of the travel industry. The study highlighted that the greatest obstacle to Nigerian tourism companies' growth is still infrastructural shortcomings, implying that achieving the nation's tourist potential depends on wise infrastructure investments.

Conceptual framework

Tourism expansion

Expanding tourism refers to the development and diversity of tourism-related activities and services, therefore generating more visitors and more general economic effects. This expansion drives infrastructural development, improves world connectivity, and stimulates economic growth through job creation and cultural interaction. Moreover, we require sustainable methods to manage environmental impacts and ensure enduring sustainability. Knowing how tourism interacts with economic, cultural, and environmental elements becomes essential as it grows because it helps to create strategic plans and policies that maximise the advantages of tourist expansion while reducing possible negative consequences for destinations.

Infrastructure development

Infrastructure development is the systematic construction, improvement, and maintenance of fundamental physical and organisational systems required for a society's or economy's operation. Public infrastructure, utilities, communication networks, and transport systems are crucial for facilitating economic activity and raising quality of life. Effective, improved access to resources and services, as well as effective infrastructure development, can support sustainable development, drive economic growth, and aid social integration. In the context of tourism, adequately built infrastructure is essential for improving accessibility, attracting visitors, and guaranteeing a seamless and gratifying experience, thereby supporting the sector's long-term viability and competitiveness.

Security infrastructure

Within a specific context, security infrastructure is the physical, technological, and organisational system meant to guard people, assets, and information. Surveillance systems, safe communication networks, access control mechanisms, and emergency response protocols are all crucial for maintaining safety and order. Strong security infrastructure is absolutely essential in the context of tourism to guarantee the safety of guests and employees, improve destination appeal, and create a feeling of security that promotes travel activity. By reducing risks and fostering a safe environment for all stakeholders, effective security infrastructure helps the viability and stability of tourism businesses.

Communication infrastructure

There are telecommunications networks, internet connectivity, and broadcasting services. Communication infrastructure refers to the technologies and systems that allow the distribution of knowledge over distances. It forms the foundation of modern communication, facilitating the exchange of data, voice, and multimedia among individuals and organizations. Strong communication infrastructure is critical in the travel industry for operational coordination, improving service delivery, and providing real-time information to visitors. It advances digital marketing, online booking systems, and mobile apps, enhancing the whole travel experience and operational effectiveness. The development, competitiveness, and sustainability of tourism locations depend on strong communication infrastructure.

Utility infrastructure

Utility infrastructure is the basic services and facilities needed by companies and communities to offer waste management, water, electricity, and sanitation. As a result, these systems are fundamental; public health, safety, and the smooth operation of economies depend on them. Reliable utility infrastructure is essential in tourism for the operation of hotels, restaurants, and other services, thus directly influencing the quality of the visitor experience. By lowering operating interruptions and improving service delivery, sufficient utilities help tourism businesses to be sustainable. Therefore, the long-term survival and appeal of tourism locations depend on strong investment in utility infrastructure.

Financial infrastructure

Financial infrastructure refers to the organisations, markets, and systems that facilitate capital access, financial resource management, and financial transactions. This covers financial stability and efficiency-ensuring banking services, payment systems, credit facilities, and regulatory systems. Well-developed financial infrastructure is essential in tourism if we are to support the expansion of tourism companies, enable investments in tourism projects, and ease visitor transactions. It ensures that financial services are available to both customers and industry providers, thus strengthening financial resilience. Strong financial infrastructure is necessary to maintain tourism growth and promote economic development in travel destinations.

MATERIALS AND METHODS

Researchers investigated how infrastructure development affected the growth of tourism-related companies using multiple regression analysis. Drawing from tourism companies in the study area, the study had a sample size of 270 respondents. The study chose this statistical approach to evaluate the simultaneous effect of several independent variables, such as security, communication, utility, and financial infrastructure, on the dependent variable, the expansion of tourism enterprises.

Throughout data collection, researchers extensively verified the questionnaire for validity and dependability. Expert evaluation helped us ensure content validity by matching the questionnaire items to the research goals. The researcher verified construct validity via factor analysis and ensured that the items fairly assessed the intended constructions. This study used Cronbach's alpha to evaluate dependability. Results on all scales exceeded 0.70, indicating a high degree of internal consistency. The questionnaire's strong validity and dependability guaranteed the precision and confidence of the data acquired, thereby supporting the legitimacy of the study's results.

RESULTS AND DISCUSSIONS

The model summary shows a quite favourable correlation between tourism increase and infrastructural development (R = 0.362).

An R square value of 0.131 helps to explain 13.1% of the variance in tourism expansion: financial, utilities, communication, and security infrastructure.

With a modified R square of 0.118, the number of predictors explains 11.8% of the variation.

The 0.84292 standard error points to a noteworthy, inexplicable variance. Still, the model is statistically significant, as evidenced by a F change of 9.980 and a significance level of 0.000.

With a Durbin-Watson score of 1.197, the residuals show modestly positive autocorrelation (Table 1).

Table 1. Model Summary on Effect of Infrastructure Development on the Expansion of Tourism Businesses in AgodiGardens, Ibadan. Oyo State Nigeria

Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**	**Change Statistics**					**Durbin-Watson**
					R Square Change		df1	df2	Sig. F Change	
1	.362[a]	.131	.118	.84292	.131	1.197	4	265	.000	1.197

a. Predictors: (Constant), Financial Infrastructure, Utility Infrastructure, Communication Infrastructure, Security Infrastructure
b. Dependent Variable: Tourism Expansion
Source: Field work, 2024.

According to the ANOVA (Table 2), the regression model explains the statistically significant impact of infrastructure development on tourism growth. The independent variables, such as financial, utility, communication, and security infrastructure, explain the heterogeneity in the expansion of tourism with 28.365 as the regression sum of squares. The residual sum of squares, 188.287, reveals the inexplicable variance. The mean square for the regression is 7.091 with 4 degrees of freedom; for the residuals, it is 0.711 with 265. With a significance level of 0.000, the F-statistic of 9.980 verifies that the independent factors taken together have a statistically significant influence on the growth of tourism.

Table 2. ANOVA on Effect of Infrastructure Development on the Expansion of Tourism Businesses in Agodi Gardens Ibadan, Oyo State, Nigeria

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	28.365	4	7.091	9.980	.000[b]
Residual	188.287	265	.711		
Total	216.652	269			

a. Dependent Variable: Tourism Expansion.
b. Predictors: (Constant), Financial Infrastructure, Utility Infrastructure, Communication Infrastructure, Security Infrastructure
Source: Field work, 2024.

The coefficient table (Table 3) provides an understanding of how different types of infrastructure affect tourism growth. When other infrastructure factors stay constant, the constant (B = 3.919) implies a baseline level of 3.919 for travel development. With an unstandardised coefficient (B) of 0.496 and a high t-value of 5.794 (p = 0.000), security infrastructure shows a strong positive impact on tourism growth. The communication infrastructure suffers with a coefficient of -0.275 and a t-value of -3.309 (p = 0.001), indicating a significant negative association.
Utility infrastructure has similar adverse impacts on tourism development (B = -0.0201, t = -3.064, and p = 0.002). Though its influence is less evident, financial infrastructure also exhibits a negative effect (B = -0.110, t = -2.152, p = 0.032). These findings show that while other forms of infrastructure have negative effects, security infrastructure favourably stimulates tourism growth.

Table 3. Coefficients on Effect of Infrastructure Development on the Expansion of Tourism Businesses in Agodi Gardens Ibadan, Oyo State Nigeria

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Correlations		
	B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part
(Constant)	3.919	.384		10.208	.000	3.163	4.675			
Security Infrastructure	.496	.086	.462	5.794	.000	.327	.664	.206	.335	.332
Communication Infrastructure	-.275	.083	-.261	-3.309	.001	-.438	-.111	-.023	-.199	-.190
Utility Infrastructure	-.201	.066	-.183	-3.064	.002	-.330	-.072	-.130	-.185	-.175
Financial Infrastructure	-.110	.051	-.133	-2.152	.032	-.211	-.009	-.046	-.131	-.123

a. Dependent Variable: Tourism Expansion
Source: Field work, 2024.

Discussion of findings

With a coefficient (B) of 0.496 and a high t-value of 5.794 (p = 0.000), our findings show that security infrastructure has a positive and noteworthy influence on tourism development. This is consistent with the general knowledge that tourism expansion depends on security, since safe surroundings motivate more travel and investment in tourism companies. Previous research, however, paid less attention to this particular emphasis on security infrastructure, implying that in environments such as Nigeria, where security issues are more salient, this element may be especially important.
On the other hand, [11] research in Switzerland found that increased access and operational efficiency of advanced communication infrastructure significantly boosts tourism firms. The state and functionality of the communication infrastructure in a developed nation like Switzerland and a developing nation like Nigeria could help to explain this disparity. In

Nigeria, inadequate or poor communication infrastructure could still cause problems rather than help tourism flourish.

In our analysis, utility infrastructure likewise had a negative impact on the growth in tourism (B = -0.0201, t = -3.064, p = 0.002). Improvements in utilities, such as electricity and water supply, significantly improve the quality of services provided by tourism companies, supporting their growth in Taiwan [4] and [7]. In our case, the inadequate or erratic quality of utility services may discourage rather than inspire travel behaviour.

The study also highlights the less significant negative impact of financial infrastructure on tourism growth (B = -0.110, t = -2.252, p = 0.032). This outcome contradicts most of the studies, as improved financial infrastructure typically enables companies to expand by providing access to capital and financial tools. Our study indicates that problems including limited credit availability, excessive interest rates, or ineffective financial institutions could impede rather than encourage the growth of the travel sector.

Although our findings emphasise the importance of security infrastructure in promoting tourism development, they overall show major difficulties with Nigeria's communication, utility, and finance infrastructure. These results emphasise the need for context-specific infrastructure development plans, especially in underdeveloped countries where infrastructure deficiencies may be the main impediments to tourism growth.

Contribution to knowledge

It highlights the importance of security infrastructure in promoting travel expansion. The study demonstrates the significant and beneficial impact of investing in security to create suitable environments for tourism expansion. This outcome adds to the body of knowledge by stressing the importance of security in the expansion of tourism, which could be especially relevant in circumstances when security concerns are of major relevance.

Unlike results from affluent nations, the research demonstrates an unexpected detrimental influence of communication infrastructure. This implies that the present level of communication infrastructure in Nigeria could be insufficient or ineffective, therefore influencing travel negatively. This paper provides fresh ideas on how communication infrastructure could impede rather than promote tourism expansion in underdeveloped areas.

The study also notes how negatively utilities and banking infrastructure affect tourism growth. These results contradict the conventional wisdom based on earlier studies in developed and underdeveloped nations, where such infrastructure usually helps tourism to flourish. This study provides important evidence of the need for targeted improvements in utilities and financial systems to remove obstacles to Nigeria's tourism growth.

This study enhances the scholarly debate in general by providing a thorough understanding of the various effects of different infrastructure forms on the growth of tourism in a developing nation environment. It gives legislators a basis to customise infrastructure development plans that address specific possibilities and problems in the Nigerian travel industry.

CONCLUSIONS

This paper exposed the surprising negative effects of communication, utility, and financial infrastructure, as well as the vital need for security infrastructure. It also looked at how various infrastructure components influence the growth of Nigerian travel agencies. The findings reveal that in this aspect, shortcomings in communication, utility, and finance systems may hinder development, even if security infrastructure encourages tourism expansion.

These results emphasise the need for a cautious approach to infrastructure development that handles the specific issues faced by the Nigerian travel sector.

The study implies the following:

1. Invest in improved security systems to ensure a safer environment for companies and guests. This can mean improving monitoring

systems, increasing police presence, and ensuring ready availability of emergency services. Enhanced security will most likely attract more guests and boost company growth.

2.Modernising and improving communication infrastructure would help to support tourism companies' effective operations. To guarantee better accessibility and service delivery, these covers enhancing internet connectivity, telephone networks, and digital platforms.

3. Invest in dependable energy and water delivery systems to help solve flaws in the utility infrastructure. Improvements in these areas will help tourism companies deliver better services and reduce running interruptions, promoting the sector's growth.

4. Enhance Financial Infrastructure: By implementing improved banking services, facilitating easier access to credit facilities, and lowering interest rates, we can increase the financial resources available to tourism firms. Supporting financial infrastructure will allow companies in the tourism industry to overcome financing obstacles and enable expansion and investment.

Following these suggestions will help Nigeria solve the identified infrastructural deficiencies and provide a more favourable environment for the establishment of tourism businesses, thereby promoting sector growth and supporting economic development.

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OPERATIONAL ISSUES IN SYSTEMATIC LAND REGISTRATION PROJECTS IN ROMANIA. A STUDY CASE IN A ROMANIAN SMALL AND MEDIUM ENTERPRISE

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Abstract

By 2024 land in only 7% of administrative units in Romania were registered through The Romanian National Program for Land Registration. This paper looks at possible delays caused by that the providers of work, the private sector, due to operational issues. Most of the companies involved in providing services are SME's. Using an action research methodology, this research employs a focus group from a Romanian SME that critically analyse the processes that take place in a project of systematic registration of land. The focus group looks: at the purpose of activities, the places in which the activities take place, the sequence in which activities are being done, the people that do the activities and the methods of realization. The research proposes a new process map to speed up the process and eliminate bottlenecks and a revision of the human resource policy and operational approach in the company studied.

Key words*: systematic land registration, cadastre, operations management, processes*

INTRODUCTION

The global agenda emphasizes the importance of The United Nations Sustainable Development Goals in order to address issues such as: hunger, poverty, malnutrition, climate change or environmental protection [2].

To achieve these goals, the world needs to find ways to exploit resources without depleting them and keep the balance of nature [3].

Climate change has brought a lot of uncertainty in agricultural production [47]. This is also emphasized by the European Union that calls for urgent action to stop "global warming and the loss of ecosystems and biodiversity" [22].

Reversing this trend and achieving sustainable development isn't possible without sound policies for land management.

For over 70% of the land on our planet, there is no connection between the land and the people that use it [51, 24]. This means that this asset, that people have, can't be valorised, being what [19] calls "dead capital". Poverty reduction and sustainable development may be reduced when this unregistered land will be moved into the official economy and use.

There are a few steps in the process of land registration: "land adjudication, demarcation, surveying and recording of land with the focus on recording" [67, 28].

The process of land registration is done by surveyors with the help of people in legal profession. It can be done either by state employees or by the private sector.

Usually, the operations employed in registering land, sporadically or systematically, consists of: analysis of deeds or titles, determining the spatial position of the object through different types of measurements, demarcation of boundaries with the help of the owners, a process of verification done by state officials or the private sector and the registration of the land in the cadastral documents .

Romania struggles to register all its land for over a century. The Romanian National

Program for Land Registration (PNCCF) was launched in 2015 with the aim to register all localities in the country by 2023. However, until February 2024, in spite of many attempts, only 7% of administrative units in the country are registered. The Romanian National Program of Land Registration is implemented by The National Agency for Cadastre and Land Registration (ANCPI). It is an institution that regulates the process, and has attributions in designing the legislation, verify the work and takes care of the public acquisitions.

PNCCF has been analysed by several authors. Legal aspects are treated by [59, 35, 25, 63], while more technical aspects are underlined by [9, 42]. Other authors are concerned with describing the stages, processes, 3D rights, strategy or quality issues [45, 62, 48, 40, 44, 43]. However, there are no studies concerning operational practices that the private sector employs in providing the service of systematic land registration.

There have been few attempts to view the process of systematic land registration from an operational perspective. This paper looks ate the way private companies that provide this kind of projects can avoid delays and how they can improve their operations. The analysis is conducted in an Romanian SME. The research questions are the following:

-What is the operational workflow that a company engaged in a process of systematic land registration employs?

-How can these operations be improved?

In the following chapters of the research, a literature review in which land registration is defined and the operations that take place in such a project are described. Literature concerning process monitoring and control and operational improvement are also analysed. This research is conducted in a constructivist paradigm using the methodology of action research by means of a focus group. The last section of this study presents the conclusion.

Stages in The Romanian National Program for Land Registration

Several authors have shown the advantages of systematic land registration: increase of investments, tenure land security, covering of large areas, higher agricultural productivity, decreased costs and faster transactions and registration [4, 66, 12, 46, 21, 53]. On the other hand, the benefits of systematic land registration don’t seem to appear in some cases. [13] and [8] observe that new land disputes may arise and increase uncertainty. Also, land rights don’t necessarily lead to more investment in agricultural land, increase farm or eases access to credit [20, 54].

In order to complete the project, Romanian providers of services have to respect the stages required in the Technical Specifications that are as follows [5]: “contract signing, input data and analysing input data, information campaign, collection of spatial data, data processing, property titles collection, data introduction, delivery of documents to local cadastral offices, correction of errors, public display of documents, receiving complaints, final delivery of documents”.

Operations management

Operations management refers to the process in which transformation processes are managed in order to produce goods and services [1]. The aim of any kind of service is to deliver good quality services or products through design of the product, process, human resources and planning and control [10].

To achieve good quality for service and products, there is a need to be able to evaluate the performance of the operations that produce them. Elements like: facility output, productivity, cost, quality, flexibility, new product introduction, innovativeness and new process introduction can be considered [50, 33]. On the other hand, areas like: financial efficiency, activity based costing, partial and total productivity measures and time based productivity measures, are seen by [60, 36, 27, 23, 17, 7] as indicators of operations success. However, most of these evaluations are based on financial aspects.

Successful operations mean more than cost efficient processes. That is why more elements, that form the mix for efficient operations have to be considered.

To judge operations, they have to be mapped first. Process maps have the purpose to control and visualize the processes that take place in an organization in order to find solutions for improvement [31, 6]. These visual representations are useful to view the inputs, links between activities and the outputs of a project.

In designing them, [57] recommends: identifying the start and finishing points of the process, gathering data and prepare the process, transformation of the data into visual representation. After the analysis and finding of improvements, they are represented on new, "future state maps", that show the improved process [31].

Process monitoring and control

Monitoring and control of the processes has the purpose to minimize disruptions in the activity [65]. Process performance can be assessed using multiple tools and techniques like: balance scorecard, self-assessment, workflow-based monitoring or statistical process control [38, 29].

However, some of these methods concentrate on the process as a whole, while others, like the statistical approach, don't take into consideration the influence of the human factor.

An approach that is more complete and more appropriate on processes in the land administration system that can integrate the social dimension of such projects is the model that [55] proposes in order to critically analyse each step of the operations that take place.

Besides the quantitative aspects of each activity, this critical analysis takes into consideration the qualitative aspects by including the people that execute the activities. By isolating each activity, with specific questions about the way they are performed, this approach aims to find problems and bottlenecks.

To examine the process, the following problems were considered: purpose of each activity, the place in which each activity takes place, the sequence in which the activity elements are being done, who is doing the activity and the method in which the activity is realized [55].

Operations improvement

Operations are constantly observed and controlled in order for them to be improved. Better operations mean higher efficiency and increased performances.

Lowering the costs of production, improved quality of products, services or processes that are fast and reliable can offer an organization competitive advantage in the market.

Process improvement can be done by redesigning or reengineering.

To redesign a process, means to: eliminate some parts of the activity, combine some parts of the activity, change the order in which activities are being done and simplify the activity.

However, many times there is a need for changes that affect not just processes, but the entire organization.

Reengineering processes is such an approach that consists of a number of steps enumerated by [55]: rethinking processes in order for the activities to be naturally organized in the work flow, searching for major improvements by radically rethinking and redesigning activities, redesigning the processes in order for them to be suppliers and clients for each other, people that do the activities must not be separated from those who supervise and control the activity.

MATERIALS AND METHODS

Paradigm of research

Positivist researchers make sense of reality by measuring phenomena through objective methods [18, 41, 61]. On the other hand, constructivists or interpretivists, view the reality as a social construct through interaction [37, 34, 39]. The world is perceived subjectively, the reality is put into context and it is usually studied employing qualitative methods [32]. This research is conducted in a constructivist paradigm using qualitative methodologies and methods to answer the research questions.

Methodology

"Action research seeks to bring together action and reflection, theory and practice, in participation with others in the pursuit of practical solutions, to issues of pressing concern to the people" [49]. This method is at the border between organizational consulting and research [11]. In this type of qualitative research, the researcher and the participants construct a partnership and, through their interaction, they aim to find solutions to the research issues and, sometimes, implement them.

[58] see the methodology as having five stages: diagnosing, action planning, action taking, evaluating and learning, while a four stages model consisting of: planning, acting, observing and reflecting, is proposed by [30].

Having many stages similar to the process of consulting, there is much debate, among different authors, if this methodology has indeed scientific value or not [16, 52, 26, 11]. One difference is that a consultant is paid by an organization to find solutions to problems and create value [64], while the researcher wants to contribute to the development of the body of knowledge in the researched field without financial gain. Another difference consists in the fact that in action research, co-participants are treated as co-researchers, sharing the research experience, basing their approach on theoretical explanations. While a consultancy is done “on people”, the research is done “with people” [11]. Through action research, an organization learns from itself. However, the most important difference is that the researcher disseminates the knowledge acquired in the process to enrich the knowledge in the field of study, while a consultant benefits from the experience and uses the knowledge in other projects for his/her own benefit.

This research studies the operations that take place in a Romanian company that implements a systematic land registration project in Romania in The National Program of Systematic Land Registration.

The stages of action research used in this study were:

-*Problem diagnosing*. Consisted on finding the specific problems that the organization has by looking at internal documents concerning profitability of the project, deadlines respected and polls that show employees complaints;

-*Action planning*. The research method was chosen (focus group) and the co-participants in the research;

-*Action taking*. Consisted in analysing the processes in the projects of systematic land registration that take place inside the organization and find solutions for improvement together with the co-researchers;

-*Evaluation*. This stage takes place after the solutions are implemented. However, for this research, this stage is not considered as the implementation process is undergoing;

-*Learning*. Consisted in a questionnaire that evaluated the learning process of the co-researchers.

Method

In the problem diagnosing stage, to analyse the problems that the organization is facing, an analysis regarding delays in the systematic registration projects was performed taking into consideration the deadline of the contracts and the actual finish date of the project.

The method chosen for the action planning stage was the focus group. That usually consist groups of 6 to 12 people debating certain topics [56].

For anonymity reasons, the company in which the focus group was held will be called company A.

The meetings lasted between one and two hours and were programmed during four days. All meetings had predefined subjects: process mapping, process analysis (2 meetings), process reengineering and redesign.

For each activity of the operations analysed, the topic was put in the discussion in the group.

During the discussion, the moderator encouraged exchanging of ideas, questions and explanations in order to obtain what is called “the group effect” [15,14].

There was no obligation to get involved in the discussions, every member of the group decided on the amount of personal implication. The meetings were audio recorded.

Six persons were considered in the focus group, with an equal number of men and women. These people have an extended experience in projects of systematic land registration (between 3 and 11 years).

The first task of the focus group was to analyse the processes in systematic registration of land that they performed for the organization and map them.

Then every stage of the project was critically analysed by the group following the model proposed by [55]. For each stage, the questions in the table were asked to the participants in the focus group.

RESULTS AND DISCUSSIONS

Problem diagnosing

Out of 40 projects of systematic land registration that Company A has worked on, 9 of the were analysed to observe delays. As seen in Table 1, all the localities in analysis registered delays from 32 to 128 weeks.

Table 1. The 9 localities analysed in Company A

Administrative unit name	Contract duration (weeks)	Real duration of project (weeks)	Difference (weeks)
Cerbal	76	120	44
Chinteni	76	204	128
Ciugud	76	207	131
Ghelari	76	119	43
Lelese	76	152	76
Madaras	76	179	103
Santimbru	76	189	113
Tulca	76	128	52
Vultureni	76	108	32

Source: Paunescu, et al., 2024.

The problem that Company A faces is that the project of systematic land registration has significant delays.

Action planning

For finding solutions to reduce the delays that Company A faces, an analysis of the operations that are employed by the company is necessary.

This will help decision makers in the organization to find out what processes are not properly done, where are the bottlenecks in the processes and what processes need to be redesigned or reengineered. For this, a focus group composed of six middle managers from Company A will analyse the operations of systematic registration of land.

Action taking

Process mapping. The first step in analysing the process was to ask the members of the focus group to draw a workflow for systematic registration processes.

Figure 1 shows the workflow adopted in systematic land registration projects. After the contract signing (stage 1), the provider gathers all relevant data from local cadastral offices and other institutions and analyses them (stage 2). Citizens in the administrative unit are informed about the project through an information campaign (stage 3). In the next stages, data is collected through geodetic measurements in the field (stage 4), parcels are constructed with the help of specialized software. For this stage, the people in the focus group showed that the process can be done in two ways: collect property titles from the owners (stage 6) and introducing the data collected in stage 7 or do it together with the data processing (drawing of parcels and data introduction done simultaneously), stage 5.1.

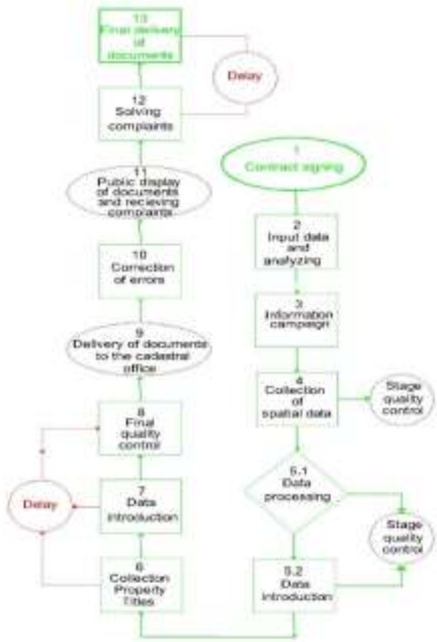

Fig. 1. Process map of the process in systematic land registration projects
Source: Original figure.

The work goes to the local cadastral office for verification (stage 8). After the correction of errors, the work is displayed to the public and the people can issue complaints if they consider necessary (stages 9 and 10). The provider, together with representatives from the local cadastral office and the administrative unit personnel solve the complaints, and the final documents are delivered (stages 11 and 12). The focus group identified delays in the project in stages 6, 7, 9 and 11.

Process analysis

Purpose of each activity. The focus group was of the opinion that there are certain activities that can be done in a different way. Even if the administrative unit is obliged by the law to help with the registration, the focus group agreed that in the stages of information campaign, collection of data and public display, the administrative unit personnel should be more involved in the process in order for the people in the administrative unit to gain trust and participate in the process. Another issue raised by the focus group at this stage was that people doing activities 5 and 7 have to be better trained by the company and more emphasize on the quality control should be taking into consideration.

The place in which each activity takes place. Where the activity takes place is more or less defined in the Terms of Reference issued by ANCPI. For example, the data collection must happen in the field because the parcels are there. On the other hand, there are activities that could be done elsewhere: data collection can be done with higher precision for urban areas and lower precision for rural areas, while data processing can also be done at places in the administrative units in order to be closer to the source of information if any problems occur. However, the focus group considered that the place in which the activities are being done at the moment are mostly suitable for the efficiency of the process.

The sequence in which the activity elements are being done. There is agreement in the focus group that the data collection (measurements in the field) has to be done before collecting ownership data from the citizens. In this way, the textual data will be the referenced to the graphic component, not the other way around, in order to have spatial reference. As observed in Figure 1, some members in the focus group do the data introduction in the data base before collecting all the information from the owners. This happens because most of the data concerning property titles is already available from other sources and the property title collection stage is used only to complement or to verify the data base with the data that is collected from the owners. On the other hand, members of the focus group propose something else. Because available sources that contain the property titles may not be complete, so the focus group propose that the data from these titles be introduced after they are collected.

A part of the focus group considers that collecting the property titles directly from the owners and then introducing them is a safer method. The focus group found that there are some changes that should be done, but they mainly consist on changing the sequence set by ANCPI. The public display of the documents should be done before the verification of the cadastral office, not like it is done now. This would shorten the process significantly as at the verification time of 60 days, the time for correction is added.

Who is doing the activity? Company A works in project teams that consist of 2-4 people for every project. These teams have a Technical Responsible that deals with the technical component of the project. For every 3-4 projects there is a Project Manager that supervises and implements the operational strategy for every project.

The main problem observed by the focus group consists on working with subcontractors.

They are of the opinion that all processes should be done by the company in order to ensure the quality of the work.

However, one of the issues raised was that the teams, many times, lack in sufficient personnel or the personnel is poorly trained. This is causing significant delays in execution and lower quality of the work.

The method in which the activity is realized. The focus group sees most of the methods they are using as being appropriate.

However, the stages in which the focus group agrees improvements should be made are:

-Information campaign. The members of the focus group want a higher level of involvement from the administrative unit's employees.

-Data processing with data introduction. The members of the focus group agree that the process should be done in collaboration with personnel of the administrative unit. On the other hand, some members of the focus group see the stage of data introduction as being done later in the process.

-Correction of errors. Members of the focus group agree that the correction of errors procedure has to be changed. Instead of the cadastral office verifying the work and sending the errors to be corrected by the provider, a more collaborative process should be designed.

-Public display of documents and receiving complaints. The public display method should be changed in the focus group member's opinion.

Because the people don't really understand what is displayed, members of the focus group state that a solution would be to issue provisional land book extras that the people would understand better. In the cadastral plan, instead of the identification number, the name of the owner should be written.

Also, the sporadic registration, which goes in parallel with the systematic registration, should be put on hold during the period of complaints solving and data actualization.

Operational improvements

In the last stage of this this research, the members of the focus group had to find operations improvements for activities mentioned in sections 3.3 and 3.4.

These solutions had to be consistent with the principles of operational redesign and reengineering.

Some processes are added to improve the relation between them, while other activities are designed to improve the process.

These were the following:

Process map.

The focus group is of the opinion that quality is a prerequisite of a successful project.

They believe that keeping a tight control on the project and managing every phase will ensure that the technical specifications are applied and the work is at the required standards. A higher quality of work is mandatory because the errors will be less present and the delays caused by corrections will diminish. In light of these findings, the focus group proposes the following:

-Every stage of the project should have *quality control performed* by the Technical Responsible *during the execution* of the process

-A separate team in the company should do *quality control after the finalization* of the process

With these solutions applied, there will be no more need for extensive repairs and the bottlenecks will be eliminated.

The focus group proceed at drawing a new process map. Quality control was added in certain stages of the process and at the end of it as shown in Figure 2.

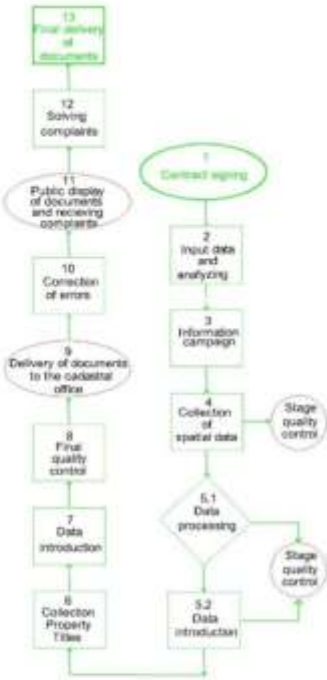

Fig. 2. Improved process map of the process in systematic land registration projects
Source: Original figure.

-*Process analysis*. Following the process analysis the first recommendation of the focus group for Company A is to redesign the human resource policy. A high turnover of personnel leads to insufficient members in the teams which, in turn, lead to higher times for execution. The focus group considers that the number of people working in the project teams should be increased from 2-4 to 6. Keeping experienced personnel in the company should be a priority. The focus group members recommend measures like: salary increases, performance bonuses and a decrease in the work burden for team members in order to create a better balance between work and personal life. Another proposal was for the company to design a specific training program in the induction phase for people that are newly hired. The enlargement of the teams should give more time to managers to concentrate on training people instead on operational activities.

The personnel of administrative units need to get involved more in the process especially in the stage of information campaign and public display of documents in order to get more support from the citizens.

ANCPI can think to redesign the project. According to the focus group members, the stage of public display of documents should be done before OCPI verification because, usually, the projects stay in the process of verification for more than the 60 legal days. If this approach changes, corrections, verifications and complaints solving can be done after the public display.

Learning

The last step in the action research is to evaluate what was learned by applying the methodology of action research. For this a questionnaire was designed (Table 2). Two of the respondents learned how other teams solve the same problems that they also encountered, while three members learned new ideas for process innovation. The members of the focus group appreciated the group interaction and the dynamics that occurred during the discussions. The sharing of information showed, what are the activities that every team makes and that was considered helpful by some of the participants. All members of the focus group declared that they will participate again in such activities.

Table 2. Answers for the learning questionnaire for the learning aspect of action research

Question	Answer	Number of answers
What have I learned during this focus group?	different ways of solving the problems	5
	ideas for innovation	3
How would you describe the activities that you took part in?	the flow of ideas and the group interaction was appreciated	4
	helpful in finding out how other teams work	2
Would you participate in such activities in the future?	Yes	5

Source: Original data.

CONCLUSIONS

This research presented an operational overview of the activities that take place in a Romanian SME that is involved with projects of land registration in a systematic way. The activities were analyzed using a focus group of six people from the company in a process of action research. The focus group analyzed in a critical way the activities and found ways for improvement.

The main findings of the study, for each aspect analysed are:

-A new improved process map. The new process map proposed by the focus group shows the way improvements in the process, mainly the addition of a quality control stage, can eliminate errors that cause delays.

-Process improvement. For the way processes are being performed, the focus group recommends introducing better training procedures and increasing the number of people in project teams. Together with these, the focus group agreed that involving more the administrative unit in the process and the stage of public display should be done before the verifications performed by the local cadastral offices in order to gain time. Recommendations are also done for administrative unit’s personnel in order to be more involved in the process.

Projects of systematic land registration don’t benefit from an extended literature. These findings can be viewed as attempting to bring this subject in attention for public authorities and scholars. Organizations that face similar problems can benefit from this research in the following way:

-To apply a new methodology for identifying operational challenges that their companies face

-To redesign their processes using findings from this research

-To apply a different workflow to improve their processes.

Future research is needed to expand the findings of this study. In order to increase the reliability of such researches there is a need to expand it to other companies that do similar projects and see if the results are in accordance with those obtained here. There is a need for thoroughly analysis of operational aspects not only in the companies that execute the work for PNCCF, but also for the state institutions that take care of these projects.

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RESEARCH REGARDING THE ENERGY EFFICIENCY OF MAIZE CROP CULTIVATED IN ECOLOGICAL AND CONVENTIONAL SYSTEMS IN ROMANIAN PLAIN

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Abstract

Agriculture involves complex activities, which require the updating of farmers' knowledge and the adaptation of their strategies in order to have economic efficiency. Producers must make decisions regarding the structure of crops adapted so as to cultivate species that bring material satisfaction, but last but not least, adapted to current climate changes and new culture technologies. Corn is one of the crops that bring significant financial results, but the irrigation factor and the genetic material must be taken into account. The aim of this research is to analyze the energy and economic efficiency of a corn hybrid grown without irrigation conditions in the southern part of Romania, in a conventional and ecological technology system. The results highlighted the higher productivity of the conventional variant, 8,200 kg/ha, a higher fuel consumption of 93.4 l/ha compared to the ecological system where 89.9 l/ha were consumed. The energy consumption for obtaining a ton of corn was 0.126 kwh, in conventional culture system and 0.143 kwh for the ecological system. The energy efficiency is influenced by the productions obtained, the conventional system being superior from this point of view, for the P9241 hybrid, for the applied technology and for the pedoclimatic conditions of the respective area.

Key words: *maize, conventional system, ecological system, , economic efficiency, energy efficiency*

INTRODUCTION

Agriculture is a complex field of activity where farmers are focused every year on what kind of crops to cultivate on their land and what surface to allot to each plant. The decisions are always linked to economic efficiency of each cultivate hectare, more exactly on net returns level [4,11]. Besides wheat and rice, maize is an important human food resource, accounting for 94% of all cereal consumption at world level [5].

Maize is an important cereal proving high nutritional value food products for human and animal consumption.

Maize has a high production potential, by 50 % higher than the other cereals. It is able to produce constant harvests, it is good in monoculture for many years, a good prior plant for most of crops, and its cultivation is mecanisable 100 %, it has a good feed-back to fertilization and irrigation, it has a good resistance to drought, it could be cultivated on various soil types, and could be used for many purposes [25, 26]. In Romania was being cultivate on 47.1 % of the agricultural land cultivated with cereals [18]. Romania is placed in the top in the EU-28 and among the top producers in the EU and in the world for its maize cultivated area [13, 26].

Also, maize is an agro-food product required for export, Romania's trade balance being a positive one [23].

Most of the corn production in the world is used for animal feed. Average productions can reach 10 t/ha in some countries. In the vast majority of cases, corn is harvested at full maturity when it is used in fodder rations. corn is the food with the highest caloric content, which contains more oil than wheat and has a lower protein content than other cereals [28].

In the traditional system, the maize crop had the largest cultivated area (2,605,165 ha), and the smallest cultivated area in the organic farming system 23,136 ha, which represents a percentage of 0.88 % of the total area [3]. During the years (1992, 1993, 1995, 1996,1997, 1998, 1999, 2000, 2003, 2004), the area was greater than 3 million hectares, the absolute record being recorded in 1992, when there were cultivated 3.3 million ha with grain corn [19].

In the last ten years, the productivity performances were the result of the farmers' efforts regarding the modernization of production technologies and the increase of the economic efficiency of wheat, corn or sunflower crops. Productive performances would have been superior if climate changes had not intensified, environmental factors being the main elements that influence plant development and, finally, the productivity [21]. The deviations of temperature and precipitations from climatological norms are considered a high risk for agriculture.[2]. A study carried out and published by the European Commission concluded the comparison made between the two agricultural models - organic and conventional - to see which is more profitable [17, 30, 31]. Following research, it has been proven that organic farming brings slightly higher incomes in some cases [17, 31].

The European Parliament has made the recent assessments which confirm a diminished cereals production in the EU main producing countries due to the extreme meteorological phenomena, mainly concerning high temperatures, heat waves and long and serious droughts [5, 6].

In Romania, the consumption of ecological products is starting to gain ground, according to some studies. However, it remains quite low, approx. 2%, of the total food, compared to a consumption between 3-5% in Western Europe. According to the Association of operators of Organic Agriculture "Bio Romania", approximately 80% of the annual bio products arrive on export, the value of their being of about 200 million euros, these being exported, particularly in Germany, Austria and Belgium [24, 29]. Green products have undergone significant development in the past two decades [10]. The application of mineral fertilizers determines higher yields and significant increases in production. The unbalanced application of chemical fertilizers can produce imbalances in the plant and the crop increases recorded are increasingly lower as the amount administered increases beyond the useful limit for the plants, which causes higher expenses that are not found in the increases achieved.

This analysis followed the reaction of hybrid to the applied technology and choose for the future the one that brought us the best results without generating large expenses [15].New technologies with fewer inputs have to be delivered to farmers helping them to optimize costs, sustain production and obtain high quality products and their business to be economically viable [20].The International Federation of Organic Agriculture Movements (IFOAM) defines organic agriculture as "a production system that supports the health of soils, ecosystems and people" [1]. Organic agriculture differs from conventional agriculture in two aspects: in the concept of plant nutrition and fertilization, as well as in the nature of the means used to protect plants against the attack of diseases and pests [27]. The main advantage of organic farming is that it does not use the dangerous chemicals of conventional agriculture [1]. Conventional agriculture has determined the decrease in the content of organic matter in the soil and the accumulation of toxic compounds through the use of pesticides. By using organic fertilizers in ecological agriculture, the percentage of organic matter in the soil is increased and maintained [9].

In the area of Transylvania, it was possible to achieve an optimal combination between fertilization and plant protection in the ecological agriculture system, which could be an alternative to the conventional system, for corn and wheat. [8]. The concept of "reduced inputs" in organic farming leads to the reduction of transport and other inputs. Organic farming is a management system of agricultural production that favors renewable resources and recycling and does not harm the environment [14]. Minimum tillage in winter crop results in equal or slightly higher yields than those resulted from conventional soil tillage; in maize, yield was 5-11% lower, as it was a less favourable year for this crop. The energy consumed for the crop decreased in minimum tillage, resulting from lower fuel consumption/ha [12].

Energy types can be converted into each other, and energies can be stored and transferred by various methods. Measuring the energy consumed in agricultural production is a process of considerable complexity.

The purpose of the observations was to compare the results from the point of view of the production achieved in the non-irrigated maize culture, the expenses incurred, the incomes obtained and the profit achieved in the two variants, ecological and conventional. Another aspect followed was the determination of the energy consumption and efficiency of these two culture systems.

MATERIALS AND METHODS

The study carried out in the Experimental Field of the Research and Development Station for Pomiculture Băneasa, Moara Domneasca, during the period 2021-2022. It was interpreted the average data of this period.

Moara Domnească is located at 30' north latitude, 260 13' east longitude, at an altitude of 90 m, N-E of the city of Bucharest.

To the west and north, the Experimental Base where the experiments were located, is bordered by the Afumati commune, to the east by the village of Moara Domneasca and to the south by the Bucharest city belt.

The territory of the locality is included in the relief of the Romanian Plain, the subdivision of the Vlăsia Plain, in the transition zone from the forest-steppe to the forest area. In order to highlight the impact of climatic conditions on the productions achieved, Table 1 shows the amounts of precipitation recorded during the period in which the experiments were carried out.

In 2020, the amount of accumulated precipitation was 378 mm, in 2021 ,539.4 mm and in 2022, 494.8 mm. All values are below the 50-year multiannual average of 548.0 mm. but above the average of the three years studied, 477.4 mm, in the years 2021 and 2022 (Figure 1).

Regarding the year 2022, the amounts of precipitation recorded had satisfactory values in the months of May, June and July, totaling 175.4 mm, an amount that favored the development of corn plants in optimal parameters, which was reflected in obtaining a relatively good harvest, in the absence of irrigation.

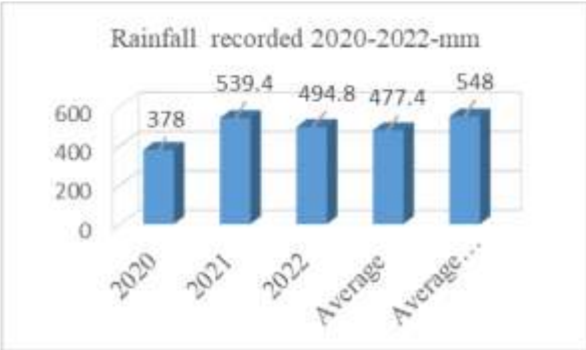

Fig. 1. Rainfall recorded during 2020-2022 (mm)
Source : own representation based on the data from Meteo Station Moara Domneasca [17].

The soil. The type of soil is reddish preluvosoil, having loam-clay texture [16].

This type of soil has the following physical-chemical characteristics:

the texture is loamy-clay throughout the profile, the main hydro-physical indices have medium to high values (CH Around 9% in A and up to almost 10% in B; CO over 13% in A and over 14% in B; CC 26-25% in A and 24-21% in B; the humus content is medium in A (2.77-2.16%) and remains relatively high in A/B (around 1.2%). The sum of exchange bases has high values, generally over 21 me/100 g of soil, on the entire profile; exchangeable hydrogen has small and very small values (2-5 me);the degree of saturation in bases usually presents high values (79-89%);the reaction is weakly acid-neutral (in A, pH=6.2-6.6 and in B, pH=6.0-6.5);

Table 1. Recorded precipitation during period2020-2022

Luna	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**mm**
2020	31.8	3.0	16.4	30.0	73.4	31.0	52.2	8.4	40.0	32.8	29.6	29.4	**378.0**
2021	58.4	20.4	26.4	5.4	44.2	96.4	163.2	22.4	31.4	33.8	10.8	46.6	**539.4**
2022	28.4	31.4	31.2	29.8	49.6	67.4	58.4	27.6	21.8	37.6	10.2	101.4	**494.8**
Mean													**477.4**
Mean 50 years													**548.0**

Source: Meteo Station Moara Domneasca [17].

The nitrogen indices are medium in A (above 2) and low in B (below 2), which shows a medium and weak nitrogen supply, respectively; at a depth of 20 cm from the surface (the active start of roots), the soil is moderately supplied in mobile phosphorus (17 ppm PAL) and well supplied in mobile potassium (184 ppm KAL) [17].

To achieve the objectives, a monofactorial experience was carried out where

a1: Conventional agriculture

a2: Organic farming

The size of the experimental plot was 480 m^2 (16x30) and that of the harvestable plot was 176 m^2 (8x22), following the elimination of the edges.

The hybrid sown was Pioneer P9241 Aquamax, semi-early hybrid, with excellent production capacity, it has a very well developed root system, the height of the plant is medium-tall. It has a good ability to adapt to thermal and water stress. As elements of productivity, the hybrid has a number of rows per cob of 14-16, a number of seeds per row of 44-47 and MMB of 350-396 g. These elements ensure high productions. The favorable culture areas for this hybrid are the semi-arid and semi-humid ones in the west and southeast of the country. The recommended density for non-irrigated is 66,000 - 75,000 harvestable plants/ha.

RESULTS AND DISCUSSIONS

To obtain agricultural production (Ec), a whole series of energy costs are included:

- direct active energy or direct external energy (human energy, mechanical energy, etc.);
- indirect active energy, necessary for the production of consumable goods in a single production process (seeds, pesticides, chemical fertilizers, etc.);
- passive energy, necessary for the production of fixed means (machines, constructions, etc.) used in agriculture [17, 22]. Active energy, especially direct active energy, has the largest share of energy from the total energy consumed to obtain agricultural plant production, mainly determined by the consumption of fuel for the movement of agricultural aggregates during the technological links. From the total amount of agricultural work, the highest consumption is realized during the execution of soil works [15, 22]. Mechanized land use consumes a lot of energy, with the highest energy consumption observed in basic soil work (ploughing), and this parameter is significantly influenced by soil characteristics (texture, structure and moisture). Plowing consumes the largest amount of mechanical energy, representing about 35% of the total energy consumed for the mechanized execution of works in plant production [15,

22]. The consumption of indirect active energy is largely determined by the consumption of chemical fertilizers [22].

Comparisons between fuels

Historically, mankind has generally obtained energy by consuming fossil fuels, so comparing fuel sources in terms of the amount of unit energy they contain helps with this calculation.

1 kg of anthracite (4% moisture) = 36MJ = 10 kWh

1 m3 natural gas = 39 MJ = 10.8 kWh

1 liter of petrol = 34 MJ = 9.4 kWh

1 liter of diesel = 40 MJ = 11.1 kWh

1 liter of liquefied petroleum gas = 41 MJ = 11.4 kWh

1 liter of fuel oil = 44 MJ = 12.2 kWh

By comparison, 1kg of renewable fuel such as woody biomass typically contains 4.2 kWh. 1 liter of diesel contains approximately 18% more energy than 1 liter of petrol [17, 22].

The sowing was carried out on April 27. The predecessor plant was wheat. The production achieved in the non-irrigated culture was 8,200 kg/ha in the conventional system and 7,000 kg/ha in the ecological system.

Table 2. Technological sheet of the maize crop cultivated in conventional system

Indicator	Diesel consumption Liters/ha	Expenses Lei/ha
Stubble-turning 8-12cm	6.0	42.0
Disk 15cm	5.6	88.5
Fertilize	1.2	33.8
Plowgh	25	400.0
Disk 15cm	5.6	88.5
Combinator	4.0	56.3
Treat the seed with insecto-fungicides	1.0	
Seed transport	2.6	3.75
Sowing	5.0	119.3
Serviced seeders	-	-
Fertilized with solid fertilizers	1.5	33.8
Foliar fertilizer + phytosanitary treatment	1.5	27.8
Herbicide X 2	1.5	71.5
Insecticide treatment	1.7	41.9
Fungicide treatment	1.7	41.9
Harvesting	11.0	500.0
Transportation 5 km away	5.0	60.0
TOTAL GENERAL	**93.4**	**1,609.0**

Source: Own calculation.

Following the performance of various soil works, maintenance works (phytosanitary treatments), harvesting, 93.4 liters of diesel were consumed, representing an expenditure of 1,609.0 lei per hectare.

Table 2 shows the fuel consumption for each technological link, technology applied in the conventional system.

In order to ensure the prevention of some diseases and pests, seed treatments were carried out for sowing with the product Nuprid 600 FS. Over time, such treatments applied by other researchers have led to positive results such as an increase in biomass, dry matter and a proper development of the plant. Application of bio-stimulator treatments resulted in improvement of all biometric indicators of maize plants. Treatments applied determined increases of MMB, MH, starch, U% and protein but those were not statistically assured [7]. The materials used in the corn culture were: for sowing - seed from the P9241 hybrid, for fertilizing - DAP 18:46 fertilizers in a dose of 250 kg/ha, urea and nitrolime, to fight diseases and pests, products such as Retengo, Coragen, to fight weeds, the Rekord Max product.

Table 3 shows that the application of these products generated expenses of 2,816.5 lei/ha. In conclusion, the expenditure on inputs exceeded the expenditure on fuel. Taken together, these expenses reached the value of 4,425.5 lei.

To this value, 10% indirect expenses were added, resulting in a sum of 4,868.05 lei total expenses related to the establishment of a hectare of corn in a conventional, non-irrigated system.

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Table 3. Products applied for fertilization and phytosanitary treatments

Indicator	Materials	U.M.	Doses	Expenses- lei
Fertilizer	DAP 18:46	Kg	250	875
Treat the seed with insecticide	Nuprid 600 FS	l	0.2	74
Sowing	Hybrid P9241	sac	0.83	705
Herbicide	Rekord Max(Callam+Samson Extra+ Dash)	l	0.2	255
Tratament for biostimulation	Maize top	Kg	2	70
Fertilize	Uree	Kg	100	190
Fertilize	Nitrocalcar	l	100	140
Foliar fertilizer + biostimulant treatment	Blacjack	l	1	60
	Azospeed amino	l	5	125
Insecticide + fungicide treatment	Retengo	l	1	150
	Coragen	l	0.125	172.5
TOTAL				**2,816.5**

Source: Own Calculation.

Regarding the ecological culture system, the material expenses generated the amount of 2,425.0 lei/ha, expenses consisting of fertilizers with Bio Ceres NOK, Aminotop, but also seed treatment products, Freya Seed, Germinoseed which ensured protection against plant diseases.

The Zapper product was applied to combat weeds. The doses and applied products are presented in Table 4.

Table 4. Products applied for fertilization and phytosanitary treatments

Indicator	Materials	U.M.	Doses	Expenses- lei
Fertilization	Bio SSP	Kg	200	400
Fertilize	Bio Ceres NOK	kg	200	400
Soil treatment	Pachet –Bacter, Country, Terra Clean+P-FIX+Roots	l	190	190
Treat the seed	Freya Seed	l	0.5	130
	Germinoseed	l	0.5	46
Sowing	Hybrid P9241	sac	0.83	705
Tratament for biostimulation	Aminotop Zinc	l	1	70
	Aminotop N	l	1	62
	Aminotop Ultra	l	1	62
Foliar fertilizer + biostimulant treatment	Aminotop Zn	l	1	70
	Alg Green	l	1	70
Insecticide treatment	Zapper	l	1	220
TOTAL				**2,425.0**

Source: Own Calculation.

From the data presented in Table 5, it appears that soil works such as plowing, tilling or preparing the germinal bed as well as sowing or phytosanitary treatments generated a consumption of 89.9 l diesel per hectare and an expense of 1,817.5 lei/ha.

Total material expenses + fuel = 4,242.5 lei. To this value, 10% indirect expenses were added, resulting in a sum of 4,666.75 lei total expenses related to the establishment of a hectare of corn in an ecological, non-irrigated system.

The economic efficiency is shown in Table 6, from which it appears that following the sale of the harvest at the price of 1.31 lei/kg, incomes in the conventional culture of 10,742 lei were obtained.

For the corn from the ecological system, sold at the price of 1.32 lei/kg, revenues of 9,240 lei/ha were recorded, with 1,502 lei less than the revenues obtained by capitalizing on the corn grown in the conventional system. The higher productions achieved in the culture using conventional technology (1,200 kg/ha) was generated this difference. For the establishment one hectare of corn, the expenses incurred were about 4,868.05 lei in the conventional system and 4,666.75 lei/ha, in the ecological system, the difference was coming from a reduce number of phytosanitary treatments. The profit recorded was bigger (5,873.95 lei/ha) for the conventional system and smaller (4,573.25 lei/ha) for the ecological system, the difference of 1,300 lei/ha was the result of increased production. The profit rate was higher, 120%, for the conventional version and 98%, for the ecological version. A rate of profit of 120% means that the profit made is 120% of the initial investment or income generated. This indicates that for every unit of currency invested or earned, an additional 1.20 units of profit was earned. Nor is the rate of profit achieved in the ecological culture system low.

Table 5. The technological sheet of the maize crop grown in ecological system

Indicator	Diesel consumption Liters	Expenses Lei
Stubble-turning 8-12cm	6.0	88.5
Disk 15cm	5.6	88.5
Fertilized equipment serviced		
Fertilize	1.2	33.8
Plowgh	25.0	362.3
Disk 15cm	5.6	88.5
Combinator	4.0	56.3
Treat the seed with insecto-fungicides	1.0	-
Seed transport	2.6	3.75
Sowing	5.0	119.3
Serviced seeders	-	-
Fertilized with solid fertilizers	1.2	80.8
Foliar fertilizer + phytosanitary treatment	1.0	7.8
Transport	1.0	27.8
Herbicide	1.8	11.0
Serviced crop treated equipment	-	8.8
Transport	1.5	7.8
Insecticide treatment	1.7	41.9
Fungicide treatment	1.7	41.9
Harvesting	11.0	600.0
Transportation 5 km away	5.0	60.0
Chopping vegetable scraps	4.0	89.0
Straw balling	4.0	-
TOTAL GENERAL	**89.9**	**1,817.5**

Source: Own Calculation.

A percentage of 98% highlights an efficient business strategy, which allows the company to control costs and maximize revenues, in conclusion to optimize the activity.

Table 6. The economic efficiency of the studied systems

Indicator	Conventional System	Ecological System
Yield-kg/ha	8,200	7,000
Price /kg-lei	1.31	1.32
Income- lei/ha	10,742	9,240
Expenses- lei/ha	4,868.05	4,666.75
Profit lei/ha(brut)	5,873.95	4,573.25
Profit rate %	120	98
Unit cost/ton- lei/to	600	670

Source: Own calculation.

The two values of the profit rate denote that the financial resources of the unit are sufficient to invest in development and improvement of the activity. The cost of obtaining a product unit (ton) was lower in the conventional system, 600 lei/ton, which is a positive aspect from an economic point of view, and 670 lei/ton in the ecological system.

Energy efficiency analysis - Maize conventional system

Total energy consumption

Diesel consumption (litres) xkw/l diesel

93.4x11.1=1,036.7 kw

Energy consumption/unit of harvested product

Total energy consumption: production (kg)

1,036.7:8,200=0.126 kwh

Energy efficiency analysis - Maize ecological system

Total energy consumption

Diesel consumption (litres) x kw/l diesel

89.9x11.1=997.9 kw

Energy consumption/unit of harvested product

Total energy consumption: production (kg) 997.9:7,000=0.143 kwh.

Regarding the energy efficiency of the two corn cultivation systems, we observe from Table 7 that in the conventional culture system 93.4 l of diesel per hectare were consumed compared with ecological culture system were only 89.9 l/ha were used, which means that the interventions performed on the culture were reduced as number.

Table 7. Energy efficiency of the analyzed systems

Indicator	Conventional system	Ecological System
Diesel consumption-l/ha	93.4	89.9
Diesel consumption-lei/ha	1,609.0	1,817.5
Total technological costs–lei/ha	4,868.05	4,666.75
Total energy consumption-kw/ha	1,036.7	997.9
Energy consumption/unit of harvested product kwh	0.126	0.143
Yield –kg/ha	8,200	7,000

Source: Own calculation.

Implicitly, the technological costs for each hectare were lower, 4,666.75 lei, for the ecological system and 4,868.05 lei, in the case of the conventional culture system. The consumption of diesel transformed into energy, is about 1,036.7 kw/ha for the conventional version and 997.9 kw/ha, for the ecological system. The transformation of this consumption into energy consumed to obtain a unit of product (ton) was carried out by dividing the total energy consumption by the realized production. In the conventional culture system, a consumption of 0.126 kwh was required compared to 0.143 kwh, in the ecological system. The recorded difference is generated by the larger productions made in the conventional system. High yields lead to lower energy consumption for obtaining them, implicitly, a lower cost price per product unit. Finally, they lead to energy and economic efficiency.

CONCLUSIONS

In the conventional culture system, fuel consumption was higher.

For obtaining a product unit (ton), the costs was lower in the conventional system, 600 lei/ton comparative with 670 lei/ton, in the ecological system.

This production cost influences the selling price, the profit, the profitability of the company and the strategy it will adopt in the future. In our case, the conventional technological system brought better results compared to the ecological system. The profit and the profit rate were higher. In the conventional technology system, for obtaining one ton of product was needed an energy consumption of 0.126 kwh and in the ecological system, 0.143 kwh. The difference between the values is the result of the higher productions obtained in the conventional system. Higher yields need lower energy consumption to obtain them, the lower energy consumption, lower cost price of the product unit, which means energy and economic efficiency. The energy efficiency is influenced by the productions obtained, the conventional system being superior from this point of view, for the P9241 hybrid, for the applied technology and for the respective pedoclimatic conditions.

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THE INFLUENCE OF SOCIO-DEMOGRAPHIC CHARACTERISTICS ON AGRI-FOOD CONSUMPTION BEHAVIOR IN THE CONTEXT OF EUROPEAN POLICIES

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Abstract

In the global context of sustainable development and facilitating the transition from production and consumption models to more sustainable ones in relation to environmental resources but also to the health of the population, consumer behavior on agri-food markets is represented in most policies and directions of action. The 2030 Agenda for Sustainable Development, the European Green Deal and the Farm to Fork Strategy, as well as the European directives on various characteristics of agricultural production, transposed at national level, are just some of the official reference documents for this research subject. The paper aims to identify optimal solutions for the effective promotion of sustainable agri-food product behavior. In this approach, one of the key specific objectives is outlined, which is to determine the influence that some socio-demographic characteristics exert within the purchasing process on reference markets, at the level of consumers in Romania. In order to identify the synergy between the independent and dependent variables, a series of marketing studies were conducted at the level of 4 product groups, namely nuts, whole grains, berries and green vegetables. In order to achieve the main goals of this work, specific methods were used, both from qualitative and quantitative research field. To determine the current context at the level of the studied markets, several publications were analyzed (previous studies related to the topic, official documents included in European legislative framework, statistical data published in official databases (Eurostat, FAO, NIS). Also, among the Romanian consumers, a questionnaire was applied, in order to determine their behavior on nuts, whole grains, berries and green vegetables markets. The research results interpretation highlights a trend of consumers towards a balanced lifestyle, and a relevant awareness degree regarding the benefits of introducing the mentioned categories into the daily diet. However, it is also observed the link between the socio-demographic characteristics of respondents (income level, professional status and gender) and the consumption behavior. Consumers perception, childhood habits, the awareness degree cultural factors should also be mention as important independent variables related to the research topic.

Key words*: *From Farm to Fork Strategy, consumer behavior, sustainable agri-food products

INTRODUCTION

Starting from FAO definition for the sustainable diets concept, it can be observed that all the three dimensions of the sustainable development (economic, ecological and social) [22]: “sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources” [13]. Although there is no universal definition for the sustainable diet, it can be observed the essence of this concept: ensuring the balance between the well-being of agricultural producers, the optimal health of the population and the preservation of the environment [16].

Raising consumers awareness related to the sustainable food choices, replacing conventional food products with healthier options and ensuring natural resources conservation [6] are one of the main objectives identified at the European level, within the strategies and policies in force related to the topic [10;11].

Promoting sustainable food consumption and facilitating the transition to healthy, sustainable diets represents the core element included into the Farm to Fork Strategy [10]. Regarding this direction, the population’s food intake habbits are still described as “unsustainable”, in terms of natural resource conservation but as well from human health protection [17].

Current consumption habits identified at the level of European member states reflect a reduced consumption compared to the recommendations of nutrition specialists [14, 23] at specific categories such as *nuts, whole grains, fruits and vegetables* [8,12].

At national level, in Romania, there are various publications spotlighed on the consumers behaviour, focusing on the relation between the eating habbits and the food safety and security maintenance [5].

According to previous studies, there is a significant improve regarding the food products consumption patterns in Romania [9]. However, statistical values place the national context below the European average values, at several categories, such as fruits, vegetables, whole grains and nuts [15].

This study presents the main results obtained in the quantitative research conducted among Romanian consumers on the target markets: nuts, whole grains, berries and green vegetables. By completing the specific objectives, the goal is achieved, which is to substantiate proposals regarding strategic measures in order to facilitate the transition to sustainable food consumption, in relation with European directives.

MATERIALS AND METHODS

In order to carry out this work, specific techniques were used, both from qualitative and quantitative research [7].

Among the *qualitative research methods,* we mention, without limiting ourselves to: content analysis of published specialized studies relevant to the studied topic, official documents that are components of the European legislative framework and not only, as well as the interpretation of statistical data published in official databases (Eurostat, FAO, NIS). The purpose of implementing these qualitative techniques was to determine the current context at the level of the studied markets.

The instrument used in the quantitative research was a questionnaire, applied to consumers in Romania, for each of the mentioned categories: nuts, whole grains, berries and green vegetables.

The marketing studies conducted among Romanian consumers had as general objective the determination of the level of awareness of Romanian consumers regarding the benefits brought by the consumption of products from the reference categories. Among the specific common objectives outlined at the research level, the determination of consumption trends on the reference market at the level of the investigated sample as well as the identification of independent variables that significantly influence the frequency of responses to the questions in the questionnaire are mentioned.

All three questionnaires applied were structured in a similar manner, however, including certain specific questions depending on the typology of the products studied. The average number of the questions included in the questionnaire was 24, divided in three section: questions related to the consumers perception regarding the research subject, questions regarding the consumption patterns regarding the fresh products preferences and questions regarding the processed products preferences.

The questionnaires were completed by consumers using the Google Forms platform and the sampling method used was random [15]. Research result were centralized, codified and interpreted using the statistic software program SPSS [24].

RESULTS AND DISCUSSIONS

As a general approach, without a universally accepted definition in the specialized literature, *consumer behavior* can be defined "as a multidimensional concept, as the specific result of a system of dynamic relationships between the processes of perception, information, attitude, motivation and effective manifestation". During consumer behavior studying process, regardless of the products nature, establishing the determining factors that influence the way in which the individual acts has represented one of the key points of this field [2].

There are numerous studies in the specialized literature on consumer behavior in the agri-food market that test the influence that the individual's socio-demographic variables exert in the purchasing decision-making process [3]. Among the most common socio-demographic characteristic, respondent's age, gender, income and education level, social and marital status are often mention in marketing studies conducted at the consumer level [4; 20]. Other more recent studies place acceptance on consumer motivations, beliefs, perceptions and environmental awareness as a determining factor in purchasing agri-food products process [21].

During consumer's preferences investigations regarding the consumption of nuts, whole grains, forest fruits and green vegetables we included as independent variables respondents socio-demographic characteristics, such as *age, gender, income and education level, professional status, marital status*. In table one it can be observed the sample dimension and the structure by gender.

The sample size and the structure by gender and is presented in Table 1.

Also, regarding the level of income and education of the respondents who were included among this research, it is mentioned that most of them are graduates of higher education, with medium or high incomes. Thus, it is considered that the sample is representative for this study.

Through the main research objectives several expected outcomes can be mentioned, without resuming at this list:

(i)determining the current consumption habits on the reference market, both for fresh and processed products;

(ii)determining the reasons and barriers to consumption at the level of specific product categories;

(iii)identifying the degree of awareness of the benefits brought by the consumption of sustainable products with a low degree of processing;

(iv)identifying the consumers' perception on the reference subject;

(v)projecting consumer trends on the reference market,

(vi)identifying the basic criteria in the purchase decision.

Table 1.Sample size and structure by gender and age

Target products	Sample size	Sample structure by gender (%)*	Sample structure by age (%)**
Nuts	140	F-65%; M-35%	18-25 y.o. - 8.6% 26-34 y.o. - 14.3% 35-42 y.o. - 34.3% 43-52 y.o. - 25.7% 53 – 60 y.o.- 11.4% over 60 y.o - 5.7%
Whole grains	126	F-74%; M-26%	18-25 y.o. - 38.1% 26-34 y.o. - 42.9 % 35-42 y.o. - 19%
Forest fruits and Green vegetables	126	F-80%; M-20%	18-25 y.o. - 10% 26-34 y.o. - 40% 35-42 y.o. - 20% 43-52 y.o. - 20 % 53 – 60 y.o.- 10%

*F-female, M-male; ** y.o. - years old

Source: sample structure based on the respondents answers.

Consumers behaviour on nuts market – main findings

The consumers participating at this research have a predominantly favorable perception regarding the consumption of nuts, consuming mainly *walnuts, pistachios, almonds and hazelnuts*. However, they are not familiar with the products obtained from the processing of nuts such as milk, vegetable butter or oil. They prefer to eat them fresh and the main reason they do it is because they like their taste. Although consumers are aware regarding the benefits given by nuts consumption related to reducing the risk of medical conditions, such as cardiovascular disease or diabetes, they don't consume them at the urging of medical specialists. Nuts are eaten throughout the year, but in larger quantities, during the fasting period or when they prepare homemade sweets, such as cakes or baklava. Thus, the influence of traditions, customs on the consumption of agri-food products can be observed, even in this case. The main criteria underlying the purchase process are: *quality/price ratio, taste and freshness of nuts*. *Price* is also a major factor in the purchase process, even if this is not explicitly mentioned by the respondents, however the preferences regarding the choice of the manufacturer on this market demonstrate the importance of prices (the choice especially of the own brands of some hypermarkets) [18].

Consumers behaviour on whole grains market – main findings

The Romanian consumer is informed about the concept of whole grains, the types of whole grains and the main differences between conventional and whole grains and correctly identifies the health benefits brought by their consumption. From the price point of view, respondents have not thought about this aspect on the whole grain market and those who have thought about it consider that the reference price is high. Related to conventional cereals conventional, it can be seen that bakery products are preferred by respondents, while the whole grain market, pasta and rice are mainly chosen by respondents. Bread is also consumed by respondents very frequently, regardless of its type or presentation. Most respondents choose whole grain products for breakfast or snacks and do not take into account when cooking whether the raw material is based on whole or refined grains. Most of the respondents choose whole grain products to diversify their diet when fasting or dieting. For a small percentage of respondents, the taste differences felt in the consumption of whole grains made them give them up. Paradoxically, although respondents do not use smart apps to shape their eating lifestyle, the Internet, including social media, is still the main source of information. This shows the undeniable usefulness of campaigns or short articles on the ways of using and the benefits of the mentioned profile applications, possibly on communication channels such as Facebook or Instagram, social networks more accessible to consumers, regardless the age or level of education. An important share declares that the source of information is represented by health experts, which is positively appreciated. Thus, against the background of the diversification of the typology of information found on the internet, viral marketing ("word of mouth") loses its effectiveness, a small percentage of the sample having family members or friends as a source of information [19].

Consumers behaviour on forest fruits and green vegetables market – main findings

The majority of respondents have a very favorable perception regarding the consumption of fruits and vegetables, stating that they include these types of products in their daily diet. Apples, citrus fruits, pears and berries are consumed more frequently by respondents. Regarding the consumption of vegetables, the respondents' choices confirm the hierarchy resulting from the interpretation of the statistical data [15], resulting in a higher frequency of consumption for potatoes, onions and cabbage and lower for cauliflower, mushrooms, spinach and zucchini. On the vegetable market, the lowest frequency of responses is identified at the level of asparagus while on the fruit market at categories such as apricots, cherries, cherries and plums.

A high influence of product characteristics such as seasonality, shelf availability and price can be observed, in terms of consumers' choice of reference questions. Consumers' choices are based on preferences related to taste, texture, childhood habits and the presence of the mentioned products on the reference markets. Following the centralization of the respondents' answers, it can be said that they consume green vegetables more often than berries. At the level of berries, consumers' preferences regarding the consumption of raspberries, strawberries and blueberries are identified, and as regards the categories of green vegetables proposed, cabbage and lettuce were predominantly chosen. Product quality, the supply location, the local origin and the internal use of the fruits and vegetables studied are mainly the characteristics that positively influence the consumers' decision, while the high price level and availability, accessibility of the products in terms of the distribution strategy remain the main barriers in fruits and vegetables consumption. Supermarkets and hypermarkets remain the preferred locations for purchasing fruits and vegetables, followed by agro - food markets. The prices in the reference markets are mostly perceived by consumers as being too high. Most of consumers eats fresh berries,

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Vol. 25, Issue 1, 2025
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regardless of their weight management efforts. Secondarily, they buy berries for making fruit preserves at home (jam, jelly). Most respondents perceive fresh berries as beneficial, based on quality/price considerations or to avoid food waste. The majority of respondents state that they include green vegetables in their daily diet more often during periods when they are on a diet or fasting, preferring seasonal, locally sourced green vegetables. They rarely use green vegetables for making cream soups or preserves at home, preferring other types of vegetables in such cases. In this instance, the choice of frozen green vegetables is not considered beneficial by the research sample, but rather inefficient, due to the loss of properties like taste and nutrient content after consumption. On the market for processed fruit and vegetable products, respondents more frequently purchase juices, jams, jellies, frozen fruits, and vegetable preserves, such as tomato paste or pickles. The quality/price ratio, as well as the brand reputation, are the main criteria applied by respondents when choosing industrial products made from vegetables and fruits. Regarding consumer preferences related to the range of juices available in specialized markets, apple juice and berry juice are predominantly identified within the sample.

In Figure 1 it is presented a brief summary of the preliminary analysis of the research outcomes related to the target markets.

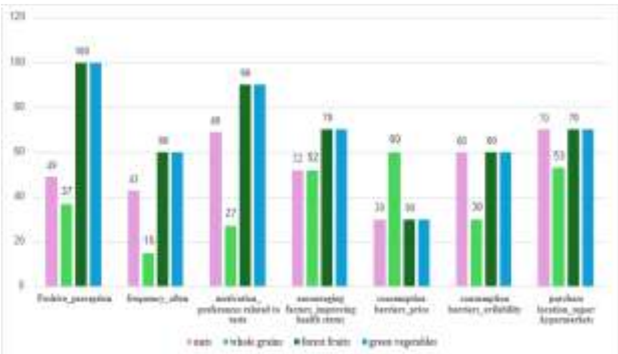

Fig. 1. Research preliminary results on the target markets related to consumers perception and consumption patterns (% sample share)

Source: author's processing based on the results obtained from running the univariate analysis in SPSS.

Testing the correlations between the socio-demographic characteristics and the research outcomes on target markets

Using the SPSS program, the values of the chi-square test were calculated to determine if there is a relationship between the dependent and independent variables (*for values < 0.005*), and the contingency coefficient was calculated in order to determine the strength of the relationship between the two variables [1].

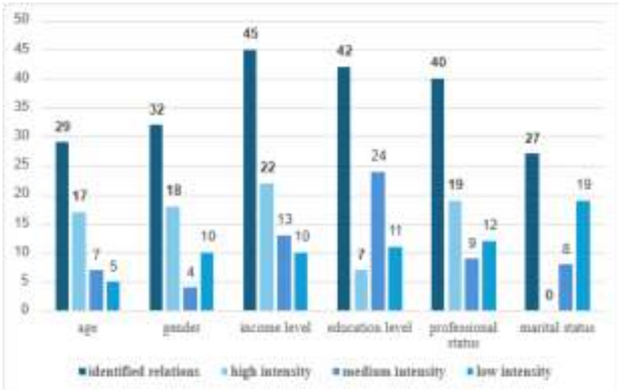

Fig. 2. Identified correlation between independent and dependent variables by intensity type (number)

Source: author's processing based on the results obtained from running the bivariate analysis in SPSS.

Thus, during the SPSS crosstabs analysis a total number of 73 correlations between the research variables were test. Following the simulation of the model a number of links were generated, corresponding to the situation when chi-square values is smaller than 0.005 (Figure 2). After calculating the contingency coefficient values, a higher intensity link is highlighted for income level, professional status and gender and a lower one for marital status.

Continuing the investigations regarding the influence of socio-demographic characteristics regarding the respondent's options related to the research questions, some particularities can be observed among the studied markets (Figure 3).

Thus, the respondents age and gender has a higher influence on nuts and whole grains market, while income level has a significant influence on whole grains consumption habits. In a smaller extension, professional status and education level influence the acquisition consumer decision on nuts and

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whole grains market. Therefore, it is observed that women have a higher inclination to try new, healthier products, their motivation being represented both by the improvement of their health condition and correlated with body weight management. They also make up the part of the sample that consumes more types of berries, whole grains, or nuts, including processed ones. A higher level of education is usually associated with a greater degree of consumer awareness regarding the benefits of consuming sustainable products. The age of the respondents influences consumption trends in the studies conducted for the product categories analyzed, in the sense that a higher inclination towards purchasing healthier products is observed at both ends of the age spectrum, namely among younger respondents and those over 50 years old.

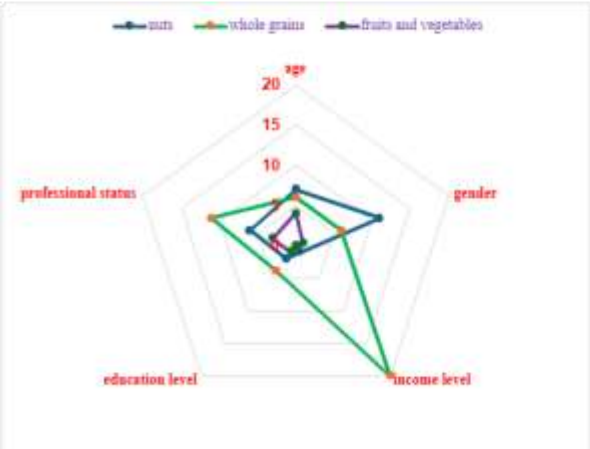

Fig. 3. The number of higher intensity links between research variables by products type
Source: author's processing based on the results obtained from running the bivariate analysis in SPSS.

People active in the labor market consume nuts more frequently as snacks during the day, considering them efficient given the time they allocate throughout the day. Upon interpreting the results, a greater variety of consumption is observed, especially for whole grain-based products, among individuals with higher incomes.
Among all the categories studied, it was observed in the research conducted that socio-demographic characteristics had a less significant influence on the berry market in terms of consumption behavior. The purchasing process in the reference market was mainly influenced by product characteristics such as seasonality or availability in the local market.

CONCLUSIONS

This paper presents, in a concise form, the results obtained within the project 'Marketing Studies on Sustainable Products Markets in the Context of the From Farm to Fork Strategy,' with a focus on the synergy between the dependent variables (consumers responses) and the independent variables under investigation (socio-demographic characteristics). Using the methodology specific to marketing research, this study joins to other numerous publications in the specialized literature that highlight the influence of age, gender, education level, professional status, and income level of respondents on their consumption behavior, both in the agro-food product markets and beyond. However, the main results shows also that consumers perception, childhood habits and their awareness degree also influence in a significant extent their food products options. Also, cultural factors could be included in shaping the respondents' behaviour, related to their habits concerning the increase in consumption frequency of certain product categories during traditional holidays or fasting periods.
Thus, it is essential to continue public relations campaigns to raise consumer awareness about the health benefits and environmental resource conservation associated with incorporating healthy, minimally processed products. This is even more important given the evident positive effects of the strategic directions implemented at the European level in this regard. However, it is important for ensuring the campaign efficiency to promote a message aligned with the characteristics of the target audience, considering not only socio-demographic factors but also the motivations, aspirations, and attitudes toward the campaign's topic.

ACKNOWLEDGEMENTS

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SUSTAINABILITY IN SILK PRODUCTION AND SILK TEXTILE INDUSTRY

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Abstract

The goal of the paper was to analyze and present the way in which sericiculture and silk and silk textile industry has succeeded and what it should done to be entirely attain the sustainability goals along the product chain. The statistical data have been provided by International Sericicultural Commission, UNESCO, European Union and have been processed using regression equations to assess the trends in the dynamics of silk production globally and in China and India, the top silk producing countries in the interval 2016-2023. A large number of articles, published in well-known scientific research reviews were carefully studied bringing the novelties regarding the new solutions for a sustainable silk production, textile and clothes industry. The study presents a selection of various opinions, experiments, innovations, sustainable technologies, procedures, products and case studies. The results showed a positive trend in global silk output which in 2023 attained 94 Thousand MT, being by 2.95% higher than in 2022, the main contributors being China by 53.2% and India by 41.4%. Silkworm growing based on mulberry leaves should pass on a larger scale to eco-friendly and animal-friendly solutions like "peace silk" production system, and also important measures must be taken to improve work conditions, gender discrimination, to implement integrated system to sustain productivity, silk and textiles quality and efficiency. Genetic engineering and biotechnology have to be more involved in bringing new solutions for enlarging silk fibers offer, and smart silk-based textiles, silk-based sensors and biomaterials to look for new applications. The revival of silk garments as a feed-back to the end of "fast fashion" must continue to offer new high quality and long lasting clothes in various designs, colors, textures, based on traditional inspirations, and on the minimalist principle, preserving silk precious and unique features, elegance and luxury appearance to better satisfy modern consumers.

Key words**:** *sustainability, silkworm rearing, silk, textiles, clothes, industry*

INTRODUCTION

Silk is "the queen" of the natural fibers, grace to its protein made of fibroin produced by the larvae of some insects which form cocoons. The largest spread type of produced silk comes from the mulberry silkworm *Bombyx mori* [64, 67, 73].

Silk played an important role in the history of mankind by creating the 1st trade route at the global level with deep implications in the exchange of commodities, ideas, technology, arts, culture and gastronomy and in shaping a prosperous future to the producers and traders, in the development of the states and cities by linking Asia, Europe and Africa, and then with Americas and Oceania, sustaining the intercontinental trade, creating a cultural landscape and economy of the entire world [26].

It is unanimously recognized that silk has a lot of wonderful and beneficial properties such as: soft touch, biocompatibility based on its no allergic texture, high moisture absorbency, high breathability reducing the risk of overheating, moderate to poor elasticity, thermal regulation of the wearer's body, drying speed, shining and biodegradability, and all these have led to its use especially in the silk fabrics and clothing industry with a high importance in the development of a special niche in the international trade [48, 49].

Silk is a symbol of luxury, splendid and elegant clothes of a large variety making the wearer to feel beautiful, confident, luxuriating and proud [13].

Besides its use in textile and clothing industry, silk has proved to be an important raw material utilized in furnishing applications, in producing other industrial products, medicine, and in the sector of biomaterials [41, 52, 74].

There are different types of silk: Mulberry silk, Tasar silk, Eri silk, and Muga silk.

But, the development of sericiculture is based mainly on silkworms rearing because the silk fiber has a high quality, strength and length. About 2,500 silkworms could produce a pound of raw silk, and from each cocoon, it is possible to obtain about 600-900 m of usable silk [15].

Silkworms growing requires the existence of mulberry trees plantations from which leaves are harvested and used to nourish the worms.

Silkworms rearing is an important sub-branch of agriculture with a high economic and social importance in many countries mainly in the developing ones: it creates jobs, assures full employment, it is suitable for women involvement as labor force, it brings income to the growers [62], it supports cooperative activities, strengthens social networks and stimulates setting up partnership projects, it assures economic development and improve life quality for the people living in the rural areas, it is an antipoverty factor and prevents migration to urban area [31, 47].

However, silkworm rearing has also some disadvantages among which it deserved to be mentioned:

-limitations caused by climate change which affects mulberry leaves production;

-a high consumption of chemicals like fertilizers and pesticides in mulberry tree growing;

- much man work because many operations are still manually done;

- a high water, energy and time-consumption across the silkworm growing and cocoons processing [17, 54];

- a high production cost for silk as raw material and silk fabric, taking also into consideration the expenses with mulberry trees growing;

-silk extraction from cocoons involves the killing of the larvae which does not compile with animal welfare [13];

- silk wastes pollute soil and waters [19, 57];

- worms could have diseases and workers could develop respiratory problems working in non proper conditions in the silkworm rearing rooms [78].

- being an animal-based product, silk has a high environmental footprint (carbon monoxide is produced during the rearing process) compared to other natural fibers like cotton and wool.

Nowadays, silk and silk products demand and offer are increasing, but the higher and higher competitiveness in the international market [16], climate change [6], production costs, price fluctuations [65], and environment problems have obliged silk industry to remodel its strategies towards a sustainable development, high tech solutions and a new orientation to better satisfy consumer preferences for clothes and accessories, home decorations, medicinal products etc.

In silk textile and fashion industry, sustainability means to use as organic inputs as raw materials, to avoid chemicals, recycling the remains according to the circular economy, to offer fair work and health conditions for the employees, to practice an environmental-friendly production system which must also assure animal well-being, collecting and processing the wastes to avoid environment pollution [2].

In this context, the paper aimed to approach how sustainability should be carry out in the field of sericiculture from mulberry tree growing to silk worm raising, and till obtaining silk filament, fibers and textiles and even how fashion industry prospects the future of sustainable silk in luxury garments.

The study continues our researches in the actual conditions when sustainability must be adopted for diminishing climate change, for increasing production using eco-friendly technologies and procedures and assuring high quality products to better satisfy the needs of the actual consumers.

MATERIALS AND METHODS

For setting up this research, it was started with a large documentation based on a selection of over 80 published papers on the topic in important international scientific research journals and also from other information sources like reports published by various international bodies: International Sericicultural Organization, UNESCO, European Union and other opinions in order to pick up the main ideas about sustainability in general and how it should be implemented in the field of silk production and processing from fiber to textiles and clothes.

The material presents, in the authors' own vision, the situation of silk and silk textiles production and market at the global level, a synthesis of the consulted literature pointing out the main new technologies, procedures, solutions, research results for assuring sustainability on the whole silk chain.

The statistical data regarding silk production were provided by International Sericicultural Commission for the period 2016-2023 and have been processed using regression equations and the determination coefficient R square to characterize the dynamics of the global silk production, and also its evolution in the two top silk producers: China and India.

A special accent is put on the ways how silk could be produced in a sustainable way, making a comparative analysis of the production systems and showing which of them is relevant and must be maintained in order to name the silk industry sustainable.

A series of novelties in science, resulting from the experiments carried by various researchers, the challenges and opportunities, and trends in the field of silk textile and clothing industry are also mentioned.

Finally, the main conclusions have been issued regarding how silk production and silk textile industry succeeded to become more sustainable and it has to continue its efforts in the future to meet the sustainability goals.

RESULTS AND DISCUSSIONS

Global Silk production

The higher and higher demand had determined an increased silk production which at the global level, in 2023 reached 94 Thousand MT, being by 2.95% higher than in 2022 (Fig. 1).

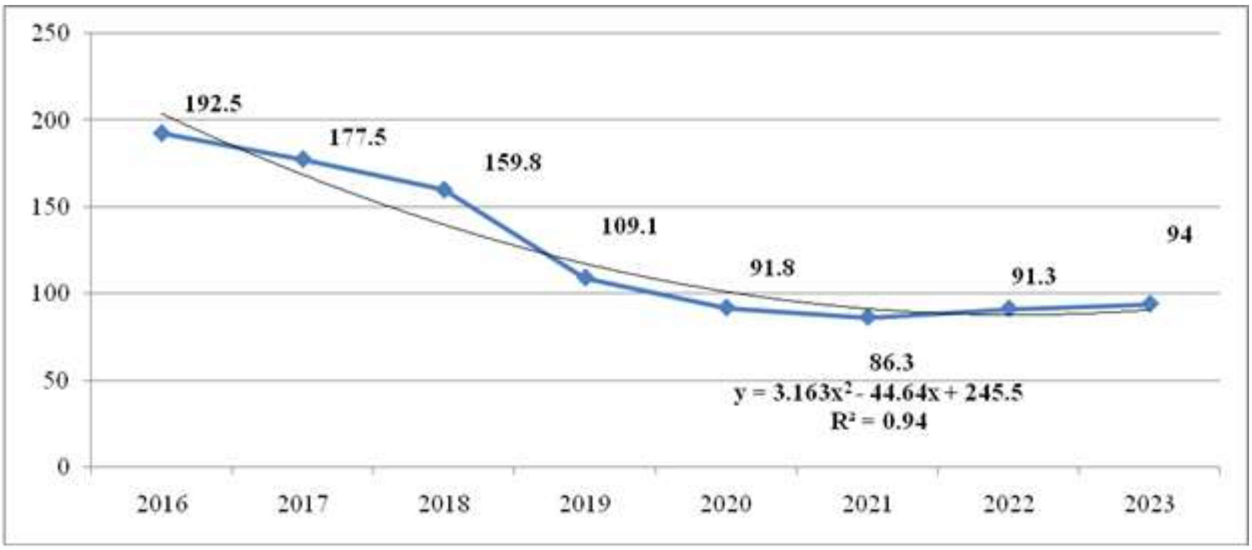

Fig. 1. Dynamics of the world silk production, 2016-2023 (Thousand metric tonnes)
Source: Own design based on the data from [20].

However, since 2016, the graphic shows a continuous decline from 192.5 Thousand MT to the lowest level, in the analyzed interval 2016-2023, reached in the year 2021 and accounting for 86.3 Thousand MT, which was by 55.2 % less than in the first year.

After this moment, silk production restarted to raise so that in the year 2022 it was by 5.79% higher than in 2021 and din 2023, by 2.95% higher than in the previous year.

The largest silk producers are China and India, which maintain their top positions, in 2023, together producing 94.6% of the global silk production (China 53.2% and India 41.4%). They are followed by Uzbekistan and Vietnam, with much smaller contributions, summing 3.7%. All these four countries together carried out 98.3% of the global silk production (Fig. 2).

The trend lines in Figure 2 are different in India than in China. It is obviously, that in China silk production decreased from 158.5 thousand MT in 2016 to 46.7 thousand MT in 2021, but in the coming two years it slightly went up to 50 thousand MT. India registered a continuous ascending trend in silk production from 30.3 thousand MT in 2016 to 38.9 thousand MT in 2023, meaning by 28.2% more than in the first year of the interval.

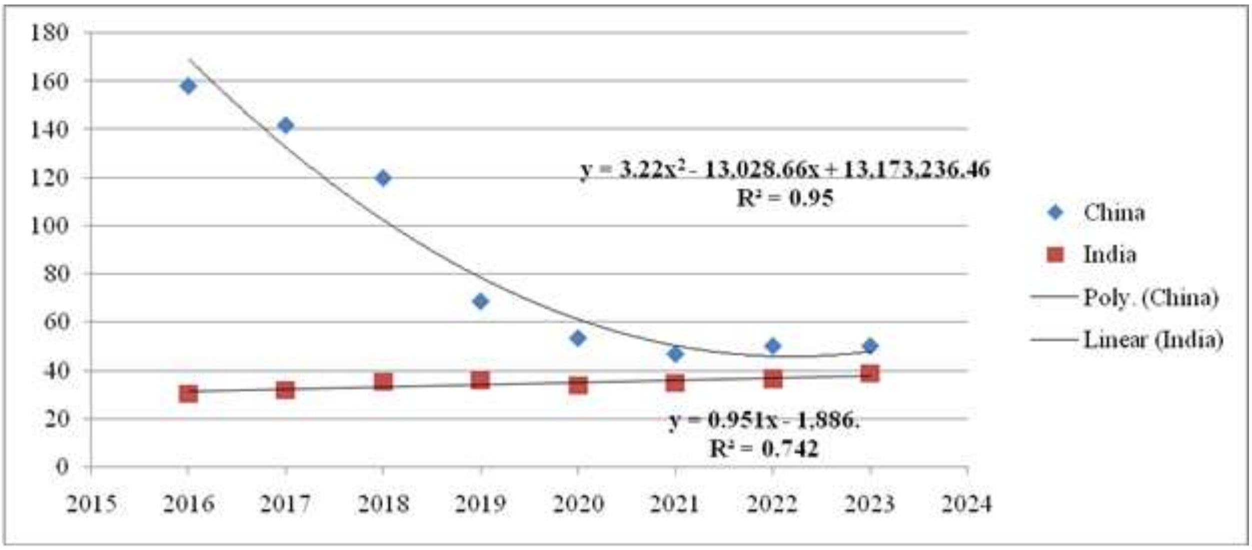

Fig. 2. Dynamics of Silk production in China and India, 2016-2023 (Thousand metric tons)
Source: Own design based on the data from [20].

Global production of natural fibers of animal origin including silk and wool increased in the last decade as mentioned [50], while the trade with raw silk has intensified its flow worldwide, the main directions being oriented from the Asian countries which are the top producers and exporters to the EU countries (Italy, Germany, France, Spain etc) where raw silk is processed into sofisticated garments and other products as mentioned [51].

Global Silk market size accounted for USD 19.51 Billion in 2023 and from 2024 till 2030 it is expected to grow at a CAGR of 7.6%. Therefore, in 2030, silk market value will attain USD 32.59 Billion.

These figures are very small compared to the market size of other fibers, silk market accounting for only 0.2% in total value of global textile fibers which reached 109 Million tonnes in the year 2020 and it is projected to grow to 145 Million tonnes in 2025 and to 160 Million tonnes in 2030 [11, 66].

However, taking into account silk and silk commodities, the share of silk in the value of global textile fibers is much higher because raw silk costing is 20 times higher than cotton.

Compared to production costs of other fibers, silk production costs are much smaller because the silkworm growing technology does not require expensive machinery or equipment, only low investment, but more labor force.

The high demand for silk for producing textiles, cosmetics, medicines etc favors silk market growth.

China and India are the main players, the former for garments and the latter for apparel market.

Silk market is dominated about 60% by Tussar silk, 20% by Eri silk, and 10% by other types.

China is the leader in silk exports, whose value reached USD 945 Million in 2023, while Italy is the top silk importing country, its import accounting for USD 322 Million [63].

Photo 1. Chinese silk blouse
Source: Original.

Global Silk textile market size

In 2023, global silk textile market had a value of USD 124.2 Billion and it is expected that by 2030 to increase by a growth rate (CAGR) of 8%.

The market structure by product reflects that apparel keeps about 50%, followed by accessories with about 20%, beddings accounting for about 10% and the remaining for other products.

By end-use, the world silk textile market is structured in: 51% fashion, 25% home furnishings, 8% health care, 9% automotive and 6% others [18].

Factors influencing silk market

Silk production is influenced by the existence of land, mulberry tree plantation, silkworm eggs from high genetic potential breeds and hybrids, fertilizers, pesticides, medicines, water, energy, labor force, price of inputs, production cost, experience and training level of the farmer, silk worm growing system (conventional or organic, peace and mixed organic peace), financial resources of the grower, state policy in the field of sericiculture, the existence or not of an integrated farm management, market demand for silk and silk textiles and products etc.

-Labour availability is very important in a sericicultural farm, as production is a work-intensive activity. Labour cost depends on the workforce market availability, the business size and salary that the employer's offer.

-Silk demand and offer ratio on the domestic and international market, which have a deep impact on silk price;

-Trade policy could be favorable or not and in a close relationship with the exchange rate of the national currency against USD or Euro, whose level could fluctuate and have a substantial impact on production, consumption, export etc.

- In case of export, the level of silk and silk textiles and other products quality, and also the amounts available to be sold on external market, the level of tariffs and product controls have a influence on silk competitiveness on various markets;

-If the exporting country has a weak currency against USD or Euro, its silk and silk products are very attractive for the foreign importing countries in the international market. If the country has a strong currency versus a foreign country's currency which is more expensive, then, sales on the international market decline being not competitive and unprofitable.

-Sales depend on consumer preferences and their purchasing power and behavior. Silk and the products made of silk are expensive products all over the world. Therefore, they are required by a special market segment of people with high incomes in general.

-Consumer preferences depends on their age, education level, needs and differ from a client to another.

-Also, consumer habits are changing, year by year depending on the level of demand satisfaction in the previous times, information accumulated in the meanwhile, the need to change the taste and to try to be aligned to the fashion trends. Being more conscious of sustainability, more and more consumers are oriented to eco-friendly products and which also respect the ethical rules regarding the use of animals. Product quality in relation to price level is the most determinant factor to draw the final decision: to buy or not to buy. In many cases, the fidelity for a special brand is the decisive factor.

- The increased offer of sustainable silk garments has shift consumers' preferences to this kind of products which are of high quality, durability, elegance and also made in a safe environment and respect human and animal rights. The labels of the products give information about the origin of the raw material, on what technology the mulberry leaves were produced to feed the silkworms, how the silk cocoons were extracted and if the sustainability standards have been respected along the product chain. "Green" products are more and more required which is a guarantee of the correlation exiting between the product quality, price and the respect for humans, animals and environment.

The "fast-clothing" era is at the end, a new orientation to high quality textiles and clothes favor silk products to pay a high price and benefit of that product for a longer period of time.

Photo 2. Chinese silk scarf
Source: Original.

Silk revival is reflected by the growth of production and export intensification at the global level.

Market offer is more and more diversified, as the interest of producers is to better satisfy consumers preferences for more and more sophisticated products, not only from the field of fashion, but also for home deco, furnishing, medical sector and other domains [13].

The negative impact of the textile and fast fashion industry on the environment

At present, fashion and clothing industry is based 66% on synthetic fibers which have a low production cost and attractive price of the final product across its chain from design, production, distribution and sale to consumers. The length of garments manufacturing is short of about two to eight weeks depending on the producing company, and for this reason this type of fashion is nicknamed "fast fashion industry".

The increased consumption of "fast fashion" products, which are cheap and of low quality, has led to a negative impact on the environment.

For example, in the EU, it the year 2020, it was estimated that the annual textile consumption per citizen is on average: 400 m^2 land, 9 m^3 water, 391 kg raw materials and causes 270 kg carbon footprint [12] and

if we take into consideration the EU population in 2024 of 449.2 million inhabitants, this means 18 Million a land, 40.4 Billion m^3 water, 1,756.4 Million Tonnes raw materials and 121.4 Tonnes carbon footprint.

Fashion industry comes on the 2nd position among the water consuming industries diminishing the water resources, it has a high carbon footprint, representing about 10% of the world carbon dioxide emissions, it needs high amounts of chemicals degrading the land and polluting the waters and soil. About 85% of textiles are thrown to dumps, 20% of waste waters pollute the rivers and 500 thousand tonnes microfibers are released into the ocean yearly. All these aspects accuse fashion industry, besides other industries, as being a highly polluting economic sector and responsible of the climate crisis and also of affecting health of the local population, wildlife, ecosystems and biodiversity. Also, in some countries this industry has a negative social impact, exploiting children as labor force [12, 30, 40, 59, 81].

The negative impact of sericulture practices in the conventional production system

Conventional silkworm rearing is largely practiced as it has a high economic and social role in assuring jobs, and incomes sustaining the rural population and communities in many countries like China, India, Uzbekistan, Vietnam, Iran, North Korea, Brazil, Thailand, Tajikistan and Bangladesh. The obtained filament is of the highest quality and length, which allow to have a large variety of utilizations in textile, home and fashion industry.

Silk production in the conventional or traditional production system involves the cultivation of mulberry trees, from where the leaves are harvested to nourish the silkworms. At the beginning of the process, the silkworm eggs need special conditions to hatch into larvae, whose growth is sustained by feeding with mulberry leaves. After several weeks, the silkworms develop cocoons of silk fiber. Before the moths to emerge from the cocoons, these cocoons are boiled or steamed, killing the worms as, only in this way, the sericin could be softened and silk filaments could be continuously extracted and then twisted together to become silk threads or yarns, which later on are dyed and woven into fabric. In many countries it is still practiced the traditional weaving technique which is manually done and carry out beautiful and unique artisanal silk fabric. But, nowadays, in more and more countries, to increase output efficiency, modern mechanical looms have replaced the traditional and low efficient methods and also reducing the labor force [14].

The negative impact of silk producing could be approached from, three points of view:

(a) from the point of view of environmental impact, during the silkworm growing and processing the cocoons into silk filament it is needed, firsts of all, of *land*, for cultivating the mulberry trees, which sometimes requires deforestation, affecting the landscapes, habitat loss for animals, disrupting the balance of the ecosystems. Secondly, sericiculture requires *a lot of water*, for irrigating and sustaining mulberry trees and silkworm growing, for degumming and dyeing the silk fibers. Thirdly, sericiculture needs *a lot of chemicals*, in terms of fertilizers and pesticides to sustain the mulberry leaves production, but all these pollute soil, water sources and air. Also, chemicals are used in the degumming process and the less treated resulting waters could pollute soil and the water sources. Fourthly, *a lot of energy* is involved in the reeling and spinning of the silk fibers, in the units where the process is mechanized using modern machinery and equipment and this led to the increase of gas emissions and climate change. In the units where the traditional process is still used based on *more workforce*, energy footprint is lower, and *productivity and efficiency* as well. Fifthly, sericiculture release *a lot of wastes* resulting from the silk production and processing affecting water bodies, aquatic systems, and human health. Also, the solid wastes could favor environment pollution, if silkworm pupae are not recycled for other purposes such as: animal feed, food products, medicines, compost etc.

Therefore, to raise the worms during several weeks till the moment of silk is obtained and processed into fabric, sericiculture produce ecological degradation by polluting soil, waters and air.

(b)from the point of view regarding the social impact, we may emphasize the negative influence on the employees, working in silk worm rearing, who are obliged to work *long hours a day* across of the weeks, and at the end of the day to be exhausted and, more than this, their work is carried out in *closed rooms*, where the microclimate is favorable for silkworms, but not for workers, who could contract respiratory diseases. The *salary is very low* many times as working in the silkworm growing requires a large manpower. Another negative social aspect is related to the fact that, in various developing countries, some employers *exploit children* as work force.

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(c) from the point of view regarding animal well being, the conventional system of silkworms rearing, which is the most practiced systems all over the world, *requires the killing of the silkworms* by boiling or steaming them before the emergence of moths, which raises ethical concerns on animal cruelty [80].

Only by studying the silk production process along various stages of sericiculture and its environmental implications, assessing the resource consumption and pollution, it is possible to offer solutions for good, ethical and eco-friendly practices for obtaining silk filament and fabric in the local communities [14].

It is obviously that the conventional silk production system does not compile with sustainability in silk production, as it has the following disadvantages:

- it is limited to the use of a genetic fund of silkworm breeds and hybrids mainly of mulberry type, which does not sustain biodiversity;
- in the rearing process, silkworms are exposed to a high risk to contract diseases and to be attacked by pests;
- silkworm growing requires land for cultivate mulberry trees, chemicals: fertilizers, pesticides, treatments for pest control, high consumption of water and energy, resulting in relatively high costs [46];
- work is exhausting and being run in non proper conditions, and do not justify a small salary;
- the resulting wastes pollute environment;
- this system does not compile with animal well-being standards, because it involves silk extraction by boiling of silkworms alive.
-therefore, the conventional system of silk and textile production is not eco-friendly, not animal-friendly and not a human-friendly production system.

Therefore, the whole process does not reflect that silk and textile industry compiles with the objectives and principles of the sustainable development.

Sustainable Silk and Textile Production

In UNESCO's vision, sustainability is defined as "*a resolution to meet the needs of the present without compromising the future"* and this *"encompasses populations, animal and plant species, ecosystems, natural resources – water, air, energy"* [75].

The five definitions of sustainability given by University of Rochester are: *"(1)Integration of environmental, social, human and economic goals in policies and activities. (2)Equal opportunity and community participation/sustainable community. (3)Conservation of biodiversity and ecological integrity. (4)Ensuring inter-generational equity. (5)Recognizing the global integration of localities"* [77].

Also, UNESCO, in its "Agenda for Sustainable Development 2030" adopted on 6 July 2017 mentioned the 17 SDGs indicators as follows: *"G1-No poverty, G2-Zero hunger, G3-Good health and well-being, G4-Quality education, G5-Gendre equality, G6-Clean water and sanitation,G7-Affordable and clean energy, G8-Decet work and economic growth, G9-Industry, Innovation, Technology and Infrastructure, G10-Reduced inequality, G11-Sustainable cities and Communities, G12-Responsible consumption and production, G13-Climate action, G14-Life below water, G-15,Life on land, G16-Peace, justice and string institutions and G17-Partnerships for the Goals"* [76].

Photo 5. Italian silk dress
Source: Original.

Taking into account the new orientation in consumer demand and the need to develop a "green" textile industry in order to face the pressure of a higher and higher competitiveness, sericiculture and silk textile industry have to adapt the technological process to become more friendly with the environment and to compile with ethical practices regarding employees and animals. In a word, it has to become a sustainable sector.

But this must start with silk production system which is practiced in various countries and farms and after a critical analysis to identify which alternative is more sustainable and what other solutions could be adopted as silk along its chain to be entirely a sustainable product.

New sustainable alternatives for silk production in an eco-friendly and animal-friendly system

From this point of view, "organic silk", "peace silk" and "organic peace silk" are seen as alternatives to conventional silk.

-*Organic silk production* is based on the use of an environmental friendly silkworm growing, according to the ecological standards, characterized by feeding the worms with mulberry leaves organically cultivated, without synthetic fertilizers and pesticides and GMOs [55].

Also, organic silk is obtained under the condition to assure silk worms well-being till the end of their life cycle into moths, to use a lower water consumption, to protect environment, preserve biodiversity maintaining a balanced ecosystem.

Organic silk and textile production processing involves innovations in the cocoons processing into filament and yarn, using eco-friendly degumming and dyeing methods to mitigate the environmental impact [3, 72, 85].

Also, in the sustainable production practices must be used biodegradable chemicals [23], recycled wastewaters [28], energy-efficient technologies [56, 61], recycled silk wastes [29].

Natural dyes based on plants and minerals could have a beneficial effect on environment and also, the use of closed-loop water recycling systems in silk processing could preserve water and diminish pollution [68].

However, organic silkworm rearing does not entirely respect the ethic treatment as long as the worms are still killed.

-*Peace silk (Ahimsa) production* is another alternative to conventional silkworms growing, the only difference being the fact that during silk extraction process, animal well-being is assured across the whole life cycle of the worms till the moment when the moths emerge from the cocoons which are then broken. The disadvantage of peace silk production is the lower quality of the filament due to its shorter length which leads to rougher fabrics [60].

-*Organic peace silk production* is an alternative system practiced by a silkworm growers who combines the advantages of the organic silk with the ones belonging to the peace silk, concerning the standards for animal well-being and environmental friendly silk production [13, 80].

Sustainable practices in silk production and processing

-***Organic Farming Methods***, such as: using manure for improving soil fertility, and increasing the yield of mulberry leaves, using integrated soil and disease and pest management, which make sericiculture to become an eco-friendly and farmers-friendly sector, and also a more profitable business. Biocomposting, green manuring, micro-bio-fertilizers, bio pest control improves mulberry productivity and leaves quality [53].

-***Integrating farming in mulberry tree culture*** which combines multiple agricultural practices to optimize resource utilization for enhancing soil fertility and leaves yield, leading to additional incomes for farmers and silkworm growers [25].

- ***The Integrating Mulberry Cultivation, Sericulture and Fish Farming*** is one of the models of integrated mulberry cultivation, silkworm rearing and fish farming, promoting silk reeling and other processing industries [4].

-***Integrating sericiculture with agro-forestry system*** including mulberry growing, silkworm rearing, field crops, fruit plants, and fodder grasses and rice cropping had lead to higher returns in the hilly and valley land of north-eastern India [8].

-Integrated Pest Management in sericulture, for example: using Uzi trap solution which is safe to silkworms, pets and also to human beings, as it eliminates the use of toxic chemicals [9].

-Integrated sericiculture in family reproduction farms. A model of integrated family reproduction sericicultural farms was developed in Romania by Matei and Popescu (2013). The farm needs 1 ha land which is used 50 % for mulberry plantation and 50 % for seed plantation, layer making field, sowing field), and 150 m^2 for silkworms rearing space. Such a farm could produce 400 kg silk cocoons, of which: the most could be used for producing 1,000 egg boxes for selling to other farmers, 10 kg cocoons for silk filament, 25 kg pupae for pharmaceutical purpose, 50 kg unreeling cocoons for producing handicrafts in the farm, 10 kg lint, 2,000 kg layer wastes for fish feeding. From the 30 variants of this model, 10 variants could assure a profit varying between Euro 80,223 Euro and respectively Euro 126,088 to the farmer [37].

-Integrated sericiculture between Mulberry tree culture, Silk worm rearing and Silk cocoon processing (unreeling cocoons) in handicrafts (knitted belts), has proved to be a model with the highest Net Present Value as proved by the feasibility study [45].

-Integrated production in silkworm rearing [42].

-Integrated production and diversification in sericiculture [43, 44].

-Ethical Treatment of Silk-Producing Insects In this case, Ahimsa silk production is a humane alternative as silk cocoons are collected and processed after the moth has hatched from the cocoon [82].

-***Eco-Friendly Dyeing Processes in silk fabric*** For example, using an optimum amount of bio and chemical mordants for bio-dying silk fabric, there were obtained moderate to good and excellent colour fastness ratings [70].

-***Waste Reduction, Recycling, Circular economy***

-*Waste reduction and converting into organic manure using vermicomposting technology* and *earthworms.* Such a biomanure is used for soil fertilization in the mulberry tree plantation and increase yield of leaves [5].

-*Waste reduction and recycled into organic manure for fertilizing mulberry tree plantation:*

The wastes generated by sericiculture are: surplus mulberry twigs, leaves, fruits, bed waste and cocoon reeling waste like pupae from silkworm rearing. It is estimated that 45% of the ingested leaves by silkworms are expelled as waste, of which 250–300 kg could be used for 2,500 kg of farm manure, fertilizing about 0.067 ha as mentioned Wenhua (2001) cited by Kannihalli et al. (2024) [22, 79, 15].

-*Waste reduction and used as a source of renewable energy.* The seri waste including leaves residues mixed with excrements from silkworms could be used for producing biogas as affirmed Mao et al. (2015) cited by Kannihalli et al. (2024) [32].

-*Waste reduction and the use of fermented mulberry leaf meal as fishmeal replacer* [1].

-*Waste cocoons and silk could be used for producing handicrafts* enhancing the farmers' profit and sustainability in sericulture [5].

-Ethic and Social Responsibility in sericiculture involves an ethical behavior versus silkworm growers, employees, silkworms, customers, local community, respecting regulations and laws, international norms of behavior, and human rights.

Jayakumari et al (2024) [21] carried out a comprehensive synthesis of the main aspects related to ethical and social responsability problems in the textile industry: "*human exploitation* (long working hours, low salary, unsafe working conditions, child labor, forced labor, gender discrimination"; "*environmental impact* (resource spoliation: land, water, energy, soil degradation, chemical pollution, carbon footprint, gas emissions, waste generation, deforestation etc)"; "*supply chain transparency*: visibility and accountability at each stage of production, traceability"; "*risk management, stakeholder engagement*"; "*consumer awareness and involvement*"; "*animal well-being*"; "*worker health and safety*, work place safety"; "*waste management, reuse and recycling*";

"*renewable energy*"; "*producer responsibility*" etc. [21].

Sustainable silk production, Traceability and Certification [10].

Photo 4. Japanese silk scarf
Source: Original.

Impact of the sustainable sericiculture on rural areas and communities

The development of a sustainable sericiculture by silk producers will sustain their business bringing a higher income and profit and improving their lives and living standard for their families too.

The farmers who are successful in their business with sustainable sericiculture will be a good example for others to follow their model.

Farmers will be interested to invest and implement innovations resulting from the scientific research for strengthen their efforts to obtain a higher silk and fabric output based on an eco-friendly, human-friendly and animal-friendly production system.

In this way, the local communities will prosper and have a better life.

In addition, sustainable sericiculture applying eco-friendly technologies will contribute to the maintenance of a clean environment (soil, waters, air, landscapes) with a positive influence on eco-systems maintaining their balance and biodiversity.

Also, farmers, stakeholders, and local authorities should keep a close relationship and collaboration with government and non-government organizations, so that the best practices to be sustained with responsibility at all the levels and along the life cycle. In this way, silk market could have a larger resilience and inclusiveness.

Consumers' attitude versus sustainable sericiculture and textile industry

Consumers have become more and more aware of the role and economic, social and environment importance that sustainable sericiculture has and will be more interested to chose and buy silk sustainable products and to spread information to other potential beneficiaries.

In this way, consumers could become "the drivers" of demand of natural and healthy silk products and brands and promote the new sustainable technologies and products.

During the last decade, consumers have become more conscious of the need to buy and use healthier products made of natural fibers and obtained by using eco-friendly technologies, textile and fashion products being included, women looking to be more attracted to change their behavior than man [27].

The consumer perception of eco-friendly products is positive and the decision to buy them is closely connected to the knowledge if the products were achieved in an environment friendly manner, if they are certified and labeled, and have a higher price that the products carried out in a conventional way [38].

Consumer choice is also much more determined by the circular product attributes such as: durability, recyclability, repairability, and recycled content, than by price [24].

Consumers' decision to buy high quality and comfortable garments is also positively influenced by social media which plays an more and more significant role in increasing consumers' awareness and knowledge which have to justify their purchasing choice [58].

The role of Scientific Research, Development and Innovation in sustainable silk production and textile industry

A high importance in finding new alternatives, solutions, innovations will have scientific research which is called to continue its work destined to diminish climate change impact, to offer more sustainable and ethical practices, innovations in farming and processing technologies, and waste management in silk and textile industry.

-***Innovation in sericiculture for increasing productivity using a reeling machine*** *in a peasant individual farm* [34].

-***The achievements of new technologies and biotechnology*** could increase sustainable silk production, fiber quality and multiply the fields of application by a multidisciplinary approach and collaboration between sciences like biology, genetics, chemistry, and physics.

-*Technological advancements regarding the new achievements in silk worm breeds and hybrids*, and genetic engineering could improve the quality of silk fiber as never before. For example, Teule et al.(2012) succeeded to create "transgenic silkworms encoding chimeric silkworm/spider silk proteins" which is a stronger silk fiber with improved mechanical properties that spider silk could not have. this new type of fibers could be used as biomaterials with large applications in medicine and other fields [39, 71].

-*Studying the phenotipic and genetic characters variability of the egg and larva* from native genetic stock of Silkmoth *Bombyx mori* L.sp**.** [33, 35].

-*Optimization of the silkworm breeds stock from the gene stock Sp. Bombyx Mori* L. [36].

Biotechnology is of much help in the creation of synthetic silk fibers, with similar features like the natural fiber, and which are produced by inserting the genetic information for creating silk protein into bacteria under a fermentation process. These synthetic silk fibers are a sustainable solution in silk production technology eliminating the technological stages of mulberry tree growing, silkworm raising, saving the land and silkworms, and assuring a health environment and also synthetic fibers enlarge the opportunities to find new utilizations in various fields [7].

Smart silk-based textiles are intelligent and multifunctional fibers and textiles, as natural silk is largely required in medicines and smart fiber technology because the accessibility, biocompatibility, mechanical properties of the silk [84].

These features of silk fiber are used in silk-based technology for producing ***silk-based sensors, conductive fibers and actuators***, which are utilized in wearable garments and accessories which could provide information on heartbeat and body temperature, for the people with health problems, sportsmen, fitness lovers [83].

In addition, ***the nanotechnology for high performance and functional silk-based intelligent textiles*** are used in the benefits of the wearers providing them information on "moisture management, ultraviolet rays protection, antimicrobial and anti-odour uses and temperature regulation". The fabrics offer comfort to the wearer who feels cool and while is making sport or exercises [69].

Trends in Silk Fashion and Design

Silk lives and enjoys its revival for traditional dresses of a splendid beauty, so that both fashion and design are flourishing again.

Silk keeps pace with the changes regarding materials, but it preserves its first position of "Queen", accepting cultural changes, traditional diversity and quiet elegance at different levels.

Revival of traditional silk garments is combined with new trends regarding the kimonos, saris, qipaos, which are redesigned from a modern perspective.

Various colors, designs and textures are combined with embroideries reflecting the cultural inheritance. Artisanal-made silk products look to be well received and appreciated. At present, the designers proceed to make artisanal products such as: jackets, blouses, gowns, dresses, accessories, home decorations, which are requested by buyers to be personalized. Production is many times at a small scale which does not affect environment.

The actual trends put an accent on minimalist fashion, with a sharp contour of silhouette and high quality and luxurious appearance with a long length of wearing as silk could assure a sustainable fashion. The clients are conscious consumers desiring clothes achieved from eco-friendly and luxury materials.

Silk could be combined with other materials (cotton, bamboo) resulting a new fabric and hybrid blends, which keep silk softness, breathability and durability. Also, silk could be mixed with synthetic fibers (nylon, spandex) resulting stretch and quick-drying fabrics of which the designers create exactly what the customers desire according to the modern trends and demand [13].

CONCLUSIONS

The study presents the actual study of silk production at the global level, pointing out its revival since the year 2022 after a long period of decline. I, 2023, the world silk output reached 94 Thousand MT, being by 2.95% higher than in 2022.

China and India maintain their top positions, together accounting for 94.6% of the world silk production, China contributing by 53.2% and India by 41.4%. While China's production is maintained at 50,000 Thousand MT, India's production has a continuous increase. Uzbekistan and Vietnam have just a small contribution together (3.7%). China remained the top silk exporting country, while Italy is the top importing country.

In 2023, the value of Global Silk market was USD 19.51 Billion and it is forecasted to reach USD 32.52 Billion in 2030.

In 2023, the value of global silk textile market accounted for USD 124.2 Billion and it is expected to raise by 8% CAGR by 2030.

Silk market is influenced by consumer preferences and purchasing power, farm land, labor force, potential of the genetic resources, financial resources, demand/offer ratio, trade policy, inflation and exchange rate., opportunities in the international market.

The paper presents a comparison between the conventional silk worm rearing and other eco-friendly alternatives like organic silk and peace silk. The best variant assuring an eco-friendly and animal friendly silk is "peace silk".

The study presents a large variety of sustainable solutions for solving different problems raised in sericicultural practice which could be used by farmers: peace silk farming system, the use of micro-bio fertilizers, bio pest control, integrated farm management, integrated sericiculture with agro-forestry system, integrated pest management, integrated sericiculture in family reproduction farms, integrated production and silk processing at the farm level, eco-friendly dyeing using bio and chemical mordants, waste reduction by biocomposting for green manure, by producing bioenergy, by transforming wastes into meals for fishes, poultry, pigs etc, the use of the results of the genetic engineering for increasing production, of biotechnology and biomaterials for creating new sorts of silk fibers, textiles and garments etc. and other silk-based solutions for other fields of activity (industries, medical sector, sport sector etc).

Fashion industry is passing through a crucial moment in its history, the sustainability goals obliging this sector to stop the era of "fast fashion" which has proved to be a polluting system and to pass to an offer of high quality and long lasting eco-friendly, human-friendly and animal-friendly garments.

At present, fashion changing its orientation to produce new high quality and long lasting garments in various designs, colors, textures, compiling with the minimalist principle and inspired from the traditional style, but also conserving the silk precious and unique characteristics, brilliant, luxury and elegant appearance to better satisfy modern consumers.

Consumers must be more and better informed about the environmental and ethical impact of their demand for textiles and fashion products, for becoming aware that they must apply for silk products achieved in organic and other alternative production systems which are friendly with the environment and respect animal well-being standards. Only in this way, textile and fashion industry could become sectors aligned to a sustainable development of the economy.

Sustainability requires to join all the forces: farmers, stakeholders, local communities, governments, consumers etc in finding the best solutions for a sustainable development of the silk textile and fashion sectors.

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DISPARITIES IN ROMANIA'S AGRICULTURE AMONG THE REGIONS OF DEVELOPMENT

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Abstract

The research aimed to assess the discrepancies exiting among Romania's NUTS-2 microregions of development using a large number of indicators reflecting the status of agriculture in the year 2020, 2022 and 2023, using as information source Eurostat database for which the data were available in March 2025. The research methods utilized in this study refer to: structural index, showing the share of each region in the total level or value of the studied indicator, rank-order method to identify the hierarchy of the regions, comparison method, Herfindahl-Hirschman Index(HHI) to evaluate the competitiveness/concentration among regions for each indicator. The results confirmed that in Romania there are still discrepancies among regions in the development of agriculture. The hierarchy of the regions based on the number of points accumulated for 14 main indicators is the following: Rank 1-63 points, South Muntenia, Rank 2-66 points, North East region, Rank 3-85 points South East region, Rank 4-93 points North West region, Rank 5-117 points South West Oltenia, Rank 6-118 points Central region, Rank 7-139 points West region and Rank 8-165 points Bucharest Ilfov. HHI below 0.15 reflected a competition or lack of concentration among regions for population, labour force, intermediary consumption, factor income, entrepreneurial income; HHI between 0.15-0.25 showed a moderate competition/concentration among regions for area in organic farming, number of farms, crop and animal output, gross value added and gross capital formation. HHI greater than 0.25 reflected a high competition for GDP. Therefore, the disparities among regions still exist and leave "an empty box" for looking for solutions to create a balanced and convergent economic and social development in Romania.

Key words: *agriculture, development, NUTS 2 regions, discrepancies, Romania*

INTRODUCTION

The large inequalities among the regions of a country are not beneficial for a harmonious economic, social and environment development.
That is why scientific research is called to offer viable solutions to diminish these disparities and enhance a sustainable development of each region and of the country as a whole.
Regional development is affected by transmission channels which creates an unbalanced economic growth sustaining the rich regions and cities to become more prosperous [13].
In the EU, the territorial disparities are still commonly seen because of the inequalities between rural and urban areas [11, 12].
A balanced economic growth and cohesion among the EU territories imposes the reduction of the gaps between urban and rural areas [34].
For attaining this goal, new strategies and models of sustainable development adapted to the actual situation are necessary for assuring the cohesion [11].
Romania plays an important role in the EU and especially in agriculture and for this

reason the harmonisation of the territorial units is a factor of sustainable development in the future [7, 8].

Among the NUTS-2 microregions of Romania there are still large discrepancies as shown by various specific economic and social indicators, which do not reflect a required convergence [33].

A specific situation has Bucharest Ilfov microregion which is hilly development compared to the rest of 7 microregions [36].

For enhancing a good regional development, Romania must use the structural and cohesion funds for monitoring spatial planning, strengthening administrative capacity, developing modern techniques and tools [2].

Agriculture is must assure food security and be involved in the bioharmonized development of the Romanian regions [9, 10].

A large range of indicators, especially from the economic field must be used to characterize the development of territorial units. GDP is one of these indicators reflecting the development of a country and also of the regions and of the living standard in terms of GDPPPS/inhabitant. It also should be studied in relationship with other economic and social indicators like fixed assets, employment, unemployment, productivity [16, 26].

Romania has not yet a convergent and harmonious economic development as long as the disparities among the microregions still exist [18, 27].

An unbalanced food system with a negative impact on food security is supported by the regional disparities reflected by agriculture contribution to GDP and also by the non corresponding ratio between internal food production, export and import [23].

The territorial disparities are confirmed by the evolution of GDP by region and especially in agriculture in Romania [28].

A more detailed analysis at the county level, that is in the NUTS-3 territorial units could offer a more comprehensive and realistic image of the economic and social development [35].

Also, the gaps of development between rural and urban areas are more suggestive when the convergence is analyzed in Romania [32].

In Romania's agriculture is still working a high share of the population which also reflect the level of development of agricultural production, productivity and rural areas [21, 29, 31].

This fact is also attested the existence of large differences in labour productivity in agriculture among the EU member states and by NUTS-2 regions [21, 22].

Looking for new models to assess territorial inequalities, a synthetic index was created taking into consideration GDP/capita, labor productivity and life expectancy [6].

Another model named PEESH is a multidimensional and compositional index which takes into account: population, economy, education, social, and health). It could be successfully used for assessing the EU territorial development [37].

In this context, this research aimed to present a comprehensive image of the present situation regarding the regional development in Romania and its NUTS-2 microregions, based on a large variety of indicators for which Eurostat Database was able to provide data.

The conception of this paper is an original one and highlights the role of agriculture in the territorial development and also reflect the existing discrepancies among the microregions of the country.

MATERIALS AND METHODS

To set up this research work on the development of agriculture in Romania's eight regions NUTS-2, the data provided by various sites Eurostat have been collected for the list of main indicators selected to characterize the territorial units [3, 4, 5]

For shortening the repeated expressions text, the names of the microregions of development were symbolized as: North West (NW), Center (C), North East (NE), South East (SE), South Muntenia (S Munt), Bucharest Ilfov (B IF), South West Oltenia (SW Olt), and West (W).

For this analysis, *a number of 14 main indicators* has been taken into consideration at the level of Romania and by each NUTS-2 region as follows:

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-Territorial area
-Population: total and population density
-Urban-rural typology
-GDP (nominal, PPS) and GDP PPS/inhabitant
-Utilized agricultural area (UAA) and surface converted to organic farming
-Number of agricultural holdings- total and by standard output: less than Euro 8,000/farm and Euro 8,000 and over
-Labour force in agriculture (AWU)
-Number of farm managers - total and by age (less than 35 years old, between35-54 years adn 54 and over)
-Agricultural output- total, crop output and animal output, output of agricultural industry
-Total intermediate consumption
-Gross Value Added (GVA)
-Factor income
-Entrepreneurial income
-Gross fixed capital (Investment).

The data have been collected from Eurostat, various sites, especially for the year 2020, 2022 and 2023 for which the data have been available both for Romania and by each NUTS-2 region and even for NUTS-3 regions where it was the case.

The territorial absolute figures for each region have been transformed into the structural index in order to establish the hierarchy of each microregion for each indicator taken into account.

The rank-order method for each indicator was applied for each region taking into consideration the rule:
-rank 1 is allotted for the highest performance
-rank 8 is allotted for the lowest performance.

The sum of the points received by each region for all the indicators was finally established.

Then, the rank of each region was allotted considering that the region which registered the smallest number of points comes on the top position.

In the decreasing order of the total number of points, it was allotted the rank for all the other 7 regions.

Hefindahl-Hirschman Index, HHI, was calculated for the 14 indicators to assess the competitiveness degree among the 8 microregions of development. For this purpose, it was used the formula:

$$HHI_j = \sum_{i=1}^{n} g_i^2 \quad \text{...(1)}$$

HHI value was determined by summing the squared share of the regions "*g*" for each indicator in the total level or value of each indicator taken into consideration.

The graphical method was utilized to help the readers to better understand the obtained results looking at the illustrations.

Also, a part of the results were tabled.

The comparison method was utilized to explain the differences among regions for each analyzed indicator.

Suitable comments and interpretations accompanied the results and finally the conclusion highlighted the main results.

RESULTS AND DISCUSSIONS

Territorial area

Romania has a surface of 238,398 km^2, of which 15.5% is in NE, 15% is in SE, 14.4% is in S Munt, 14.3% is in NV and also 14.3% is in the Center, 13.4% is in the W, 12.3% is in SW Olt and 0.8% is in BIF (Fig. 1).

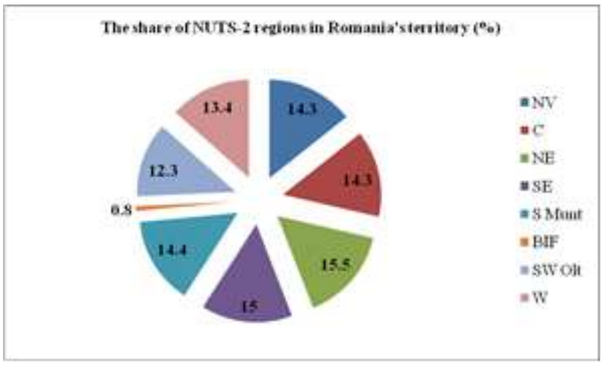

Fig. 1. Distribution of the microregions on Romania's territory based on their area (%).
Source: Own calculation and design based on the data from Eurostat.

Population by region

In 2024, Romania had 19,068,376 inhabitants, whose distribution by microregions was the following: NW 13.3%, Centre 12%, NE 16.9%, SE 12.3%, S Munt 14.9%, BIF 12.1%, SW Olt 9.7%, W 8.8%. This reflects inequalities in the territory regarding human resources (Fig. 2).

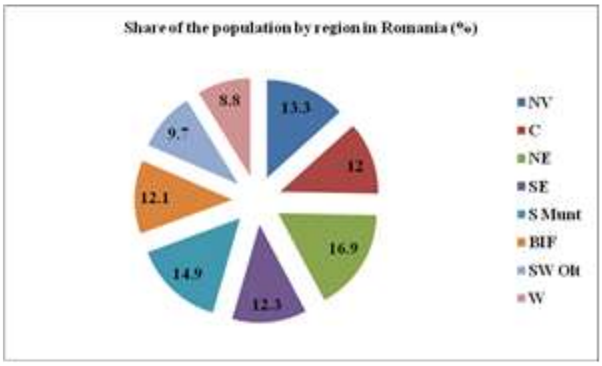

Fig. 2. The distribution of Romania's population by microregion
Source: Own calculation and design based on the data from Eurostat.

A relatively equal percentage of about 12% was found in 3 regions: Centre, South East and Bucharest Ilfov.

The variations from a region to another are determined by demographic, economic, social factors like: births, deaths, economic growth, jobs availability, income sources, migration, living standard etc.

The population density is much more different. Bucharest Ilfov region has 1,278 inhabitants/km^2, becuase of the attraction of the capital of Romania. It is followed by NE with 87.5 inhabitants per km^2, S Munt (82.2), NW (74.3), Center (67.1), SE (65.5), SW Olt (63.5) and W (52.2) (Fig. 3).

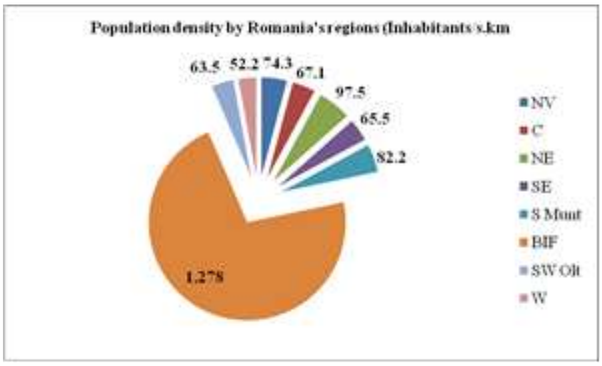

Fig. 3. Population density by region (Inhabitants/km^2)
Source: Own calculation and design based on Eurostat data.

Romania - a rural country

Taking into consideration the "Urban-Rural Typology" which regards the NUTS level 3 regions, that is "counties" in case of Romania, it was established their classification [5].

From this point of view, Romania's regions could be divided into 3 categories:

-*Predominantly Urban Region (PUR)*, where in urban clusters live more than 80% of the population. A typical example for Romania is Ilfov County and Bucharest, the capital of the country.

-*Intermediate Region (IR)*, where in urban clusters live between 50% and 80% of the population. In this case, there are 12 counties which could be considered as IR: Arad, Timis, Dolj, Constanta, Braila, Prahova, Hunedoara, Cluj, Iasi, Galati, Brasov and Sibiu.

-*Predominantly Rural Regions (PRR)*, where more than 50% of the population live in "rural grid cells". In this category, tehre are included the remaining 28 counties: Bihor, Caras Severin, Mehedinti, Gorj, Olt, Teleorman, Giurgiu, Calarasi, Tulcea, Buzau, Dambovita, Arges, Valcea, Alba, Satu Mare, Maramures, Bistrita-Nasaud, Suceava, Botosani, Neamt, Vaslui, Bacau, Vrancea, Covasna, Harghita, Mures, Ialomita si Salaj).

Therefore, we could easily affirm that Romania is a rural country.

However, rural population in Romania is characterized by similar heatures like in many EU countries in terms of aging, lower education level, dealing especially with agriculture in family farms, young people looking for jobs in the cities [14]

Economic development of the regions in terms of GDP

Contribution of the microregions to GDP

In 2023, Romania carried out a nominal GDP accounting for 324,158.45 Euro Million and in terms of PPS it achieved 565,717.34 Euro Million.

The contribution of the regions to the economic development is different from a territorial unit to another.

The contribution of the regions to GDP is the following: 29.5% BIF, 12.1% NW, 11.4% SMunt, 10.7% Center, 10.1% NE, 9.7% SE, 8.8% W, and 7.7% SW Olt. Therefore, from an economic point of view, BIF region comes on the top position, its contribution to GDP being 2.43 times higher than in NW region which comes on the 2nd position. This is justified by the fact that in this part of the country various economic branches are very well developed.

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The SW Oltenia is at the oposite pole with only 7.7% contribution (Fig. 4).

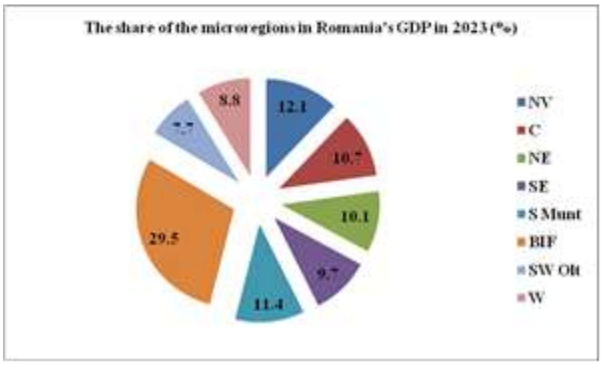

Fig. 4. The contribution of the microregions to Romania's GDP in 2023
Source: Own calculation and design based on the data from Eurostat.

GDP per inhabitant

As an indicator reflecting the living standard, GDP PPS per inhabitant reached Euro 30,388.75 in Romania in the year 2023.

Bucharest Ilfov occupies a special place becuase it includes the capital and for this reason, it is situated in the top of the list with 72,600 Euro/capita, which is 4.1 times higher than only 17,700 Euro/capita achieved in the NE Romania.

On the 2nd position comes the West region, being followed by NW, Center, SW Olt, and SE which carried out each between 27,000 Euro/capita and 23,310 Euro/capita.

Below 23,300 Euro/inhabitant, it was registered in S munt and NE, teh last region recording the lowest GDP of only 17,700 Euro/capita (Fig. 5).

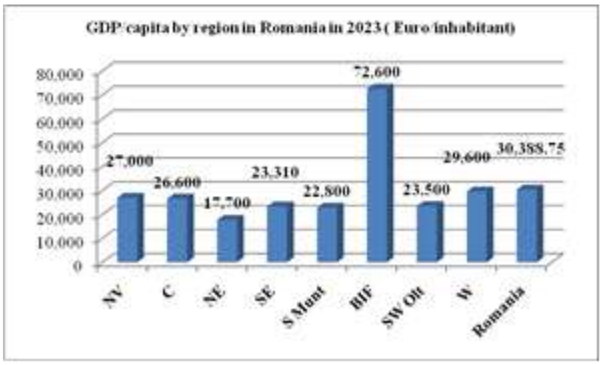

Fig. 5. GDP per inhabitant by microregion of Romania in 2023 (Euro/capita).
Source: Own design based on the data from Eurostat.

Utilized Agricultural Area (UAA)

In Romania, *the utilized agricultural area* represents 12,093,620.81 ha.

Romania's UAA represents 7.68% of the EU-27 UAA, accounting for 157,414,160 ha.

Important variations exist between the microregions from this point of view.

On the top position comes S Munt with a share in total UAA of 17.8%, followed by SE (16.8%), NE (15.5%), NV (13.7%), W Olt (12.1%), Center (11.9%), W (11.6%) and BIF with the smallest weight of only 0.6% (Fig. 6).

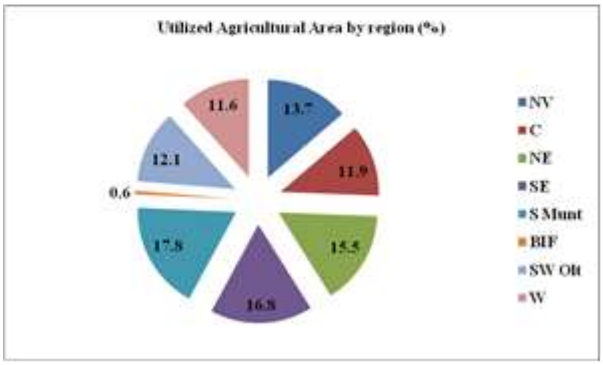

Fig. 6. Distribution of UAA by region in Romania
Source: Own calculation and design based on the data from Eurostat.

Arable land

Also, from the EU-27 arable land of 98,093,810 ha, Romania keeps 8,570, 730 ha, meaning 8.73%.

Agricultural surface converted to organic farming

A high importance in producing a healthier food and more suitable for human metabolism in close connection to environment protection and preservation plays the area which is fully converted to organic farming.

According to the EU and Romania's legislation, in the organic farming the use of genetic modified organisms is forbidden, also the synthetic fertilizers and pesticides as well as the growth stimulators, hormones and antibiotics are interdicted.

Organic agriculture supposes not only production, but also processing, labelling, trade, import, inspection and certification.

At the EU-27 level, the surface used in organic farming system represented 13,076,530 ha, meaning 9.1% of UAA in the year 2020.

In 2024, in the EU, four countries France, Spain, Italy and Germany work all together about 60 % of the surface in organic farming.

In Romania, there are only about 600,000 ha destined for achieving organic production, meaning 5.1% the total UAA .

The share of the regions in organic farming are: SE having the largest cultivated areas (33.6%), W (19%), NW (14.6%), C (13%). In the other regions, the share is below 9% (Fig. 7).

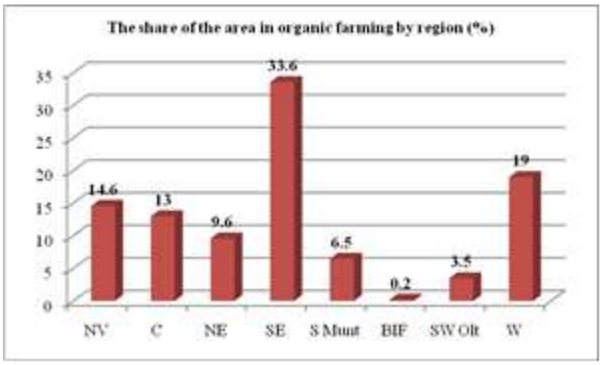

Fig. 7. The share of the surface in organic farming by region (%)
Source: Own calculation and design based on Eurostat.

Number of agricultural holdings

In 2020, the EU-27 had 9,067,300 holdings, while in Romania there were 2,887,078 farms, accounting for 31.8%.

The distribution of farms by microregions is shown in Fig. 8.

In the year 2020, their physical size is small in Romania being in average about 4.3 ha/farm while at the EU level the average size is 17.4 ha/holding. However, only 18% of farms were this size and over. About 64% of these farms are smaller than 5 ha.

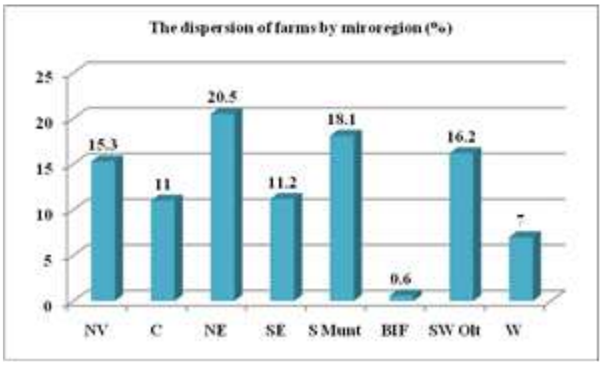

Fig. 8. Distribution of farms by region in Romania
Source: Own calculation and design based on the data from Eurostat.

Regarding the economic size, of the total number of holdings in the EU, 65.6% that is 5,946,618 farms have a standard output smaller than Euro 8,000 and 34.4%, that is 3,120,698 farms have a standard output of Euro 8,000 and over.

In Romania, the economic farm size is the smallest in the EU.

Of the total 2,887,078 farms, 93.7%, meaning 2,794,180 farms are small farms with a standard output below Euro 8,000 and only 6.3% farms, that is 182,880 holdings are able to produce a standard output of over Euro 8,000.

The situation by microregion reflects a large variation of the number of farms and their standard output in the territory of Romania (Table 1).

Table 1. Number of agricultural holdings in Romania by standard output and region of development

	NV	C	NE	SE	SMunt	BIF	SWOlt	W	Romania
Total holdings	493,060	318,480	593,000	324,060	521,960	17,230	466,510	202,770	2,887,078
Less than Euro 8,000	92.2	91.2	95.3	91.8	95.1	96.0	95.7	89.9	93.6
Euro 8,000 and over	7.8	8.8	4.7	8.2	4.9	4.0	4.3	10.1	6.4

Source: Own calculation based on the data from Eurostat.

The West region has 20,530 farms, that is 10.1% farms, which are able to produce more standard output than Euro 8,000. Also, in the Center region 28,100 farms and in the South East 26,650 farms, meaning 8.8%, and, respectively, 8.2% are also powerful holdings from an economic point of view.

In BIF region, 690 holdings, representing 4% carry out over Euro 8,000.

This situation is explained by the high share of the family farms which in the EU-27 accounts for 93.1%, of which less than 50% represent 5.3% and 50% and over is represented by 87.5%.

In Romania, agriculture is dominated by family farms which account for 97.5%, of which below 59% represent 4.1% and over 50% account for 93.5%.

Labour force in agriculture

In the EU-27, labour force accounted for 7,174,690 AWU (Annual Working Unit). In Romania, the level of this indicator is 629,220 AWU, meaning 8.76% of the EU-27 labour force.

Fig. 8 shows the distribution of work force by microregion in Romania.

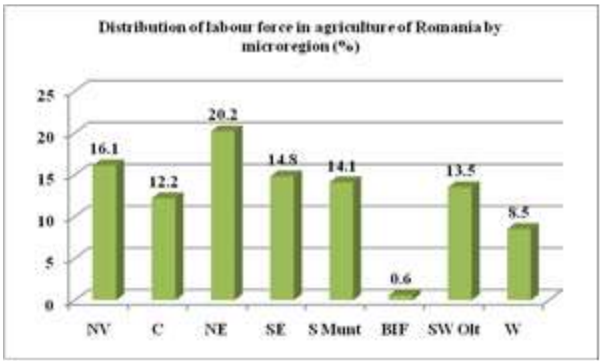

Fig. 8. Dispersion of work force by region
Source: Own calculation and design based on the data from Eurostat.

The regions with the most numerous labour force working in agriculture are NE, NV, SE, S Munt, while BIF has only 0.6% of the total AWU.

Labour productivity in agriculture is enough smaller compared to productivity level in other economic sectors of Romania.

Also, it is smaller than in other EU countries. This is because of the low technical endowment in the small-sized farms which in average have just 4.7 ha/holding [17, 30]

Managers of agricultural holdings

Among other factors, the success in agribusiness depends on the farm manager in terms of training level and experience in the field.

The majority of managers have a practical training, a small percentage has a basic training level and just a few managers have a full training.

Training level, translated into knowledge and skills, is a factor with a deep impact on labour productivity.

Also, the age of the farmers is dominated by the ones over 57 years. Just a few managers are younger than 40 and in general, in Romania, like at the EU level, it is needed to have younger farm managers.

For this reason, the EU adopted special measures to financially support young people to open an agribusiness.

Table 2 presents the situation of the number of holdings managed by farmers classified into three categories in close relationship to their age: younger than 35 years, between 35-54 years old and over 55 years in Romania's microregions in 2020.

Table 2. Number of holdings by region and manager's age in Romania in 2020

Age	NV	C	NE	SE	SMunt	BIF	SW Olt	W	Romania
-	443,060	318,480	593,000	324,060	521,960	17,230	466,518	202, 770	2,887,078
Less than 35 years	15.9	9.5	21.9	12.3	16.2	0.3	16.5	7.4	166,580
35-54 years	15.8	10.4	21.4	11.3	17.8	0.6	15.5	7.1	1,003,600
55 and over	68.3	80.1	56.7	76.4	66	91.1	68.0	85.5	1,716,998

Source: Own calculations based on the data from Eurostat.

The youngest farmers, whose age is below 35 years, manage 166,580 farms, that is 5.76% of holdings in Romania.

Another category of farmers, whose age is ranging between 35 and 54 years, manage 1,003,600 holdings, representing 34.75% of the total farms.

Finally, the farmers older than 54 years manage 1,716,998 farms accounting for 59.47%.

Analyzing the situation by region, it is easily to notice from Table 2 that the farmers younger than 35 years manage 21.9% farms in NE, 16.5% farms in SW Olt, 16.2% in S Munt, and 15.9% farms in NW. Only 0.3% farms in BIF are managed by young farmers.

The farmers whose age is between 35-54 years manage 21.4% farms in NE, 17.8% farms in S Munt, 15.8% in NW and 15.5 % in SW Olt.

The oldest farmers manage 91.1% farms in BIF, 85.5% farms in West region, 80.1% in Center region, 76.4% farms in SE.

In the EU-27, in 2020, 9,867,300 farms had young managers, of which 588,780 farms (6%) have managers younger than 35 years and 3,258,330 farms (33%) have managers between 35-54 years old.

Agricultural output

Total agricultural output

In the year 2022, Romania's agricultural output accounted for 20,368.45 Euro Million, of which 14,583.47 Euro Million crop output and 5,219.41 Euro Million animal output, representing 71.5% and, respectively, 25.6%. The difference of 2.9% is represented by agricultural services.

The output of agricultural industry accounted for 22,218.82 Euro Million.

The highest agricultural output was carried out in S Munt (23%), SE (15.8%), NE (15%), NV (11.3%) and the lowest level in BIF (1.9%) (Fig. 9).

The crop output registered the top level of 26% in S Munt, followed by SE (16.5%), SW Olt (13.8%), NE (13.4%) and the lowest level of 1.1% in BIF region (Fig. 10).

Most of the farmers develop business in cereals and oil seed plants cropping. Maize, wheat and barley are the main cereals cultivated in Romania, the country being recognized as a top cereal producer and exporter in the EU. Also, the country is also considered an important producer of sunflower and rape seeds for oil and producing renewable energy [20, 24].

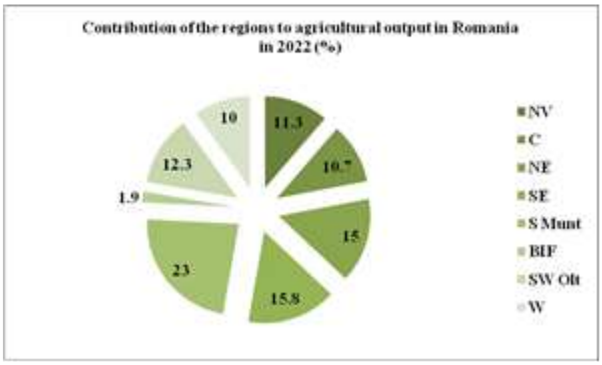

Fig. 9. Share of agricultural output by region (%)
Source: Own calculation and design based on the data from Eurostat.

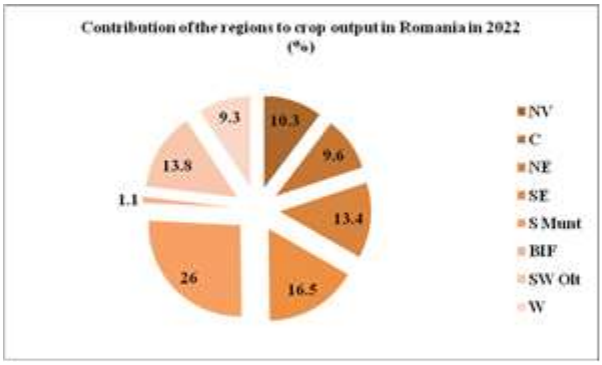

Fig. 10. Share of crop output by region (%)
Source: Own calculation and design based on the data from Eurostat.

Most of the farmers develop business in cereals and oil seed plants cropping. Maize, wheat and barley are the main cereals cultivated in Romania, the country being recognized as a top cereal producer and exporter in the EU. Also, the country is also considered an important producer of sunflower and rape seeds for oil and producing renewable energy [20, 24].

The animal output represents 25.6% of the agricultural output because many farmers have been much more oriented to crop production which is easier and more convenient to be practiced and brings income in shorter period of time. Other reasons of the decline in livestock and animal production are: the lower forage production determined by the severe droughts, various diseases affecting pigs, poultry and sheep, the low acquisition price for milk and live animals [15, 25, 19]

The top animal output was registered in NE (19.9%), S Munt (15.7%), NV (15.1%), Center (14.3%) and the lowest level of only 0.3% in BIF region (Fig. 11).

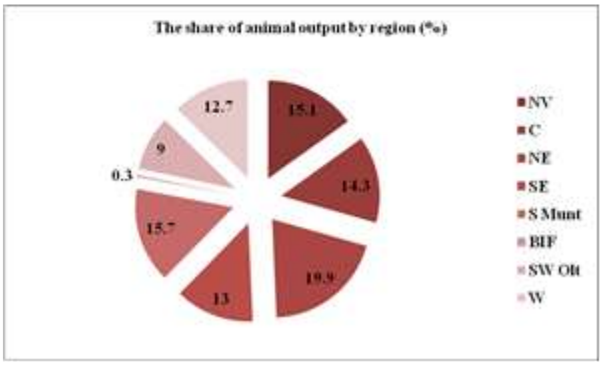

Fig.11. Share of animal output by region (%)
Source: Own calculation and design based on the data from Eurostat.

The highest weight of output in agricultural industry was noticed in S Munt (22.15%), followed by SE (15.5%0 and NE (15.4%) and the smallest level of 1.8% in BIF region (Fig. 12).

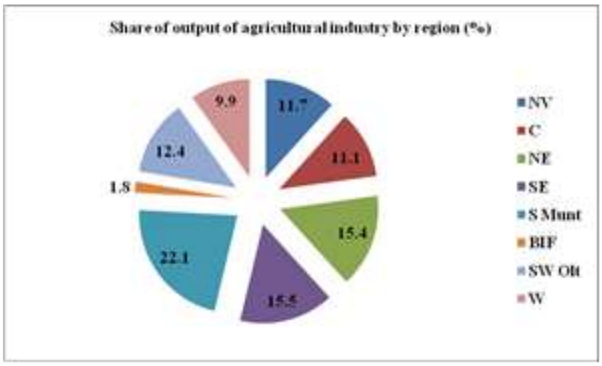

Fig.12. Share of output of agricultural industry by region (%)
Source: Own calculation and design based on the data from Eurostat.

Total intermediate consumption in agriculture

For running the production process, agriculture requires a large variety of inputs such as: seeds, planting material, fertilizers, herbicides, pesticides, animals, forages, medicines, fuel, energy, agricultural services etc. All these translated in money represent the total intermediate consumption in this field.

Romania registered 12,289.28 Euro Million intermediate consumption in agriculture in the year 2022.

By region, the situation is as follows: S Munt 21.72%, followed by NE 15.9%, SE 15.8% and NV 12.1%. The lowest intermediate consumption was registered in BIF, only 0.8% (Fig. 13).

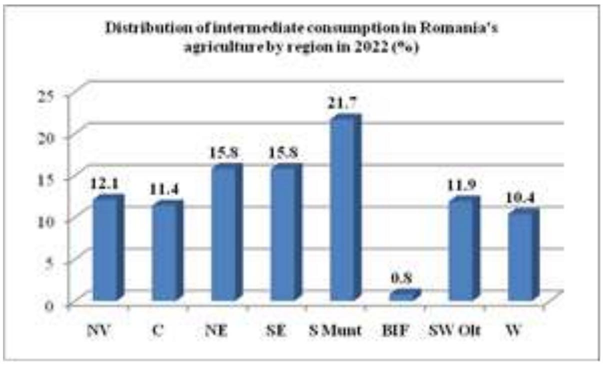

Fig. 13. Dispersion of intermediate consumption in agriculture in 2022 (%)
Source: Own calculation and design based on the data from Eurostat.

Gross Value Added -GVA produced in agriculture

In 2022, Romania carried out 9,929.62 Euro Million at basic price GVA in agriculture.

S Munt is the region producing the highest level of GVA, accounting for 21.7% of the total in the country. Other regions produced: SE 15.9%, NE also 15.9% and NW 12.8%.

The smallest GVA is achieved in BIF, only.0.8 % (Fig. 14).

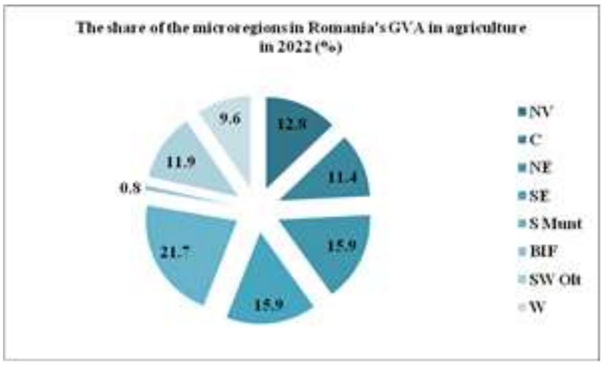

Fig. 14. The contribution of the regions to GVA in Romani's agriculture in 2022 (%)
Source: Own calculation and design based on the data from Eurostat.

Compared to 2015=100, in 2023, the real growth rate of GVA at basic price was the following by region: 188.5% BIF, 150.5% NW, 145.9% W, 125% Center, 105.2@ SE, 102.2% NE. But, other two regions achieved only 96.9% SW Olt and 91.2% SMunt.

Factor income

Production factors could generate income flows. In agriculture, factor income comes from the use of land (rent), capital (profit) and labour force (wages). Therefore, it measures the remuneration of all the production factors mentioned above.

It corresponds to "the net value added at factor cost. Agricultural factor income is a sum of the value of variable input costs, depreciation, taxes on products and production, and subsidies [1] In 2022, Romania carried out 7,534.90 Euro Million factor income from agriculture. The top level was achieved by S Munt accounting for 22.5% of the total. Then, SE has a share of 16.6%, NE 14.7%. The lowest factor income was got in BIF, only 2.7% (Fig. 15).

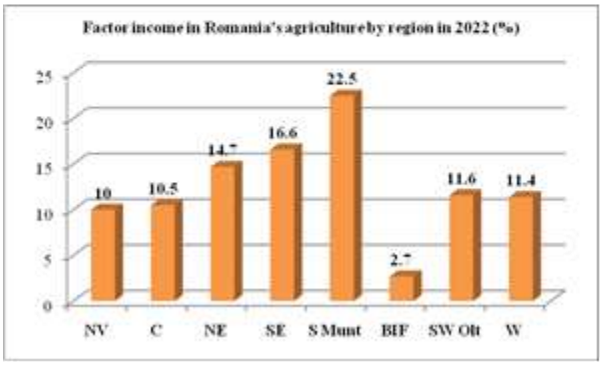

Fig. 15. Factor income by region in Romania's agriculture

Source: Own calculation and design based on the data from Eurostat.

Entrepreneurial income in agriculture

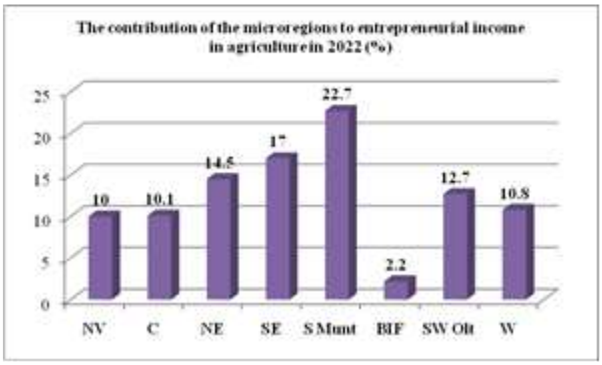

Fig. 16. The contribution of the microregions to Romania's entrepreneurial income in agriculture

Source: Own calculation and design based on the data from Eurostat.

The income resulting from economic activities in agriculture is named "entrepreneurial income" and could be used for the remuneration of own production factors (family labour, farm land, own capital). In the year 2022, Romania obtained 5,821,67 Euro Million entrepreneurial income in agriculture and the contribution of the microregion to this figure was the following: SMunt 22.7%, the top share, SE 17%, NE 14,5%, SW Olt 12.7. The smallest contribution was given by BIK, only 2.2% (Fig. 16).

Gross fixed capital formation - Investment in agriculture

The development of a modern agriculture requires investment in various fixed assets: new machinery, installations, sheds etc.

In Romania, in 2022, the value of investment (excluding VAT) in agriculture accounted for 2,058.88 Euro Million. By region, the situation was as follows: SE kept the highest share in gross capital formation 23.2%, followed by S Munt 17.7%, Center 16.4% and NE 14.6%. The lowest weight in total investment belonged to BIF, only 0.5% (Fig. 17).

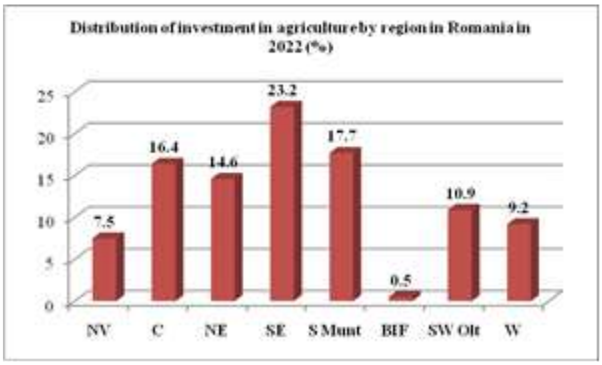

Fig. 17. The distribution of investment by microregion in Romania's agriculture in 2022 (%)

Source: Own calculation and design based on the data from Eurostat.

The regions hierarchy based on the final points

Taking into account the points received by each microregion for each criterion, it was established the rank of each region of Romania as shown in Table 3.

Therefore, as shown in Table 3, the hierarchy of the microregions based on their performance achieved for the indicators used as criteria for comparison is the following one in the decreasing order: South Muntenia, North East, South East, North West, South West Oltenia, Center, West and Bucharest Ilfov.

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Table 3. Total number of points and the rank of each microregion in Romania based on the whole assessment based on the level of all indicators used as reference term

	NV	C	NE	SE	S Munt	BIF	SW Olt	W
Total points	93	118	66	85	63	165	117	139
Rank	4	6	2	3	1	8	5	7

Source: Own calculations.

The competitiveness among the development regions NUTS-2 in Romania

The results for Herfindahl-Hirschman Index determined for 14 indicators are shown in Table 4.

Table 4. The competitiveness among regions of development in Romania

Indicator	HHI	Interpretation
Population-total	0.1299	Competitiveness, lack of concentration
GDP-total	0.2985	High concentration degree
Utilized agricultural area (UAA)	0.1446	Competitiveness, lack of concentration
Area in Organic farming	0.2017	Moderate competitiveness or concentration degree
Number of farms	0.1534	Moderate competitiveness or concentration degree
Labour force	0.1439	Competitiveness, lack of concentration
Agricultural output	0.1500	Moderate concentration or competitiveness
Crop output	0.1603	Moderate competitiveness or concentration degree
Animal output	0.1614	Moderate competitiveness or concentration degree
Intermediary consumption	0.1497	Competitiveness, lack of concentration
Gross Value Added (GVA)	0.1505	Moderate competitiveness or concentration degree
Factor income	0.1409	Competitiveness, lack of concentration
Entrepreneurial income	0.1415	Competitiveness, lack of concentration
Gross capital formation (Investment)	0.1593	Moderate competitiveness or concentration degree

Source: Own calculations.

To remind how the valued of HHI must be interpreted:

-HHI equal to zero or 0.01 tells us that among regions it is a very high competitiveness

-HHI smaller than 0.15 reflects competitiveness among regions or, in other words, it shows that it is a lack of concentration regarding the indicator in discussion;

- HHI between 0.15 and 0.25 reflects a moderate concentration;

-HHI over 0.25 shows a lack of competitiveness, in other words a high concentration;

-HHI equal to 1 means a monopoly that is only one region dominate all the other regions for the indicator in discussion.

CONCLUSIONS

This research identified again the discrepancies exiting among the microregions of Romania, a fact which produce delays in the balances and sustainable development of the whole country and of its territorial units.

On the top position with the smallest number of points accounting for 63 is South Muntenia which has the largest UAA, the highest agricultural output, the highest intermediary consumption and GVA, the top factor income and entrepreneurial income. For the number of holdings and managers it comes on the 2nd position and also for animal output.

On the 2nd position with 66 points is NE region, which has the largest territorial area and it ranked the 1st for the number of holdings and managers, and for the managers' age structure and for animal output, but for crop output it comes on the 4th place.

On the 3rd position with 85 points it is situated the SE region. For the utilized agricultural area it is situated on the 2nd position, but for the surface for organic farming it is comes on the 1st place. It comes on the 5th position for the number of holdings, managers and also for their age structure. But for agricultural output and crop output, this region is ranked the 2nd, as well as for intermediary consumption, GVA, factor income and entrepreneurial income. Also, it is on the 1st position for gross fixed capital (investments in agriculture).

The NW region is situated on the 4th position for its 93 points. It is ranked the 4th for utilized agricultural area, number of holdings, standard output/farm, managers whose age is over 54 years, also it comes on the 5th position for agricultural output and crop output, on the 3rd position for animal output and GVA and on the 7th place for factor income, entrepreneurial income and investment.

SW Oltenia region registered 117 points for which it is ranked the 5th. For utilized agricultural area it is also placed on the 5th position, but for the area in organic farming it comes on the 7th position, also for the number of holdings and managers, but it is on the 2nd position for young managers less than 35 years. For agricultural output, the region is situated on the 4th position, but for crop output is on the 3rd position, while for animal output it is ranked the 7th. In case of internal consumption, GVA, income it comes the 4th.

On the 6th position is situate the Central region, which accumulated 118 points. Its UAA is much smaller, but organic farming offer the region the 4th position among the other regions. The region has a smaller number of holdings, but their economic size places the region on the 2nd position, both for farms with less than Euro 8,000 and over Euro 8,000/farm and year. The managers are older than in the previous regions, agricultural output is smaller and place the region on the 6th position, as well as for crop output. But, the region comes on the 4th position for animal output, on the 5th position for intermediary consumption and GVA, and on the 6th place for factor income.

The West region registered 139 points which passed it on the 7th place among the other regions. For the majority of indicators, this region was ranked the 7, and just for income it came on the 6th position.

Finally, Bucharest Ilfov region is ranked the 8th for 165 points. It is on the top position for population and its density and for GDP/inhabitant. But regarding the performance in agriculture it came on the 8th position for 90% of the indicators used in its assessment. This prove that agriculture has a low importance in this region which has the privilege to include the capital of Romania where people have more chances for applying for better paid jobs and a higher living standard.

This study confirmed the existence of disparities among the NUTS-2 microregions of Romania and leave "an empty box" for finding solutions to eliminate this gaps of economic and social development in Romania.

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QUANTITATIVE INDICATORS OF PIG CARCASSES OF DANISH AND CANADIAN ORIGIN WITH DIFFERENT PRE-SLAUGHTER LIVE WEIGHTS

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Abstract

The article studied the quality of pig carcasses of Danish and Canadian origin, fattened under industrial pig production conditions and slaughtered at pre-slaughter weights of 110 and 130 kg. It was found that animals slaughtered at a live weight of 110 kg had 4.2% higher weight loss during transportation in gilts compared to barrows, and 0.7% higher weight loss in Danish pigs compared to their Canadian counterparts. A significant advantage was found in Danish pigs, with a higher loin weight of 8.8% and 1.0% more meat yield in the carcass, although they experienced a 0.7% increase in weight loss during transportation and fasting. At the same time, Danish gilts significantly outperformed barrows of the same genotype in terms of slaughter yield by 2.4%, loin eye area by 4.3%, and loin weight by 7.3%, but showed 0.6% higher weight loss during transportation. In contrast, Canadian barrows had significantly lower transportation weight losses by 4.8%. When pre-slaughter weight increased to 130 kg, Danish pigs demonstrated significant advantages in bacon half length by 0.8%, loin eye area by 6.8%, loin weight by 4.4%, along with 1.6% higher live weight losses during transportation. When comparing gilts and barrows slaughtered at this live weight of 130 kg, Danish-origin gilts showed significant advantages over barrows in terms of chilled carcass weight by 2.3%, ham weight by 5.3%, and loin weight by 7.6%.

Key words*: *pig, genotype, growth intensity, carcass quality, pre-slaughter weight, weight loss

INTRODUCTION

According to researches [25, 32, 48, 30, 67], global pork production is expected to continue growing, as it remains one of the most consumed types of meat worldwide. As reported by [40], in recent years, the growth rate of pork production in EU countries has somewhat slowed, with the exception of Spain, which continues to maintain high levels of production and remains a significant player in the global pork market. According to raports [66], Ukraine exports almost no pork, and the country's self-sufficiency in this product hovers around 90%. At the same time, pork production levels have been steadily declining due to Russian aggression, the resulting economic crisis, and complex epizootic conditions. To increase the competitiveness of domestic pork production and ensure food security, [35] state that local producers need to mobilize all possible reserves to improve pig productivity and production efficiency. Furthermore, to access European and global markets, the quality of pork must be continuously improved and maintained at global standards. One of the factors for increasing production efficiency is to raise output through the use of modern pig genotypes, which allow for feeding to heavier conditions while maintaining carcass characteristics and meat quality.

The breed characteristics of pigs [9, 18, 24, 26, 28, 29, 33, 41] are a critical component in improving pork production efficiency. This becomes particularly significant [18, 23, 39, 56] when crossbreeding, and even more so when hybridization, is applied. Superior efficiency in pig breeding [1, 20, 24, 38] is achieved when using specialized terminal sires in the final stage of breeding. When hybridization is used, with two-breed maternal lines and terminal sires in the final crossing stage, the commercial pig population [8, 22, 57] shows intermediate inheritance of slaughter and meat traits, as well as meat quality indicators.

Apart from breed type and breeding methods, significant influence on carcass morphometry, composition, and meat quality [1, 7, 28, 44, 46, 47, 55, 58, 68] comes from the sex of the pigs. According to swine scientists [14, 17, 21, 43, 52, 56, 63, 66], in addition to genotype, breeding methods, and sex, the quality of carcasses and the organoleptic properties of meat are also influenced by the feeding method and the composition and nutritional value of the pig diet.

Various authors [4, 5, 10, 12, 37, 39, 45, 48, 65] have also pointed out that pre-slaughter live weight significantly influences carcass characteristics. According to [11, 54,], environmental factors such as air temperature and its fluctuations, humidity, and the duration of daylight also play a significant role in determining slaughter and meat traits in pigs. [62] has reported a substantial impact of the seasons on carcass characteristics and meat quality, while other studies [61] point to the influence of age at slaughter on the morphological composition of carcasses.

Additionally, according to [31], housing conditions and swine management significantly affect carcass and meat quality. In addition to the economic feasibility of selecting slaughter weights, as noted by [15, 16, 32], it is also determined by specific national preferences and government standards. At the same time, advancements in pig breeding for increased leanness and improvements in feeding conditions and feed quality, as reported by [60, 64], allow producers to increase the pre-slaughter weight of pigs without compromising carcass characteristics and meat quality. However, contrasting views have been expressed [29], suggesting that higher slaughter weights may reduce pig growth intensity, worsen feed conversion, and increase subcutaneous fat thickness, leading to a decrease in lean meat content.

In Ukraine, several studies have been conducted on the effects of pre-slaughter weight of pigs of different domestic and foreign genotypes on carcass characteristics and meat quality [2, 6, 19, 23, 35, 36, 40, 48, 50, 53]. At the same time, new pig genotypes from different parts of the world are being continuously imported and their breeding potential tested. The climate in Ukraine is also rapidly changing, with rising temperatures, which imported animals may not be adapted to. According to [49, 50, 51], this can lead to heat stress in pigs, reducing feed intake and growth intensity, and as suggested by [11, 31, 59], may worsen carcass characteristics and lower meat quality.

Thus, the current issue is the study of the relationship between slaughter and meat qualities in new pig genotypes in southern Ukraine and determining the connections between specific slaughter traits to adjust future breeding programs.

MATERIALS AND METHODS

Upon the completion of the study on the fattening qualities of pigs of Danish and

Canadian origin, all the experimental animals were individually weighed and additionally identified by tattooing a number on both of their hind legs. All the pigs were loaded into separate compartments of specialized vehicles, taking into account their weight and origin, and were transported to the slaughterhouse at Globinsky Meat Processing Plant LLC. Upon arrival at the plant, they were weighed in groups and placed in separate pens for further fasting. After the fasting period (24 hours from departure from the pig farm), all the experimental pigs were weighed individually again, and their body weight was marked on their backs with a special marker. Based on the weighing results, four groups of pigs were formed, consisting of an equal number of gilts and castrated boars. The first group included Danish-origin pigs with a weight close to 110 kg, comprising 10 gilts and 10 castrates. The second group consisted of the same number of Canadian-origin pigs with similar weight. The third group included 10 gilts and 10 castrates of Danish origin, weighing close to 130 kg. The fourth experimental group was formed from Canadian-origin pigs of similar weight, consisting of gilts and castrates.

All the pigs were processed in sequential group order at the slaughterhouse, where they were humanely euthanized in gas chamber before being moved to the slaughter conveyor line of the processing department. After scalding in the scalding tank, they were further identified by attaching tags with identical numbers to their hind limbs. After slaughter and carcass processing, the weight of each half-carcass was determined. The pigs were then sent to a cooling chamber to be chilled to 4°C. After 24 hours of cooling, all the experimental pig carcasses were individually weighed upon entering the boning department. In the hanging position, measurements were taken of the backfat thickness (together with the skin) at the 6th-7th thoracic vertebrae, the thickest part of the shoulder, and the sacral vertebrae. The carcass length was measured from the front edge of the first cervical vertebra to the front edge of the pubic symphysis. The length of the bacon side of the carcass was measured from the front edge of the pubic bone to the middle of the front edge of the first rib. After being placed on the conveyor, the weight of the ham was measured, separated by a transverse cut between the last and penultimate lumbar vertebrae without the leg. After isolating the middle section of the carcass, an imprint of the cross-sectional area of the longest back muscle was made on tracing paper between the last thoracic and first lumbar vertebrae. After full deboning of the carcass, the weight of both loins, as well as the weight of the meat, fat with skin, and bones, was recorded. Based on the slaughter results, a comprehensive index of fattening and meat qualities was determined for each group using the method of B. Tyler, as described in the textbook [27], according to the following formula:

$$I = 100 + (242 \times К) – (4.13 \times L) \qquad (1)$$

where:

I – comprehensive index of fattening and meat qualities; K – average daily gain in kg; L – backfat thickness at the level of the 6th-7th thoracic vertebrae, mm; 242 and 4.13 – constant coefficients.

The research results were processed biometrically [27], using the applied software packages MS Excel 2016 and Statistica V.5.5. The significance of differences between the indicators of groups of animals of different origins, pre-slaughter weight, and sex was determined using Student’s t-test (*p<0.05; **p<0.01; and ***p<0.001).

RESULTS AND DISCUSSIONS

According to the results of the study presented in Tables 1, 2, 3 and 4, it was found that animals slaughtered at a weight close to 110 kg had slightly lower starting weights and average daily gains compared to those slaughtered at 130 kg. As shown in Table 1, the lowest starting weight for fattening was observed in Danish-origin gilts, while the highest was in Canadian-origin barrows. During fattening, the average daily gains varied within 2.0%, with the highest gains in Danish-origin gilts and the lowest in

Canadian-origin gilts. The final weight after fattening ranged from 114.4 kg for Canadian-origin gilts to 116.9 kg for Danish-origin gilts, but this difference was within the margin of statistical error.

However, during transport and fasting, a statistically significant difference ($p<0.01$) in weight loss was observed between Danish-origin gilts, which lost 0.6% more weight than barrows. Additionally, Canadian-origin barrows had 0.4% higher weight loss during transport compared to gilts. When comparing weight loss during transport and fasting between Danish- and Canadian-origin pigs, significantly higher losses (0.7%) were found in Danish-origin animals ($p<0.001$).

Overall, the pre-slaughter live weight of the experimental animals ranged from 109.8 kg in Canadian-origin gilts to 111.3 kg in Canadian-origin barrows, with a 0.3% difference between the control and experimental groups.

Table 1. Weight of pigs at the beginning and end of fattening, their intensity of growth and weight loss during transportation and during starvation of pigs slaughtered at 110 kg

Indicators	Groups					
	I control (Danish origin)			II experimental (Canadian origin)		
	gilts	castrate	group average	gilts	castrate	group average
Starting weight for fattening, kg	28.5±0.57	29.1±0.69	28.8±0.63	29.1±0.63	29.8±0.57	29.45±0.59
Final weight after fattening, kg	116.9±0.96	115.9±1.04	116.4±1.00	114.4±0.46	116.2±0.57	115.3±0.49
Weight loss during transport and fasting, kg	5.9±0.19 ^{aa}	5.2±0.17	5.5±0.17 ^{bbb}	4.6±0.11	4.9±0.09 ^{aa}	4.7±0.11
Weight loss during transport and fasting, %	5.3	4.7	5	4.2	4.4	4.3
Average daily gain, g	911±5.8	895±7.3	903±6.4	880±4.7	891±4.9	885±4.7
Pre-slaughter weight, kg	111.0±0.35	110.7±1.37	110.9±0.93	109.8±0.49	111.3±0.67	110.6±0.53

Notes: aaa – difference between females and males, bbb – difference between Danish and Canadian genetics, ccc – difference between pre-slaughter weights of 110 kg and 130 kg
Source: own calculations.

Regarding weight loss during transport and fasting, a statistically significant difference ($p<0.01$) was found between Danish-origin females, which lost 0.6% more weight than castrates during this period. In contrast, for Canadian-origin animals, castrated males showed 0.4% greater transport-related losses compared to females. A comparison of weight loss during transport between Danish and Canadian-origin pigs revealed significantly higher losses (by 0.7%) in Danish-origin animals ($p<0.001$).

The overall pre-slaughter live weight of the experimental animals ranged from 109.8 kg for Canadian-origin females to 111.3 kg for castrates of the same origin, with the difference between the control and experimental groups being 0.3%.

Thus, in animals slaughtered at a live weight of 110 kg, there was no difference between groups of different origins or between females and castrates regarding either the starting fattening weight or the pre-slaughter live weight. However, a 4.2% higher weight loss during transport and fasting was observed in females compared to castrates, and a 0.7% higher loss was recorded in Danish-origin animals compared to Canadian counterparts.

The slaughter weight is determined by both the pre-slaughter live weight and the slaughter yield. As shown in Table 2, there was no significant difference in slaughter weight between Danish and Canadian-origin animals, nor between pigs of different sexes.

However, a tendency was observed for Danish-origin animals to have a 0.4% higher slaughter weight compared to Canadian-origin animals, and for females to exceed castrates by 1.6%. Additionally, a significantly higher slaughter yield (by 1.7%, $p<0.05$) was found in Danish-origin females compared to castrates.

Weight loss during cooling was equal for the carcasses of animals from both genotypes, amounting to 1.7 kg. Castrated males, however, lost 0.3 kg more weight during this period compared to females. At the same time, an opposite trend in weight loss was observed between males and females in animals of Danish and Canadian origin.

Measurements of backfat thickness at various locations showed no significant differences between animals of different genotypes or genders. However, in Canadian pigs, there was a tendency for an increase of 1.3 mm in backfat thickness over the 6-7 thoracic vertebrae, an increase of 0.5 mm in the hips, and a decrease of 2.3 mm at the withers. Castrated males demonstrated a reduction in backfat thickness at all three points, ranging from 0.6 to 1.6 mm.

No significant difference was found in carcass length between animals of Danish and Canadian origin, nor between females and castrates. A similar trend was noted for the length of the bacon half of the carcass.

There was no difference in the weight of the hind leg between animals of different genetic origins and opposite sexes, but there was a tendency for a slight increase of 0.4 kg in this measure among Canadian selection animals and the same increase in females compared to castrated males.

No difference was found in the area of the "muscle eye" between animals of Danish and Canadian origin or between males and females of the two genotypes. At the same time, a significant increase of 2.7 cm² ($p<0.05$) in the area of the longest muscle in the back was established in females of Danish origin compared to males of the same origin.

Table 2. Slaughter indicators of Danish and Canadian-origin pigs at a pre-slaughter weight of 110 kg

Indicators	Groups					
	I control (Danish origin)			II experimental (Canadian origin)		
	gilts	Castrate	group average	gilts	castrate	group average
Slaughter weight, kg	82.1±0.77	80.1±1.79	81.1±1.19	80.8±0.37	80.2±0.65	80.5±0.51
Slaughter yield, %	74.0±0.41[a]	72.3±0.72	73.2±0.63	73.6±0.49	72.1±0.66	72.9±0.57
Weight of chilled carcass, kg	80.5±0.71	78.0±1.70	79.2±1.26	79.3±0.35	78.4±0.61	78.9±0.49
Losses after 24 hours of cooling, kg	1.6±0.21	1.9±0.34	1.7±0.29	1.5±0.17	1.8±0.11	1.7±1.14
Losses after 24 hours of cooling, %	1.9	2.3	2.1	1.9	2.2	2.0
Thickness of backfat:						
Above the 6-7th thoracic vertebra, mm	22.1±1.71	21.8±1.81	21.9±1.73	23.6±1.16	22.8±0.76	23.2±0.93
In the loins, mm	16.3±2.13	15.6±2.03	16.0±2.07	16.8±1.76	16.1±0.93	16.5±1.47
At the withers, mm	42.1±1.33	40.4±1.76	41.3±1.52	39.7±1.29	38.3±1.63	39.0±1.47
Length of carcass, cm	99.5±0.74	98.8±1.23	99.1±0.96	100.1±0.93	99.7±0.89	99.9±0.91
Length of bacon half, cm	85.7±0.86	84.3±1.12	85.0±0.93	86.9±0.93	85.1±1.17	86.0±1.06
Weight of hind leg, kg	13.1±0.21	12.8±0.31	13.0±0.25	13.6±0.33	13.1±0.17	13.4±0.26
Area of the longest back muscle, cm²	65.8±0.86 [a]	63.1±1.01	64.5±0.89	63.0±0.96	61.3±1.16	62.2±1.09
Weight of both hams	5.9±0.07 [aaa]	5.5±0.10	5.7±0.08 [bbb]	5.3±0.11	5.1±0.07	5.2±0.09
Meat yield, %	62.8±0.24[c]	62.2±0.36 [c]	62.5±0.30[b c]	61.9±0.33	61.2±0.21	61.6±0.23
Composite index of fattening and meat qualities	229.2	226.5	228.1	215.4	221.4	218.4

Notes: aaa - between females and males, bbb - between Danish and Canadian genetic, ccc - between pre-slaughter weights of 110 kg and 130 kg.
Source: own calculations.

In terms of the combined weight of both hams, Danish pigs had a statistically significant advantage of 0.5 kg ($p<0.001$) over their Canadian counterparts. A statistically significant advantage of 0.4 kg ($p<0.001$) was also noted for Danish females over males of the same origin regarding this measure. There was also a trend of an increase of 0.2 kg in the weight of both hams in Canadian females compared to males, while the overall advantage of females over castrates was 0.3 kg.

The meat yield from the carcass is currently a commercially significant measure. As seen in Table 2, the meat yield in the carcasses of Danish origin animals was statistically significantly 1.0% higher compared to Canadian counterparts ($p<0.05$). At the same time, there was a trend of a better meat yield, by 1.2%, in Danish pigs slaughtered at a live weight of 110 kg compared to those slaughtered at a live weight of 130 kg. Among Danish females slaughtered at a live weight of 110 kg, the meat yield was significantly higher by 1.2% ($p<0.05$) compared to counterparts slaughtered at 130 kg, while for castrates of the same origin, the difference was 1.4%.

According to the calculation of the comprehensive index of fattening and meat quality, there was an increase of 9.7 points in Danish origin animals compared to Canadian, while the difference between the average indicators for females and castrated males was 1.7 points in favor of castrates.

Thus, when comparing the slaughter indicators of pigs slaughtered at 110 kg, a significant advantage of Danish origin pigs was established regarding the weight of both hams at 8.8% and the meat yield in the carcass at 1.0%, along with an increase in weight loss during transportation and fasting by 0.7%. At the same time, Danish females significantly surpassed castrates of the same genotype in slaughter yield by 2.4%, in the area of the "muscle eye" by 4.3%, and in the weight of both hams by 7.3%, but lagged behind castrates by 0.6% in weight loss during transportation and fasting.

Table 3. Weight of pigs at the beginning and end of fattening, their growth intensity, and weight loss during transportation and fasting of pigs slaughtered at 130 kg

Indicators	Groups					
	I control (Danish origin)			II experimental (Canadian origin)		
	Gilts	castrate	group average	Gilts	castrate	group average
Initial weight at the start of fattening, kg	30.1±0.39^{cc}	30.9±0.41^{c}	30.5±0.39 ^{cc}	31.3±0.54 ^{cc}	32.4±0.47 ^{cc}	31.85±0.49 ^{cc}
Weight at the end of fattening, kg	139.1±0.69 ^{ccc}	138.1±0.56 ^{ccc}	138.6±0.57 ^{ccc}	136.3±0.74 ^{ccc}	137.4±0.36 ^{ccc}	136.9±0.57 ^{ccc}
Average daily gain, g	1,123±9.1 ^{ccc}	1,106±6.3 ^{ccc}	1,114±8.5 ^{ccc}	1,083±9.8 ^{ccc}	1,083±7.6 ^{ccc}	1,083±8.4 ^{ccc}
Weight loss during transportation and fasting, kg	8.4±0.11 $^{aaa\ ccc}$	7.9±0.09 ^{ccc}	8.2±0.11 $^{bbb\ ccc}$	6.6±0.08 ^{ccc}	6.5±0.06 ^{ccc}	6.6±0.07 ^{ccc}
Weight loss during transportation and fasting, %	6.4	6.1	6.25	5.1	5.0	5.05
Pre-slaughter weight, kg	130.7±0.55 ^{ccc}	130.2±0.45 ^{ccc}	130.5±0.43 ^{ccc}	129.7±0.69 ^{ccc}	130.9±0.27 ^{ccc}	130.3±0.93 ^{ccc}

Notes: aaa - between females and males, bbb - between Danish and Canadian genetic, ccc - between pre-slaughter weights of 110 kg and 130 kg.
Source: own calculations.

Castrated males of Canadian origin had statistically significantly lower weight losses during transportation and fasting by 4.8%. For the remaining slaughter indicators between females and males slaughtered at 110 kg, no significant difference was found.

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Comparing the slaughter qualities of Danish and Canadian pigs slaughtered at 130 kg (Tables 3 and 4), significant advantages were found in Danish genetics animals with a difference of 1.6 kg ($p<0.001$) in weight loss during transportation and fasting, a difference of 0.7 cm in the length of the bacon half of the carcass ($p<0.01$), a difference of 4.9 cm² in the area of the cross-section of the longest muscle in the back, and a difference of 0.3 kg ($p<0.001$) in the weight of both hams.

Comparing the growth intensity and weight losses during transportation and fasting of male and female animals of both genotypes, as well as their slaughter qualities, it was found that the average indicators for females of both genotypes surpassed those of castrates by an average of 9 g in daily weight gain, 0.2% in weight loss during transportation and fasting, 1.1 kg in slaughter weight, 1.0% in dressing percentage, 1.5 kg in cooled carcass weight, and in the weight of both hams. In animals of Danish origin, a significant difference was found in females compared to males regarding weight loss during transportation and fasting (0.3 kg, $p<0.001$), cooled carcass weight (1.2 kg, $p<0.05$), hind leg weight (0.8 kg, $p<0.05$), and the weight of both hams (0.5 kg, $p<0.001$). In contrast, among Canadian-origin pigs, no significant differences were found between males and females for these traits, although a similar trend was observed toward increased values in females compared to castrates.

When comparing the composite index of fattening and slaughter qualities in pigs of Danish and Canadian origin at a slaughter weight of 130 kg, this index was found to be higher by 4.9 points in Canadian pigs. However, for this pre-slaughter weight, the calculated index showed that females outperformed castrates by 1.9 points. At the same time, by genotype, the advantage of females over males was 0.4 points in Danish animals and 1.3 points in their Canadian counterparts.

Thus, with an increase in pre-slaughter weight to 130 kg, a significant advantage was established for Danish pigs in the length of the bacon half by 0.8%, in the area of the "muscle eye" by 6.8%, and in the weight of both hams by 4.4%. However, they exhibited greater losses in live weight during transportation and fasting by 1.6%. When comparing the performance of females and males slaughtered at this live weight, significant advantages were found in Danish animals for cooled carcass weight (2.3%), hind leg weight (5.3%), and the weight of both hams (7.6%). At the same time, they showed higher losses in live weight during transportation and fasting by 1.3%.

In contrast, among Canadian-origin animals, significant advantages were found for females over males in dressing percentage (1.5%), carcass length (0.4%), length of the bacon half (1.9%), hind leg weight (3.6%), and the weight of both hams (4.7%).

According to the composite index of fattening and meat qualities, Danish pigs outperformed their Canadian counterparts by 2.1%, while the difference between the average indicators of females and males of both genotypes was only 0.8% in favor of females.

Comparing the growth intensity and slaughter indicators of pigs of both studied genotypes and both sexes, a superiority was established for almost all studied indicators in animals slaughtered with a higher weight category.

For Danish pigs, an increase in pre-slaughter live weight by 19.6 kg resulted in a slaughter weight increase of 16.4 kg, a 1.5% rise in dressing percentage, a 16.3 kg increase in cooled carcass weight, and a 0.3 kg increase in carcass weight loss after cooling. At the same time, the thickness of fat over the 6th-7th thoracic vertebrae increased by 11.4 mm, in the sacral area by 6.4 mm, carcass length increased by 4.5 cm, and the length of the bacon half also increased by 4.5 cm. Meanwhile, hind leg weight rose by 3.3 kg, the weight of both hams increased by 1.2 kg, the area of the "muscle eye" grew by 8.0 cm², while the yield of meat parts in the carcass decreased by 2.0%.

In pigs of Canadian origin, an increase of 19.7 kg in pre-slaughter live weight was also associated with a highly significant increase in slaughter weight by 18.1 kg, dressing percentage by 2.9%, cooled carcass weight by 21.3 kg, losses in carcass weight after cooling by 0.3 kg, thickness of fat over the 6th-7th thoracic vertebrae by 7.1 mm, in the sacral area by 6.3 mm, carcass length by 5.6 cm, and the length of the bacon half by 0.7 cm, as well as hind leg weight by 3.4 kg, weight of both hams by 1.4 kg, and area of the cross-section of the longest back muscle by 5.4 cm², with a decrease in the lean portion of the carcass by 1.1%.

Table 4. Slaughter indicators of Danish and Canadian-origin pigs at a pre-slaughter weight of 130 kg

Indicators	**Groups**					
	I control (Danish origin)			II experimental (Canadian origin)		
	gilts	castrate	group average	gilts	castrate	group average
Slaughter weight, kg	98.3±0.58 ^{ccc}	96.7±0.74 ^{ccc}	97.5±0.63 ^{ccc}	98.8±0.36 ^{ccc}	98.3±0.52 ^{ccc}	98.6±0.49 ^{ccc}
Dressing percentage, %	75.2±0.25^{c}	74.3±0.47 ^{c}	74.7±0.36 ^{c}	76.2±0.36$^{aa\ ccc}$	75.1±0.21 ^{ccc}	75.7±0.23 ^{ccc}
Cooled carcass weight, kg	96.6±0.47$^{a\ ccc}$	94.5±0.94 ^{ccc}	95.5±0.49 ^{ccc}	97.0±0.63 ^{ccc}	96.2±0.49 ^{ccc}	96.6±0.54 ^{ccc}
Losses after cooling, kg	1.7±0.21	2.2±0.33	2.0±0.30	1.8±0.17	2.1±0.32	2.0±0.24
Losses after cooling 24 hours, %	1.7	2.3	2.0	1.8	2.1	2.0
Thickness of fat:						
Over the 6th-7th thoracic vertebrae, mm	33.7±1.06 ^{ccc}	32.9±0.74 ^{ccc}	33.3±0.93 ^{ccc}	29.9±0.37 ^{ccc}	30.6±0.42 ^{ccc}	30.3±0.38$^{bb\ ccc}$
In the sacral area, mm	22.7±0.98^{cc}	22.0±1.67^{c}	22.4±1.36 ^{c}	23.5±1.03 ^{cc}	22.0±0.93 ^{ccc}	22.8±0.97 ^{cc}
At the withers, mm	41.5±1.39	40.5±1.14	41.0±1.25	39.7±0.93	38.3±0.78	39.0±0.83
Carcass length, cm	106.5±0.84 ^{ccc}	105.0±0.66 ^{ccc}	105.7±0.73 ^{ccc}	105.3±0.54$^{aa\ ccc}$	103.6±0.49^{cc}	104.5±0.47 ^{ccc}
Length of the bacon half, cm	88.4±0.53^{c}	86.4±0.51	87.4±0.49 $^{bb\ c}$	87.5±0.39^{aa}	85.9±0.37	86.7±0.37
Hind leg weight, kg	16.7±0.31$^{a\ ccc}$	15.9±0.23 ^{ccc}	16.3±0.24 ^{ccc}	17.1±0.17 $^{a\ ccc}$	16.5±0.23 ^{ccc}	16.8±0.19 ^{ccc}
Area of the cross-section of the longest back muscle, cm²	73.0±0.57 ^{ccc}	72.0±0.63 ^{ccc}	72.5±0.59 $^{bbb\ ccc}$	67.9±0.43 ^{ccc}	67.3±0.54 ^{ccc}	67.6±0.49 ^{ccc}
Weight of both hams, kg	7.1±0.04 $^{aaa\ ccc}$	6.6±0.08 ^{ccc}	6.9±0.05 $^{bbb\ ccc}$	6.7±0.03 $^{aaa\ ccc}$	6.4±0.03 ^{ccc}	6.6±0.03 ^{ccc}
Meat yield in the carcass, %	61.7±0.35	60.8±0.40	61.3±0.37	60.9±0.39	60.1±0.51	60.5±0.46
Composite index of fattening and meat qualities	232.7	231.8	232.2	238.5	235.7	237.1

Notes: aaa - between females and males, bbb - between Danish and Canadian genetic, ccc - between pre-slaughter weights of 110 kg and 130 kg
Source: own calculations.

Comparing the changes in slaughter indicators between pigs of different sexes, it was established that in gilts, an increase in pre-slaughter live weight by 19.8 kg resulted in a highly significant increase in slaughter weight by 17.1 kg, dressing percentage by 1.9%, cooled carcass weight by 20.5 kg, losses in carcass weight after cooling by 0.2 kg, thickness of fat over the 6th-7th thoracic vertebrae by 9.0 mm, in the sacral area by 6.6 mm, carcass length by 6.3 cm, and the length of the bacon half by 1.6 cm, hind leg weight by 3.4 kg, weight of both hams by 1.3 kg, area of the cross-section of the longest back muscle by 7.0 cm², and led to a decrease in meat yield in the carcass by 1.3%. Meanwhile, in castrated males, an increase of 19.2 kg in live weight before slaughter caused a significant increase in slaughter weight by 18.4 kg, dressing percentage by 3.5%, cooled carcass weight by 18.6 kg, thickness of fat over the 6th-7th thoracic vertebrae by 9.5 mm, in the sacral area by 7.3 mm, at the withers by 1.3 mm, carcass length by 6.9 cm, and the length of the bacon half by 3.3 cm, hind leg weight by 4.0 kg, weight of both hams by 1.6 kg, area of the cross-section of the longest back muscle by 7.5 cm², and led to a decrease in losses in carcass weight after cooling by 0.1 kg and meat yield in the carcass by 0.4%.

With the increase in pre-slaughter live weight from 110 to 130 kg, there was an increase in the composite index of fattening and meat qualities in all animals. As shown in Table 4, in pigs of Danish origin, this increase amounted to 4.1 points, while in Canadian-origin animals, it was 18.7 points. When comparing changes in the calculated index in pigs of different sexes, it was found that in gilts, this index increased by 13.3 points, whereas in castrates, the increase was only 9.8 points.

Thus, in pigs of Danish origin, an increase in pre-slaughter live weight by 17.6% resulted in an increase in slaughter weight by 20.2%, dressing percentage by 1.5%, cooled carcass weight by 20.6%, thickness of fat over the 6th-7th thoracic vertebrae by 52.0%, in the sacral area by 39.7%, carcass length by 4.5%, and the length of the bacon half by 2.8%, hind leg weight by 25.4%, weight of both hams by 20.2%, area of the cross-section of the longest back muscle by 12.4%, as well as a decrease of 0.1% in losses of carcass weight after cooling and 1.3% in meat yield. In pigs of Canadian origin, an increase in pre-slaughter live weight by 17.8% resulted in an increase in slaughter weight by 22.4%, dressing percentage by 2.9%, cooled carcass weight by 28.3%, thickness of fat over the 6th-7th thoracic vertebrae by 30.4%, in the sacral area by 37.9%, carcass length by 5.6%, and the length of the bacon half by 0.8%, hind leg weight by 25.4%, weight of both hams by 26.0%, area of the cross-section of the longest back muscle by 8.7%, with a decrease in losses of carcass weight after cooling by 0.1% and the lean portion of the carcass by 1.1%.

Comparing the dynamics of changes in slaughter indicators in pigs of different sexes with an increase in pre-slaughter weight from 110 to 130 kg, it was established that in gilts, slaughter weight increased by 21.0%, dressing percentage by 1.9%, cooled carcass weight by 26.9%, thickness of fat over the 6th-7th thoracic vertebrae by 39.2%, in the sacral area by 39.6%, carcass length by 6.3%, and the length of the bacon half by 1.8%, hind leg weight by 26.6%, weight of both hams by 23.2%, area of the cross-section of the longest back muscle by 10.9%, and led to a decrease in losses of carcass weight after cooling by 0.1% and meat yield in the carcass by 1.3%. At the same time, in castrates, there was an increase in slaughter weight by 23.0%, dressing percentage by 3.5%, cooled carcass weight by 23.8%, thickness of fat over the 6th-7th thoracic vertebrae by 42.6%, in the sacral area by 45.7%, at the withers by 3.2%, carcass length by 6.9 cm, and the length of the bacon half by 3.8 cm, hind leg weight by 30.5%, weight of both hams by 30.2%, area of the cross-section of the longest back muscle by 11.8%, and caused a decrease in losses of carcass weight after cooling by 0.5% and meat yield in the carcass by 0.4%.

The composite index of fattening and meat qualities increased by 1.8% in pigs of Danish origin, while in Canadian-origin animals, this increase was 8.6%, meaning that in Canadian pigs, this index rose by 13.3% more compared to Danish-origin animals. In gilts, on average, this index increased by 13.3%, while in castrates, it increased only by 9.8%.

Our conclusions regarding the significant advantage of Danish-origin pigs by 8.8% for the weight of both hams and 1.0% for meat yield in carcasses align with the results published in the works [24, 25, 32, 38], which also indicate a significant influence of genotype on the slaughter qualities of pigs. Our findings that gilts significantly surpassed castrates of the same genotype in terms of slaughter yield by 2.4%, muscle eye area by

4.3%, and the weight of both hams by 7.3% are consistent with reports [29], which stated that castrates had a lower yield of lean carcass parts compared to gilts, and other [34], which reported higher meatiness of gilts' carcasses compared to those of castrates. However, these findings do not align with reports [40, 48], which noted that surgically castrated boars had reduced carcass yield and less backfat thickness compared to gilts, as our research did not find a significant difference in backfat thickness between males and females, and Danish-origin gilts had a higher slaughter yield compared to boars.

Our conclusions regarding the probable advantage of pigs with increased pre-slaughter weight from 110 to 130 kg in terms of bacon half-length by 0.8%, muscle eye area by 6.8%, and the weight of both hams by 4.4% are consistent with reports [2, 6, 24, 35, 42, 48, 50], which state that pigs slaughtered at a pre-slaughter weight of 130 kg significantly outperformed their counterparts slaughtered at a weight of 110 kg in terms of slaughter weight, cooled carcass weight, backfat thickness over the 6-7 thoracic vertebrae, in the withers and in the loins, carcass length, and its bacon half, ham weight, and muscle eye area. At the same time, our data contradict reports [3], which found no relationship between backfat thickness and meatiness of the carcass based on the pre-slaughter weight of hybrid American pigs, and with reports [13], which noted that with an increase in pre-slaughter weight, there was a significant increase in carcass weight, but it did not affect the proportions of muscle tissue, fat, and bones. They found no evidence that increasing slaughter weight deteriorates carcass characteristics.

Considering the dynamic changes in genetic material in pig farming in Ukraine, we deem it appropriate to continue researching the changes in meat qualities of foreign-genotype pigs at varying pre-slaughter weights.

CONCLUSIONS

It has been established that Danish-origin animals, compared to Canadian-origin counterparts slaughtered at a live weight of 110 kg, have advantages in the weight of both loins and meat yield in the carcass, along with increased weight loss during transportation. When the pre-slaughter weight was raised to 130 kg, a significant advantage was noted for Danish pigs in the length of the bacon half, the area of the "muscle eye," and the weight of both loins, although they exhibited greater weight loss during transport.

It has been proven that at a slaughter weight of 110 kg, Danish sows outperformed castrates of the same genotype in terms of slaughter yield, muscle eye area, and the weight of both loins but fell short against castrates regarding weight loss during transportation. In contrast, Canadian-origin castrates had significantly lower weight loss during transport.

It has been established that at a live weight of 130 kg, Danish sows exceeded castrates in terms of the weight of the chilled carcass, ham weight, and the weight of both loins. However, they lagged behind in live weight loss during transport. At the same time, among Canadian-origin animals, female advantages over males were observed in slaughter yield, carcass length, bacon half length, ham weight, and the weight of both loins.

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RURAL SUSTAINABILITY THROUGH SHORT SUPPLY CHAINS

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Abstract

This research focuses on consumers' level of interest and perception regarding short supply chains of local agri-food products in the context of rural development. The study aims to analyze a series of aspects regarding the factors that motivate consumers to choose local products, the barriers against the expansion of these short supply chains, and their economic efficiency. Through the case study conducted at the level of the Central Region (Alba and Sibiu counties), theer were also analyzed consumers' perceptions regarding the advantages and disadvantages of these short supply chains, including their impact on prices, product quality, diversity of offer and their accessibility for different consumer groups. The research contributes to the formulation of recommendations for improving and strengthening this type of supply, to support the development of a more sustainable local food economy and to meet consumer requirements and preferences. The findings highlight that interest in local products is often influenced by socio-cultural and economic factors, such as concerns about health and sustainability, but also by the accessibility of these products.

Key words*: *short supply chain, agricultural marketing, sustainable agriculture, local economy

INTRODUCTION

In the recent decades, globalization and increased international trade have significantly changed the structure of agri-food supply chains. In this context, there is a growing trend of consumers reorienting themselves towards local food products, especially in the context of concerns about health, food safety and environmental impact [13], [9]. Short supply chains of local agri-food products – those distribution systems that involve a reduced number of intermediaries and/or direct contact between producers and consumers – have become a topic of interest in economic, social and ecological research, being seen as a sustainable alternative to traditional globalized supply models [5], [2].

The growing consumer interest in local products is influenced by a combination of economic, environmental and social factors. First, a large proportion of consumers perceive local products as having a higher quality than those coming from long supply chains [14]. This perception is fueled by the idea that local products are fresher, more natural and less processed, having, in many cases, a more authentic taste [16]. There is also a general belief that local products are safer because consumers can have direct access to information about their provenance and production methods [4]. In addition, the interest in supporting local economies plays an important role, being seen as an act of solidarity towards small farmers and producers, who directly benefit from this type of consumption [18].

On the other hand, consumers are increasingly aware of the environmental impact of their food choices [17]. Short supply chains are perceived as an environmentally friendly solution, helping to reduce the carbon footprint associated with long-distance transportation [7]. These are seen as a way to support a more sustainable food system, in which local production is promoted, thus protecting natural resources and reducing dependence on global agri-food industries, which often have a significant impact on the environment [20]. In addition, short chains are considered more resilient, as they are based on direct and transparent relationships between producers and consumers, which can contribute to greater economic stability at local and regional levels [12], [11].

However, consumer perceptions and attitudes towards short supply chains are often divided, and several practical barriers may limit their expansion [6], [1]. One of the main obstacles identified is the higher price of local products, which are often not accessible to all consumers, especially the more economically vulnerable segments [3], [15]. Furthermore, the accessibility of these products is often limited by insufficient infrastructure, either due to the lack of adequate local markets or the difficulty of reaching points of sale, especially in rural or more remote areas. Furthermore, some studies suggest considerable uncertainty about the sustainability and safety of local agri-food products, despite general trust in them [19], [8]. These uncertainties may be linked to the lack of clear regulations on production standards, as well as concerns about the ability of these supply chains to cope with scalability and long-term sustainability requirements [10].

In this context, the purpose of this research is to investigate the level of interest and consumer perception towards short supply chains of local agri-food products, a central topic in the context of sustainable development of rural areas, presenting a study case in the Central region of Romania, including Alba and Sibiu counties.

MATERIALS AND METHODS

To achieve the main purpose of the paper, several research methods were used that allowed a comprehensive approach to the subject. First, a comparative analysis was used, from both a quantitative and qualitative perspective, to obtain a detailed and nuanced understanding of consumers' perceptions and attitudes towards short supply chains of local agri-food products. Quantitative analysis was applied to identify significant trends and correlations between the studied variables, while the qualitative approach allowed for exploring consumers' opinions and motivations more deeply, detailing not only what consumers think, but also why they think that way. By combining these methods, the aim was to obtain a complete set of data to support the research conclusions.

One of the main tools used in the survey was the questionnaire, which was applied to a number of 250 respondents from the Centru Region, including Alba and Sibiu counties. The choice of this region was motivated by the economic and social diversity of the area, which includes both urban areas with easy access to local products and rural communities, where short supply chains could play an essential role in sustainable development. The questionnaire was designed to capture a wide range of information, from the level of consumer interest in local products to the perceived obstacles in their access to products from short supply chains. It was distributed in both urban and rural areas, to ensure a diversity of responses and a wider coverage of the socio-economic context.

Regarding the structure of the questionnaire, formulating the questions was a carefully planned process, given the need to obtain clear and relevant information. The questions were designed to address both objective aspects, such as the frequency of purchasing local products, and subjective aspects, such as consumers' attitudes and perceptions towards short supply chains. Ordering them in a logical sequence was essential to facilitate the natural flow of the questionnaire and encourage respondents to express their opinions coherently. In addition, the questionnaire was structured in such a way as to allow comparative analysis between groups of consumers with different socio-demographic characteristics, such as age, income or education.

The questionnaire was applied face-to-face, through direct interviews during August-September 2024 in Alba County and during October-November 2004 in Sibiu County. The locations where the interviews were conducted covered urban areas (Sibiu and Alba Iulia), but also rural areas in the vicinity of these cities: Ciugud and Oarda Communes in Alba County, as well as Șelimbăr and Cristian Communes in Sibiu County.

Face-to-face interviews offered the possibility of support in completing the questionnaire, ensuring that all questions were correctly understood by the respondents. Finally, the completed questionnaires were processed and analyzed using appropriate statistical methods, to draw clear conclusions regarding the level of interest and barriers perceived by consumers regarding short supply chains for local products.

RESULTS AND DISCUSSIONS

The Central Region of Romania, which includes the counties of Alba and Sibiu, is one with a diverse rural landscape and a deep-rooted agricultural tradition.

Agriculture continues to be an essential sector for the economic development of the region, having a significant impact on the economic and social structure of rural localities. In this rural area, agricultural activities predominate, including both cereal and vegetable production, as well as activities related to animal husbandry and fruit growing.

Many of the inhabitants of these counties directly depend on agriculture, and small and medium-sized farms represent the backbone of the local economy, contributing significantly to employment and maintaining agricultural traditions.

At a time when the local economy is facing multiple challenges, including rural population migration and market globalization, short supply chains can represent a solution for the revitalization of rural communities.

Through this field research, it was aimed to obtain a clear picture of how consumers in Alba and Sibiu counties perceive these short chains, as well as their behaviors regarding the purchase of local products.

This information is essential to understand whether the interest in local products is a sustainable trend in the long term, which could support the economic development of rural regions.

In addition to identifying consumer interest, the questionnaire also focuses on potential obstacles that may hinder the development of short supply chains.

In this regard, the questions were designed to explore both the difficulties consumers face in accessing local products and the challenges they perceive related to prices, infrastructure and food safety.

Understanding these barriers is necessary for the development of local and regional strategies to support small producers and improve consumer access to local food products.

Thus, the questionnaire becomes a valuable tool in the context of sustainable development, which not only supports the rural economy, but also reduces the ecological footprint associated with the transport and distribution of food products.

Thus, by analyzing the data obtained, we can identify best practices and innovative solutions to improve distribution processes and increase transparency in the supply chain, and we can better understand how to build a more efficient local supply system that meets both consumer needs and economic and environmental sustainability requirements.

In order to obtain the greatest possible variety of answers, the 250 respondents from Alba and Sibiu counties who answered the questionnaire were 39% from rural areas and 61% from urban areas.

Regarding the gender of the questioned individuals, the situation is: 55% were women and 45% men.

The age category of the respondents varied, 20% under 25 years old, 40% between 25-40 years old, 30% between 41-60 years old and 10% over 60 years old.

Regarding ***the consumption habits*** of the respondents, we wanted to find out how often they buy local products (Fig. 1).

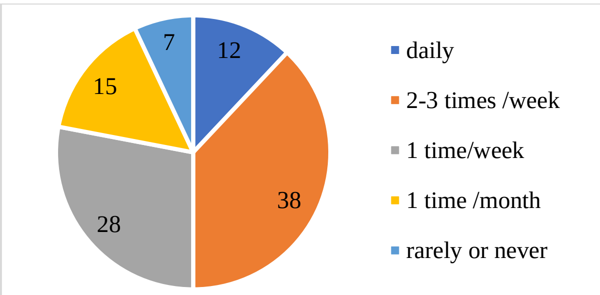

Fig. 1. How often do you buy local agri-food products?
Source: Own design based on questionnaire output data.

We also wanted to know ***what types of products are purchased most often***. We offered respondents the opportunity to choose a maximum of 3 products from the list, and the answers indicated their purchasing tendency (Fig. 2). From this point of view, it resulted the following situation in the decreasing order: vegetables, fruits, dairy products, meat and meat preparations and honey.

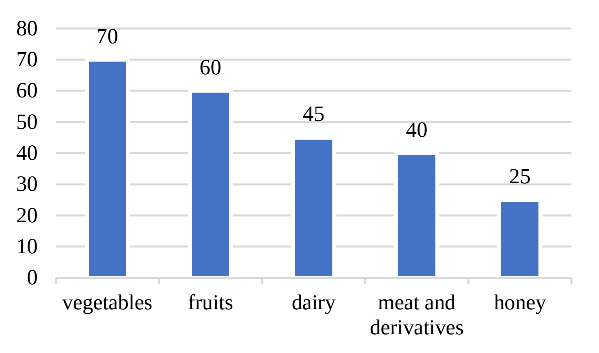

Fig. 2. What type of local products do you consume most often?
Source: Own design based on questionnaire output data.

At the question: ***which are the sources of purchase for local products,*** it was offered the possibility to provide multiple answers, the obtained results being: 55% of respondents generally buy from agri-food markets, 42% directly from producers, 30% from local stores, 12% supermarkets and only 8% use online platforms (Fig. 3).

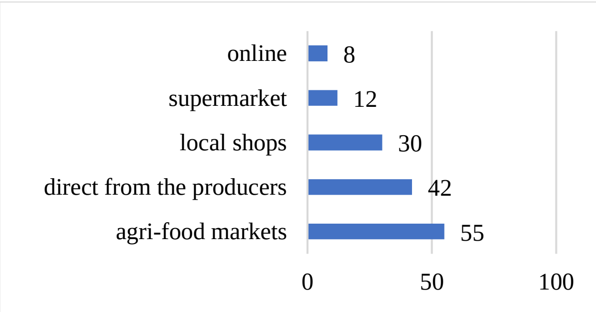

Fig. 3. Where do you usually buy local products?
Source: Own design based on questionnaire output data.

Regarding ***consumer perceptions of local products and short supply chains***, we wanted to find out which are the most important aspects taken into account by respondents to buy local products, offering the possibility of multiple answers (Fig. 4).
Most of the interviewees, 65%, considered that product quality is the main reason to buy a product, 44% considered that the product must be fresh and healthy, 36% buy products from local producers and 31% buy depending on the product price.

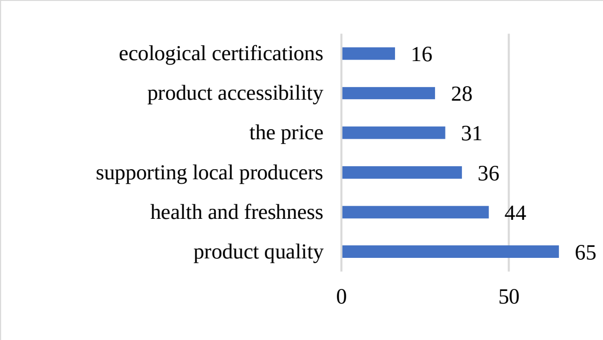

Fig. 4. What aspects do you consider most important when buying local products?
Source: Own design based on questionnaire output data.

We also wanted to find out ***the opinion of potential consumers regarding the main obstacles to buying local products***, noting that this question also had the possibility of a maximum of 3 answers, and the answers received were: 63% higher prices, 43% reduced variety of products, 31% problems related to distribution and delivery, 26% lack of access to points of sale, 12% lack of information about producers, 8% lack of trust in the quality of the products (Fig. 5).

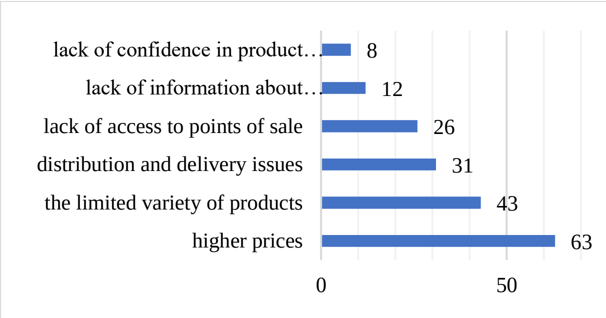

Fig. 5. What aspects do you consider most important when buying local products?
Source: Own design based on questionnaire output data.

Regarding consumers' interest in the short supply chain, we wanted to find out if they would be interested in ***purchasing local products through a direct delivery system from producers***: 55% considered that such a system would be very useful, 28% would accept this system, but only for certain products, and 17% do not accept this idea, being used to purchasing local products from regular sales outlets (Fig. 6).

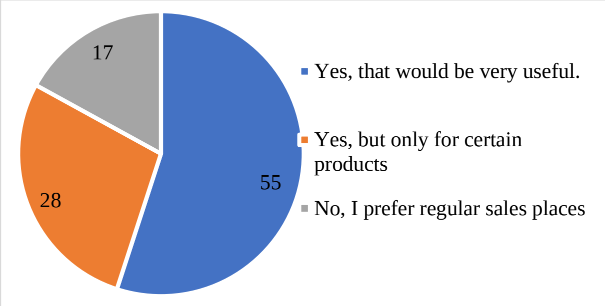

Fig. 6. Would you be interested in purchasing local products through a direct delivery system from producers?
Source: Own design based on questionnaire output data.

We also analyzed the correlation between some variables:

- Age and frequency of purchases: people between 25-40 years old are the most active in purchasing local products (50% buy several times a week).
- Preferred purchase channel by age: people under 25 prefer online purchases, while those over 40 prefer agri-food markets.
- Interest in direct delivery: 55% of respondents consider a direct delivery system from producers to be very useful.
- Obstacles and price perception: those who do not buy frequently cite high prices and lack of accessibility as the main barriers.

CONCLUSIONS

Short supply chains for local agri-food products have started to become an increasingly relevant option for the development and support of rural economies in the Centre Region. These short chains are characterized by a direct link between producers and consumers, without the intervention of major intermediaries, which allows for a fast and efficient distribution of local agri-food products. They also represent an opportunity to promote sustainable agriculture and healthy products and support small farmers who, in many cases, face difficulties in accessing large markets or competing with imported products. In Alba and Sibiu counties, these short chains can contribute to strengthening economic and social ties between communities, fostering the growth of a circular economy and reducing the environmental impact of food transport.

However, the implementation and development of short supply chains in this region is not without challenges. Although there is a growing interest from consumers for local products, limited access to markets, poor infrastructure in some areas and lack of information on the benefits of local consumption can represent important obstacles. In addition, consumers in rural areas, although familiar with local products, sometimes face higher prices and a narrower offer, which can affect their purchasing decision.

In this context, for short chains to become a viable and sustainable option, constant support from local and regional authorities is necessary, as well as continuous education of consumers on the advantages of local products, both in terms of quality and economic and environmental impact.

Recommendations for improving the short supply chain to support the sustainability of rural areas:

- Developing a direct delivery system: a significant percentage of consumers are interested in such an initiative.
- Consumer education: increasing the level of information on the benefits of local consumption through awareness campaigns.
- Diversifying the products offered: expanding the range of products available can help attract more consumers.
- Creating dedicated local markets: the accessibility of points of sale is an essential factor.
- Policies to support local producers: reducing distribution costs and promoting support schemes for small producers.

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ANALYZING THE TECHNICAL EFFICIENCY OF FARMERS GROWING DIFFERENT CROPS IN DISTRICT MANSEHRA, PAKISTAN

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Abstract

The agriculture sector of Pakistan is characterized by unsustainable traditional practices and inefficiency in farming. Appropriate ways to increase productivity and efficiency are therefore, essential for individual households' welfare and the country's economy. Thus, this study aims to analyze and estimate the factors affecting the technical efficiency and to identify the level of satisfaction of farmers on their cultivation experiences in District Mansehra, Pakistan. An aggregate sample of 96 farmers and four government officials were interviewed, using the purposive sampling technique. A stochastic frontier production function was used to evaluate the technical efficiency, using Frontier 4.1 for its utility in inefficiency estimations. While, average technical efficiency of the selected crops i.e potato, onion and tomato was estimated79%, 74%, and 69%, respectively, indicating space for improvement in efficiency by 21%, 26%, and 31% by effective usage of available resources. This indicates that using proper amounts of fertilizer, agrochemicals, seeds, labor, and machinery could increase the production of crops and the efficiency, of farmers that are intervening near to the frontier level of efficiency.

Key words*: *technical efficiency, crop production, Stochastic Frontier Function, Mansehra, Pakistan

INTRODUCTION

Agriculture being an essential and beneficial economic activity, is one of the main sectors for the economic development of Pakistan [19]. Agriculture plays an important role in eradicating poverty, ensuring security of food, and bolstering the economy [17]. The agriculture sector is responsible for around 19% of the total gross domestic product (GDP) and employs around 42% of the country's labor force. Approximately 62–64% of the population lives in rural areas, agriculture being their only source of income [18]. Due to the strong links of agriculture and economic development, a developed and profitable agricultural sector can improve the lives of rural communities [18]. Unfortunately, the agriculture sector in Pakistan is not as productive as expected, hampered by several factors that threaten the overall sustainability of agricultural production of the country [22]. The contribution of this sector to the total national production has declined over time by one hundred percent, from 42 percent in the seventies to 21 percent in recent past [8].

There are many reasons for the decline of the sector. The major constraints to agricultural productivity of Pakistan are the ever-increasing population stress in addition to the dominant use of conventional agricultural practices, including outdated farm tools, traditional technology, low usage of latest inputs like seeds and fertilizers, low pace for agriculture extension services and changes in cropping patterns [30]. Such obstacles make the agriculture sector less productive and beneficial, which in turn results in low levels of income for the people engaged in the sector. The repercussions of these problems have devastating impacts on productivity, which in turn affects the farmer's quality of life [10].

A major cause for low growth output, according to Arshad and Shafqat [9], is the low literacy rate of majority of the farmers coupled with the lack of physical capital, creating a lack of ability to understand and employ the latest technologies and inputs. A significant expansion in production output can result from incremental changes to the efficiency of production. Hence, it is important to analyze how the inputs of existing resources are being utilized and what probabilities exist to improve the efficiency of productivity, considering the resource constraints.

Gains in productivity through advancement of efficiency levels are especially significant. Thus, measures of efficiency are computed by comparing observed performance with a specified standard [11]. The efficiency of a farm can be measured in terms of allocative efficiency and technical efficiency (TE). In this study, we focus on the latter (i.e., TE). Shanmugam and Venkataramani [28] briefly define TE as *"the ratio between actual and potential output of a production unit"*. The chances of improving agricultural production by expanding the usage of technology have been decreasing. Thus, reducing existing inefficiency of farmers can end up being more cost effective than presenting new technologies for expanding agricultural output and farmer's income [15]. Determination of levels of efficiency and factors responsible are thus of vital importance for improvement in productivity in all production systems [4].

In most of developing countries including Pakistan, conventional agricultural systems are predominant. Typically, farmers are poor and have large family sizes with lower productivity output and a higher commodity demand to meet. Pressure from an increasing population coupled with land scarcity along with a decline in productivity [7] has made it difficult to keep pace with the increasing demand. This forces the farmers either to adopt the latest technological advancements or to effectively utilize the resources to enhance output. Due to the unavailability of resources and technological advancements, currently more importance is attached to the use of already existing resources, which can be determined by efficiency measurements [1]. Thus, to increase the output of crop production producers need a sound knowledge of the prevailing inefficiency level along with the factors responsible for this level of inefficiency.

Despite the capacity and potential of the study area in terms of agricultural productivity, it is not currently up to the mark. Thus, the requirement for the effective allocation of present productive resources is emphasized [13]. In areas with high inefficiency level, attempting to bring advancement in technology might not yield expected results, until the factors related to inefficiency levels among farmers are identified and followed upon. It is therefore important to analyze the technical efficiency to find out determinants of production and to identify farm specific attributes associated with low production efficiency [16].

Technical efficiency is mostly evaluated by two methods: a parametric approach and a non-parametric approach. The parametric approach uses econometric techniques, whereas the non-parametric approach enables data evaluation through mathematical techniques, i.e. data envelopment analysis (DEA) [21]. Econometric techniques are known as stochastic, and these techniques differentiate the effect of random error from the effect of inefficiency. Non-parametric techniques combine the errors and are thus known as combination inefficiency.

Production function models are the building block models used in macroeconomics. These models link the relationship between the input and output [23, 25] and are specific functions that are extensively applied to express the relationship between more than one input to the output [3]. Accordingly, in this study stochastic frontier analysis (SFA) was used. The observed origination of SFA is the production frontier model, originally mapped out by Aigner et al., [2]. The econometrics of stochastic frontier analysis (SFA) provides techniques for modeling the frontier concept within a regression framework so that inefficiency can be estimated. The benefit of SFA is the prospect that it offers factors of productivity variation into parts, which have direct economic interpretations. The main role of SFA is to have an estimator for one of the constituents of agriculture production, the degree of technical efficiency [5]. Since this study is rooted in both economic and social perspective, thus the main objective of this study is to estimate the level of technical efficiency and to determine the factors affecting the technical efficiency of farmers in the study area along with the satisfaction level of farmers on their experience of cultivation.

MATERIALS AND METHODS

A quantitative approach was employed to gain a better understanding of the situation through providing in-depth detail about main causes, factor dimensions and status of technical efficiency and the framework in which the program is functioning.

Study Area and Sampling

Tanda and Bajna, two villages from District Mansehra were selected for this study. Both areas were selected for reason that these areas are considered important production zones in the District. District Mansehra in general is one of the very low-income districts in Khyber Pakhtunkhwa province of Pakistan [26]. Agriculture is the prominent source of livelihoods in the study area followed by livestock, rangelands and forest, and off-farm incomes generated by small businesses. District Mansehra has fertile land with plenty of water, with both irrigated and rain fed land areas. Wheat and maize are the most grown crops followed by vegetables such as tomatoes, potatoes, onions, spinach and peas along with other green vegetables. This particular area was selected for its lower levels of efficiency despite the favorable conditions of production including richness of soil and favorable climate.

The purposive sampling technique was employed to select a total of 100 respondents out of which 96 were farmers and 4 were the Government officials from agriculture departments and extension service providers.

Data Collection

Both primary and secondary data was collected for the study. A structured, pre-tested questionnaire was used for the collection of the primary data for the study. In person interviews were conducted with household heads to get an insight into the various aspects of production from the last one year. Information regarding inputs and outputs and production, was collected in monetary terms and utilized for productivity analysis. Data regarding farm inputs comprised of fertilizers, seeds, machinery, labor and irrigation information, whereas data concerning farm outputs included information on gross production.

Data related to the socio-economic characteristics of the farmers was also collected and analyzed. This included data on their age, literacy level, household size, farm size and farming experience etc. Although a large number of farmers grow a variety of crops in the area, this study focuses on tomato, potato and onion crops only. Total production of crops (assessed in Pakistani Rupees "Rs.") was the dependent variable of the study. Crop inputs analyzed were fertilizers, agrochemicals, seeds (own or hybrid), hired labor, cost of mechanization and cost of transportation, and were expressed in terms of their aggregate values. This method was used to make up for the lack of crop data per unit area (kg/kanal), especially in the case of agrochemicals. Hired labor and the cost of machinery were measured in terms of their monetary value. This included data on machine rent as well as ploughing and threshing. Farmers mostly rely on borrowed traditional tools and equipment such as tractors and threshers.

Theoretical and analytical framework

The Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA) are two commonly used methods for productivity estimation in terms of productive efficiency and related determinants. They can be used for multi-inputs and one output or as in the case of DEA for multiple-input and multiple-output technologies of production, by using a nonparametric approach [24].

Considering the determining factors, the stochastic frontier production function was used in the study to assess the Technical Efficiency (TE) of the production of crops on the farms. According to Coelli [14] SFA is preferable than other production function models regarding agricultural production. Data is determined at both end measurements of errors, peculiarly in developing countries [27]. The SFA developed by Aigner *et al*., [2] was deemed appropriate for this study.

Considering the frontier production as the maximum output in relation to the given inputs, the analysis validates the relation among farm and threshold output.

The Cobb−Douglas model is used to fit the production function. The benefit of using the Cobb−Douglas production model and the reasons why it was employed in this study is that it allows the analysis of outputs to the different inputs used in the process of production [6]. If Yi is the true level of production, then:

$$Yi = f(Xi)\varepsilon i \ldots (1)$$

where: ε*i* signifies dispersion from the perfect production ranging from zero to one. However it cannot be negative. If the value of ε*i* is greater than zero, the output is presumed to be influenced by a random error.

The stochastic production frontier of Cobb-Douglas is:

$$ln\,\mathrm{Yi} = \beta\,\mathrm{o} + \sum_{j=1}^{x} \beta\,\mathrm{j}ln\mathrm{Xj} + \mathrm{vi} - \mathrm{ui} \quad \ldots (2)$$

where: *ln* denotes natural logarithm and Yi represents gross production of crop in PKRs of the *ith* farm. β_0 represents the intercept, whereas β1-7 depicts parameters of responses to be valued corresponding to each input (i=1, 2, 3, 7). X_1 is hired labor cost in Rs/kanal. Fertilizer cost is X_2 in Rs/ kanal, X_3 reflects agrochemical cost in Rs/kanal, X_4 is purchased seeds in Rs/kanal, X_5 is transportation cost Rs/ kanal, X_6 machinery cost in Rs/kanal and X_7 is the other costs applied in numbers for crop. In the other hand translog frontier model, j, k, m and n represent the seven different variables interact.

V_i is a two-sided error component and indicates differences in output because of circumstances beyond the farmer's control. It also captures the effects of measurement errors in the output variable and other statistical noise. σ_2, v and u_i are a non-negative random variable, assumed to be normally distributed with zero mean-variance, of technical inefficiency (TIE). In general the normal distribution of the output is supposed to be zero and should be independent. Whereas, the mean depict μ_i and variance σ^2. While, the μ_i is described as:

$$\mathrm{u_i} = \delta_o \sum_{n=1}^{7} \delta_{\ \mathrm{i}}\,\mathrm{lnZ_{ni}} - \mathrm{u_i} \qquad (3)$$

In the equation above, μ_i denotes effects of inefficiency, δ_0 shows the intercept term and $\delta_{1\text{-}7}$ represents a parameter for the *ith* explanatory variable. *Z*1 denotes farm size in kanals; *Z*2 shows age of farmers in years; *Z*3 represents literacy level of the farmers in terms of (number of years in school); *Z*4 indicates the farming experience of farmers in years; *Z*5 represents usage of agricultural machinery; *Z*6 shows the role of agricultural credits or loans; *Z*7 is a variable for the extension services.

The Maximum Likelihood Estimates (MLE) indicated in the first three equations for all parameters of the stochastic frontier production model, was employed using the program FRONTIER 4.1 [6]. Further, the variance parameters were elaborated as follows:

$$\sigma^2 = \sigma_v^2 + \sigma_u^2 \qquad (4)$$

$$Y = \sigma_u^2 / \sigma^{\ 2} \qquad (5)$$

So that 0≤ γ ≥1: The γ value ranges from 0 to 1 the values close to 1 representing that random component of the inefficiency effects has a significant contribution to the analysis of the production system. The technical efficiency of production of the *i*-th farmer (TE*i*) given the levels of inputs used is defined by:

$$TE_i = \exp(-U_i) \qquad (6)$$

The TE of a farmer ranges from 0 to 1 and is inversely related to the degree of technical inefficiency [28]. The TE is also calculated using FRONTIER 4.1, calculating the estimated ML of the dependent variable mentioned in the formula 6 that is for its provisional probability, given the observed value of (V*i*-U*i*). If U*i* is equal to 0, the farm is technically efficient. When U*i* is greater than 0, the production lies below the frontier, which means the farm is technically inefficient [12]. Technical inefficiency estimates are only possible if the inefficiencies are stochastic and follow a specific distribution [29].

RESULTS AND DISCUSSIONS

Analysis of socio-economic and demographic variables

The socio-economic/demographic features of targeted farmers are presented in Table 1. The average age of farmers is 45.5 years and the majority of farmers selected were household heads. The average literacy rate was found to be around 2.72 years. The results from Table 1a show that the average years of experience in the study area was 25.78 years. The distance to market was almost same for all the farmers from same village with an average of 17kms. The total land area possessed by each farmer varied considerably, as it is unevenly distributed with an average of 45.29 kanals. The mean family size of 5.98 was found in study area with an average of 1.71 persons earning per household.

Most of the farmers in the study area were part time farmers with some other source of off-farm income with an average income of 19,052 RPS/month.

Table 1. Demographic Variables of Farmers

Variables	Mean	SD	Min	Max
Age years)	45.5	7.7	26	65
Education (years)	2.7	3.6	0	14
Farming experience (years)	25.7	8.8	5	50
Distance between home and market (km)	16.9	2.4	15	20
Total land Area (kanal)	45.2	27.7	8	100
Plots (nos.)	5.7	2.1	1	9
Household Members (nos.)	5.9	2.1	3	17
Earning Members (nos.)	1.7	0.6	1	4
Off-farm Income (Pk. Rs.)	19,052	12,767	5,000	45,000

Source: Field Survey 2022-2023.

Analysis of Farm and Crop Specific variables

In the study area it was found that farmers use their production for self-consumption, income generation and to sustain their livelihood. Most farmers who cultivate for commercial purposes belong to the Union Council 'Tanda-Bajna'. Lower output of farmers can be attributed to aspects such as underdeveloped irrigation system, lack of infrastructure, use of traditional machinery and inputs, lack of cold storage rooms, improper utilization of pesticides and chemicals, lack of subsidies and incentives provided.

Table 2 shows eight different types of crops grown by farmers in the study area, however, as can be seen in the given table, vegetables such as tomato, potato and onion are the major cultivated crops. Results in Table 2 show that tomato crops are the highest cultivated vegetable followed by potato and onion. Whereas the rest of crops such as spinach, tinda (round gourd) and rice has significantly lower production. Wheat and maize are grown for the purpose of self-consumption. Vegetables including tomato, potato and onion are the cash crops of area that are grown for commercial purposes.

Table 2. Types of Crops Grown by Farmers in Study Area Unit (Frequency & Percentage)

Crops	Yes	No	Total (%)
Wheat	11	85	12
Tomato	96	0	100
Potato	90	6	94
Onion	84	12	87
Spinach	30	66	32
Rice	20	76	21
Maize	13	83	14
Tinda*	20	76	21

Note: *Tinda (round gourd)
Source: Field Survey 2022-2023.

Hypothesis Testing

Log-likelihood ratio test was employed to test the hypothesis on the validity and suitability of efficiency model. This test is defined as $\lambda = -2\,[\mathrm{Ln}\,(H_0) - \mathrm{Ln}\,(H_1)]$, where Ln ($H_0$) and Ln ($H_1$), where log likelihood values are attained from the running models (restricted/unrestricted respectively). Null hypothesis (i) identifies those effects of inefficiency were not stochastic. This was strongly rejected as per the results in Table 3.

Table 3. Likelihood Ratio Test

Null Hypothesis	Log Likelihood	LR Statistics	Critical value	Decision
Tomato				
$H_o : \gamma = 0$	107.10	13.11	12.15	Reject H_0
$H_o: \gamma = \delta_0 = \delta_1 .... \delta_7$	71.02	59.24	19.10	Reject H_0
$H_o:= \delta_0 = \delta_1 .... \delta_7$	77.19	66.85	8.78	Reject H_0
$H_o:= \delta_1 .... \delta_7$	68.82	73.25	13.04	Reject H_0
Potato				
$H_o : \gamma = 0$	139.13	14.18	10.89	Reject H_0
$H_o: \gamma = \delta_0 = \delta_1 .... \delta_7$	123.44	49.82	20.19	Reject H_0
$H_o:= \delta_0 = \delta_1 .... \delta_7$	114.18	44.50	7.89	Reject H_0
$H_o:= \delta_1 .... \delta_7$	105.89	64.20	12.87	Reject H_0
Onion				
$H_o : \gamma = 0$	105.20	16.45	13.75	Reject H_0
$H_o: \gamma = \delta_0 = \delta_1 .... \delta_7$	84.09	65.74	25.08	Reject H_0
$H_o: = \delta_0 = \delta_1 .... \delta_7$	77.18	58.68	10.09	Reject H_0
$H_o: = \delta_1 .... \delta_7$	69.74	73.25	18.07	Reject H_0

Source: Field Survey 2022-2023.

Hypothesis rejection means that the function for traditional mean response is not a suitable illustration for production function. Furthermore, the hypothesis of inefficiency effects being absent (i.e., $\gamma = \delta_0 = \delta_1 \ldots \delta_7$), are rejected at 5% significance level. This clarifies that an overwhelming number of farmers work lower than technically efficient frontier, which was output oriented. With respect to the error component, there is no farmer specific or constant effect, evident from the testing of the third hypothesis. As per the results, the inclusion of the null hypothesis is rejected. The fourth hypothesis test implies collective significance of the inefficiency determinants. It rejects null hypothesis and indicates that explanatory variables influence farm efficiency collectively. However, it may not be individually significant.

Stochastic Frontier Production Function Analysis of Determinants of Productivity and Technical Efficiency of Each Crop

The general technical inefficiency impacts are assessed as far as the boundaries related with σ2 and γ parameters. The gauge for the change in σ parameter is fundamentally not quite the same as zero at 1%. This demonstrates measurable affirmation of our assumption that there are contrasts in technical efficiency. These outcomes show that the impacts of technical efficiency are significant in the production process. The assessed value for the variance of γ parameter is huge at 1%, which shows that the arbitrary part of the inefficiency impacts has a critical commitment in deciding the level and fluctuation of output yield.

The general outcome of the stochastic frontier production function gauges is introduced in Table 4.

The production flexibilities of crops cultivated are positive and critical true to form. As per the discoveries, plainly the expanding capital venture at 1%, the produce can be surplus. Opportune accessibility of agricultural contributions inside a sensible cost is a significant aspect for further developing yield in the study area.

Positive and notable flexibility for capital in the event of the extraordinary crops in the chosen area demonstrate the possibility to expand produce by expanding input use. The work versatility for crops is true to form and infers that 1% increment in consumption on employed labor will expand production yield.

The assessed coefficients of the logical factors in the model for technical inefficiency impacts are of interest and have significant implications as displayed in Table 4. The examination demonstrates that the variable of size of farm for crops is positive just as negative yet not significant. It was found that farmers who work on little landholding are actually more proficient, while others can turn out to be more productive by expanding size of activity. Age of the family head is incorporated as an intermediary for cultivating experience to have the impacts of involvement on technical inefficiency. The effect of age on effectiveness is negative at 1%, indicating that more seasoned farmers are more productive.

The use of agricultural machinery also shows a negative as well as significant effect on technical efficiency model which indicates that for different crops different levels of efficiency are present with which efficiency can be increased with usage of better technological innovations to reduce loss of time and effort.

Table 4. Determinants of Productivity and Technical Efficiency of Tomato, Potato and Onion

Variables	Tomato		Potato		Onion	
	Coefficient	t-ratio	Coefficient	t-ratio	Coefficient	t-ratio
Stochastic frontier model						
Constant	1.74	6.98***	0.74	3.51***	1.4	3.59***
Hired Labor	0.42	3.11***	0.56	6.11***	0.15	1.16
Fertilizer	0.12	2.11***	0.32	3.73***	0.37	3.70***
Agrochemical	0.39	2.88	0.25	2.89	0.24	2.45
Purchased Seeds	0.82	4.59***	0.89	2.96**	0.89	2.96***
Machinery Cost	0.65	3.47	0.95	4.85***	0.74	3.86
Transportation Cost	0.69	3.56**	0.36	2.47	0.56	3.11
Others Costs	0.33	2.49***	0.44	8.06***	0.53	4.81***
Technical inefficiency model						
Constant	0.04	0.12	-0.18	-1.4	0.1	1.91
Farm size	-0.11	-0.68	-0.14	-6.58***	0	0.32
Age	-0.01	-0.01	0.02	1.69	-0.02	-1.59
Level of education	-0.01	-2.50**	-0.01	-1.14	0	0.08
Farming Experience	-0.06	-0.13	0.01	2.29**	0.69	0.02
Use of Agri Machin	-0.09	-1.99*	-0.22	-2.88***	-0.04	-2.09**
Agricultural Credits	-0.04	-0.38	-0.13***	-1.84	-0.02	-0.93**
Extension Services	0.08	0.97***	0.15	2.24**	0.01	0.44
Variance parameters						
Sigma-square (σ^2)	0.006	3.26***	0.003	4.09***	0.01	5.20***
Gamma (γ)	0.26	11.93***	0.47	4.85***	0.75	2.09***
Ln Likelihood	99.7		144.2		83.5	

Note: *** depicts significant at 1%, ** depicts significant at 5% and * depicts significant at 10%
Source: Field Survey 2022-2023.

The results for agricultural credits are also highly significant for the efficient model which depicts that agricultural credits or loans can increase the productivity significantly in regards with farmer's coverage in case of loss or regarding purchase of other farm inputs.

For the role played by agriculture and extension service departments, we can clearly see from Table 4 that the results are positive and significant, which implies that these departments have a significant impact over the efficiency production followed by significant increase through awareness and trainings. The services provided by these departments help farmers to overcome natural disasters as well as improvement in the agricultural sector.

Frequency distribution of technical efficiency estimates

Findings about farm explicit specialized efficiencies are significant as they indicate comprehensive data on the idea of innovations utilized on farms. The assessments of the recurrence conveyance of Potato, Tomato and Onion TE are given in Table 5.

Assessed effectiveness score for Tomato demonstrates that farms are normally delivering at 78.64% of their latent capacity going from 58.61% to 94.22%, at the given current situation of innovation and input levels. This infers that the vast majority of the farms in the study area confront extreme technical inefficiency issues. It shows that the farmers in general acknowledge around 79% of their specialized capacities. Subsequently, 21% of the specialized possibilities are not understood for Tomato crops. While, in Potato crop the mean productivity score is

73.71% within the range of 50.31% to 90.01%. It demonstrates that general specialized proficiency is 26.29% than the optimal, which can be improved through the better use of available sources [20].

On the other hand, farmers cultivating Onion crops have a mean efficiency of 68.91% even lower than tomato and potato ranging between 48.63% to 88.05%. This deficiency can be improved for about 31%, by the ideal usage of available inputs and improvements through maximizing the usage of inputs and technology.

Table 5. Distribution of Tomato, Potato and Onion farms for different levels of TE

Efficiency rating	TE of Tomato		TE of Potato		TE of Onion	
	N	%	N	%	N	%
< 60	4	4	13	14	15	16
61-70	40	42	40	42	50	52
71-80	36	38	34	36	27	28
81-90	15	15	9	9	4	4
91-100	1	1	0	0	0	0
Mean Efficiency	78.64		73.71		68.91	
Minimum	58.61		50.31		46.23	
Maximum	94.22		89.01		88.05	

Source: Field Survey 2022-2023.

CONCLUSIONS

The important factors for the production were identified as capital inputs such as fertilizer, agrochemical and seeds, labor, machinery cost, transportation cost and other costs. The result shows that these aspects have a significant effect on crop production.

Nevertheless, the use of proper amounts of fertilizer, agrochemicals, seeds, labor and machinery could increase tomato, potato and onion production. Other logical variables in the technical efficiency model indulged size of farm, age, literacy rate, farming experience, agricultural credits or loans and role of extension services. The outcomes from the efficiency analysis showed that the mean technical efficiency was about 79% for tomato and 74% for potato and 69% for onion and therefore on average a farmer in the region cultivates tomato, potato and onion, 21%, 26% and 31% respectively, below the actual potential output that can be achieved through appropriate methods. This depicts that there is substantial capacity to maximize the output and the yield by expanding efficiency of less efficient farms and assisting the efficiency of farms that are intervening near to the frontier level of efficiency.

The effect of higher age indicated that older farmers are more efficient due to indigenous knowledge and experience. This likewise features the fortifying of expansion agriculture and extension service departments on the advanced lines that will work on farmer's capacities to deal with data about present day farming innovations. The determinants also entail that usage of modern machinery could reduce the inefficiency at a significant level. The agricultural credits are necessary to bear the expenses in case of loss to help farmers be motivated to cultivate in subsequent seasons, by allowing them to have credit for inputs after bearing losses in one season. The role of extension services has the most significant impact over reducing technical inefficiency because any insufficiency whether awareness, adaptability to new, difficulty at current can be accessed and resolved through provision of extension services.

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RESEARCH ON THE IMPACT OF CONSUMER BEHAVIOUR IN TIMIȘ COUNTY, ROMANIA, REGARDING THE CONSUMPTION OF BAKERY PRODUCTS AND THE POSSIBILITY OF DIVERSIFYING BY REPLACING WHEAT FLOUR WITH CHICKPEA FLOUR

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Abstract

The current trends of consumers are towards the consumption of nutritionally valuable foods with a positive impact on health, and the present work is integrated into the set of current concerns in scientific research on a domestic and international level. The aim of the work is the diversification of bakery products with functional potential based on chickpeas and fibers. For this, it was carried out a study on the impact of consumer behaviour regarding the consumption of bakery products, the knowledge of the benefits of chickpeas, the openness of consumers to the consumption of foods based on chickpeas and fibers in order to put on the market bakery products with functional potential based on chickpeas and fibers. To carry out the study, two questionnaires were applied to a number of 1,000 respondents. The sample size for each category is 500 people for each questionnaire, in total 1,000 questionnaires were applied. The obtained results were described for each sample using descriptive univariate analysis and with the help of the EXCEL program, having the database available, frequency tables containing the obtained results were generated. The questionnaires were applied between March and May 2024, in Timiş county, Romania. As a result of the study, it was found that consumers are increasingly oriented towards consuming products that offer them benefits from a nutritional point of view, and the consumption of chickpea-based bakery products represent an alternative for a healthy diet.

Key words: *consumption, organic products, Romania*

INTRODUCTION

Knowing and anticipating the requirements of the market, it is possible to satisfy consumer needs through rational production, and also promote and distribute efficiently the required goods and services to the general public. [4, p. 13]. The products that the consumer buys, can also be used as a tool for promoting a healthier lifestyle. Marketers, aquiering the data sent by the consumer, will be used to meet the needs of the consumer [6].

Bread is one of the most important basic foods, produced in various forms, consumed by mankind over time (Cauvain, 2015, p. 1), [3].

In modern times, shaped by technological innovation and changing consumer preferences, bread has undergone a remarkable transformation [7].

From a nutritional point of view, the nutritional value of flour largely reflects the quality of the bread obtained, bread is often fortified by adding other ingredients to compensate for some deficiencies of the flour or to improve its bioactive properties.

Data from the Trade Register show that almost 7,000 companies are active in the bread and bakery products production sector, until 2001, this figure has not undergone major changes in the last three years [11].

The high consumption of bakery products is also explained by the fact that Timiș County is among the counties in the country with a large number of companies in the bakery field, according to Map 1 presenting companies producing bread and bakery products.

. Current concerns worldwide are related to obtaining products with high nutritional value and functional potential.

Fig.1. Map of bakery companies in Romania according to the Trade Register
Source: [5].

The introduction of chickpeas in baking brings benefits to the human body, these include blood sugar control, weight management, a healthier heart and a good digestive health [12].

Chickpeas are a member of the pulse family, which includes beans, lentils, and dry peas [9].

The nutritional value of bakery products, especially bread, represents an important element for the daily ration.

The aim of the work is the diversification of bakery products with functional potential based on chickpeas and fibers. For this, we carried out a study on the impact of consumer behavior regarding the consumption of bakery products, the knowledge of the benefits of chickpeas, the openness of consumers to the consumption of foods based on chickpeas and fibers in order to put on the market bakery products with functional potential based on chickpeas and fibers.

MATERIALS AND METHODS

Applying specific methods and techniques, used in order to complete the research, we resorted to the consultation and analysis of specialized literature, the collection and interpretation of statistical data, the construction and access of databases, direct study through statistical surveys.

The scientific approach to the research also includes the consultation of some regulations, data provided by the INS (National Institute of Statistics of Romania) and the Regional Directorate of Statistics of Timiș County, as well as the results obtained from own research.

To carry out the study a structured questionnaire was applied to two categories of respondents: pupils aged between 14 to 18 and adults aged between 19 to 80.

The sample size was calculated using the automatic calculator [2].

This calculator computes the minimum number of necessary samples to meet the desired statistical constraints. This means 849 or more measurements/surveys are needed to have a confidence level of 98% that the real value is within ±4% of the measured/surveyed value.

The sample size for each category is 500 people for each questionnaire, in total 1,000 questionnaires were applied.

The stages of the study regarding the impact of education on the behavior of the consumer of bakery products, assume the materialization over time of the way of conducting the analysis process by going through the following sequences:

- drawing up an analysis plan;
- the collection of information from the area under study (Timiş county), based on the study of the specialized bibliography, referring to yearbooks and statistical breviaries;
- processing, interpretation and comparison of the collected information with the studies of other specialists;
- analysis and interpretation of the obtained results, formulation of conclusions and recommendations.

The obtained results were described for each sample using descriptive univariate analysis and with the help of the EXCEL program, having the database available, frequency tables containing the obtained results were generated. The questionnaires were applied between March and May 2024, in Timiş county. A questionnaire consisting of a number of 13 questions was applied to the 500 students, regarding the consumption of bakery products, their quantity and quality, the consumption of chickpeas and the interest in consuming bakery products based on chickpeas, as well as information about factual data.

The second type of questionnaire was given to adults of different age categories and social status. It is made up of a number of 16 questions, related to the consumption of bakery and chickpea-based products, as well as information about factual data.
The variables used in the study of the bakery products market are:

- dependent variables: consumer preferences for bakery products;
- independent variables: gender, age, place of residence, level of education, occupation and income [8].

RESULTS AND DISCUSSIONS

From the studies carried out, it was noticed that consumer behavior is different depending on the residence environment (urban/rural). Consumer behavior shows differences that can be determined by the following factors: the price of food products, their purchasing power, the production of food products in their own household and self-consumption, the degree of culture and education.

Respondents' consumption behavior for bakery products

Based on the responses to the questionnaires, the consumption preferences for bread categories differs among students compared to adults, as shown in Table 1.

Table 1. Comparative consumption preferences of some bread categories among students and adults

Preferences by bread category	**Answers**	
	Adults	Students
White bread	210	463
Multigrain bread	108	20
Rye bread	48	6
Black bread	134	3
TOTAL	500	492

Source: from the questionnaires applied.

From Table 1, it can be seen that, of the 500 students interviewed, 492 consume bread, a percentage of 98.40%, and 8 students declared that they do not consume bread, respectively 1.60%.
As can be seen from Fig. 1, students' preferences for white bread are higher than adults' preferences, who prefer multigrain bread and black bread.

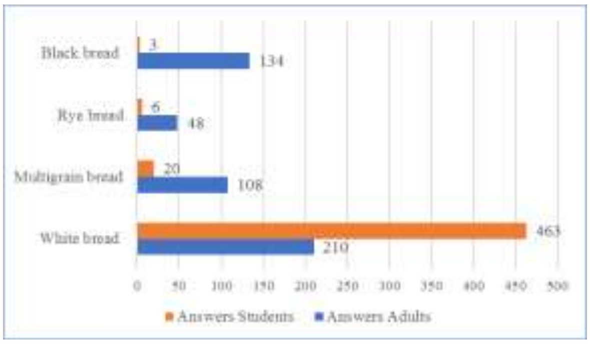

Fig. 1. Comparative study of consumer preferences among respondents
Source: from the questionnaires applied.

Thus we can conclude that adults have a balanced and healthier eating behavior, taking into account the consumption of bread.
Table 2 presents the results of the comparative study on the consumption of bakery products among respondents:

Table 2 Comparative study on the consumption of bakery products

Bakery products	Answers	
	Adults	Students
Bread	340	300
Croissants with salt	232	432
Bagels	250	350
Bars	80	220
Croissants with seeds	220	120
Other	40	65

Source: from the questionnaires applied.

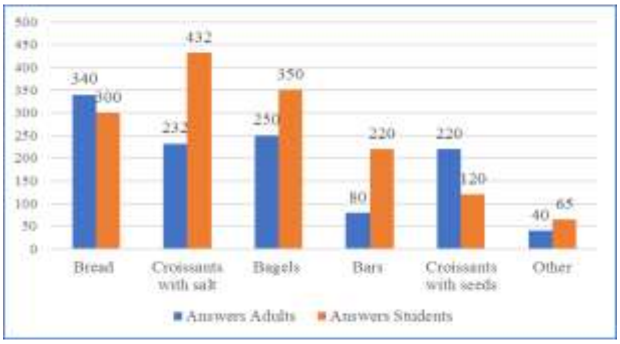

Fig. 2. Chart on the comparative study of the consumption of bakery products among the respondents.
Source: from the questionnaires applied.

According to Fig. 2, the dietary behavior of the respondents can be observed. Bakery products such as salted croissants, bagels, bars, seeded croissants have a higher share among students.
When asked about the consumption environment, "*Where do you consume bakery*

products?" the preferences of students and adults were as follows:

• 429 of the students declare the consumption of bakery products in the family;
• 121 students declare the consumption of bakery products in public food establishments;
• 40 students declare the consumption of bakery products in the canteen;
• 340 adults declare the consumption of bakery products in the family;
• 180 adults declare the consumption of bakery products in public food establishments;
• 80 adults declare the consumption of bakery products at work.

The preference for different consumption environments related to the number of students' answers can be seen in the Table 3.

Table 3. The options for the different consumption environments of the students

Consumer environment	Answers		Options related to the number of respondents %
	Students	Percentage %	
In the family	429	72.71	100.00
At the canteen	40	6.77	9.32
In public food establishments	121	20.50	28.20
Total	590	100	137.52

Source: from the questionnaires applied.

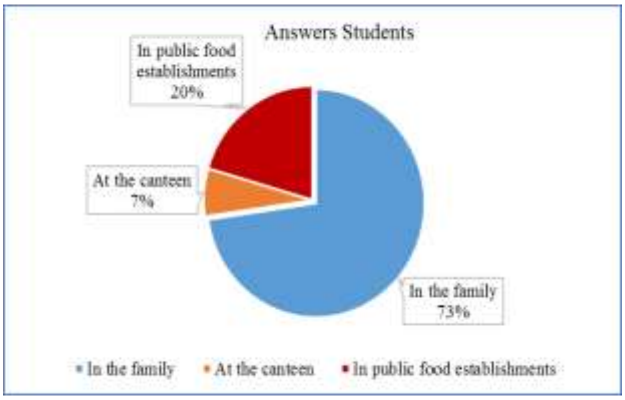

Fig. 3. The options for the different consumption environments of the students in percentages
Source: from the questionnaires applied.

As we can see from Fig, 3, most students consume bakery products at home, e.g. 73%, less than 6% at the canteen, and 20% of the students surveyed prefer to eat in public catering establishments, such as fast food and street food.

Table 4. Options for the different adult consumption environments

Consumer environment	Answers		Options* related to the number of respondents %
	Adults	Percentage %	
In the family	340	56.67	75.22
At work	80	13.33	17.70
In public food establishments	180	30	39.82
Total	600	100	132.74

*options are represented by the percentages of those who had multiple answers.
Source: from the questionnaires applied.

As we can see from Fig. 4, most adults consume bakery products at home, e.g. 57%, 13% at work, and 30% in public catering establishments.

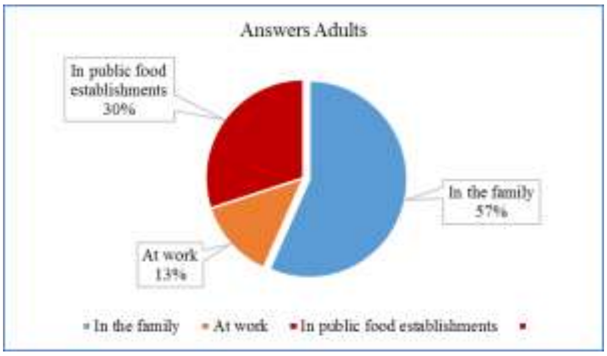

Fig. 4. The options for the different consumption environments of adults in percentage
Source: from the questionnaires applied.

Respondents' consumption behavior for chickpeas products

Following some studies, it has been shown that chickpeas, in addition to anti-allergic and anticonvulsant properties, have significant antihypertensive and hemagglutination activity, and have gastroprotective and hepatoprotective benefits [15]. The chemical composition of chickpeas flour as presented in Fig. 5.

Chickpeas are high in dietary fiber, especially galactomannans, which influence the glycemic index and cause high satiety, influencing glucose levels [16].

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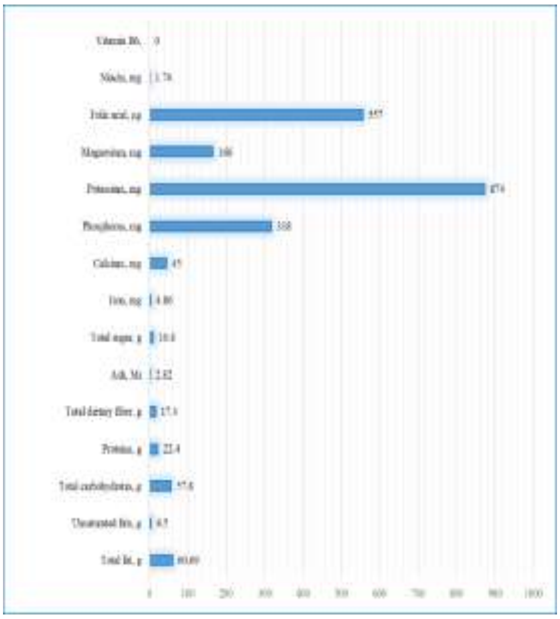

Fig. 5. Nutritional composition of chickpea flour
Source: [14].

The chickpeas contain moderately high protein (17–22%), low fat (6.48%), high available carbohydrate (50%) and crude fiber contents of 3.82% on dry basis (Saleh and El-Adawy, 2006) [13].

Chickpea flour is an excellent source of nutrients and has multiple health benefits. Being obtained from ground chickpeas, it retains most of its properties. Interest in the consumption of chickpea flour is increasing, especially due to its functional properties. such as foaming, emulsifying, gelatinization, texture and viscosity properties, water and oil absorption capacity [1].

Making a reference towards my previous question, such as knowing the nutritional value of chickpeas and chickpea-based products, after questioning the respondents the following answers resulted:

• only 10 students are unaware of nutritional value of chickpeas, e.g. a percentage of 2%;

• 498 adults answered affirmatively, e.g. a percentage of 99.6%;

• only 2 adults are unaware about the nutritional value of chickpeas, e.g. a percentage of 0.4%.

The comparative study on the consumption of chickpeas and the interest in consuming new chickpea-based products among the respondents is shown in Table 5.

Table 5. Comparative study on consumption of chickpea among respondents

Consumption of chickpeas	Answers	
	Adults	Students
Yes	290	128
No	210	372
TOTAL	500	500

Source: from the questionnaires applied.

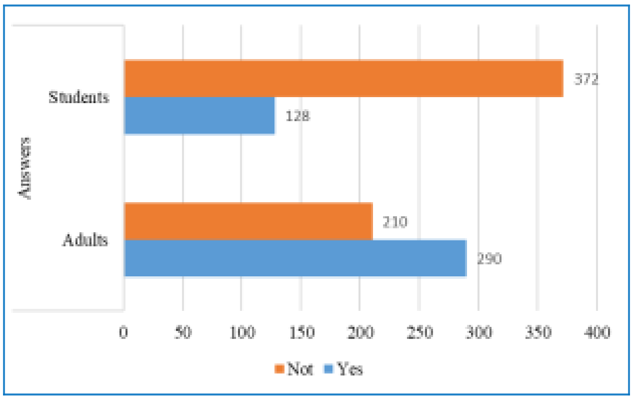

Fig. 6. Chart of the comparative study on the consumption of chickpeas among the respondents
Source: from the questionnaires applied.

Question number nine makes reference towards the consumption of chickpeas by pupils. Following the interpretation of the questionnaire, the following information resulted:

• 372 Pupils who do not consume chickpeas, measure up to, 74.4%;

• 128 Pupils who consume chickpeas, measure up to 25.6%. The high percentage of chickpea consumers among adults compared to students is influenced by tradition, the age of the respondents and the affordable price, as well as their concern to eating healthy.

Table 6. Representation of respondents' interest in consuming chickpea-based bakery products.

The interest to try consume chickpea - based bakery products	Answers	
	Adults	Students
Yes	450	385
Not	50	115
TOTAL	500	500

Source: from the questionnaires applied.

When asked about the interest in consuming chickpea-based bakery products, the following answers resulted:

• 450 Adult respondents replied affirmatively, that is, a fairly high percentage of 90%;

• 50 Adult respondents are not interested in trying new chickpea products, that is, 10%

• 385 Students answered affirmatively, that is, a fairly high percentage of 77%;

• 115 Students are not interested in trying new products based on chickpeas, that is, a percentage of 23%.

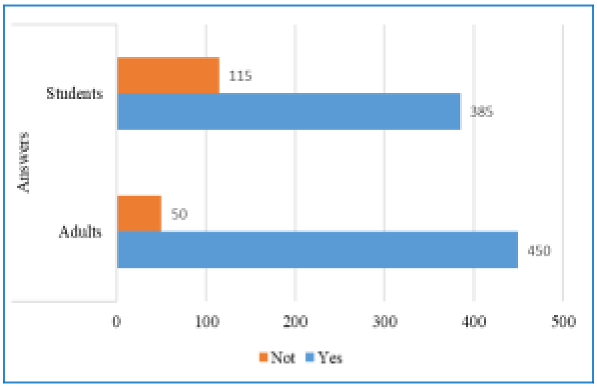

Fig. 7. Comparative study c regarding the interest of the respondents to consume chickpea - based bakery products

Source: from the questionnaires applied.

As we can see in Figure 7, the data show that most respondents are willing to consume chickpea-based bakery products. This can lead to the diversification of chickpea products on the market, given the willingness to consume them for healthier benefits.

Table 7. The influence of the media in changing the food behavior among respondents

The influence of the media on food behavior	Answers	
	Adults	Students
Yes	260	330
Not	240	170
TOTAL	500	500

Source: from the questionnaires applied.

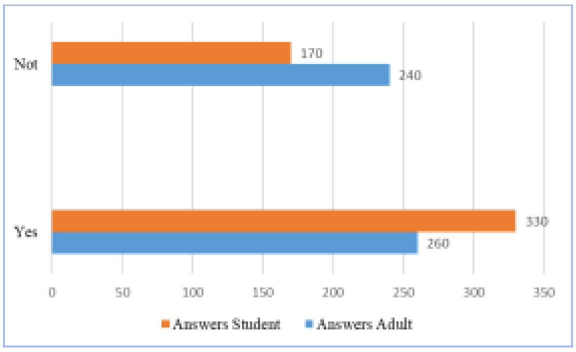

Fig. 8. Comparative study on the influence of mass media among respondents

Source: from the questionnaires applied.

For the question on how the media influences the behaviour of the consumer of bakery products, the respondents answered according to the data shown in the Table 7 and Figure 8.

The question in the questionnaire making reference towards the monthly income of the parents, the answers of the pupils were as follows:

• 48 pupils declared that the income of parents is somewhere up to 3,000 Ron.

• 122 pupils declared that the monthly income of their parents is between 3,001-5,000 Ron,

• 231 pupils declared that the monthly income of their parents is between 5,001-6,000 Ron;

• 99 pupils declared the monthly income of their parents is over 6,000 Ron.

According to INSSE data, the revenues from gross salaries and other salary rights were in 2023 as follows: 4,794.2 Ron on average per household and 1918.7 Ron on average per person, 72.2% of the income decrees from the previous year by 0.2 % [10]. From the researched data, it can be seen that most of the pupils come from families that have an income that is lower than the one established by the INSSE statistics.

At the question on the percentage of money in the income /family, which is allocated for the purchase of bakery products, respondents answered as follows:

• 340 People stated that the percentage of the amount allocated to food is 28% for the purchase of bakery products;

• 160 People stated that the percentage of the amount allocated to food is 22% for the purchase of bakery products.

The last part of the questionnaire includes factual data.

The study was conducted on a sample of 500 adults, aged between 19 and 80. According to Table 8 and 9, the second sample of 500 students are aged between14 to 18.

Table 8. Factual data on the age of the adult

Age	Answers	
	Adults	Percentage %
19-30 years	100	20
31-50 years	340	68
51-80 years	60	12
Total	500	100

Source: from the questionnaires applied.

Table 9. Factual data on the age of students

Age	Answers	
	Students	Percentage %
14-16 years	48	9.6
16-17 years	240	48
17-18 years	212	42.4
Total	500	100

Source: from the questionnaires applied.

CONCLUSIONS

Following the study, we can conclude that the majority of respondents are bread consumers: 98.40% students and 90.40% adults, a small percentage of respondents do not consume bread due to various health problems.

The preferences of the respondents in terms of bakery products differ from one age group to another.

Bakery products such as salted croissants, bagels, bars, seeded croissants have a higher share among students than adults.

According to the survey and the questionnaires carried out, we can affirm the fact that the influences among students towards the consumption of healthy food is largely determined by the school programs and the optional subjects that the school proposes. Which contain relevant and valuable information for the training and education of the consumer of valuable products from a nutritional point of view.

Promotional adverts through media channels, influence a fairly large number of respondents among both adults and pupils, due to the impact of the media on consumers.

Preferences for traditional products are higher among adults than fast food products, and among students preferences for fast food products are higher than for organic or traditional ones.

The two categories of respondents prefer to consume bakery products in the family in a fairly large proportion. The preference for bakery products is explained by the fact that they are cheaper, and can be obtained at home.

The conclusion the research made on family income allocated to the purchase of bakery products is 25% per family's total income.

From the data obtained within the research done beforehand, it can be seen that most respondents come from families with an income that falls within the INSSE statistics.

The study shows that the consumption of chickpea-based products is higher among adults than among students. This is due to the greater concern among adults for healthy eating.

As a result of the study, it was found that consumers are increasingly oriented towards consuming products that offer them benefits from a nutritional point of view, and the consumption of chickpea-based bakery products represents an alternative for a healthy diet.

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FORMATION OF AN INSTITUTE OF INDUSTRY INNOVATION SYSTEMS BASED ON THE SYMBIOSIS OF SCIENCE, STATE AND AGRIBUSINESS

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Abstract

Increasing agricultural production volumes to ensure food security of the country is inextricably linked with increasing the efficiency of integration between the state, science and agribusiness. The aim of the work is to improve the theoretical provisions for the formation of the Institute of Industry Innovation Systems and the tools for assessing the effectiveness of the Federal Scientific and Technical Program for the Development of Agriculture for 2017-2030. Methodological aspects of building the Institute of Industry Innovation Systems based on the transfer of positive foreign experience have been developed. Directions for adapting the AIS, ACIS, NARS systems to regional and industry conditions of the agricultural sector of the Russian economy have been proposed. The dynamics of production indicators for individual types of agricultural activity within the framework of the state program has been studied. Based on the results of the analysis and assessment of the effectiveness of the implementation of the FSTP subprograms, areas for growth in the production of sugar beets, potatoes, beef cattle and forage production have been identified.In order to maintain positive trends and increase agricultural production volumes, a systemic and functional approach is proposed to improve the efficiency of interaction between the state, science, and agribusiness based on the harmonization of their functions and interests. The practical significance of new models and mechanisms for the formation of the Institute of Industry Innovation Systems consists in increasing the growth of agricultural production through a balanced interaction between science, the state, and agribusiness for the neo-industrial development of the agricultural sector of the Russian economy.

Key words*: science, government, agribusiness, Institute of Innovation Systems, efficiency, industry specifics*

INTRODUCTION

Positive trends in the growth of agricultural production are based on effectively functioning state support programs in the agricultural sector of the economy. Such programs include the Federal Scientific and Technical Program for the Development of Agriculture (FSTP) and the national project "Science and Universities". Strengthening the integration of the state, science and business in the process of mastering advanced achievements and technologies in agricultural production is associated with the creation of organizational and regulatory conditions for the formation of the Institute of Innovation Systems both at the regional and industry levels. By 2030, the level of technological independence of Russia in the agri-food sector should be 66.7%, which is almost 21 percentage points higher than the level of 2023.

FSTP subprograms for individual types of activities are fully integrated into the innovation cycle, including the use of advanced solutions and technologies in agricultural production. Research support and financial support of FSTP are associated with the national project “Technological Support for Food Security” and the national project “Science and Universities” [21].

The following are recognized as the most important areas of research in agricultural production: agricultural machinery and equipment, selection and genetics, biotechnology, as well as the production of veterinary drugs and vaccines. The funding volume for these purposes is 260 billion rubles [25].

The main priorities of "Science and Universities" include the creation of an innovative environment, the development of a system for training and educating personnel for the agricultural economy. As part of the implementation of the national project, youth laboratories and student campuses have been created, and the material and technical base of the country's leading universities is being intensively updated. One of the tasks is the development and subsequent implementation of programs for the interaction of science, education and business [5]. The experience of leading regional agricultural enterprises is widely used in the scientific and educational environment [16]. Generalization of theoretical and methodological aspects of the growth of agricultural production is expressed in the development and adaptation of the triple helix theory, the quadruple helix theory of innovation, systems theory, and the theory of open innovation [6].

The issues of functioning of agro-innovation systems have been widely reflected in the research topics of foreign and Russian scientists. Of undoubted interest are studies of the institutional structure of agro-eco-innovation systems, identifying effective relationships between its participants. In agriculture of the EU countries, social partnerships that unite numerous participants play a significant role in the innovation process [18, 19]. Thus, Leeuwis, C. Represents an innovation system as «a network of organizations, enterprises and individuals that produces new products; develops and implements new processes and new forms of organization in the economy». The AIS agricultural innovation system is aimed at creating competitive agriculture and maintaining the achieved positions in a changing economic and social environment. The main feature of AIS compared to AKIS, which unites classical knowledge and innovation systems (universities and research institutes), is a wider range of participants, including both state and private organizations [15].

In addition to AKIS and AIS, there is the National Agricultural Research System (NARS), the main objective of which is the creation and transfer of innovative developments and technologies to agricultural production. According to the World Bank, this system includes institutions for organizing, coordinating and conducting research on the introduction of advanced achievements into agricultural production [30].

The AKIS (Agricultural Knowledge and Innovation System) model has become widely used; it is designed to generate information flows and improve the process of knowledge transfer while developing the relevant competencies of farmers [1].

The AKIS concept is widely used in the activities of the European Innovation Partnership on Agricultural Productivity and Sustainability (EIP-AGRI). Its practical application allows to successfully solve the issues of acceleration of innovation processes and development of rural regions. Fieldsend, A.F. focuses on the synergistic effect between various state programs both at the national and supranational levels [7].

In his opinion, EIP-AGRI coordinates cooperation between participants of social partnership, implementing an effective innovative model.

In the process of developing and implementing advanced achievements, interaction occurs between farmers, intermediaries and scientific researchers [10]. According to Ingram, J., in the process of interaction between science, government and agribusiness, it is necessary to create innovative networks [12].

In developing this theme, it is worth noting the work of Guerrero-Ocampo. The concept of agro-innovation systems defines the network as an innovative space in which subjects of innovative activity are in close interaction [24]. Research institutes as innovators and universities as knowledge generators [8]. Social networks play a significant role in the promotion of knowledge, expanding opportunities for participation in the innovation process.

The authors concluded that financial institutions are the main link in the successful implementation of innovative projects in rural areas, generating an appropriate level of state support. EU countries, which are most provided with financial resources, have the ability to implement rural development priorities, both at the national and supranational levels [9].

Amerani, E., Michailidis, A, investigated the features of the AKIS system functioning in Greek agriculture based on the SWOT analysis of the environment using an expert survey. According to the survey results, the majority of respondents from various fields noted the development of new knowledge as the advantages of the system, as well as the organization of the training process for farmers to form relevant competencies, access to communication information technologies. As constraints, 65% of respondents identified low incomes and insufficient knowledge among elderly farmers. The transition to organic and precision farming has great potential for the successful operation of AKIS. At the same time, over 80% of survey participants emphasized the imperfection of the use of the regulatory framework [2].

Kassem, H. S., Ismail, H., Ghoneim, Y. investigated the institutional linkages and communication between agricultural knowledge and information systems (AKIS) in selected agricultural regions of Egypt to assess the process of knowledge dissemination, implementation of agro-innovations, and availability of financial resources. Respondents identified higher education and research as the most important sources of knowledge dissemination in agricultural cooperatives. In turn, agricultural cooperatives also play an important role in knowledge transfer by providing information to other AKIS participants [13].

The questionnaire survey revealed low levels of interaction between NARS participants, a shortage of technology parks and a lack of technology transfer infrastructure. The need to use best practices and develop effective strategies in these areas was noted. It is recommended to strengthen the research potential in the field of agricultural sciences, increase publication activity, improvement of educational and retraining programs, training programs and projects (including virtual ones). This will improve the process of interaction between participants in the innovative agricultural system. It is recommended to create new institutions of intermediary organizations and a center for agricultural innovation to improve the functioning of the system [4, 14].

The formation of the Institute of Industry Innovation Systems in Russia is associated with increasing the efficiency of interaction between the state, science, and agribusiness. The aim of the work is to develop theoretical and methodological provisions, assessment tools, and mechanisms for the formation of the Institute of Industry Innovation Systems. The study pays much attention to the works of Russian and foreign scientists dealing with the problems of innovative agricultural systems.

MATERIALS AND METHODS

The research is based on the use of various sources of information, statistical information, regulatory documents, and expert assessments.

New data on actual and projected indicators of individual subprograms of the Federal Scientific and Technical Progress and agriculture in general, and indicators of technological development were used.

An analysis of scientific developments in the field of selection and seed production was conducted, the dynamics of production indicators were studied, and directions for increasing the efficiency of interaction between the state, science and agribusiness in the process of forming the Institute of Innovative Industry Systems were proposed.

The study also used generally accepted methods used by scientists and experts dealing with innovative problems. In methodological terms, such methods as monographic analysis, synthesis, critical assessment, and compilation of scientific approaches by other authors, logical construction of ideas and results, comparison, analogy, and visualization of statistical data were used. It is proposed to use the experience of EU countries in promoting agricultural knowledge using the example of the AIS, ACIS, NARS systems and adapt them to the agricultural sector of the Russian economy.

RESULTS AND DISCUSSIONS

Analysis and assessment of the interim results of the implementation of the Federal Scientific and Technical Program emphasizes the positive trends in the growth of agricultural production. For example, seed imports in 2024 decreased by 3 times compared to last year, of which potato seeds by 93%, barley and corn - by 80%, oilseeds - by more than 60 percent. Import substitution for sugar beet increased in 2024 to 8% compared to 3% in 2023 [11, 26]. Particular successes are characteristic of the production of domestic veterinary drugs, the production of which increased 8 times over the year, amounting to 70% of the domestic market [20].

The implementation of the results of breeding developments is characterized by significant territorial differences. In 2024, the highest rates of use of domestic seeds were observed in the Novosibirsk (68%) and Omsk (89%) regions. In the Krasnodar Territory, 70% of domestic soybean seeds were used, and in the Novosibirsk Region - 95% [17].

The results of the implementation of the national project “Science and Universities” have shown significant success in agro-economic research and development based on universities. During the period under review, 15 world-class scientific and educational centers and over 150 laboratories that meet international standards were created. 10 scientific centers were engaged in research on technological development priorities, 3 centers - in genomic research.

The West Siberian scientific and educational center of world class has created an agrobiotechnical complex, including research, educational, technical and production modules. Biological protection of plants is carried out based on the use of modern hydroponics technologies and artificial intelligence. In order to preserve the gene pool of certain species of rare wild berries, genetic and selection work is carried out for such berry plants as blueberries and cloudberries.

A new generation of mineral fertilizers with biologically active additives have been developed, the use of which increases the yield of wheat and corn by 15%. A new method for protecting oil flax crops from weeds has been developed. A promising area is the production of environmentally friendly biofertilizers [23].

Table 1. Forecast values of the FSTP indicators for individual types of agricultural products

Indicators	2025	2030	2030 to 2025 %
Domestic selection in plant growing			
Use of sunflower seeds for sowing, thousand tons	15.3	123	803.9
Use of sugar beet seeds for sowing, thousand tons	0.1	1.1	1,100
Domestic selection in animal husbandry			
Number of day-old chickens of meat crosses of chickens million heads	29.5	308.6	1,050
Number of breeding calves of dairy cattle, thousand heads	94	99	105.3
Veterinaryservices			
Number of domestic veterinary drugs, thousand packages	200.2	234.3	117.0
Number of domestic vaccines, billion dollars	19.0	21.0	110.5
Foragebase			
Volume of production capacity for the production of enzymes and feed additives, thousand tons	148	363	245.3

Source: Own calculations based on data [25].

Currently, 13 subprograms are being implemented within the framework of the Federal Scientific and Technical Program. In 2024, 17 regions implemented the subprogram on potatoes, 4 on sugar beets, 4 on oilseeds, 3 on poultry farming.

The table presents indicators of technological leadership for individual types of agricultural products obtained.

The given indicators reflect the planned formation of breeding resources of dairy cattle breeding and meat poultry farming; active use of selection achievements in the process of cultivation of sugar beet and sunflower; improvement of veterinary services and strengthening of the forage base. In 2025-2030, the volumes of sowing of domestic sunflower and sugar beet seeds should increase, respectively, by 8 and 11 times.

The synergistic effect from the introduction of innovative scientific developments in production is confirmed by the use of new agricultural technologies in accordance with the needs of agricultural producers. The number of such technologies should be 25 units in 2030, i.e. will increase 4 times compared to 2025.

A significant increase in efficiency in agriculture is expected: labor productivity will increase in 2030 by almost 16%, and investments in fixed assets - by 20% [25].

The positive results of the FSTP in 2020-2023 can be confirmed by the growth rates of production and yield of individual types of products.

The highest results were obtained during the implementation of the FSTP subprogram on potatoes. In 2023, the gross potato harvest in farms of all categories increased in Russia as a whole compared to 2022 by 6.6%, and the yield - by 10 percent. In the regions where the FSTP subprogram is in effect, these indicators were significantly higher (Fig. 1).

Fig. 2 shows the growth rates of oilseed crop yields in the leading Russian regions.

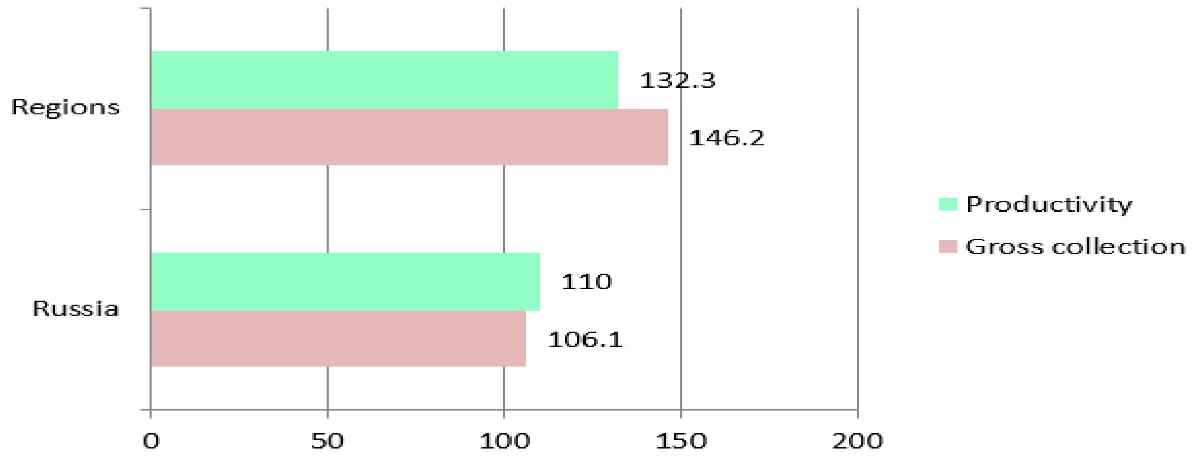

Fig.1. Growth rates of potato production and yield in 2023 compared to 2022, %
Source: Own calculations based on data [3].

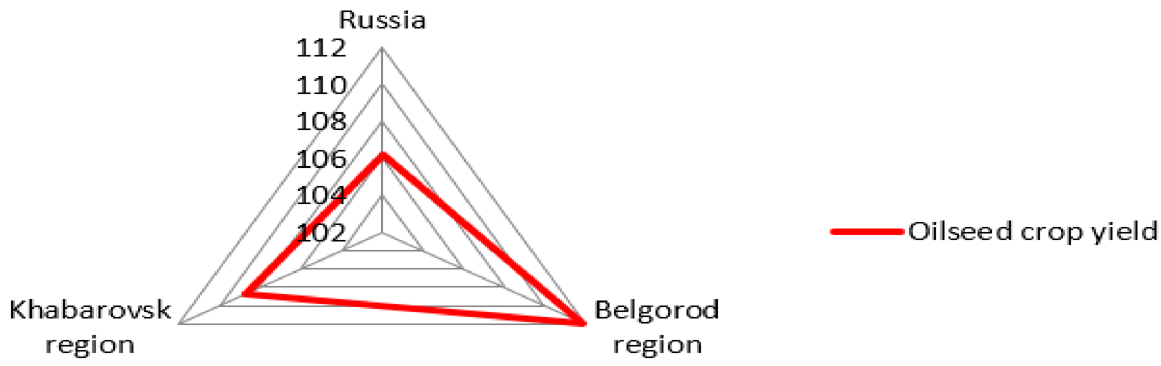

Fig. 2. Growth rates of oilseed crop yields in 2023 in Russia and its leading regions,%
Source: Own calculations based on data [3].

Preliminary results of the implementation of the FSTP subprograms demonstrate the need to strengthen state support, which is confirmed by studies by Russian scientists. The production of various types of products is associated with different adaptation to changing economic and financial conditions. For example, high adaptation is characterized by such types of activity as in crop production - growing sugar beets, growing grain and leguminous crops, oilseeds, growing vegetables, melons; in animal husbandry - pig breeding, poultry farming, breeding dairy and beef cattle. The group with average adaptation includes growing shrubs and nuts, growing grapes, breeding sheep and goats, cultivating potatoes. Types of activity with weak adaptation - breeding pedigree beef cattle. Currently, two more FSTP subprograms are being developed, covering agricultural machinery and the production of drugs.

It is planned to organize serial production of a fundamentally new generation of agricultural machinery and equipment with the attraction of additional investments in the amount of more than 6 billion rubles from the budget. Investments in the amount of more than 13 billion rubles are planned for the implementation of the subprogram for the development of immunobiological technologies and the production of veterinary drugs [29].

The implementation of both subprograms will be carried out on the principles of selecting comprehensive scientific and technical projects.

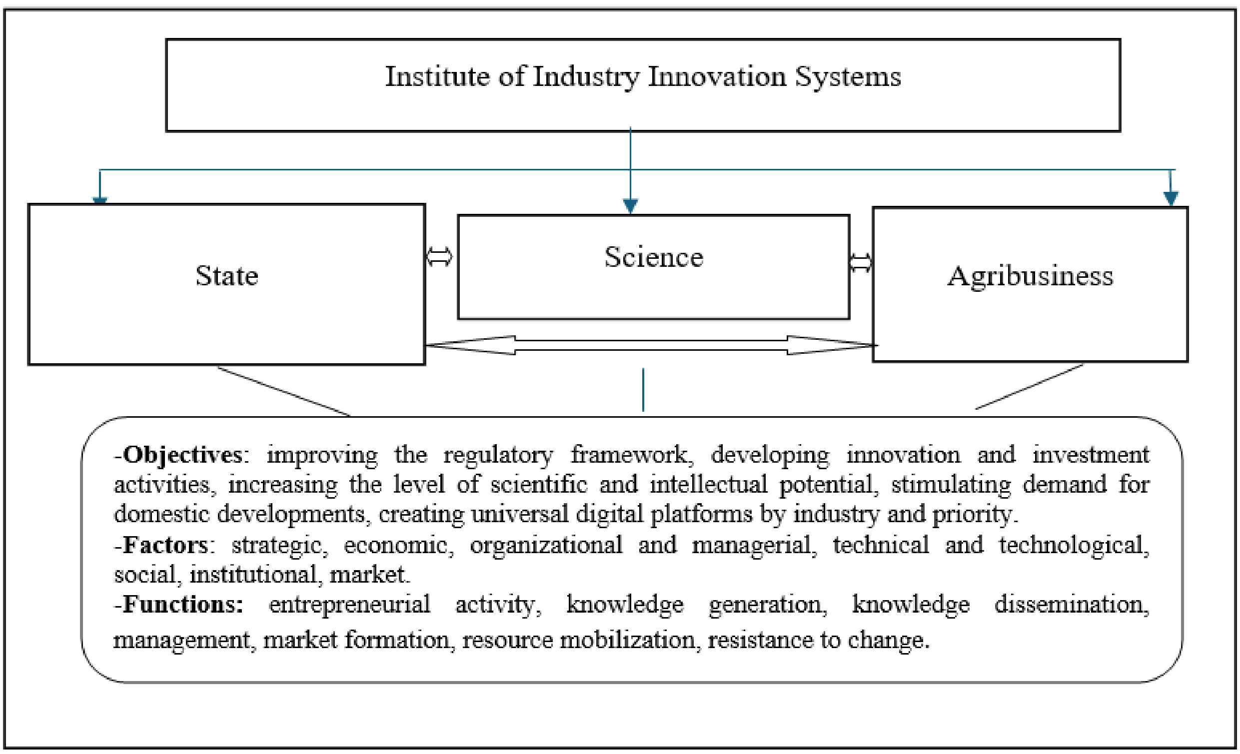

Fig.3. Scheme of formation of the Institute of industrial innovation systems
Source: Own design.

In order to maintain positive trends and increase the volume of agricultural production, a systemic and functional approach is proposed to improve the efficiency of interaction between the state, science, and agribusiness based on the harmonization of their functions and interests (Fig. 3). The paper proposes a systemic-functional approach to the construction of the Institute of Industry Innovation Systems [27].The article highlights seven functions of the proposed structural unit: entrepreneurial activity, knowledge generation, knowledge dissemination, management, market formation, resource mobilization and resistance to change for the neo-industrialization of the agricultural sector of the Russian economy [22, 28].

CONCLUSIONS

The article develops methodological aspects of building the Institute of Industry Innovation Systems based on the transfer of positive foreign experience. The directions of adaptation of the AIS, ACIS, NARS systems to regional and industry conditions of the agricultural sector of the Russian economy are proposed. The dynamics of production indicators for individual types of agricultural activity within the framework of the state program is studied.

Based on the results of the analysis and assessment of the effectiveness of the FSTP subprograms, areas of growth in the production of sugar beets, potatoes, beef cattle and forage production are identified. In order to maintain positive trends and increase the volume of agricultural production, a systemic and functional approach is proposed to improve the efficiency of interaction between the state, science and agribusiness based on the harmonization of their functions and interests.

The practical significance of new models and mechanisms for the formation of the Institute of Industry Innovation Systems lies in increasing the growth rate of agricultural production through a balanced interaction between science, the state and agribusiness for the neo-industrial development of the agricultural sector of the Russian economy.

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THE IMPACT OF THE USE OF BIOFUELS ON CO_2 EMISSIONS AT THE LEVEL OF EUROPEAN COUNTRIES FROM THE PERSPECTIVE OF ABSOLUTE DECOUPLING

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Abstract

Decoupling economic growth from CO_2 emissions completely is still a key goal of sustainability programs. According to the current research, nations with faster energy transitions and advanced technologies typically see a sharper decoupling, meaning that real GDP growth is attained without a rise in greenhouse gas emissions. This indicates that the economy is moving in the right direction. This study emphasized the various viewpoints on the dynamics of CO_2 emissions and the interplay between political, economic, and energy issues in European nations between 2021 and 2023. Both external and internal variables—such as the pandemic, energy crises, and geopolitical conflicts—have had a significant impact on CO_2 emissions. Internal elements include national policies and economic dynamics. Emissions variations have been significantly impacted by these world events, underscoring the weaknesses and adaptability of country economies. During pandemic limitations, emissions temporarily decreased in tourism-oriented nations like Malta, Italy, and Spain; however, as economic activity resumed, emissions increased. In contrast, economies focused on heavy industry, such as Poland and Germany, had a different response, driven by reliance on traditional energy sectors and the pace of the energy transition. An essential indicator for evaluating economic sustainability is the ratio between CO_2 emissions and real GDP.

In this context, the purpose of the work was to analyze and evaluate the evolution of CO_2 emissions in relation to the economic growth recorded by European countries, in the period 2021 - 2023, in the conditions of the need for energy transition and the existence of crises such as energy, the Covid-19 pandemic or geopolitical conflicts. Also, determining the degree of decoupling between CO_2 emissions and GDP growth had the objective of highlighting the differences between advanced economies and those in transition. The data that were the basis of the analysis were given by Eurostat, but also by a rich specialized literature represented by articles and scientific research. To carry out the research, we used a combination of statistical and economic methods (descriptive indicators, growth or decline rates, statistical correlations, etc.), but also graphical methods for data visualization. The research confirms that developed countries are performing better due to advanced technologies and faster transition to renewable energy sources. However, countries in transition, which are struggling due to older infrastructure and limited resources, need additional support to achieve their climate goals. Although biofuels are an important component in the transition to cleaner energy sources, their effect on reducing total emissions remains modest. Their impact is often masked by factors such as electrification policies, the adoption of renewables and the overall structure of the energy mix. To better understand the contribution of biofuels, a segmentation by economic sectors such as transport and industry is needed, which future research aims to address. In conclusion, monitoring fluctuations in CO_2 emissions and correlating them with economic and energy factors remains essential to assess progress towards climate neutrality. Country-specific policies and support for economies in transition will play a critical role in achieving global climate goals.

Key words: *biofuels, absolute decoupling, sustainable development, CO_2 emissions, GDP*

INTRODUCTION

The circular economy represents a new economic model that promotes the efficient use of resources by reducing waste, extending the life of products and recycling materials at the end of their life cycle [20, 21]. This model contrasts strongly with the traditional linear economy, which follows the principle of "extract, produce, consume and discard" [4, 16]. Globally, the transition to a circular economy is closely linked to efforts to combat climate change, reduce the consumption of natural resources and reduce environmental pollution [5, 7, 24].

The circular economy is crucial to maximizing the usage of resources needed for renewable technologies in the context of the shift to renewable energy sources [22]. By reusing materials from used equipment and prolonging their life, the circular economy can lessen reliance on primary resources [13]. To meet the targets of the Paris Agreement to keep global warming to 1.5°C over pre-industrial levels, a substantial shift in the world's energy mix is required, with a focus on renewable energy sources like solar, wind, hydropower, and bioenergy.

International and national legislation, technical advancements, and social pressures are some of the variables that impact the circular economy's global context [14, 15, 31]. With the adoption of the European Green Pact and the Action Plan for the Circular Economy, which seeks to attain carbon neutrality by 2050, the European Union is a pioneer in advancing the circular economy [1, 2, 25]. Strategies to promote the shift to a circular economy are also being implemented in other nations and regions, including China, Japan, and Canada.

Two of the best methods to lower greenhouse gas (GHG) emissions and slow down climate change are recycling waste and producing biofuel. Global warming and climate change are caused by GHG emissions, primarily carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N2O). Recycling helps cut down on the need to extract basic natural resources, which in turn lowers emissions from raw material extraction, transportation, and processing [23, 26, 28].

Recycling materials, such as metals, glass, plastic and paper, contributes to reducing emissions by saving the energy needed to produce new materials [3, 32]. In addition, recycling reduces the amount of waste that ends up in landfills, where the decomposition of organic waste generates methane, a greenhouse gas 25 times stronger than CO_2.

Biofuels (bioethanol, biodiesel, biogas) are renewable energy sources that can replace traditional fossil fuels such as oil, coal and natural gas [6]. Biofuel production uses biological raw materials such as agricultural residues, organic waste, vegetable oils and energy crops. The use of biofuels reduces net GHG emissions, because the CO2 emissions resulting from their combustion are partially offset by the absorption of CO2 by the plants used as raw materials [19, 27]. In addition to reducing emissions, biofuel production can also contribute to the efficient management of organic waste, turning a waste stream into a valuable resource. This can reduce dependence on fossil fuel imports while creating jobs and boosting the local economy [30].

The idea of "absolute decoupling"—which characterizes the situation where an economy raises its GDP without correspondingly growing its use of natural resources and its environmental impact—is closely associated with the circular economy notion.

[12, 18]. Absolute decoupling is an essential goal for long-term sustainability, as natural resources are finite and environmental pressures continue to increase due to overconsumption.

In a traditional economy, economic growth is closely linked to increased resource consumption. However, to achieve full decoupling, it is necessary to adopt policies and technologies that improve resource efficiency, promote the circular economy and stimulate innovation in renewable energies [11, 29].

Absolute decoupling can be achieved through several mechanisms, including: resource efficiency, renewable energy and circular economy. Increasing the efficiency of resource use through advanced technologies and optimized processes. The transition to renewable energy sources reduces the dependence on fossil fuels and the impact on the environment [17, 23]. Thus, recycling, reusing and extending the life of products reduce the need to extract natural resources.

However, absolute decoupling remains an ambitious and difficult goal to achieve on a global scale. Progress is often limited by factors such as population growth, increased demand for products and services, and technological barriers, and achieving full decoupling requires a concerted global effort involving governments, the private sector, civil society and citizens.

In this context, the purpose of the paper is to analyze the relationship between economic growth and CO_2 emissions, highlighting the impact of energy transition, national or European policies, as well as external factors on economic sustainability and the efficient use of resources at the level of European countries.

MATERIALS AND METHODS

This research aims to analyze CO_2 emissions and other relevant economic and energy factors for the period 2021-2023, using a combination of statistical and economic methods. The methodology describes the steps and tools used to assess the growth/decrease rates of CO_2 emissions, the analysis of the relationships between GDP and greenhouse gas emissions, and the correlations between biofuel consumption and emission intensity. Data on CO_2 emissions were collected from Eurostat databases, for the period 2021-2023. The annual evolution of emissions was determined by calculating the increase/decrease rate, using the standard percentage formula. This provides a clear insight into variations over time, highlighting positive or negative trends. The results are contextualized in relation to economic and social events, such as the global energy crisis or emission reduction measures adopted at European level. For a detailed understanding of greenhouse gas emissions, descriptive statistical indicators such as mean, median, standard deviation, minimum and maximum value, and coefficient of variation were calculated to provide a complete picture of emissions distribution and volatility.

To analyze the differences between GDP/capita compared to the EU average, the data were adjusted to the purchasing power parity (PPP) and were compared to the EU average. The differences were calculated annually, highlighting the economic gaps between the analyzed country and European standards. Bar graphs have been used to visually represent the variations between GDP/capita and the EU average, which allows a quick interpretation of economic progress or stagnation in the analyzed period.

Economic efficiency was assessed by the ratio of real GDP to CO_2 emissions, using inflation-adjusted GDP. A higher ratio reflects a lower economic intensity of emissions, which indicates a more efficient use of resources. The analysis also included the identification of economic sectors that contribute significantly to economic efficiency, comparing this evolution with other European Union member countries. Data on biofuel consumption (expressed in tonnes of oil equivalent) were analyzed to determine increasing or decreasing trends over the period. The segmentation of consumption by sector (transport, industry) allowed the identification of areas where biofuels have the greatest impact. Reducing reliance on fossil fuels and assessing the switch to renewable energy sources require this analysis. The Pearson correlation coefficient was used to examine the relationships among CO_2 emissions, emission intensity, and biofuel consumption. Because of this, it was feasible to gauge how strongly the variables were related to one another, classifying the correlations as weak, moderate, or strong based on the coefficient's value. The analysis was completed by testing the statistical significance of the correlations, to verify the validity of the results obtained.

Research tools and limitations

The research relied on the use of tools such as Microsoft Excel, Python and R, which facilitated statistical analysis and visual representation of data. The limitations of the methodology include the quality and availability of data for the analyzed period, as well as the impact of exogenous factors (public policies, economic crises), which can influence the interpretation of the results.

RESULTS AND DISCUSSIONS

In the framework of international climate commitments like the Paris Agreement and the European Green Deal, analyzing data sets that enable both the identification of trends in CO_2 emissions and the comparison of nations' energy transition performances is necessary for the development of sustainable policies as well as the assessment of the success of the steps taken to achieve climate neutrality by 2050 at the level of the European Union. Also, monitoring the effects of public policy measures on emissions, such as the implementation of renewable energies, increasing energy efficiency or reducing fossil fuel consumption, are useful tools in this endeavor. The analysis of annual emissions of carbon dioxide (CO_2) for the member states of the European Union (EU-27), as well as for other relevant countries, in the period 2014-2023 allowed us to examine the annual rates of increase or decrease in emissions leading to the identification periods of progress or regression in reducing pollution, comparing average emissions to assess the positioning of each country in relation to the EU average, but also detecting anomalies and determining factors on them. The data set included both countries with mature economies, such as Germany, France and Italy, as well as emerging economies from the Central and Eastern European region, such as Poland, Romania or Bulgaria. Non-EU countries, such as Norway, Switzerland, Serbia and Turkey, were also included, in order to obtain a broad perspective on the dynamics of emissions in Europe. This information is an integral part of a data set that tracks the accounts of atmospheric emissions, being classified according to economic activities NACE Rev. 2, being expressed in tons of carbon dioxide (CO_2) (Table 1).

Table 1. Growth/decrease rates of CO_2 emissions in Europe

Country	Growth 2019/2020	Growth 2020/2021	Growth 2021/2022	Growth 2022/2023
European Union 27 countries (from 2020)	-12.20	7.88	-0.31	-9.33
Germany	-12.56	9.04	0.85	-12.23
Poland	-5.76	11.53	-3.78	-8.72
Italy	-11.43	9.45	2.73	-8.26
France	-12.69	9.26	-1.68	-7.83
Spain	-18.44	8.37	4.92	-8.03
Netherlands	-12.64	1.54	-4.68	-7.43
Czechia	-11.45	7.05	0.58	-11.89
Belgium	-8.45	1.59	-4.06	-7.15
Denmark	-14.23	14.01	-8.73	-2.84
Romania	-5.83	3.39	-6.65	-6.24
Norway	-10.09	-4.19	1.97	-7.29
Greece	-15.46	0.72	-6.46	-14.19
Austria	-12.59	5.78	2.38	-3.13
Ireland	-31.04	8.30	24.46	-0.70
Hungary	-7.98	1.71	-1.08	-8.83
Portugal	-17.04	-1.63	5.36	-11.35
Bulgaria	-14.35	16.52	11.74	-30.65
Sweden	-13.53	7.49	-2.28	-3.58
Finland	-16.80	0.30	1.57	-12.93
Slovakia	-10.00	15.59	-12.63	-0.71
Lithuania	11.61	1.50	-7.16	-2.73
Croatia	-5.49	1.75	0.64	-6.88
Slovenia	-4.66	-1.64	-10.28	-5.58
Estonia	-28.93	13.65	15.10	-24.30
Latvia	-20.52	6.16	-1.31	1.53
Luxembourg	-10.71	0.42	-6.96	-3.77
Cyprus	-2.56	-0.99	1.66	0.35
Iceland	-21.35	0.71	27.57	11.61
Malta	-11.48	25.22	22.79	1.06
Switzerland	-20.03	6.02	3.21	-100.00
Serbia	2.06	-3.61	0.59	-100.00
Türkiye	1.00	10.77	-3.69	-100.00

Source: own processing [8].

Most countries saw significant reductions in emissions in 2020, caused by the global restrictions imposed by the pandemic. Reduced mobility, closing down of industries and declining consumption of fossil energy were the main driving factors. Ireland (-31.04%) and Estonia (-28.93%) had the biggest declines, due to their economy's dependence on sectors directly affected by the pandemic, such as international transport and heavy industry. The year 2021 was characterized by an economic recovery, which led to increases in emissions in some countries. Malta (+25.22%) exemplifies this trend, as the reopening of the tourism sector and the resumption of economic activities have led to a more intensive use of energy. However, in most countries, increases were moderate, reflecting a slow transition to pre-pandemic recovery. In 2022, the increase in emissions in countries such as Iceland (+27.57%) was due to the expansion of industrial activities, such as the extraction and processing of natural resources. On the other hand, stricter climate policies have helped keep emissions under control in many other EU member states. The energy crisis generated by the war in Ukraine has led some countries to temporarily return to the use of fossil fuels, but accompanied by the transition to renewable sources. In 2023, Bulgaria (-30.65%), reported significant reductions in emissions, caused by the transition to cleaner energy sources, but also by the reduction of industrial activities. The total decreases reported for Switzerland, Serbia and Turkey (-100%) are due to the way of reporting, not real phenomena (Table 1).

Average emission values indicate a general downward trend in most of the analyzed countries, due to continuous efforts to reduce emissions through the implementation of climate policies and the transition to renewable energy sources. The differences between the average and the median emphasize an asymmetric distribution of emissions, depending on the categories of industries, countries with more developed industries having emissions well above the average. The large standard deviation for each year indicates significant variations between the analyzed countries, which, in addition to the major structural differences in the economies, are also due to the energy mix of each country. The large difference between the maximum and minimum values reflects the inequality in terms of responsibility for emissions between countries, which underlines the importance of differentiated support for countries with emerging economies, but also the need for more coherent and coordinated policies to achieve climate neutrality at the EU level (Table 2).

Table 2. Descriptive statistical analysis of greenhouse gas emissions (2019-2023) (tons)

Year	Mean	Median	Standard Deviation	Minimum	Maximum
2019	161366346.3	42352944.61	426537404.2	2244158.71	2439651928
2020	143079283.8	35444347.82	375130918.2	1986561.15	2141996586
2021	154258252.9	41128466.51	405376356	2487478.71	2310736492
2022	153519502.9	43562540.39	404037969.4	3054450.56	2303466818
2023	128195808.6	32283670.91	366021667.7	0	2088657365

Source: own processing [8].

Starting from the fact that the analysis of the relationship between CO_2 emissions and GDP offers an important perspective on economic sustainability and the impact of economic development on the environment, this second indicator was also analyzed. However, this relationship is not a linear one and may vary depending on the level of economic development, energy mix and technological efficiency. For emerging economies, GDP growth is associated with high emissions due to reliance on polluting industries and fossil fuels. In contrast, developed countries show lower emission intensity per unit of GDP, reflecting the transition to renewable energy sources, strict climate policies and advanced technologies.

Table 3. The difference between GDP/capita in European countries compared to the EU average (%)

Country	2019	2020	2021	2022	2023
Euro area - 19 countries	6	5	5	5	5
Euro area – 20 countries	5	4	4	4	4
European Union - 27 countries	0	0	0	0	0
Albania	-70	-70	-69	-66	-64
Austria	24	23	21	23	20
Belgium	17	18	17	19	18
Bosnia and Herzegovina	-68	-67	-67	-66	-64
Bulgaria	-45	-43	-40	-38	-36
Croatia	-33	-34	-30	-28	-24
Cyprus	-7	-9	-6	-2	-3
Czechia	-5	-4	-8	-11	-10
Denmark	25	32	34	35	25
Estonia	-16	-15	-15	-16	-20
Finland	7	12	9	7	5
France	5	4	1	-2	-1
Germany	22	23	20	18	16
Greece	-34	-38	-36	-33	-31
Hungary	-27	-25	-25	-23	-23
Iceland	28	20	22	32	35
Ireland	90	105	126	138	113
Italy	-4	-7	-4	-2	-2
Japan	-12	-11	-15	-17	-15
Latvia	-34	-31	-29	-31	-30
Lithuania	-17	-13	-12	-12	-13
Luxembourg	149	156	160	152	137
Malta	6	5	9	5	7
Montenegro	-50	-56	-54	-51	-49
Netherlands	28	31	32	34	33
North Macedonia	-58	-58	-57	-58	-59
Norway	46	41	71	114	71
Poland	-26	-21	-21	-22	-23
Portugal	-23	-25	-26	-23	-19
Romania	-31	-28	-28	-26	-22
Serbia	-58	-56	-55	-54	-51
Slovakia	-30	-26	-26	-29	-26
Slovenia	-13	-12	-12	-11	-8
Spain	-9	-17	-15	-12	-9
Sweden	17	21	21	15	14
Switzerland	52	53	56	59	54
Türkiye	-41	-40	-40	-32	-28
United Kingdom	3	1	-2	2	-1

Source: own processing [9, 10].

Starting from the fact that the analysis of the relationship between CO_2 emissions and GDP provides an important perspective on economic sustainability and the impact of economic development on the environment, this second indicator was also analyzed.

However, this relationship is not a linear one and may vary depending on the level of economic development, energy mix and technological efficiency. For emerging economies, GDP growth is associated with high emissions due to reliance on polluting industries and fossil fuels. In contrast, developed countries show lower emission intensity per unit of GDP, reflecting the transition to renewable energy sources, strict climate policies and advanced technologies (Table 3).

Countries such as Luxembourg (+149 → +137) and Ireland (+90 → +113), although with strong economies, competitive industries and advanced services, or Ireland had accelerated growth due to the attraction of foreign investment. Eastern European and

Balkan countries such as Romania (-31 → -22) and Bulgaria (-45 → -36) had a slow convergence towards the EU average, supported by moderate economic growth and European funds. France and Italy have values close to 0, due to stable economies, but no major progress. The slight decline in Luxembourg and Denmark remains within normal limits for advanced economies. Economic convergence is evident for Eastern Europe, but gaps persist in regions such as the Western Balkans (-70 Albania, -64 Bosnia), highlighting the need for structural reforms and investment (Table 3).

Table 4. The ratio between CO_2 emissions and real GDP

Country	2019	2020	2021	2022	2023
Euro area - 19 countries	1.06	1.05	1.05	1.05	1.05
Euro area – 20 countries	1.05	1.04	1.04	1.04	1.04
European Union - 27 countries	1	1	1	1	1
Albania	0.3	0.3	0.31	0.34	0.36
Austria	1.24	1.23	1.21	1.23	1.2
Belgium	1.17	1.18	1.17	1.19	1.18
Bosnia and Herzegovina	0.32	0.33	0.33	0.34	0.36
Bulgaria	0.55	0.57	0.6	0.62	0.64
Croatia	0.67	0.66	0.7	0.72	0.76
Cyprus	0.93	0.91	0.94	0.98	0.97
Czechia	0.95	0.96	0.92	0.89	0.9
Denmark	1.25	1.32	1.34	1.35	1.25
Estonia	0.84	0.85	0.85	0.84	0.8
Finland	1.07	1.12	1.09	1.07	1.05
France	1.05	1.04	1.01	0.98	0.99
Germany	1.22	1.23	1.2	1.18	1.16
Greece	0.66	0.62	0.64	0.67	0.69
Hungary	0.73	0.75	0.75	0.77	0.77
Iceland	1.28	1.2	1.22	1.32	1.35
Ireland	1.9	2.05	2.26	2.38	2.13
Italy	0.96	0.93	0.96	0.98	0.98
Japan	0.88	0.89	0.85	0.83	0.85
Latvia	0.66	0.69	0.71	0.69	0.7
Lithuania	0.83	0.87	0.88	0.88	0.87
Luxembourg	2.49	2.56	2.6	2.52	2.37
Malta	1.06	1.05	1.09	1.05	1.07
Montenegro	0.5	0.44	0.46	0.49	0.51
Netherlands	1.28	1.31	1.32	1.34	1.33
North Macedonia	0.42	0.42	0.43	0.42	0.41
Norway	1.46	1.41	1.71	2.14	1.71
Poland	0.74	0.79	0.79	0.78	0.77
Portugal	0.77	0.75	0.74	0.77	0.81
Romania	0.69	0.72	0.72	0.74	0.78
Serbia	0.42	0.44	0.45	0.46	0.49
Slovakia	0.7	0.74	0.74	0.71	0.74
Slovenia	0.87	0.88	0.88	0.89	0.92
Spain	0.91	0.83	0.85	0.88	0.91
Sweden	1.17	1.21	1.21	1.15	1.14
Switzerland	1.52	1.53	1.56	1.59	1.54
Türkiye	0.59	0.6	0.6	0.68	0.72
United Kingdom	1.03	1.01	0.98	1.02	0.99

Source: own processing [9, 10].

The ratio of CO_2 emissions to real GDP shows a general stability in the EU-27 (~1) over the period 2019-2023, reflecting a moderate decoupling between economic growth and CO_2 emissions due to climate policies. Countries with high ratios (Luxembourg, Ireland, Norway) have advanced economies with high energy consumption. Countries with low ratios (Romania, Bulgaria, Serbia) have lower energy efficiency. France and Germany reduced the ratio through green technologies, while Romania and Portugal registered increases, they did not succeed in an efficient energy transition. There is therefore a need to accelerate the transition to renewables, support countries in transition and integrate decarbonisation policies to improve economic sustainability (Table 4).

Table 5. Biofuel consumption in the period 2021-2023 (Mtep)

Country	2021	2022	2023
European Union - 27 countries (from 2020)	1.674	1.748	1.833
Belgium	2	2.2	1.7
Bulgaria	1.5	1.7	1.2
Czechia	1.2	1.2	1.5
Denmark	1.8	1.7	1.5
Germany	1.4	1.4	1.3
Estonia	1.8	1.3	2.4
Ireland	1.6	1.9	1
Greece	1	0.9	2.3
Spain	1.8	1.7	2.3
France	1.9	2.1	0
Croatia	1.3	0.3	1.5
Italy	1.3	1.3	1.4
Cyprus	1.5	1.4	0
Latvia	1.1	0.4	2.1
Lithuania	2.1	2.1	4.2
Luxembourg	3.7	3.9	1.8
Hungary	1.4	1.6	2
Malta	1.8	1.9	1.5
Netherlands	1.3	1.4	1.9
Austria	1.5	1.5	1.5
Poland	1.4	1.6	2
Portugal	2	1.9	2.1
Romania	1.9	2.3	2
Slovenia	2.1	1.6	1.6
Slovakia	1.3	1.5	2.3
Finland	2.5	2.2	4.6
Sweden	4.1	4.9	
Iceland	0.9	0.7	1.8
Norway	1.7	1.7	
Serbia	0	0	

Source: own processing [9, 10].

The consumption of biofuels in the European Union (average of 27 countries) increased gradually, from 1,674% in 2021 to 1,833% in 2023, indicating a general trend of adoption. Sweden and Finland are the countries that recorded high values, with Sweden reaching a peak of 4.9% in 2022 and Finland 4.6% in 2023. Luxembourg and Lithuania also have a high consumption of biofuels, although they have significant fluctuations during the analyzed period. The data shows a general increase in biofuel consumption in Europe, with discrepancies between northern and southern countries. Countries with high consumption can be good practice examples for promoting renewable sources (Table 5).

Table 6. Correlation coefficients between biofuel consumption, CO_2 emissions and emission intensity (2021-2023)

Year	CO2 vs Biofuel	CO2 Intensity vs Biofuel
2021	-0.042885704	-0.057648879
2022	-0.00089963	-0.011070211
2023	-0.058024703	-0.049987424

Source: own processing.

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The correlation coefficients for the analyzed years indicate an insignificant linear relationship between the consumption of biofuels and CO_2 emissions, which shows that biofuels, although they represent a sustainable alternative, did not have a measurable impact in reducing total emissions at the national level, apart from a partly due to their limited use in the total energy mix, and partly due to the general increase in energy demand, which canceled out the positive effects of biofuels. The correlation between biofuel consumption and emission intensity (CO_2/GDP) is also and emission intensity (CO_2/GDP) is also very low, indicating an indirect and unclear impact of biofuel use on emissions relative to economic performance, which is due to regional and economic discrepancies. Thus countries with high GDP have lower emission intensity due to the general transition to green technologies and economic efficiency, not necessarily due to the use of biofuels (Table 6).

Biofuel consumption increased slightly between 2021 and 2023 in most European countries, but this increase was not correlated with significant reductions in emissions or improvements in emissions intensity.

The correlation coefficients for the analyzed years indicate an insignificant linear relationship between the consumption of biofuels and CO_2 emissions, which shows that biofuels, although they represent a sustainable alternative, did not have a measurable impact in reducing total emissions at the national level, apart from a partly due to their limited use in the total energy mix, and partly due to the general increase in energy demand, which canceled out the positive effects of biofuels.

The correlation between biofuel consumption CO_2 emissions are deeply influenced by the interplay of internal (politics, economy) and external (pandemics, global crises) factors, and these fluctuations must be monitored to assess progress towards climate neutrality.

CONCLUSIONS

The pandemic, energy crisis and geopolitical conflicts have had a significant impact on emissions fluctuations. Countries with economies oriented towards tourism (Malta, Italy, Spain, etc.) or those oriented towards heavy industry (Poland, Germany, etc.) had different reactions depending on their economic dynamics and energy transition.

The CO_2 emissions/real GDP ratio remains a key indicator of economic sustainability. It is found that developed countries perform better due to advanced technologies, while countries in transition require additional support to achieve climate goals.

Although biofuels play an important role in the energy transition, their effect on total emissions is modest and masked by other factors. Electrification policies, the adoption of renewable sources and the overall energy mix are determinants of reducing emissions and improving emissions intensity. We consider that a segmentation by economic sectors (e.g. transport vs. industry) could establish much more correctly the real impact of biofuels, and that is why we propose such a future analysis.

We consider that although biofuels are a sustainable solution in the energy transition, their extensive use in the European energy mix is limited by several economic, technological, political, social and ecological barriers. Thus, biofuels involve high production costs, especially those of second and third generation, which use agricultural residues or algae. The lack of economies of scale limits their competitiveness with fossil fuels. Subsidies and support policies are often insufficient or geared towards other renewable technologies such as wind and solar energy. In addition, Europe depends on imports of raw materials such as vegetable oils, which increases price volatility and affects supply chains. Technologies associated with biofuels are still immature, especially for older generations. Production and refining require specialized infrastructure, which is underdeveloped in many regions. In addition, the energy density of biofuels is lower than that of fossil fuels, which makes them less attractive for sectors such as heavy transport. The compatibility of biofuels with existing infrastructure is also a challenge, requiring significant investment. Support policies for biofuels are often inconsistent across EU member states, and frequent changes in regulations discourage private investment. In addition, the promotion of biofuels may conflict with other priorities, such as the electrification of transport or the development of hydrogen. First-generation biofuels, criticized for their impact on deforestation and food prices, receive little political support. The ecosystem may be impacted by deforestation and biodiversity loss resulting from the cultivation of raw materials for biofuels. Agricultural resources are scarce, and conflicts arise from the competition between their use for food and energy. Integrated strategies are needed to overcome these obstacles. Investments in research and development can improve the sustainability and efficiency of biofuels from the second and third generations. Their growth would be aided by the EU's adoption of a unitary regulatory framework, and their incorporation into a varied energy mix would enable their application in industries like heavy transportation and aviation where alternatives are challenging to execute. Increasing societal acceptance, however, requires public education and the fight against unfavorable stereotypes.

In conclusion, tracking changes in CO_2 emissions and how they relate to energy and economic variables is still crucial for evaluating the advancement of climate neutrality. Biofuels can help with the energy shift in certain industries, like transportation, but their contribution to complete decoupling is minimal. However, the overall energy mix and related policies have a big impact on their efficiency. Therefore, it is necessary to evaluate their effects within the framework of a comprehensive plan that incorporates electrification and the use of renewable energy sources.

At the same time, lowering emission intensity (CO_2/GDP) is essential for sustainable development, and policies that support energy efficiency and technical innovation are strongly related to this goal. In addition to lowering their emissions, nations that include renewable energy sources and implement active decoupling strategies lay the groundwork for long-term, steady economic growth.

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ECONOMIC CHARACTERISTICS OF COW'S MILK PRODUCTION ON FAMILY HOLDINGS IN SHUMADIYA AND WESTERN SERBIA

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Abstract

The subject of research in this paper is the production of cow's milk on family holdings in Serbia, on the example of the region Shumadiya and Western Serbia. By identifying the different sizes of dairy cow holdings in practice and based on the analysis of the data collected by the field survey, the most important economic features of milk production were determined, which is the main goal of this research. By applying descriptive statistics methods, it was determined that the largest share in the samples is made up of cow holdings with a size of 9 to 14 head. In the ration structure of all sizes of holdings in both samples, coarse feed makes up from 36% to 45%, and concentrated feed from 55% to 64%, which depends on the sample and therefore on the feeding season of the cows. In the total amount of milk per head of a dairy cow, the first class of milk makes up from 31% to 36%, the second class from 28% to 30%, the third class from 18% to 19% and milk outside the class from 18% to 20% according to the samples, with the more favorable structure in the first sample. According to economic indicators, the most successful is the third group of holdings with a size of 15 to 20 dairy cows in the second sample. According to the ranked seven economic indicators, this group of holdings is in first place based on three indicators, and based on the remaining four, it is ranked second. In second and third place are the groups of the largest holdings in the second and first sample, respectively. The fourth place belongs to another group of cow holdings with a size of 9 to 14 heads, also in the second sample. The rationalization of milk production costs is recommended, which is based on proper planning of the quantity, quality, structure and price of animal feed. The structure of the meal should be improved, i.e. that it contains all substances by type, quantity and quality that the throat needs according to age, production characteristics and other characteristics, as well as that the meal is financially favorable so that the holding is economically profitable and enables the economic sustainability of the holding.

Key words**:** *family holdings, dairy farms, economic analysis, characteristics of milk production*

INTRODUCTION

Population growth and changes in dietary habits are driving demand for agricultural products, both in terms of increasing quantity and product diversification [2, 19]. Livestock is an integral component of agriculture and the food industry, serving as the backbone of food production systems around the world [4, 20]. Cattle production is of great importance for rural areas and the sustainable development. Agricultural producers in Shumadiya and Western Serbia traditionally produce milk on family farms [21]. Crop production accounts for 69.80%, and livestock production for 30.20% of the total value of agricultural production in the Republic. The net index of the physical volume of agricultural production in Serbia in the current year is 8.50% higher than in the previous year. In the total utilized agricultural area of the Republic of Serbia, fields and gardens account for 76.70%, orchards for 5.70%, vineyards for 0.50%, meadows for 9.40% and pastures for 7.00%. In the structure of sown areas of arable land and gardens, cereals take part with 67.80%, industrial plants with 19.10%, vegetable plants with 1.80% and fodder plants with 8.00% [9, 25]. The total number of cattle in the Republic of Serbia is 725,000 heads, of which 355,000 are dairy cows. Annual cow milk production in Serbia is around 1.4 billion liters. The number of conditional heads decreased (by 10.80%) compared to the previous year, as did cow milk production (by 5.70%), while meat production increased (by 0.70%). Compared to the previous year, the value of livestock production is 5.30% lower.

Within the structure of livestock production, the value is lower in cattle farming, by 6.90%, in pig farming, by 5.80%, and in sheep farming, by 3.60%, and higher in poultry farming, by 1.00% [25]. Due to the small number of quality breeding cattle, the insufficient level of quality of livestock products (milk, meat, etc.), as well as the lower production characteristics of cattle compared to countries with developed cattle breeding and EU member states, it is evident that livestock production in Serbia is less competitive compared to livestock production in those countries [23,16]. Of the represented breeds of cattle that are raised in Serbia, the largest share, about 80% of the total number of cattle, is the Simmental breed, the so-called "Serbian Simmental". A very significant impact on the change in the racial composition of cattle was achieved by the introduction of artificial insemination of cattle, the importation of breeding cattle, the application of selection, as well as the crossing of domestic autochthonous breeds with noble breeds of cattle [14].

Holdings with small farms (1-9 head of dairy cows) are relatively acceptable in terms of profitability, due to the involvement of family members [15]. However, such farms have a low yield rate, around 36%. Due to the insufficient productivity of animals and the small volume of final product realization, the efficiency of small farms is not satisfactory. Collaborations between different sectors, e.g. such as agriculture, technology and finance, drive innovation for sustainable solutions, addressing challenges related to food security and environmental sustainability [6, 28, 29]. Farmers have a significant role in the national economy, and increasing their activities can stimulate rural development and the local economy [11, 26, 27]. The construction of production capacities on the farm aims to reduce labor costs per head or unit of product, the amount of investment required per head, and therefore significantly lower capital costs per unit of product obtained [2, 22, 23]. Animal nutrition has a major impact on the profitability of family farms [1, 3]. In the total costs of keeping dairy cows, the largest share is the cost of feed and ranges from 45% to 60% [19, 15, 24]. Similar results are also according to the research of other authors who state that in the structure of the costs of keeping dairy cows, the share of food costs is from 50% to 60% [16]. Farms achieving less than 5,000 liters of milk per cow per year are not sustainable, while farms with 5,000-6,000 liters per cow are sustainable but not competitive, and farms with over 6,000 liters of milk per cow are both sustainable and competitive [8]. The production of cow's milk depends on the existing genetic potential of the cow, the application of appropriate nutrition technology, the achievement of the necessary level of milking hygiene and the adequate implementation of the entire scope of work on dairy cow farms. One of the ways to improve the genetic potential of cows for milk production is by importing quality breeding cows. The positive effects of the import of breeding heifers of the Simmental breed on the improvement of milk yield and fertility characteristics of the cow population were determined in Shumadiya [13, 23]. Monitoring and recording data during production on holdings can contribute to more efficient use of production resources and better business planning and [17, 18, 28, 30]. Numerous economic factors, market conditions, etc. also affect the results of cow's milk production on family holdings. On most holdingss, plant production is organized as a feed base for livestock production [20]. Therefore, the subject of research in this paper is the economic aspects of dairy cow farms on family holdings in Shumadiya and Western Serbia. The main goal of the research is to determine basic characteristics of cow milk production based on real field data and to provide recommendations for its improvement as the basis for the economic sustainability of family farms.

MATERIALS AND METHODS

According to the subject and the set goal of the research, family farms with dairy cow farms were selected, which are located in the region of Shumadiya and Western Serbia and where milk is produced from cows is the main or only source of income. The focus is on market-oriented farms from which 30,000 and more liters of cow's milk are delivered to dairies, on average per year. In cooperation with the Agricultural Advisory Service of Serbia, a survey was conducted in the mentioned area during 2019-2022 year on 219 family agricultural farms, where the survey was carried out twice in the first and third quarters of milk production on a larger number. A total of 391 survey questionnaires were collected from producers of cow's milk. The survey covered data on the number of dairy cows, feed costs and other inputs in keeping dairy cows, as well as the quantity, price and quality of milk delivered from the farm. Based on the collected data, a descriptive statistical analysis was used to review the general characteristics of dairy farms, such as: size, structure, volume of milk production, and others, based on which the parameters for the economic analysis were determined. After the descriptive analysis and economic indicators, the ranking of the survey results of samples 1 and 2 for both quarters was done.

RESULTS AND DISCUSSIONS

Sizes of cow farms and production capacities for different sizes of dairy farms

Starting from the fact that the size of the farm on the farm has a significant impact on the production and economic results in the production of cow's milk, and for the further analysis process, groups of farms were determined according to their sizes.

The sizes of the farms on the farms where the survey was conducted were determined based on the number of cows, and then their interval grouping was performed. Depending on the number of head of cows, four groups of farms are defined: group of up to 8 head of dairy cows; a group of 9 to 14 dairy cows; a group of 15 to 20 dairy cows; and a group of over 20 dairy cows. The number of farms depending on their size, as well as their share in the first and second samples is given in Table 1.

Table 1. Number and share of dairy farms according to their size in samples 1 and 2

Farm size	***Sample 1***		***Sample 2***	
	Number of farms	**Share (%)**	**Number of farms**	**Share (%)**
Up to 8 dairy cows	41	23.84	52	23.74
From 9 to 14 dairy cows	77	44.77	103	47.03
From 15 to 20 dairy cows	39	22.67	43	19.64
Over 20 dairy cows	15	8.72	21	9.59
Total:	172	100.00	219	100.00

Source: Author's calculation based on data collected on family holdings

According to the analysis in Table 1, it was determined that the largest share is made up of farms with 9 to 14 heads of dairy cows, 44.77% in sample 1 and 47.03% in sample 2. The smallest share is made up of farms with more than 20 heads, 8.72% in sample 1 and 9.59% in sample 2. Dairy farms are a key component of the dairy sector and their development directly affects milk production [10, 5, 11, 13]. First, an analysis was made based on the data of individual samples, then an analysis and comparison of the determined indicators was carried out. In the first group of farms (up to 8 heads) in the first sample, the number of dairy cows was 283 heads in total. The average number cows in this group was 6.9 heads and varied in the interval from 5 to 8 heads. The coefficient of variation was moderate and amounted to 16.30%. Almost a quarter of the farms on which the survey was conducted belong to this group, and according to the number of heads, 13% on the analyzed holdings out of the total number of dairy cows. According to the size (from 9 to 14 heads) in the second group of farms the number of dairy cows amounted to a total of

855 heads. The average number of cows in this group was 11.1 heads, and the number physical heads was within the given interval. The coefficient of variation was moderate, slightly lower than the first group and amounted to 12.90%. Almost half of the surveyed farms in the first sample belong to this group. The second group accounts for 30% of the total number of cows. The total number of dairy cows in the third group of farms (from 15 to 20 heads) was 655 heads. In the same group, the average number of cows was 16.8 heads, while the number of cows varied in a certain interval. The coefficient of variation was also moderate, but higher than in all surveyed groups of the first and second sample and was 11.40%. According to the number of holdings included in the survey in the first sample, the third group is slightly smaller than the first group. This means that this group includes slightly less than a quarter of the surveyed farms in the first sample. The third group also includes almost a quarter of the total number of cows (approximately the same as the number of farms). The fourth groups of cow farms with a size of over 20 heads are located on 15 farms with a total number of milking cows of 414 heads. The average number in this group was 27.6 heads of milking cows, and the number of cows varied from 21 to 41 heads. The coefficient of variation was the highest of all groups of the first sample and amounted to 23.90%. According to the number of farms analyzed in the first sample, the fourth group is the smallest. This group includes slightly less than 9% of the number of farms that were included in the research in the first sample. The fourth group makes up about 15% of the total number of dairy cows. When looking at the second sample, there are a total of 354 cows in the first group of dairy farms. The average number cows in this group was 6.8 heads (almost identical to the first sample). The number of cows' heads varied in the interval from 4 to 8. The coefficient of variation was moderate and amounted to 18.40%. This group includes (as in the first sample) almost a quarter of farms on which the survey was conducted, and which produce cow's milk. The farms of the first group included about 13% of total number of dairy cows. The second group of dairy farms included a total of 1,154 cows. As in the first sample, this is the largest group. The average number of cows in this group was 11.2 heads. The number of cows was within the given interval (9-14 heads). The coefficient of variation was lower than the first group of farms and amounted to 14.10%. Half of the surveyed farms in the first sample belong to this group.

The second group includes over 40% of the total number of cows. In the third group of dairy cow farms, a total of 731 cows are included. The average number of cows in this group was 17 heads. The number of cows varied within the given interval. The coefficient of variation was the lowest of all analyzed groups of the second sample and slightly higher (by 0.10%) than the same group of the first sample and was 11.50%. In terms of the number of farms covered by the survey, the third group is 17% smaller than the first group. This group makes up slightly less than a fifth of the number of farms covered by the survey in the second sample. The third group includes over a quarter of the total number of dairy cows (approximately the same as in the first sample).

In the fourth group of milking cow farms, the size of which is over 20 heads, 21 farms with a total number of 590 heads are included. The average size of this group of farms is 28.1 head, and the number of cows varied from 21 to 50 head. The coefficient of variation was the highest of all groups of both samples and amounted to 27.70%. According to the fourth group is the smallest, considering the number of farms covered by the survey in the second sample. This group accounts for less than 10% of the number of farms covered by the survey. The fourth group has a share of almost 21% of the total number of dairy cows. The survey collected data on the type of feed by farm, as well as elements of other costs of keeping dairy cows. The analysis determined the share of concentrated and coarse fodder in the total costs of fodder for all sizes of farms in both samples (Table 2).

Table 2. Structure of feed costs per head of dairy cow by group in samples 1 and 2

Type of animal feed	**Structure of animal feed costs (%)**							
	Sample 1/ Groups				***Sample 2/ Groups***			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Concentrated food	59.92	55.48	57.40	58.69	64.43	60.28	56.53	62.85
Bulk food	41.08	44.52	42.60	41.31	35.57	39.72	43.47	37.15
Total:	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: Author's calculation based on data collected on family holdings.

In all observed groups of farms according to size and in both samples, concentrated nutrients account for a larger share of animal feed costs. Their share ranges from 64% in the first group of the second sample to 55% in the second group of the first sample. In all groups in the second sample, except for the third group of farms (size from 15 to 20 heads), the share of the costs of concentrated feed is higher than in the analogous groups of the first sample. In the second sample compared to the first, the intensity of milk production increased, expressed by the amounts of concentrated feed costs and total feed costs. The cost of coarse feed is fairly uniform per head of dairy cow, regardless of the size of the farm and the intensity of cow's milk production. The most intensive production is when the size of the cow farm is up to 8 head. With the increase in the number of cows on the farm (in both samples) up to 20 heads (groups 2 and 3), the amount of feed costs per head of cow decreases, so the intensity decreases.

However, with intensive production (the second sample), the production intensity per head is practically equal to the production intensity in the first group of the second sample. In the structure of animal feed costs, the share of concentrated feed costs ranges from 55% to 64%.

The ratio of coarse and concentrated nutrients in the meal has a great influence on the quantity and quality of milk. Unfavorable price parities of cow's milk and concentrated feed have a negative effect on the economy of production, as well as on increasing the intensity of production. An increased amount of concentrated feed in the cow's ration has a positive effect on the milk yield per cow, which increases the intensity of production. Research results, as well as the experience of producers, show that a significant increase in the milk yield of dairy cows on family farms can be achieved by improving the nutrition of cows, which consists in improving the structure and type of meals.

Production and economic characteristics of cow's milk production

The dairy industry is a vital sector on a global scale, with milk fat content playing a key role in assessing the quality of dairy products and influencing the economic and nutritional aspects of the industry's products [1, 7, 12].

According to the first survey (sample 1), data was collected from 172 farms with a total of 2,202 dairy cows.

The average size of the farm was 12.8 head of cows. The number of dairy cows per farm ranged from 5 to 41 cows. The coefficient of variation of the number of cows per farm is very high and amounts to 48.10%. The average milk yield was 5,387.30 liters of milk per head of dairy cow per year, and it varied in the interval from 2,607 to 9,125 liters.

The coefficient of variation of cow's milk yield among farms is 25.90%, which can be rated as moderately high. The second survey (sample 2) was conducted in the third quarter of 2019.

Through the process of surveying producers of cow's milk, data was collected from 219 farms with a total of 2,825 heads of dairy cows. This number includes, as stated above, 172 farms where the first survey was conducted and another 47 new farms that have a cow farm and from which milk is delivered to dairies. The average size of the dairy cow farm per farm, compared to sample 1, practically did not change and amounts to 12.9 head. The number of dairy cows per farm varies between four and fifty heads. In this case too, a very high coefficient of variation of the number of cows per farm of 51.20% is noticeable. The average annual milk yield per dairy cow is 5,649.2 liters. Milk production varies between 2,555 and 9,733 liters per head.

The coefficient of variation of milk yield is 26%, which is a moderately high coefficient. In the further analysis procedure, a comparative analysis of production and economic features in milk production between the first and second samples was conducted (Table 3). The disadvantage is that the surveys were conducted at different times of the year. The first sample was taken in winter, when in milk production there is generally higher milk yield and better milk quality due to low temperatures. The second sample was taken in the summer months when, due to high temperatures, the milk yield of cows and the quality of milk decrease.

However, despite the unfavorable impact of the season on milk production parameters, the comparative analysis showed that average milk production per cow increased by over 260 liters, or almost 5%. When analyzing the structure of milk quality, the summer period took its toll. The percentage of first-class milk decreased by 14% and percentage of non-class milk was increased by 11%. It is relatively favorable that the percentages of the second class of milk increased by 7% and the third class by 6%.

Table 3. Quantities and share of classes in the total amount of milk per head of dairy cow in samples 1 and 2 and index of changes

Milk production by the throat of a dairy cow	Sample 1		Sample 2		Index (sample 1 = 100)
	Quantity (L)	Share (%)	Quantity (L)	Share (%)	
First class	1,939.44	36.00	1,751.25	31.00	86.10
Second class	1,508.44	28.00	1,694.76	30.00	107.10
Third class	969.71	18.00	1,073.35	19.00	105.60
Milk out of class	969.71	18.00	1,129.84	20.00	111.10
Total quantity:	5,387.30	100.00	5,649.20	100.00	104.90

Source: Author's calculation based on data collected on family holdings.

According to the analysis of the share of individual classes by samples and the comparison of samples, it can be concluded that the largest share per sample is the first class of milk, but the share in the first sample is 13.90% higher compared to the long sample. Shares of second, third and unclassified milk range from 18% to 30% in both samples, with the shares in the first sample being higher from 4.90% to 11.10% compared to the second sample.

Rank of milk production indicators by groups of dairy cow farms in both samples

Based on the results of this research and the examined sample of 391 dairy cow farms located on family farms in Shumadiya and Western Serbia with a total of 5,027 head of dairy cows in both samples, this part summarizes the indicators and makes their ranking.

Based on the first sample with 179 dairy farms and an average milk production of 5,387.3 liters per head and the second sample with 217 farms and milk production of 5,649.2 liters per head, it can be concluded that milk production without government incentives is at the break-even point. It is economically profitable, first of all, due to the high yield of milk per head, which was 5,534 liters of milk and was significantly above the average of the Republic of Serbia.

The milk yield on the examined farms was 57.5%, or 2,021 liters higher than the Serbian average, i.e. 3,513 liters/head of dairy cow. With state incentives, the profitability limit of milk production is 2,252 liters per head of milking cow per year (for the first sample, 2,497.9 liters per head of cow, and for the second sample, the profitability limit is at the level of 2,007 liters per head of cow).

When the state incentives of both samples are calculated, a profit is realized, and in the first sample, an average of 59,956 RSD, and in the second sample, 68,198 RSD per head of cow per year. The average financial result per liter of milk in both samples without incentives amounts to RSD 0.14. With state incentives, the average profit per liter of milk in both samples is 11.61 RSD, with the profit in in the first sample it is around 11.13 dinars, and in the second it is 12.07 dinars. Looking at the average efficiency of milk production in both samples, it is 1.01 without state incentives, where according to the results it can be seen that milk production in the first sample is uneconomical (0.98), while in the second sample it is 3%, i.e. above the economic limit (1.03). Analyzing with state benefits, the average efficiency is 1.55, where in the first sample the efficiency is 1.53, and in the second 1.57. The general analysis is that milk production in both samples is on average economical. The highest amount of profit per cow in the first sample is achieved on farms with 15 to 20 cows, and in the second sample on farms with cows of over 20 head size.

The maximum economy of production is achieved in the first sample on farms with a size of 15 to 20 head of cows, and in the second sample on farms with a size of more than 20 head of cows.In the next step, the appropriate size of the farm was selected and its place in the sample in which the most favorable production and economic results were obtained. For this purpose, three groups of indicators were compared: production indicators, costs and economic results. The group of production indicators includes milk production per head of dairy cow and the percentage share of certain classes of milk. According to the indicators, the best-ranked farms are in the first place, and the weakest are in the last, eighth place.

The groups of farms with the highest milk production per head of cow and the highest percentage of milk in the first and second class were assigned the most favorable rank, 1. In the percentage of milk of the third class and milk outside the class, the best rank (1) was assigned to the groups of farms with the lowest percentage (Table 4).

This is logical, because the percentages of third class milk and milk out of class are negative indicators of production success. The groups of farms that have the highest value of the rank number in the overall ranking represent dairy cow farms with unfavorable indicators of milk production. On the other hand, the groups of farms that have the lowest value of the rank number in the overall ranking represent the farms that achieved the most favorable indicators of milk production.

Table 4. Rank class of milk production per head of dairy cow for all groups of farms for both samples

Indicators	Sample 1 / Groups according to the number of dairy cows				Sample 2 / Groups according to the number of dairy cows			
	< 8	9-14	15-20	>20	< 8	9-14	15-20	>20
Milk production per head of dairy cow	**1**	7	8	6	2	4	3	5
% first class milk	8	5	2	**1**	6	7	4	3
% second grade milk	7	**1**	3	8	5	2	4	6
% third grade milk	8	3	**1**	6	7	4	2	5
% milk out of class	7	**1**	2	6	4	5	3	8
Total Rank:	31	17	**16**	27	24	22	**16**	27

Source: Calculation of the authors.

According to the established rank of milk classes, it was determined that the best effects are given by cow farms with a size of 15 to 20 heads in both samples. They have the identical lowest rank total (16). The following are cow farms with a size of 9 to 15 cows in the first and then in the second sample.

The largest cow farms (over 20 cows) in both samples have the same total rank number (27). It is interesting that the worst group of farms is up to 8 head in the first sample, while the same group in the second sample (total rank number 24) is better than the largest group of cow farms in both samples. The group of indicators of production costs includes costs per head of dairy cow, namely: costs of concentrated and coarse feed in particular, total costs of animal feed and total costs in milk production.

Farm groups with the highest costs were assigned the best rank (1) and those with the lowest costs the worst rank (8). It was assumed that the level of costs for animal feed is an indicator of the level of production intensity on which production and economic effectiveness depend. However, this has generally not proven to be true, especially without state incentives, and the reason for this is the unfavorable relationship between the price of animal feed and the price of milk. Table 5 shows the ranking of costs by farm groups in samples 1 and 2.

Table 5. Rank of milk production costs of all groups of dairy cow farms in samples 1 and 2

Costs of animal feed	**Sample 1 / Groups according to the number of dairy cows**				**Sample 2 / Groups according to the number of dairy cows**			
	< 8	**9-14**	**15-20**	**>20**	**< 8**	**9-14**	**15-20**	**>20**
Concentrated food	2	8	6	7	**1**	4	5	3
Bulky food	**1**	6	7	8	4	5	2	3
Animal feed - total	2	7	6	8	**1**	5	4	**3**
Total costs	**1**	6	7	8	2	5	4	3
Total Rank:	**6**	27	26	31	**8**	19	15	12

Source: Calculation of the authors.

According to the cost ranking, the best results are for the farms of the first group in both samples (total rank number 6). They are followed by the fourth (total rank 12), third (total rank 15) and second group of farms in the second sample (total rank 19). Other groups of farms from the first sample were ranked at a much lower level. In general, the production of milk per head of dairy cow, considering the amount of feed costs, is much more intensive in the second sample. This can be explained as a result of the positive effect of the summer feeding regime of cows and the results of the implementation of the breeding and selection program. The group of economic indicators includes total income, net income and profit per head of dairy cow and per liter of milk. The mentioned indicators are absolute measures of economic success (measures of economic effectiveness), i.e. indicators of production intensity. In addition, the economy of production was also used as an economic indicator of success. Similar to the cost ranking, farm groups with the most favorable economic indicators are ranked first, and those with the weakest are ranked last, in this case eighth. Individual economic ranks, as well as the overall rank of economic results of individual groups of farms in both samples are shown in Table 6.

Table 6. Rank of economic results of milk production by groups of dairy cow farms in samples 1 and 2

Production and economic effects	**Sample 1 / Groups according to the number of dairy cows**				**Sample 2 / Groups according to the number of dairy cows**			
	< 8	**9-14**	**15-20**	**>20**	**< 8**	**9-14**	**15-20**	**>20**
Total income per cow	4	8	7	6	3	5	**1**	2
Net income per cow	8	6	4	2	7	3	**1**	5
Profit per cow	8	6	4	2	7	3	**1**	5
Total revenue per liter of milk	8	7	4	5	6	3	2	**1**
Net income per liter of milk	8	5	4	**1**	7	3	2	6
Profit per liter of milk	8	5	4	**1**	7	3	2	3
Economy of production	6	5	4	**1**	8	3	2	6
Total Rank:	50	42	**31**	18	45	26	9	**17**

Source: Calculation of the authors.

As can be seen in Table 6, the most economically successful is the third group of farms with a size of 15 to 20 dairy cows in the second sample. Out of the seven ranked indicators, this group of farms is in first place based on three indicators, and based on the remaining four, it is ranked second. In second and third place are the groups of the largest farms in the second and first sample, respectively. The fourth place belongs to another group of cow farms with a size of 9 to 14 heads, also in the second sample. In the first sample, the profitability of milk production increases with the increase in the number of cows on the analyzed farms. Maximum milk production does not necessarily mean maximum economic profitability. The farms of the first group in the first sample, despite the highest average milk production per head of cows, show the weakest economic results.

The producer's influence on the increase in the sale (repurchase) price of milk is quite limited. Therefore, producers should strive to rationalize production costs, that is, to achieve the lowest possible cost price per unit of milk produced.

Rationalization of milk production costs involves planning the quantity, quality, structure and price of animal feed. The rationalization of the structure of the meal is significant, which implies that the meal contains all substances by type, quantity and quality that the throat needs considering age, production characteristics and other characteristics, as well as that the meal is financially favorable from the aspect of business.

CONCLUSIONS

The sizes of the farms on the holdings where the survey was conducted were determined based on the number of cows, and then they were grouped by intervals. It was found that the largest share is made up of farms with 9 to 14 heads of dairy cows, 44.77% in sample 1 and 47.03% in sample 2.

The smallest share is made up of farms with over 20 heads, 8.72% in sample 1 and 9.59% in sample 2. For the first sample, data was collected from 172 farms where a total of 2,202 dairy cows are kept. The average size of the farm was 12.8 head of cows. The number of dairy cows per farm ranged from 5 to 41 cows.

The coefficient of variation of the number of cows per farm is very high and amounted to 48.10%. The average milk yield was 5,387.30 liters of milk per head of dairy cow per year. The coefficient of variation of milk yield among farms is 25.90%, which can be rated as moderately high. For the second sample, the survey was conducted in the third quarter of the calendar year. Data were collected from 219 farms with a total of 2,825 dairy cows. This number includes, as stated above, 172 farms where the first survey was conducted and another 47 new farms that have a cow farm and from which milk is delivered to dairies.

The average size of the dairy cow farm per farm, compared to sample 1, practically did not change and amounts to 12.9 head. The number of dairy cows per farm varies between four and fifty heads. In this case too, a very high coefficient of variation of the number of cows per farm of 51.20% is noticeable.

The average annual milk yield per dairy cow is 5,649.2 liters. The change index showed that the average milk production per head of cow increased by over 260 liters or close to 5%. Considering the quality of milk, the summer period had an unfavorable effect. The percentage share of first-class milk fell by 14% and percentage of non-class milk was increased by 11%. It is relatively favorable that the percentages of the second class of milk increased by 7% and the third class by 6%.

The results show that the best effects for cow farms are between 15 and 20 cows in both samples. They have the identical lowest rank total (16). The following are cow farms with a size of 9 to 15 head of cows in the first and then in the second sample. The largest cow farms (over 20 cows) in both samples have the same total rank number (27).

It is interesting that the worst group of farms is up to 8 head in the first sample, while the same group in the second sample (total rank number 24) is better than the largest group of cow farms in both samples.

According to the cost ranking, the best are the farms of the first group in both samples (total ranking number 6). They are followed by the fourth (total rank 12), third (total rank 15) and second group of farms in the second sample (total rank 19).

Out of the seven ranked indicators, this group of farms is in first place based on three indicators, and based on the remaining four, it is ranked second. Rationalization of milk production costs is based on proper planning of livestock ration. It is important to rationalize the structure of the meal, which implies that the meal contains all substances by type, quantity and quality that the throat needs considering the age, production characteristics and other features, as well as that the meal is financially favorable from the aspect of business and sustainability of the farm.

Based on the first sample with 179 dairy farms and an average milk production of 5,387.3 liters per head and the second sample with 217 farms and milk production of 5,649.2 liters per head, it can be concluded that milk production without government incentives is at the break-even point.

It is economically profitable, first of all, due to the high yield of milk per head, which was 5,534 liters of milk and was significantly above the average of the Republic of Serbia. With state incentives, the profitability limit of milk production is 2,252 liters per head of milking cow per year (for the first sample, 2,497.9 liters per head of cow, and for the second sample, the profitability limit is at the level of 2,007 liters per head of cow).

When the state incentives of both samples are calculated, a profit is realized, and in the first sample it averages 59,956 dinars, while in the second it is 68,198 dinars per head per year.

In both samples without state subsidies, the average milk production efficiency is 1.005, and according to the results, milk production in the first sample is uneconomical (0.98), and in the second sample it is 3% above the economic limit (1.03). With government benefits, the average efficiency is 1.55, with the efficiency in the first sample being 1.53 and the second being 1.57.

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EATING HABITS AND PHYSICAL EDUCATION AND SPORT-COMPONENTS OF YOUTH HEALTH EDUCATION

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Abstract

This paper provides an overview of the physical activity (PA) and dietary behaviour of college students, emphasizing the need for long-term education to lead a healthy life. Four research objectives were set, and an online study was carried out (N = 365, 65.21% women, 65.21% urban residence), using a self-administered questionnaire. The average age of the respondents was 20.34 years. The collected data was analysed, processed and interpreted accordingly with the help of tables and figures. The main results: in the families of 84.11% of those surveyed, a part of the necessary food needed is produced in the household. The main source of food supply is the hypermarket, the proportion with which the food is purchased from here varies depending on the product category: 65.48% other food products; 60.55% milk and dairy products; 46.58% meat and fish products; 46.03% bread and bakery products; 44.93 % fruits; 43.01% vegetables. The dietary habits indicate that 91.33% of young people include all food categories in their diet. Approx. 19% of the young adults have a hyperprotein diet, and 13.97%, a hypocaloric one. More than 90% of the subjects recognize the importance of physical education for human health, approximately 92% of them engage in walking as a form of PA, 41% work out in the gym, and 53.15% stated that they allocate between 1 and 5 hours for PA/week. The main motivation to practice different sports is the desire to stay healthy (score of 4.17), and the main benefit identified for their own health refers to the way they feel, full of energy (score 4.03). More than 70% of young people use digital applications to monitor the number of steps taken and PA. More than 2/3 of the study participants believe that it is important for physical education to be part of students' daily routine. Universities can generate societal change, giving young people the opportunity to adopt healthy eating habits and understand the importance of PA for both human and planetary well-being.

Key words*: *habits, food consumption, food purchase, physical education, physical activity, student, health education

INTRODUCTION

Physical activity (PA) and eating behaviour are formed from adolescence [37], and then it becomes final in adulthood, having major health consequences. These behaviours in young people are closely related to the Sustainable Development Goals of the United Nations [36], especially with SDG- 3 (good health and wellbeing), SDG 5 (quality education),respective and SDG-12 (sustainable production and consumption).The specialized literature shows that diets contribute to planetary health, food being closely linked to sustainable development goals. The health of individuals requires a holistic approach, integrated into the natural systems in which they live [32].

Increasing the level of practicing PA also contributes to achieving many of the sustainable development objectives set by the United Nations in the 2030 Agenda for Sustainable Development, with the aim of having a healthier, more sustainable and prosperous humanity [40].

PA should be part of the daily life of every individual, regardless of age. The latest recommendations (Figure 1) show that adults should do an average of 300 minutes of moderate-intensity PA each week or 150 minutes of high-intensity PA [41], with beneficial effects on physical and mental health [43].

Fig. 1. Recommendations regarding the weekly time of physical activities in adults.
Source: [42].

The aim of the work is to identify the habits of young people to purchase and consume food and to practice physical exercises, their motivation and perception of their importance to have a healthy life.
A word cloud view of the most frequent terms in the abstract of the paper is shown in Figure 2.

Fig. 2. Wordcloud view of terms from the abstract of the paper
Source: own design using [38].

To achieve the goal of the work, four objectives were established:
RO1. Identifying food purchase and consumption habits to maintain health and support PA.
RO2. Identifying the habits of practicing physical activities, their frequency and duration.
RO3. Identifying the perception regarding the importance of PA, the motivation and the main benefits brought by its practice.
RO4. Recognizing the habit of engaging in fitness, along with the duration and frequency of training, and the use of apps to enhance physical performance.

MATERIALS AND METHODS

Study design

The study is based on survey research in which a self-administered online questionnaire was used, completed by a non-probability sample of students in Sibiu, Romania. Data were collected between November 2024 and January 2025, and the total sample size was 365 young adults. The age of the study participants is at least 18 years. They were informed about the purpose of the study and about data protection (GDPR). The thematic questionnaire was constructed specifically for this research and was based on both the literature review and original research ideas aimed at addressing topics related to young people's exercise habits, their perception of the importance of physical education (PE) for maintaining health and the support of intellectual effort, the motivation underlying the practice of physical exercises and different sports, their duration and the frequency of their practice, the habit of using various mobile applications for monitoring physical effort and food consumption, identifying food purchase and consumption habits to maintain their health status. The questionnaire included 25 items on the subject, to which 6 items related to standard socio-demographic data were added. Most questions included a 5-point Likert scale for recording responses. The obtained data were analysed and exported to the Microsoft Office Excel 2017program (MS Excel; Microsoft Corporation, Washington, DC, USA), in which the data were statistically processed, including the creation of tables and figures.

Study participants

The questionnaire was completed by 365 students from the 1st and 2nd years of studies, of the "Lucian Blaga" University in Sibiu, residing in 27 counties and in the city of Bucharest. From the total number of respondents, 197 people (53.97%) live in Sibiu County, 65 people live in Vâlcea County (17.81%), 21 live in Alba County

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(5.75%), 15 people live in Brașov County (4.11%), while 18.36% of the respondents live in 23 other counties or in the city of Bucharest. Other socio-demographic data of the sample are: 65.21% (238 people) of the respondents are female, and 127 are male (34.79%); 65.21% (238 people) live in urban areas, respectively 34.79% (127 people) live in rural areas. The age of the respondents is between 18 and 57 years, and the average age is 20.34 years (Standard deviation 4.167; Confidence Level 95% = 0.428). Although all respondents are currently students in their 1st and 2nd years of study, 95.07% (347 people) are high school graduates, 3.01% (11 people) have graduated from a college, 1.37% (5 people) have graduated from a master's program, and 0.55 % (2 people) graduated from a post-secondary school. The respondents' family consists of 3.70 people on average (Standard deviation = 1.404; Confidence Level (95 %) = 0.144). The family's net monthly income is below 500 euros for 7.40% (27 people); 28.49% of people (104 people) have an average monthly income between 500 and 1,000 euros in their families; 51.78% (189 people) of people declared that the average monthly family income is between 1,001 and 2,000 euros, while only 12.33% (45 people) of people declared a net monthly family income of more than 2,001 euros (1 euro = 4.9728 lei).A question on subjective well-being was also added, for which the answers were collected on a scale from 1 to 5 (in which: 1 The income is not even enough for the bare necessities; 5 We manage to have everything we need, without much effort). The average score obtained for this item was 3.87, with the standard deviation: 0.919 and Confidence Level (95 %) = 0.094. This score shows that the surveyed subjects agree that the family income allows them to live decently, sometimes managing to buy more expensive things.

RESULTS AND DISCUSSIONS

RO1. Identifying food purchase and consumption habits to maintain health and support physical activity.

The specialized literature presents more and more evidence regarding the importance of healthy eating habits on the maintenance of health and the general well-being of individuals [13]. In this context, we aimed to identify the purchase and food consumption habits of young people, closely related to the practice of PE and sports.

The origin of the food consumed by the family

As can be seen from Figure 3, a share of 15.89% (58 people) of the respondents stated that their family does not produce food. In the case of 31.51% (115 people) of young adults, their families produce between 1 and 25% of the food needed in the household, while 24.66% (90 people) of young people believe that their family produces between 26 and 50% of the food needed. In the case of the other 17.95% of the respondents(102 people), their families produce more than 51% of the food consumed in the household.

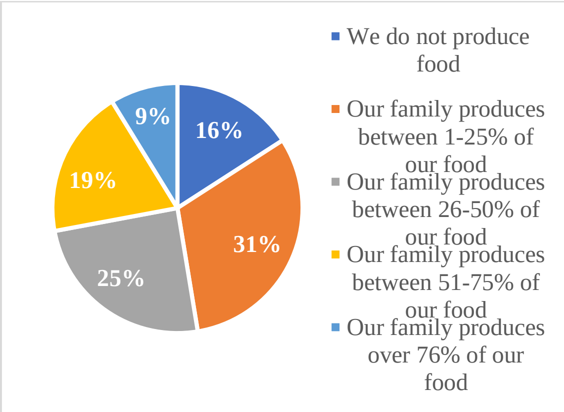

Fig. 3 Origin of food consumed in respondents' households
Source: own design

Favourite place to buy food, on assortments

Table 1 shows the preferred place for purchasing different food categories. The hypermarket/supermarket is the preferred place for purchasing food in the case of approx. 50% of families.

Although the supermarket/hypermarket remains the preferred place for purchasing food, it is observed that more than half of the respondents use to purchase milk (60.55%) and other food products (65.48%) from here. Vegetables are purchased from the supermarket only by 43.01% of the respondents, and fruits by 44.93% of them. In the case of meat and meat or fish products, after hypermarket it is noted in the case of approx. ¼ of the people, the preference for direct purchase, from the farm, from the producer (23.29%), which denotes the creation of a relationship based on the consumer's trust in the producer.

Table 1. Food supply source

Favourite place to buy food, by category	Dairy products (%)	Meat or fish products (%)	Vegetables (%)	Fruits (%)	Bread and pastries (%)	Other food products (%)
Hypermarket/Supermarket (1)	60.55	46.58	43.01	44.93	46.03	65.48
Agri-food market (2)	4.93	5.85	21.37	21.10	5.21	5.21
Direct from the producer/farm (3)	20.00	23.20	16.99	15.62	12.33	10.68
Specialized store (4)	3.01	10.68	4.93	4.38	11.51	4.66
Shop of local producers (5)	8.49	10.96	7.67	7.12	13.15	6.03
Neighbourhood shop (6)	3.02	2.73	6.03	6.85	11.77	7.94
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Source: own calculation.

Perception of the importance of local products

A good part of the food products consumed in the respondents' families are purchased from producers, either directly from the farm, or from agri-food markets, producers' stores or specialized stores. These foods are mainly perceived as tasty and beneficial for health (average score 4.22), fresh and seasonal (average score 4.18) and ecological, made with less addition of chemical substances (average score 4.05) (Table 2).Even though the registration of food products on voluntary quality schemes certifies their authenticity and organoleptic and nutritional value [13], the lowest score (3.77) was recorded for the statement that farmers' products are products registered on voluntary quality schemes quality, which denotes an insufficient knowledge of these voluntary quality schemes, existing at national or international level, as shown by other researchers [9, 10]. In general, the registration of these products on quality schemes is directly related to care for the environment, animal welfare and the creation of short food chains [7, 34], future studies are needed to highlight the value of these products for health [16]. Also, relevant authorities should carry out information and education campaigns regarding the importance and nutritional value of these products.

Table 2. Reason for buying food from farmers (from household, market or farmer's shop)

Specification	Score	Ranking
Tasty and beneficial to health	4.22	1
They are local, fresh and seasonal products	4.18	2
They are organic products, with less added chemicals	4.05	3
They are traditional products, made in the specifics of the area where they are produced	3.99	4
They are food products that have a lower impact on the environment	3.92	5
They are food products registered on voluntary quality schemes	3.77	7
They are food products obtained in an extensive system, which contributes to the well-being of farmers	3.85	6

Source: own calculation.

Frequency of household food purchases

More than 50% of the respondents use to buy food 2-3 times a week, while 27.67% buy food once a week. It is observed that 15.62% of young people use to purchase food daily (Table 3).

Table 3. Frequency of purchasing food in the household

How often do you buy food in your household?	Frequency (no.)	Percentage (%)
Daily	57	15.62
Once/week	101	27.67
2-3 times/week	184	50.41
Once every two weeks	23	6.30
Total	**365**	**100**

Source: own design.

Identification of food regimes to maintain health and support PA

The results of recent studies [8] emphasize the need for systemic change to support healthy eating behaviours with beneficial effects on health and physical performance. Healthy eating habits are created from childhood, within the family, are consolidated in adulthood and play a major role in physical and mental health in adulthood [14].

The health and well-being of individuals depends on a whole series of factors, of which nutrition plays an essential role. Young people often look to role models online, which can have a lasting impact on their eating behaviours and habits [25]. Scientific evidence shows that nutrition influences mood, energy levels and attitude towards school [6]. Mantzioris et al (2024) showed that although the beneficial effects of the Mediterranean diet on health are known, studies are needed to highlight its effects on sports performance [26].

The university context represents a favourable environment for changing and promoting healthy lifestyle habits [35], being at the same time an important vector of societal change for development [3, 32].

Weight management can be managed through nutrition appropriate to the age, body development and physical and intellectual effort of everyone [12].In general, young people and athletes do not have sufficient nutritional knowledge and do not follow the approved nutritional recommendations [20].

As can be seen from Figure 4, 91.23% (333 people) of the young people surveyed used to consume all types of food.

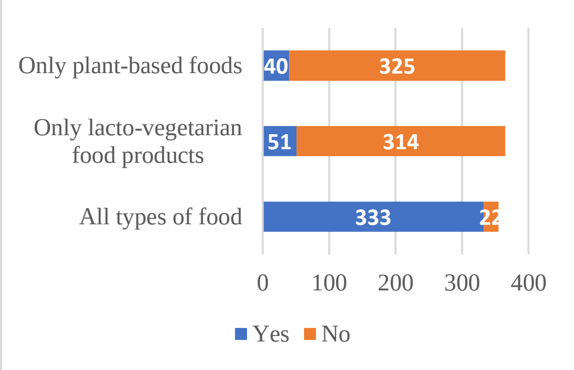

Fig. 4. Foods included in the diet to maintain health
Source: own design.

The share of those who state that they follow food diets is low: hyperprotein diet (18.63%, 68 people) or hypocaloric diet (13.97%, 51 people) (Figure 5), because at this age young people have fewer health problems.

An adult should consume an average of 55 g of protein per day, half of which should be animal protein. In 2022, a Romanian consumed on average 29.3 g of animal protein/head/day, respectively, 74 kg/inhabitant/year [31].

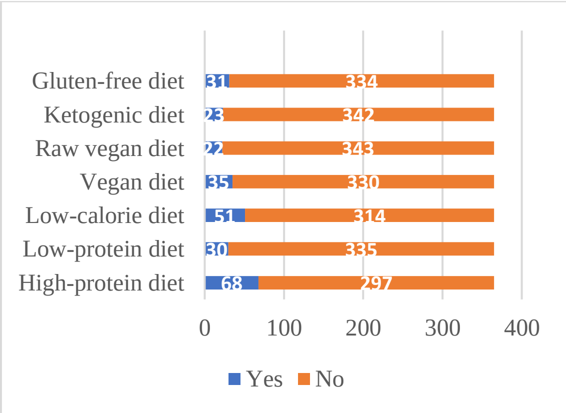

Fig. 5. Diet to maintain health
Source: own design.

Healthy diets in young people are associated with the tendency to practice various PE and sports activities [1]. Regardless of the individual's age, any nutritional recommendation should be based on scientific evidence. In the USA, the My Plate app was created, which provides information related to healthy diets [19].

RO2. Identifying the habits of practicing physical activities, their frequency and duration

Students' attitudes towards PE can be changed [29] and their knowledge of health benefits can be improved by promoting healthy behaviours [21] and prevention of internet usage addiction [15]. Young people are used to frequent PA, the most common way to exercise is walking (92.1%, 336 people), followed equally (47.9%, 175 people each) by hiking and exercising at the gym (Figure6).

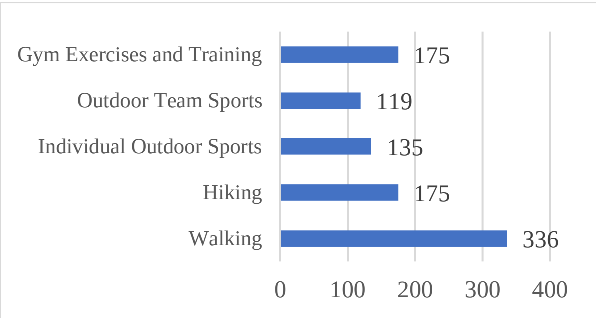

Fig. 6. The most frequently practiced type of physical activity
Source: own design.

Walking is preferred by over 91% of young people (Figure 7), being a pleasant way to exercise outdoors that does not require intense physical effort.

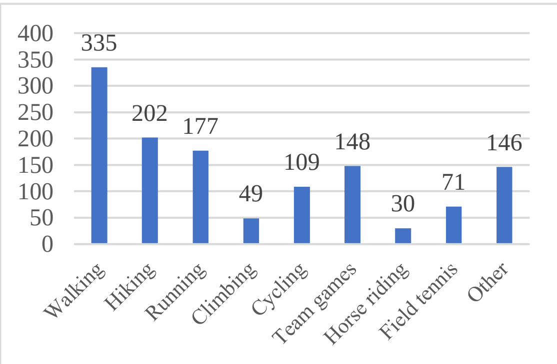

Fig. 7. Favourite physical activities of young people
Source: own design.

A study published by Zhou et al (2025) shows that the number of hours of physical education depends on factors such as grade level, location of the lesson, content of PA, and its context [44].The sports practiced regularly by the young respondents are, in order of their preferences, fitness (38.90%, 142 people), running (34.25%, 125 people) and football (22.47%, 82 people).

The frequency with which various sports are practiced is in the case of 45.48% of the respondents 1-2 times a week, for 29.04% of them 3-4 times a week, for 12.33% 5-6 times a week, and for 6.30 % daily. There is also a share of 6.85% (23 people) among young people who declared that they do not practice sports (Figure 8).

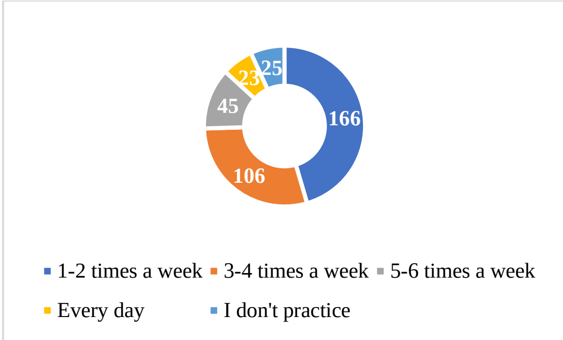

Fig. 8. Frequency of practicing various sports
Source: own design.

The weekly time allocated to the practice of various sports is for 53.15 % (194 people) of young people between 1 and 5 hours. There are also 21.37% (78 people) of the study participants who declared that they do less than 1 hour of sports per week or not at all. Almost a quarter of the young adults questioned (24.66 %, 90 people) declared that the weekly time allocated to practicing sports is between 6 and 20 hours, falling within the recommendations of the World Health Organization regarding the exercise regime of adults. Only 0.82 % (3 people) of the respondents perform physical activities more than 21 hours per week (Figure 9).

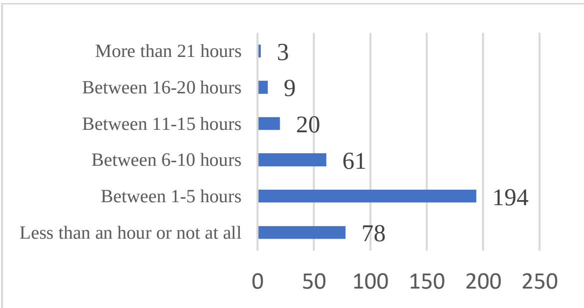

Fig. 9. Weekly time allocated to practicing sports
Source: own design.

A study conducted among young people in Norway shows that the time they spend on physical activities is decreasing [17], with young people preferring to spend a large part of their time on social media networks.

Another study in China found that people with higher education and higher incomes have a modern and more active lifestyle, developing long-term healthy behaviours [23].

RO3. Identifying the perception regarding the importance of physical activity, the motivation and the main benefits brought by its practice.

Almost 90% (320 people) of young people agree with the great importance of PE for human health. The average score recorded for the importance of PE for health is 4.19 (Standard deviation = 0.977, Sample variation = 0.955, Confidence level at 95 % = 0.100) (Table 4).

Table 4. Descriptive statistics on the perception of the importance of physical education for health

Mean	4.1890
Standard Error	0.0511
Median	4
Mode	4
Standard Deviation	0.9777
Sample Variance	0.9559
Kurtosis	3.5379
Skewness	-1.7875
Range	4
Minimum	1
Maximum	5
Sum	1,529
Count	365
Largest (1)	5
Smallest (1)	1
Confidence Level (95.0%)	0.1006

Source: own calculation.

The first objectives (Table 5) pursued by practicing PE and various sports are in ranking order: improving physical condition (score 4.19), maintaining body weight (score 3.61), and increasing muscle mass (score 3.57).Strategies are needed to promote PA and healthy eating habits among young people, which would prevent life-threatening diseases in adulthood [4].

PE and diets based on good quality food can help maintain an optimal body weight and a healthy lifestyle [30].

The social support provided by friends and socialization in general correlates positively with the level of PE practice by students [39].

Table 5. Objectives pursued by practicing sport

The main objectives pursued by practicing PE and sports	Score	Ranking
Increase muscle mass	3.57	3
Weight loss	3.29	4
Maintain body weight	3.61	2
Improve physical condition	4.19	1
Other	3.25	5

Soruce: own calculation.

The motivation to practice different sports is mainly related to the desire to stay healthy (score 4.17), the way young people feel when they exercise (score 4.13), the way they look (score 4.02).

Young people recognize the importance of practicing PE and sports and for learning new things about healthy eating (score 3.70) or for socializing (score 3.34) (Table 6).

Table 6. Motivation to stay active

Specification	Score	Ranking
The way I feel	4.13	2
The way I look	4.02	3
Helps me stay healthy	4.17	1
Helps me socialize	3.34	5
I can learn new things about healthy eating	3.70	4

Soruce: own calculation.

Numerous studies have highlighted the benefits that young people perceive by practicing PE and sports: maintaining physical health, general well-being [27], the perception of a state of well-being [28], improving social behaviours, confidence [11], and anxiety prevention.

In the chosen sample, young people note the benefits (Table 7) that practicing sports brings to the way they feel and to their well-being. Thus, the main benefit refers to the surplus of daily energy I feel (score 4.03), to the reduction of stress and anxiety (score 4.00), respectively to the improvement of the body's immunity and a more peaceful and restful sleep (score 3.99). The lowest score was obtained regarding the perception of the advantages of practicing sports on the improvement of school results (score 3.22).

Table 7. The benefits felt by young people by practicing sports

Specification	Score	Ranking
It helps me feel better, with more energy	4.03	1
It helps me reduce stress and anxiety	4	2
It helps me maintain an optimal body weight	3.95	5
It helps me sleep better	3.99	3
It helps me have more self-confidence	3.97	4
It improves my body's immunity	3.99	3
It helps me achieve better school results	3.22	6
Average score	**3.88**	

Soruce: own calculation.

More than 77% (282 people) of those surveyed say that it is important for PE to be part of students' daily routine.

Table 8. Descriptive statistics regarding the agreement that physical activities are part of the students' daily routine

Mean	4.1945
Standard Error	0.0487
Median	4
Mode	5
Standard Deviation	0.9305
Sample Variance	0.86590
Kurtosis	0.79045
Skewness	-1.05461
Range	4
Minimum	1
Maximum	5
Sum	1,531
Count	365
Largest(1)	5
Smallest(1)	1
Confidence Level (95.0%)	0.0957

Source: own calculation.

The average score recorded for the agreement that physical activities are part of the students' daily routine is 4.19 (Standard deviation = 0.930, Sample variation = 0.865, Confidence level at 95 % = 0.095) (Table 8).

About 61.10% of young people say that they have enough time to practice different physical activities. Among the obstacles encountered in practicing physical activities are, however, lack of time (score 3.64) and high costs to work with a personal trainer (score 3.44) (Figure 10). Lack of time, energy, skills and resources as barriers that prevent young people from practicing PE are also reported by Bobo-Arce et al (2024) [5].

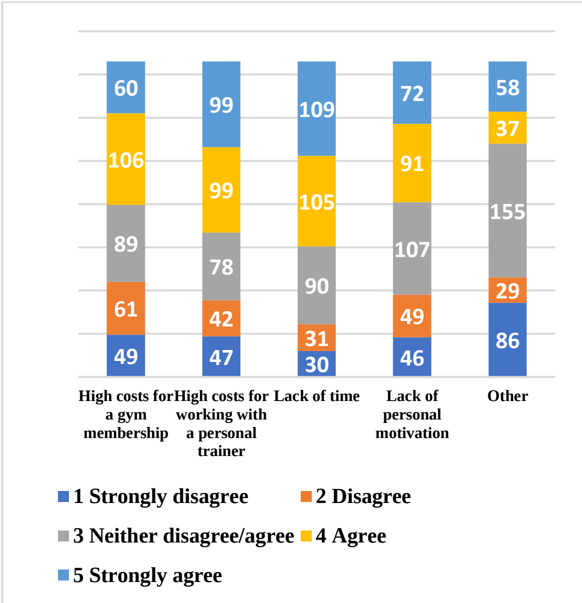

Fig. 10. Obstacles in practicing PA
Source: own design.

RO4. Recognizing the habit of engaging in fitness, along with the duration and frequency of training, and the use of apps to enhance physical performance.

The young generation puts a lot of emphasis on how they look, with a good number of young people having gym memberships. In the present sample, 41% (149 people) of young people train at the gym: 3-4 times a week (17%, 61 people), 1-2 times a week (15%, 56 people), 5- 6 times a week (8%, 30 people) or even daily (1%, 2 people) (Figure 11).Approximately 60% (221 people) of young people who regularly go to the gym train alone or with a partner.

Approximately 7.7% (28 people) of young people train with a personal trainer or with an instructor for a group of people, 2.47% train with a group of people, without benefiting from the services of an instructor, and 29.32% of young people do not train at all.

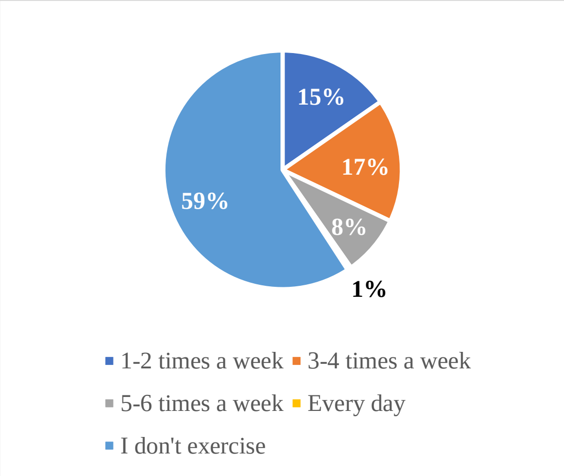

Fig. 11. Training frequency at the fitness gym
Source: own design.

The young generation is familiar with the use of digital technology, getting used to using applications that (Figure 12): allow them to track the number of steps and monitor sports activity (71.23%, 260 people), applications that provide them with training plans and exercise instructions (52.52%, 192 people), nutrition applications (42.74%, 156 people) or combined applications (29.32 %, 107 people).

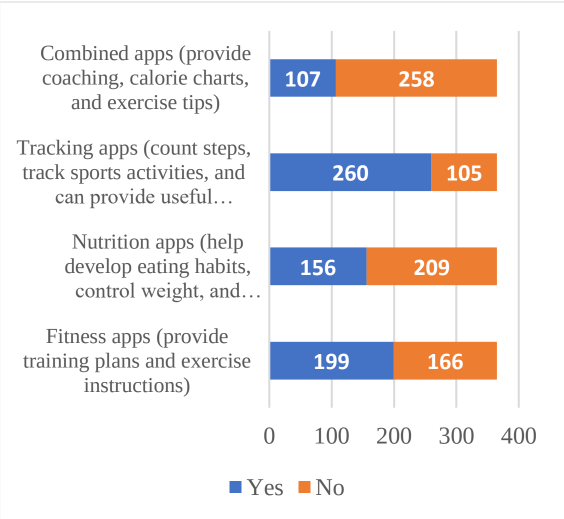

Fig. 12. Use of mobile applications
Source: own design.

The most frequently used mobile applications are (Table 9): Apple Health (36.99%, 135 people), which monitors steps, distance travelled and calories; MyFitnessPal, which allows tracking of food, exercise and calories burned (31.51%, 115 people).

Table 9. Use of digital applications for monitoring nutrition and exercise (number of responses)

Using mobile apps	Yes	No
MyFitnessPal (tracks nutrition, exercise, and calories burned)	115	250
Fitbit (tracks distance, calories burned, and sleep)	53	312
Strava (tracks routes, distances, speed, and social connections)	30	335
Nike Training Club (provides workout tutorials and allows you to create a personalized workout)	43	322
Lose It! (allows you to track calories, get nutritional information by scanning food labels, and provides personalized weight loss recommendations)	32	333
Apple Health (tracks steps, distance, calories, and workouts)	135	230
Google Fit (allows you to set goals for physical activity and health)	85	280
JEFIT (helps you create and track personalized workout programs)	16	349
MyPlate (includes nutrition and health information)	25	240
Fitbod (creates workouts based on your equipment and fitness level)	15	350
Other digital apps	164	201

Source: own calculation.

Sharma et al (2024) show that mobile applications are increasingly used in the post-pandemic period, providing health and fitness benefits to users [33]. Mobile applications enable data collection and analysis, and a better understanding of the importance of a healthy lifestyle [24].

The average use of digital fitness apps in EU member states was 27.43% in 2023, double the global average (13.42%) [22].

In Romania, there are no studies highlighting the use of technology in sports [2]. A recently published study by He et al (2024) shows that rigorous research in this direction needs to continue to better understand the potential benefits of using mobile apps in youth PA [18].

CONCLUSIONS

The work comes to complete the body of specialized literature on education for a healthy lifestyle of Romanian students, analysed from the perspective of purchasing and food consumption habits and the practice of PE and sports.

Universities have a significant role as a factor of social change, being the ideal place for young people to learn healthy eating habits and understand the importance of PA for harmonious development and a healthy life.

For these reasons, we advocate that aspects related to healthy eating, such as balanced diets and food sustainability, should also be addressed during university training, in PE classes.

Intervention programs are needed to stimulate the practice of physical exercise and sport in universities, to improve the sports infrastructure of universities and to promote PA and sport for recreational purposes. University sports clubs, for example, can offer accessible facilities to all students for the recreational practice of various sports, and can contribute to the promotion of PA by organizing amateur competitions and organizing extracurricular activities attractive to young people.

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WHAT CONTRIBUTES TO THE ATTRACTIVENESS AND POPULARITY OF A RURAL TOURISM DESTINATION? EXAMPLE OF GOOD PRACTICES – PORUMBACU DE JOS COMMUNE, SIBIU COUNTY, ROMANIA

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Abstract

The attractiveness and popularity of a rural tourism destination depend on a whole series of factors, the most important of which refer to the beauty of the landscape and the provision of unique, memorable and authentic experiences. The commune of Porumbacu de Jos is part of the ethnogeographic area "Țara Oltului", is located in the mountainous area of Sibiu County, Romania, with 34% of its surface covered with forests and is the access point to the mountain hiking trails in the Făgăraș Mountains. The initiative of some tourism entrepreneurs who built here some unique attractions, such as the "Clay Castle" ("Castelul de Lut") and the "Calendar Story" ("Povestea Calendarului") theme park, have brought thousands of tourists to the commune annually. Currently, there are 35 accommodation facilities operating in the commune, generally, these are rustic houses, decorated in the traditional style of peasant houses in Transylvania. In the commune, there is a registered a family-owned restaurant and a local gastronomic point. The operational accommodation capacity in 2024 was 6,944 bed-days. The highest values of tourism indicators were recorded in 2022 (tourism traffic density was 2.13, and tourism traffic intensity was 3.98). The tourism operation rate in 2024 was 0.108.The local tourism offer is promoted on various information and booking platforms, with tourists praising the quality and comfort of the accommodations, the tranquillity, the beauty of the landscape, the hospitality of the hosts, and the uniqueness of the experience. In the future, sustained efforts are needed to improve market-oriented promotion and to digitally transform the tourism offer.

Key words: *rural tourism, agrotourism, attractivity, popularity, sustainable development, Porumbacu de Jos, Romania*

INTRODUCTION

The competitiveness of tourist destinations is becoming increasingly important for countries seeking to develop their tourism market [35]. In the 2024 edition of the Travel & Tourism Development Index, published by the World Economic Forum, Romania achieved a score of 4.19, ranking 43rd out of 119 countries evaluated. This index assesses a set of factors and policies that contribute to the sustainable and resilient development of the tourism and travel sector, providing insight into the competitiveness and potential of countries in this field [41].

Tourism competitiveness is a complex indicator that includes a wide range of both quantitative and qualitative variables [2].

The attractiveness and competitiveness of a rural tourism destination depend on the local community's ability to provide tourists with high-quality services and innovative, niche offers, while sustainably utilizing local natural and cultural tourism resources [35].

Rural tourism, in all its forms, can contribute to the diversification of economic activities in rural households, the creation of jobs, especially for young people and women, the reduction of depopulation, the generation of supplementary income alongside agricultural revenues, the enhancement of local cohesion, the preservation of landscapes and cultural values, and the revitalization of rural areas. [26, 40].The development of rural tourism and agrotourism involves the efficient utilization of all natural and cultural resources, bringing numerous economic, socio-cultural, and environmental benefits to rural communities [28], serving as a valuable tool for sustainable local development [17]. The success of tourism activities also depends on the type of tourism structure, without being significantly influenced by its location in an urban or rural environment [32].

The main criteria for choosing a rural tourism destination are the beauty of the landscape, the quality of services, and the diversity of activities for leisure [38].

Seasonality also has a major influence on rural tourism and agrotourism, due to its direct connection with agriculture and the lifestyle of agrotourism guesthouse owners. The results published by Gordan et al. (2024) show that the impact of seasonality can be reduced through a better utilization of tourism potential [14]. The duration of a tourist stays and its extension into the off-season are also influenced by the bioclimatic potential of the area, particularly by the thermal comfort index, which determines the feasibility of outdoor activities or the utilization of local therapeutic resources [21].

Some authors associate rural tourism and agrotourism with creative tourism [20] or regenerative tourism [17], highlighting that it takes place on a small scale, is based on a specific community lifestyle, originates in local traditions and culture, and emphasizes social, economic, cultural, and environmental sustainability.

Other authors explore aspects related to the assessment of service quality from the perspective of ecotourism or nature-based tourism, concepts closely related to rural tourism and agrotourism. Glamping is considered a form of sustainable tourism that emphasizes service quality [27] and targets tourists with a sustainable mindset or those willing to change their travel habits to be more environmentally friendly and transition toward a circular economy [3]. The awarding of the ecological label in agrotourism is based on mandatory and additional criteria [11]. The analysed criteria mainly refer to energy consumption, water usage, public transportation, and management systems [7].

The sustainable development of tourism also depends on the level of tourist satisfaction [1, 6, 15, 18]. Some authors have highlighted age-related differences in satisfaction levels regarding the quality of services and offers in Romanian rural tourism. Older tourists appreciate authentic experiences based on the involvement of local communities in promoting the natural and cultural resources of the area [10].

Authentic agrotourism involves serving culinary dishes prepared according to traditional recipes specific to the region, made from fresh, seasonal ingredients sourced from the household’s own farm or other local producers [4], contributing to the creation of an authentic and memorable experience [9].

The purpose of the paper

Starting from the premise that there are major challenges for rural communities and local public authorities in stimulating development and improving living conditions for residents [19], we have chosen to analyse the state of rural tourism and agrotourism development in Porumbacu de Jos commune, Sibiu County, Romania. The commune is among the preferred rural tourism destinations in Romania in recent years, and we aimed to identify the elements that have contributed to its attractiveness and popularity.

MATERIALS AND METHODS

The research work was based on documentary research, literature review, statistical analysis of secondary data, field visit, observations, and on the collection of information from the case study in Porumbacu de Jos commune.

The methodology included at the beginning desk research methods and procedures to collect the primary data from official information sources and data bases regarding lodging and travel services provided. In this case it was used the site of The National Authority for Tourism under the coordination of the ministry in charge of tourism activities. Also, the data were picked up from the

National Agency of Mountain Area. After setting up the data collection for this research work, there were calculated some tourist traffic indicators of rural tourism in Porumbacu de Jos commune, Sibiu County. These indicators are tourist traffic density, tourist traffic intensity and tourist operation rate [36].

Tourist traffic density (TD) is the indicator that directly links tourist traffic with the resident population (on January 1). It is calculated as the ratio between the number of tourists arriving in the area (TA) and the resident population of the area on January 1 (P).

$$TD = \frac{TA}{P} \quad (1)$$

The intensity of tourist flow was determined dividing the number of overnight stays to the resident population in the village (on 1 January).

$$TI = \frac{Os}{P} \quad (2)$$

where:
Ti = tourist traffic intensity
Os = number of tourist overnight stays
P = total population on 1 January

To assess the size of the tourist development in the studied area, it was evaluated the *tourist operation rate*, whose formula involves calculating the ratio between the total number of accommodation units and the resident population.

$$Tfr = Tacu/P \quad (3)$$

where:
Tfr = tourism function rate Tacu = total number of accommodation units P = total population on 1 January

Excel, v. 365 Microsoft, was used for data processing.

The main research objectives are:

O1. Description of the rural tourism and agrotourism potential of Sibiu County, Romania
O2. Obtaining general information regarding the tourism potential of Porumbacu de Jos commune, Sibiu County, Romania
O3. Obtaining data on the number of tourist structures, by type, degree of comfort and their accommodation capacity
O4. Calculation of the main indicators of tourist circulation
O5. Identifying the presence of tourist structures in the village of Porumbacu de Sus on various promotion and reservation platforms.

RESULTS AND DISCUSSIONS

O1. Description of the rural tourism and agrotourism potential of Sibiu County, Romania

Sibiu County covers an area of 5,432 km² and had a resident population of 393,776 inhabitants as of January 1, 2024, of which 37.2% lived in rural areas [31]. Sibiu County is among the counties with high rural tourism potential, primarily due to its natural tourist resources in the mountainous region and the existence of villages where traditions and the lifestyle derived from the residents' main occupations are well preserved, complemented by the authenticity of the area.

The mountainous area of Sibiu County represents approximately 30% of the county's surface and is a region where rural tourism and agrotourism blend with mountain and adventure tourism. Within the county, there are two ecotourism destinations: ”Mărginimea Sibiului” and ”Colinele Transilvaniei”, which are part of the Discover Romania network.

The inhabitants of mountain villages generally have a more developed entrepreneurial spirit, with many starting rural tourism businesses that contribute to the sustainable development of villages and stimulate local economic and social growth. The development of tourism in Sibiu County was influenced by the designation of the county’s capital city as the European Capital of Culture in 2007 and the achievement of the title European Gastronomic Region in 2019. Additionally, in 2021-2022, Sibiu hosted EuroRando, the largest European hiking event, with the support of the European Ramblers Association. All these efforts have resulted in the international recognition of Sibiu County, the development of a network of tourist information centres, the creation of thematic tourist routes, the marking and maintenance of mountain trails, and the organization of numerous tourism programs and events. Notable examples include "Anii Drumeției" (The Hiking Years) and the Ecotourism Fair, held under the patronage of the Sibiu County Council and the Sibiu County Tourism Association [33]. At the beginning of 2025, the tourism accommodation infrastructure in Sibiu County included 1,060 accommodation units [13]. By type, the largest shares were held by rental rooms (30.85%), tourist guesthouses (26.60%), rental apartments (18.96%), and hotels (8.96%), together accounting for over 85% of the county's total accommodation offer. The rural localities with the highest number of tourist accommodation structures in Sibiu County are: Săliște and its affiliated villages Galeș, Fântânele, Sibiel, and Vale (61 units), Cârțișoara (48 units), Porumbacu de Jos, including its villages Colun, Sărata, and Porumbacu de Sus (35 units), Gura Râului (34 units), Rășinari (31 units), Poplaca (26 units), Șelimbăr (32 units), Bazna (19 units), and Biertan (16 units).The tourist accommodation structures in the rural areas of Sibiu County are generally small-scale and highly diverse, including tourist guesthouses, agrotourism guesthouses, cabins, villas, hostels, campsites, camping cottages, rental rooms, and apartments. However, a few hotels can also be found in the rural areas of Sibiu County. The evolution of the number of tourist and agrotourism guesthouses in Sibiu County between 2022 and 2024 is presented in Figure 1. Compared to 2022, there is a declining trend in their number.

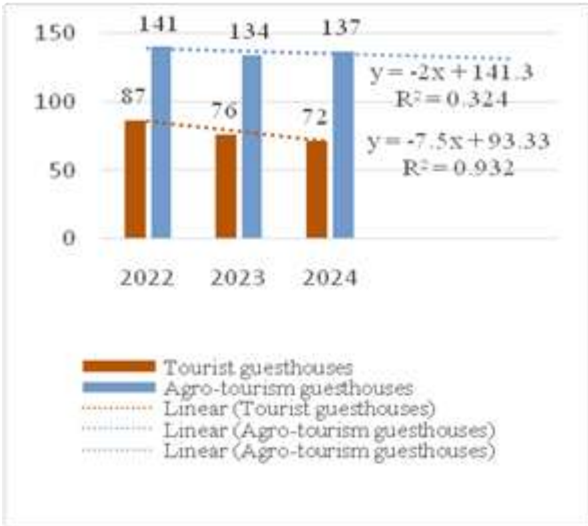

Fig. 1. Evolution of the number of tourist and agrotourist guest houses in Sibiu County, Romania, 2022-2024.
Source: [24].

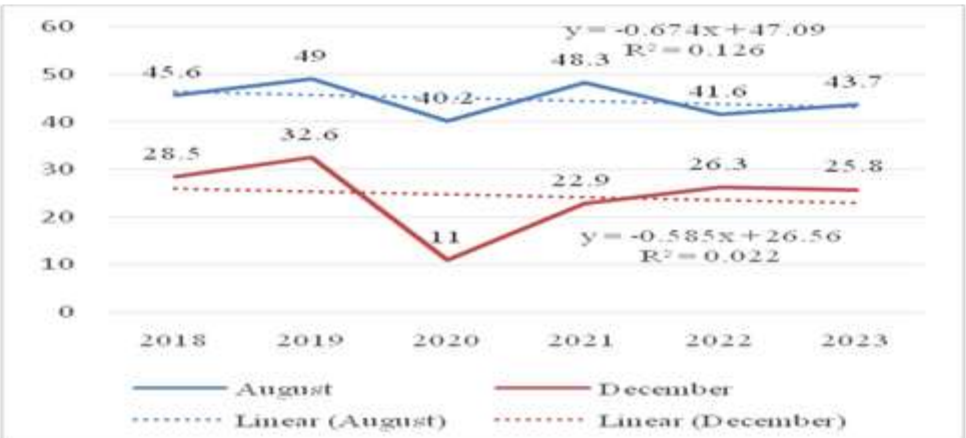

Fig. 2. Evolution of the net utilization index of Accommodation capacity in Sibiu county, during 2018-2023
Source: [24].

During the period 2018–2023, as expected, the net occupancy rate of accommodation capacity in Sibiu County recorded its lowest values during the Covid-19 pandemic, specifically in 2020. That year, the occupancy rate was 40.2% in August and dropped to 11% in December (Figure 2).

O2. General Information on the Tourism Potential of Porumbacu de Jos Commune, Sibiu County, Romania

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The Porumbacu de Jos Commune is located in the Făgăraș Depression and is part of the ethnogeographic region known as "Țara Oltului". It has been documented since the year 1223. The commune consists of five villages, covering a total area of 18,468 hectares, of which 10,378 hectares are agricultural land (of which arable land is 2,921 ha). Additionally, 34% of its territory is covered by forests and forest vegetation (Figure 3).

Fig. 3. The location of the village of Porumbacu de Sus (a) on the map of ethnogeographic areas of Sibiu County (b), and (c) images from the tourist attractions in the village ("Clay Castle" and "The Story of the Calendar", 2024)
Source: own design based on: [34].

In ”Țara Oltului”, the traditional occupation of the locals was animal husbandry and agriculture. In many villages within this area, the craft of leather processing developed in close connection with the needs of the inhabitants. Traditional folk attire in the region still includes numerous leather and fur garments, such as sheepskin coats (cojoace), vests (pieptare), and hats (căciuli). Between the 16th and 18th centuries, glass manufacturing workshops also emerged in the area.

The village of Porumbacu de Sus is administratively part of the Porumbacu de Jos commune. It is located in the mountainous area of Sibiu County, at the foot of the Făgăraș Mountains, approximately 40 km from Sibiu, the county seat. The village lies at the base of Negoiu Peak in the Făgăraș Mountains and covers an area of approximately 91 hectares. According to the 2011 census, the village had a population of around 832 inhabitants [29]. As of January 1, 2024, the total population of the commune was 3,245 inhabitants.

According to the local development strategy, the Porumbacu de Jos commune offers various types of tourism products, with notable highlights including mountain tourism, leisure tourism, and adventure tourism.

From the village of Porumbacu de Sus, visitors can access hiking trails leading into the Făgăraș Mountains. Thanks to the facilities provided by local tourism businesses, visitors can engage in a variety of

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activities, including fishing and hunting, cycling, horseback riding, hiking, ATV rides, climbing, snowboarding, paragliding, zip-lining, and even outdoor movie screenings in the forest. Additionally, tourists can enjoy the local gastronomy, experiencing traditional culinary delights. The commune has preserved the tradition of "Șezătoarea" (traditional gatherings) and the customs specific to winter holidays, keeping the local cultural heritage alive.

The local public administration has implemented various projects, including the rehabilitation of a public recreational space and the development of a multifunctional area for hosting cultural events.

Future plans include the construction of a bicycle path, the development of a parking area in the tourist zone, and the creation of a bypass road around the village to provide direct access to the tourist area [29].

Out of the 33 local gastronomic points registered in Sibiu County between 2018 and 2025, two are in the analysed commune, specifically in the villages of Colun and Porumbacu de Sus [22]. These establishments can accommodate groups of up to 15 people for dining, offering visitors a taste of the region's culinary traditions.

In addition, the commune is home to two local producers registered in the national "Mountain Product" register, managed by the National Agency for the Mountain Area [23]. One producer, based in Sărata village, specializes in organically grown vegetables, while another, from Porumbacu de Sus, produces and sells various types of honey, contributing to the preservation of traditional and sustainable agricultural practices.

O3. Data on the number of tourist establishments by type, comfort level, and accommodation capacity

Table 1. The number of tourist establishments, comfort level, and accommodation capacity in Porumbacu de Jos commune in the year 2024

Type of tourist structure	No	Comfort level (stars/flowers)					No. of rooms	No. of seats
		1	2	3	4	5		
Porumbacu de Sus Village								
Tourist guesthouse	7	-		4	3	-	49	109
Agrotourism guesthouse	3	-	-	2	1	-	19	40
Camping cottages	1	-	-	1	-	-	2	4
Apartments for rent	4	1		3	-	-	5	35
Rooms for rent	8	-	3	5		-	35	66
TOTAL accommodation capacity Porumbacu de Sus village	**23**	**1**	**3**	**15**	**4**	**-**	**110**	**254**
Porumbacu de Jos Village								
Tourist guesthouse	4	-	1	2	1	-	25	51
Rooms for rent	2	-	2	-	-	-	12	25
TOTAL accommodation capacity Porumbacu de Jos village	**6**	**-**	**3**	**2**	**1**	**-**	**37**	**76**
Colun Village								
Tourist pension	1	-	-	-	1	-	2	4
Agrotourism pension	1	-	-	1	-	-	2	4
TOTAL accommodation capacity Colun village	**2**	**-**	**-**	**1**	**1**	**-**	**4**	**8**
Sărata Village								
Agrotourism pension	1	-	-	-	1	-	3	6
Rooms for rent	1	-	-	1	-	-	4	8
Camping	1	1	-	-	-	-	5	20
Cabin	1	-	1	-	-	-	26	111
TOTAL accommodation capacity Sărata village	**4**	**1**	**1**	**1**	**1**	**-**	**38**	**145**
Total accommodation capacity Porumbacu de Jos commune	**35**	**2**	**7**	**19**	**7**	**-**	**189**	**483**

Source: own design based on [13].

According to the Ministry of Economy, Digitalization, Entrepreneurship, and Tourism the number of tourist establishments in Porumbacu de Jos commune are classified by capacity and comfort level as presented in Table 1.

In the village of Porumbacu de Sus, there are 23 classified tourist establishments offering accommodation, with a total capacity of 254 beds. Most of these establishments consist of rental rooms and apartments (52.17%), followed by tourist guesthouses (30.43%). Most accommodations have a rustic charm, often incorporating the traditional architectural style of Transylvanian rural houses. In terms of comfort classification, the largest share belongs to three-star/three-flower establishments (65.21%), followed by four-star/four-flower accommodations (17.39%) and two-star/two-flower options (13.04%). The village also has a single family-style restaurant, classified as a two-star establishment.

It is worth noting that there are discrepancies between the data provided by the National Institute of Statistics (NIS) and those reported by the Ministry of Economy, Digitalization, Entrepreneurship, and Tourism regarding the number of accommodation units. For the year 2025, the Ministry's website lists 35 classified tourist structures, while the NIS reports 18 tourist establishments in the analyzed commune.

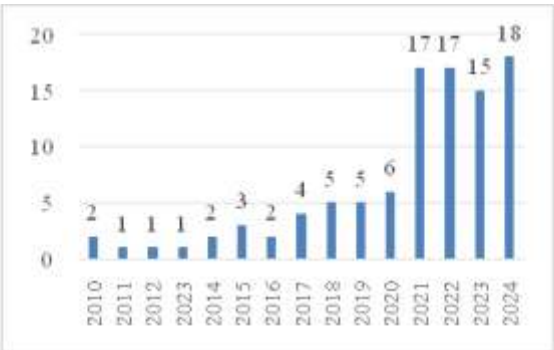

Fig. 4. Evolution of the number of accommodation structures in the commune of Porumbacu de Jos
Source: processing based on [24].

Fig. 5. Evolution of the number of overnight stays in Porumbacu de Jos commune (number of overnight stays)
Source: processing based on [24].

Based on data from the National Institute of Statistics, Figure 4 presents the dynamics of the number of tourist accommodation structures in Porumbacu de Jos commune between 2010 and 2024.

The evolution of the number of available accommodation places is shown in Figure 5. The operational accommodation capacity reached its highest value in 2024, summing 6,944 place-days, closely correlating with the increased number of tourist establishments.

O4. Determination of Key Indicators of Tourist Circulation

Tourist circulation density reflects the relationship between tourist traffic and the resident population as of January 1st. During the period 2021-2023, this indicator recorded a value greater than one, indicating a higher number of tourists relative to the local population (Figure 6).

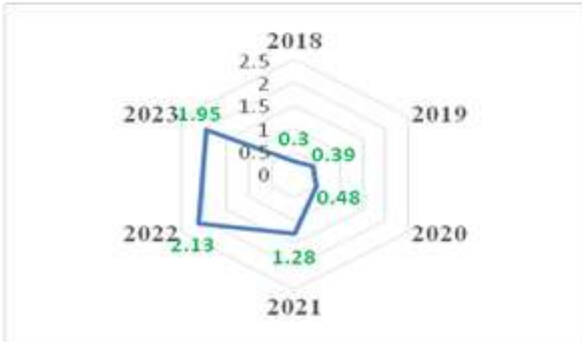

Fig. 6. Dynamics of tourist traffic density in Porumbacu de Jos commune, between 2018-2023
Source: Own calculation based on [24].

Fig. 7. Dynamics of tourist traffic intensity Porumbacu de Jos commune, between 2018-2023 Source: Own calculation based on [24].

The data in Figure 6 show that between 2018 and 2023, the tourist flow density reached its lowest value of 0.30 in 2018 and peaked at 2.13 in 2022. In comparison, in Gura Râului, a tourist village in Mărginimea Sibiului with 34 accommodation structures, the highest tourist traffic density was 2.04 in 2022 [36].

The lowest value of tourist traffic intensity was recorded in 2019, at 0.59, while the highest value, 3.98, was reached in 2022 (Figure 7). In comparison, in Gura Râului, the highest tourist traffic intensity was 3.86 in 2022 [36].

The degree of tourism development in the studied area can be assessed based on the tourism operation rate, calculated as the number of tourist accommodation establishments relative to the resident population as of January 1st. For 2024, this indicator has a value of 0.108, significantly exceeding the corresponding value for Gura Râului commune, which was 0.08 in 2022 [36].

O5. Identifying the Presence of Tourist Establishments in Porumbacu de Sus on Various Promotion and Booking Platforms as Part of Tourism Marketing

During the Covid-19 pandemic, virtual tourism emerged as an integral part of sustainable tourism, combining virtual reality and gamification with content promoted through social media platforms. This evolution has been further enhanced by the integration of artificial intelligence, the Internet of Things, Big Data, machine learning, and GIS technologies. As part of the smart tourism ecosystem, virtual social platforms can play a significant role in promoting tourism sustainability by offering immersive experiences, improving accessibility, and optimizing resource management [25]. The profile of the smart tourist [16] describes an experienced traveller who actively uses smart technologies and maintains close connections with various tourism stakeholders. This engagement fosters interaction between different actors in the tourism sector and contributes to the co-creation of tourism content, enhancing both personalized experiences and destination marketing.

The internet is the primary source of information for tourists [37], serving not only as a tool for gathering travel details but also for trip planning, booking tourism services, and leaving reviews after their stay [12]. In recent years, alongside the creation of web pages for tourism operators, various digital tools designed for tourism—such as virtual tours and augmented reality—have significantly contributed to the industry's growth by offering interactive sensory experiences.

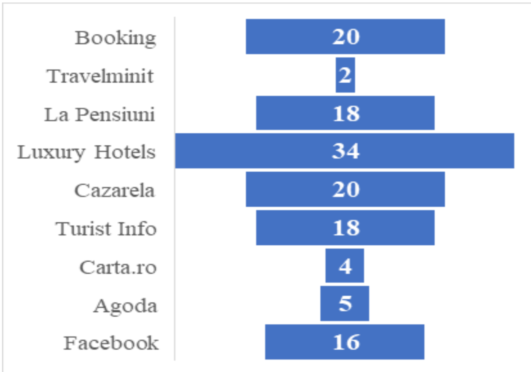

Fig. 8. Number of tourist accommodation structures in Porumbacu de Jos commune present on promotion and reservation platforms
Source: own design.

Fig. 9. Most common words found in tourist reviews
Source: own design based on [5].

A 2024 study analyzed the websites of 154 wineries to assess how wine tourism is promoted in Romania, highlighting that most winery owners have limited digital skills [40]. For Porumbacu de Jos commune, an analysis was conducted on the presence of tourist accommodation establishments on major promotion and booking platforms (Figure 8). On Booking.com, there are 1,192 reviews, with ratings ranging between 8.9 and 9.9.

Tourist reviews frequently highlight the quality and comfort of the locations, the peaceful atmosphere, natural surroundings, hospitality of hosts, attention to detail in courtyard arrangements, responsiveness to visitor needs, and the uniqueness of the experience (Fig. 9).

Local Tourist Attractions

The popularity of Porumbacu de Sus as a rural tourism destination has been significantly influenced by entrepreneurial initiatives. One of the key attractions is “Povestea Calendarului” (The Calendar Story), a theme park established in 2021, covering approximately 15,000 square meters. The park features 12 uniquely designed cottages, each representing a month of the year, under the "patronage" of a specific folklore character [39] (Photo 1 and 2).

Visitors to “Povestea Calendarului” can explore the folklore story of each month and take part in a variety of activities, such as gastronomy workshops, pottery, and creative workshops in painting, sculpture, and decorative crafting, all tailored to different age groups. Additionally, the park hosts music, theater, and dance performances, enriching the cultural experience. According to park representatives, in August 2022, “Povestea Calendarului” welcomed approximately 4,000 visitors, of whom around 30% were foreign tourists, highlighting its growing international appeal.

The smooth operation of the theme park is supported by a team of 16 employees, ensuring a high-quality visitor experience. Additionally, the location features a restaurant with a seating capacity of welcoming and immersive setting.

The first man-made tourist attraction in the area was established in 2014 and has since become widely known as the "Clay Castle" (Castelul de Lut) (Photo 3 and 4).


Photo 1 and Photo 2 Images from the "Calendar Story" theme park, Porumbacu de Sus village, Romania, 2024
Original photos.

Located in a picturesque mountain landscape, near the Făgăraș Mountains, within the tourist area of Porumbacu de Sus, the Clay Castle (Castelul de Lut) has gained widespread popularity due to its unique architecture and extensive promotion on social media platforms. These factors have contributed to the attraction drawing thousands of visitors annually.

Currently, the site features a restaurant, and in 2025, a luxury hotel is set to open, further enhancing the visitor experience and accommodation options.

Other successful rural tourism businesses in the area include The guesthouse "Dealul Verde", where the owners have created themed rooms carved into a hillside, each representing a traditional craft—such as the farmer’s room, blacksmith’s room, carpenter’s room, and weaver’s room. The guesthouse offers full board or half board, with menus based on traditional cuisine [8].

Another notable venture is a tourism complex consisting of eight restored traditional houses, owned by a well-known journalist [30].

Additionally, Pensiunea "Porumbacu 316" is housed in a renovated traditional home and is owned by a nationally renowned singer. This location also features a local gastronomic point, enhancing its appeal to visitors seeking authentic culinary experiences.

Photo 3 and Photo 4. Images of the premises of the Valley of the Fairies (”Valea Zânelor”) location – The ”Clay Castle” (”Castelul de Lut”), Porumbacu de Sus, Romania (April, 2024).
Source: Original photos.

CONCLUSIONS

In addition to agriculture and animal husbandry, the residents of Porumbacu de Jos commune can and should fully capitalize on the area's natural and man-made tourism potential, bringing social, environmental, economic, and cultural benefits.

Although the commune currently enjoys significant popularity and ranks third in Sibiu County in terms of the number of established tourist structures, further efforts are needed to enhance market-oriented promotion and digitally transform the tourism offering. A dedicated website and a mobile application would be essential tools for promoting the commune's tourism potential, improving visitor accessibility, and consolidating its position as a leading rural tourism destination.

In the past, Porumbacu commune was primarily known as a gateway to hiking trails in the Făgăraș Mountains. Today, however, it has evolved into a highly popular rural tourism destination, attracting both national and international visitors.

The commune boasts a well-developed accommodation infrastructure, providing tourists with authentic experiences and numerous opportunities to engage in outdoor activities surrounded by nature.

Investments are needed in the development of cycling routes, the restoration and maintenance of mountain trail markings, and the organization of cultural events to attract more visitors. Additionally, better signage for the tourist area is essential, including the installation of directional signs and informational panels, improving accessibility and enhancing the overall visitor experience.

The local community must ensure the sustainable management of its tourism resources, as tourism serves as a key driver of local development.

The attractiveness and popularity of a rural tourism destination depend on a wide range of factors, including the location of the village, the beauty of the landscape, accessibility, the preservation of traditions and local crafts, the quality of services, the hospitality of hosts, and the availability of unique and authentic experiences. Additionally, the presence of traditional households and the effective promotion of both natural and cultural tourism resources play a crucial role in enhancing the destination's appeal.

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STUDY ON THE IMPACT OF THE CIRCULAR ECONOMY IN AGRICULTURE AND RURAL DEVELOPMENT THROUGH NON-REFUNDABLE FUNDS

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Abstract

This paper analyzes the distribution of projects financed under the measure DR 30 – Installation of young farmers during the period January-December 2024, with a focus on the implementation of criterion 6.3 (modern technologies, renewable energy, automatic irrigation). The study highlights regional differences in accessing the measure, as well as the main benefits and difficulties encountered by farmers. The sources of information are the database from Agency for Financing Rural Investments (AFIR, selection of reports and the questionnaire applied to farmers, and the methods used are descriptive analysis, the chi-square test as well as statistical interpretation and correlation of results. The results show that most projects were financed in the North-West (1,612 projects) and South-Muntenia (422 projects) regions, while Bucharest-Ilfov (45 projects) and Center (161 projects) had a low representation. Only 40.7% of farmers applied criterion 6.3, the main technologies that started to be implemented by the end of 2024 were sensors for monitoring crops (7 responses) and automatic irrigation systems (5 responses). The benefits reported by farmers included increased productivity (70%) and reduced production costs (30%). Among the major difficulties identified, administrative problems (68.8%), lack of technical support (58.3%) and high implementation costs were highlighted. Farmers highlighted the need for continuous support from authorities (55.8%) and technical training sessions (18.6%) to encourage the adoption of modern technologies. The findings suggest the need for tailored regional policies to reduce administrative barriers, facilitate access to sustainable technologies and improve technical education among farmers.

Key words: *modern technologies, modern agriculture, non-reimbursable funding, rural development, sustainable technologies*

INTRODUCTION

Modern agriculture is in a period of transition, where emerging technologies such as automation, artificial intelligence [8] and renewable energy play an increasingly important role in increasing farm productivity and sustainability [5]. In this context, DR measure 30 – "Setting up young farmers" – is an essential tool to support farmers in adopting innovative and sustainable farming practices. This measure aims not only to support young farmers through financing, but also to promote the use of modern technologies with low environmental impact, through criteria such as 6.3, which encourages the implementation of automated irrigation systems, renewable energy and digital solutions [1]. However, the adoption of these technologies varies significantly between the development regions of Romania, being influenced by factors such as access to resources, technical support and administrative barriers [3]. Recent studies by Romanian authors show that regions such as Southwest Oltenia and Northwest have greater access to modern technologies due to local initiatives and financial support [10, 4]. Other research highlights the need for technical training and continuous support for farmers as critical factors in the adoption of modern solutions [7]. Romania accessed European funds for agriculture and rural development during the period 2014-2020. During this funding period, Romania received over 8.12 billion euro's from the European Union budget, namely from the European Agricultural Fund for Rural Development (EAFRD), through the National Rural Development Program (NRDP) [13] [12]. To use new technologies to achieve real improvement and to increase productivity in a business can only be achieved by analysing the current state of the company [11]. Romanian agriculture began to develop with the entry into the European Union, thus a strong pressure factor was installed to modernize Romanian agriculture and economy.

The main agricultural products, cultivated in Romania are: wheat, potatoes, corn, sunflower, rapeseed, peas, beans, red and yellow melons. The year 2020 represented a deadlock for the economy and agriculture, and besides the pandemic, another problem that affected agriculture was drought, being one of the most serious in the last 50 years. The agricultural sector suffered due to the pandemic, because it only produced negative effects on the activity of farmers and on their opportunity to sell the resulting production. Agriculture is an industry that requires numerous investments, but this can only be achieved with the active help of the state and farmers. An improvement is necessary both in the systems used to care for crops, and in the equipment used. Thus, future directions in machine learning intervene here. For now, Romania is in the early stages of applying artificial intelligence methods, but companies have already emerged that offer consultancy and various programs to achieve quality agriculture.

The circular economy plays an essential role in the sustainable development of agriculture, by reducing resource waste and promoting the reuse of biological and energy materials, Popescu emphasizes that the application of this concept in farms can contribute to reducing production costs and improving energy efficiency, by adopting solutions such as composting organic waste and using bioenergy [9]. In a study on circular economy models applied in agricultural holdings, Ionescu shows that the integration of smart irrigation systems, precision agriculture and renewable energies can significantly contribute to reducing the consumption of natural resources. These models allow for an optimization of agricultural inputs and an increase in long-term sustainability [6].

On the other hand, Dumitrescu highlights the fact that, in Romania, the degree of implementation of the circular economy in agriculture is still low, and adapted policies and strategies are needed to stimulate the adoption of this model. Among the main challenges mentioned are the lack of access to technology, high costs, and lack of training for farmers in the use of sustainable solutions [2].

In this context, the research goal is to assess the distribution of projects financed under the measure DR 30 – "Installation of young farmers during the period January-December 2024", emphasizing the implementation of criterion 6.3 regarding modern technologies, renewable energy, automatic irrigation. also, regional differences, benefits and difficulties to access this measure have been highlighted.

MATERIALS AND METHODS

The study was conducted between January and December 2024 and had as its main objective the analysis of the impact of the implementation of modern technologies, on the development of agriculture in Romania through the DR 30 measure - "Settlement of young farmers". The analysis targeted all development regions of Romania (North-East, South-East, South-Muntenia, South-West Oltenia, West, North-West, Center and Bucharest-Ilfov).

The primary data set consisted of:

-***Data provided*** by the Agency for Financing Rural Investments (AFIR), extracted from reports published online, which included information on the number of projects financed, the total value of funds granted (70,000 euros/project), and the selection criteria met, including criterion 6.3 ("Promoting modern production technologies and techniques with reduced environmental impact and streamlining the use of natural resources").

-***A questionnaire*** applied to the beneficiaries of the DR 30 measure, to obtain qualitative and quantitative data on the effective implementation of the projects, the difficulties encountered and the impact of the technologies used. The questionnaire was completed by a sample of farmers selected from each development region.

The analysis was carried out in two main directions:

(i)Statistical evaluation of data on the total number of projects financed, their value and distribution by regions.

(ii)Analysis of questionnaire responses to identify the impact of technologies promoted through criterion 6.3.

Statistical methods: descriptive analysis, chi-square test .

To understand the relationship between the development region and the implementation of criterion 6.3, we used the Chi-square test. This test helps us verify whether the differences observed between projects that complied with criterion 6.3 or not are significant or coincidental.

How the analysis was done?

(a)We organized the projects according to development regions and separated the projects that met criterion 6.3 from those that did not.

(b)Chi-square test, with the formula below:

$$X^2 = \Sigma\frac{(O-E)^2}{E} \qquad (1)$$

where:

O – observed value (actual number of projects for each category);

-E – expected value.

(c)P-value: after calculating the X^2 value, we determined the probability p, which shows whether the differences are significant. If $p<0.05$, it means that the differences are real, not random.

Questionnaire: The questionnaire was structured into 8 questions (6 closed and 2 open), being applied online via Google Forms. The questions were designed to obtain clear information about:

- Development region (Question 1).
- Project implementation status (Questions 2).
- Obtaining additional points for criterion 6.3 and the technologies used (Questions 3, 4).
- Impact of technology implementation (Question 5).
- Difficulties encountered (Questions 6, 7, 8)

RESULTS AND DISCUSSIONS

During January - December 2024, at national level, 3,306 projects (70,000 euros each project) were financed through measure DR 30 Installation of young farmers, with a total eligible value of 231,420,000 euros, of which 48 projects received a score for selection criterion 6.3, and the remaining 3,258 projects did not receive a score for this selection criterion, from which it can be seen that 1.47% of the total number of projects received a score through this selection criterion (Table 1).

Table 1. Situation of projects financed with or without criterion 6.3 - modern technologies, renewable energy, automated irrigation

Publication date	Number of projects in each region															
	R 1 North East		R 2 South East		R 3 S. Muntenia		R 4 SW Oltenia		R 5 West		R 6 North West		R 7 Center		R 8 B. Ilfov	
	Without CS 6.3	With CS 6.3	Without CS 6.3	With CS 6.3	Without CS 6.3	With CS 6.3	Without CS 6.3	With CS 6.3	Without CS 6.3	With CS 6.3	Without CS 6.3	With CS 6.3	Without CS 6.3	With CS 6.3	Without CS 6.3	With CS 6.3
Feb. 2024	7	0	13	2	1	0	0	0	29	0	257	0	33	0	0	0
Mar. 2024	5	0	27	0	25	8	24	1	94	1	80	0	5	0	6	0
Apr. 2024	9	0	10	0	5	0	6	0	105	2	291	2	63	0	0	0
Jun 2024	17	0	71	0	236	2	189	15	192	2	751	0	19	0	30	1
Jul. 2024	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Aug. 2024	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Nov. 2024	21	0	41	0	143	2	47	9	125	1	231	0	40	0	8	0
Total projects with/without CS 6.3	**59**	**0**	**162**	**2**	**410**	**12**	**267**	**25**	**545**	**6**	**1,610**	**2**	**161**	**0**	**44**	**1**
Total projects	**59**		**164**		**422**		**292**		**551**		**1,612**		**161**		**45**	

Source: Own calculation based on afir.ro [1].

In Development Region 1 (North-East) there were 59 funded projects, this region did not register any projects that met criterion 6.3, indicating a non-existent adoption of modern technologies. Region 2 (South-East) had 164 funded projects, but only 2 of them integrated criterion 6.3, suggesting a limited openness towards sustainable solutions. Region 3 (South-Muntenia) out of the 422 funded projects, 12 obtained additional points by applying criterion 6.3, positioning the region among the most open to modern technologies. Region 4 (South-West Oltenia) registered 292 funded projects, of which 25 met criterion 6.3, demonstrating a significant adoption of innovative solutions. Region 5 (West) with 551 funded projects had only 6 projects compliant with criterion 6.3, which highlights a modest adoption of modern technologies in relation to the total number of projects. Region 6 (North-West), with 1,612 projects funded, is the region with the highest volume of funding, but only 2 projects met criterion 6.3, highlighting an extremely low adoption of sustainable technologies. Region 7 (Center), out of the 161 projects funded, none integrated criterion 6.3, indicating a major lack of access to modern technologies. Region 8 (Bucharest-Ilfov) with only 45 projects funded, had only one project that met criterion 6.3, reflecting a minimal interest in sustainable solutions (Table 1).

Table 2. Contingency table for the number of projects that comply and do not comply with criterion 6.3

Region	Projects without 6.3.	Projects with 6.3	total
1. North East	59	0	59
2. South East	162	2	164
3. South Muntenia	410	12	422
4. South West Oltenia	267	25	292
5. West	545	6	551
6. North West	1,610	2	1,612
7. Center	161	0	161
8. Bucharest - Ilfov	44	1	45
Total	3,258	48	3,306

Source: Own calculation based on afir.ro [1].

Table 3. Chi-square test results and associated probabilities (p-value) for each region

Region	Chi-square (Without 6.3)	Chi-square (Cu 6.3)	Total Chi-square	P-value
1. North East	0.01	0.86	0.87	0.0000000002
2. South East	0.00	0.06	0.06	0.0000000002
3. South Muntenia	0.08	5.63	5.71	0.0000000002
4. South West Oltenia	1.50	101.66	103.16	0.0000000002
5. West	0.01	0.50	0.51	0.0000000002
6. North West	0.29	19.58	19.87	0.0000000002
7. Center	0.03	2.34	2.37	0.0000000002
8. Bucharest - Ilfov	0.00	0.18	0.18	0.0000000002

Source: Own calculation.

In Region 1 North-East, the differences between observed and expected projects are very small (Total Chi-square = 0.87), in this region, criterion 6.3 does not have a significant influence.

In the case of Region 2 Southeast, the differences are insignificant (Total Chi-square = 0.06), most projects did not apply criterion 6.3. In Region 3 South-Muntenia the differences are moderate (Total Chi-square = 5.71), which shows that this region has a greater openness towards criterion 6.3.

In the case of Region 4 South-West Oltenia, the differences are very large (Total Chi-square = 103.16), indicating a high use of criterion 6.3. Farmers in this region were among the most active in applying this criterion. In Region 5 West, the differences are very small (Total Chi-square = 0.51), this region has a low influence on criterion 6.3. In Region 6 North-West, the differences are large (Total Chi-square = 19.87), indicating a significant influence on the adoption of criterion 6.3. In Region 7 Center, the differences are insignificant (Total Chi-square = 2.37), few farmers applied for the score on criterion 6.3. In Region 8 Bucharest-Ilfov the differences are very small (Total chi-square = 0.18), in this region, criterion 6.3 was rarely applied (Table 3).

The South-West Oltenia and North-West regions stood out with a significant adoption of criterion 6.3, due to the increased interest in modern technologies, such as renewable energy or automated irrigation. Regions such as North-East, West, and Bucharest-Ilfov had a reduced contribution, which suggests either a lack of access to resources or a low interest in applying the technologies promoted by criterion 6.3 (Table 3).

Figure 1 shows that the highest number of responses came from the South-West Oltenia Region (27.6%) and the South-Muntenia Region (20.7%), which coincide with the regions that had a higher adoption of criterion 6.3 in the overall analysis. Regions with lower participation include the North-West (13.8%), the West (13.8%), and the Center (10.3%), which suggests lower interest or representation in the questionnaire.

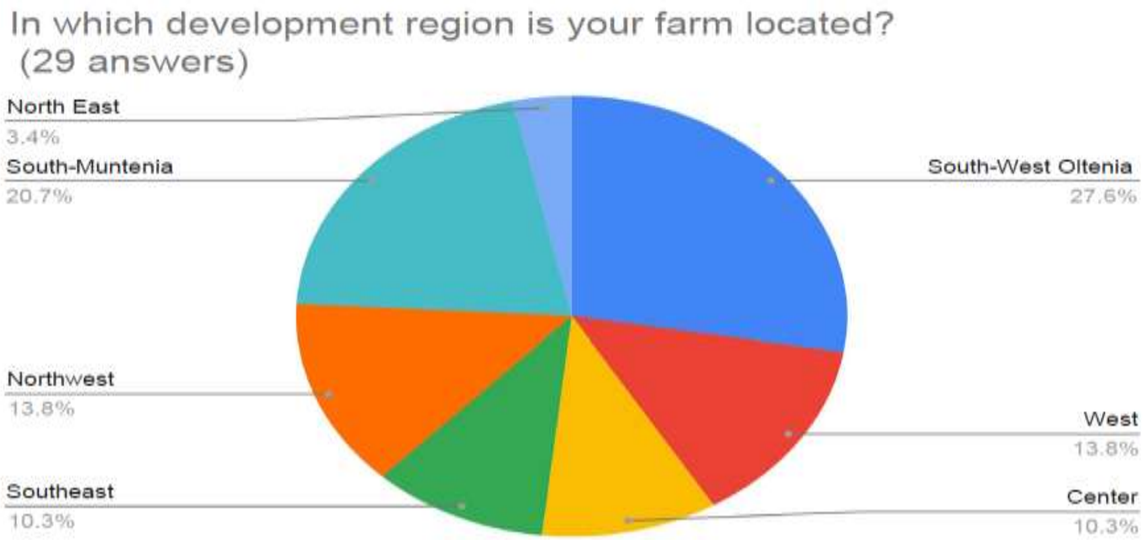

Fig. 1. The location of the farm by development region
Source: Own construction with google forms.

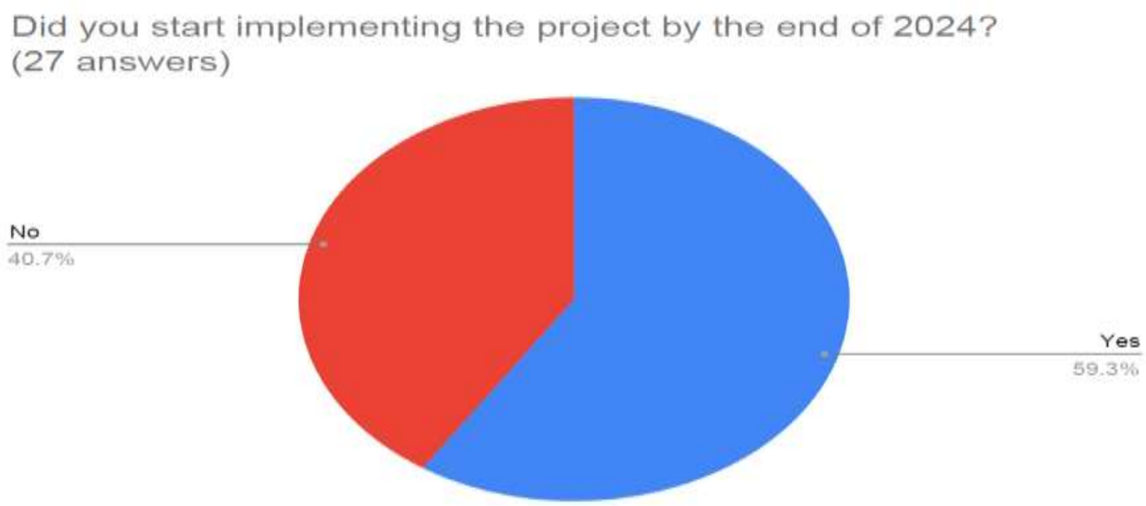

Fig. 2. Farmers who started and not started implementing projects by the end of 2024
Source: Own construction with google forms.

Figure 2 shows that 59.3% of farmers were able to start implementing the projects, suggesting a moderate degree of success. 40.7% were unable to start implementing the projects, and the reasons probably include administrative or financial difficulties, also reflected in subsequent responses. It is observed that 40.7% of farmers scored by applying criterion 6.3, which shows a relatively good interest in modern technologies. However, 59.3% did not apply this criterion, which indicates barriers in the adoption of promoted technologies (Figure 3).

Figure 4 shows that the most commonly used technologies were: Crop monitoring sensors (7 responses), Automatic irrigation systems (5 responses), Renewable energy (3 responses). More advanced technologies, such as farm management software (AI), are less frequently used (1 response), suggesting limited adoption of modern technologies.

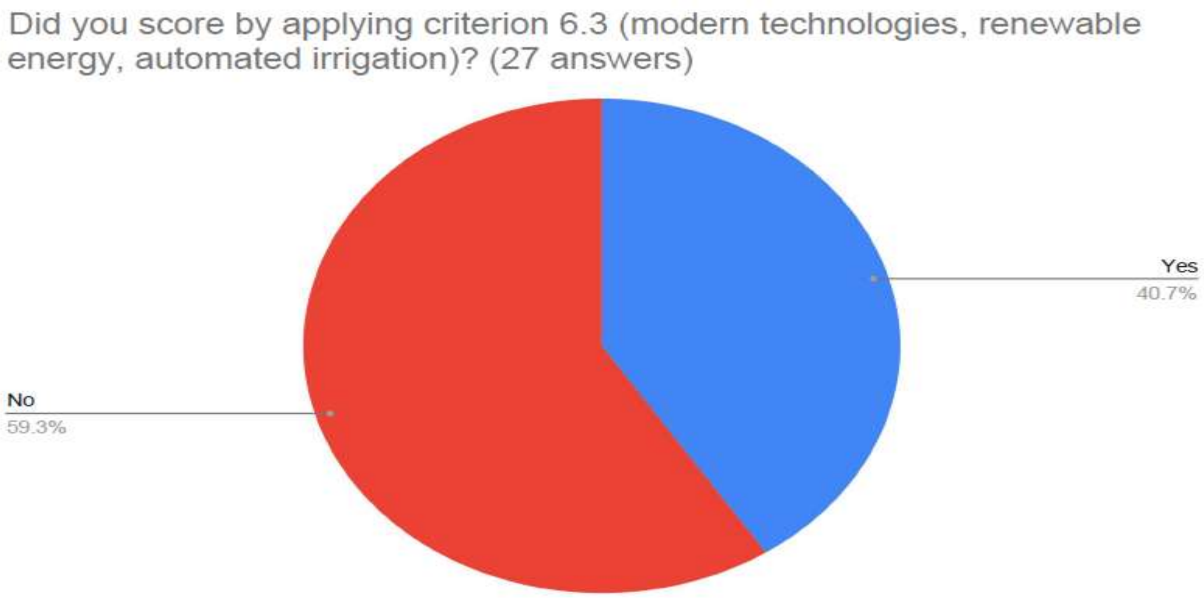

Fig. 3. Application of criterion 6.3
Source: Own construction with google forms.

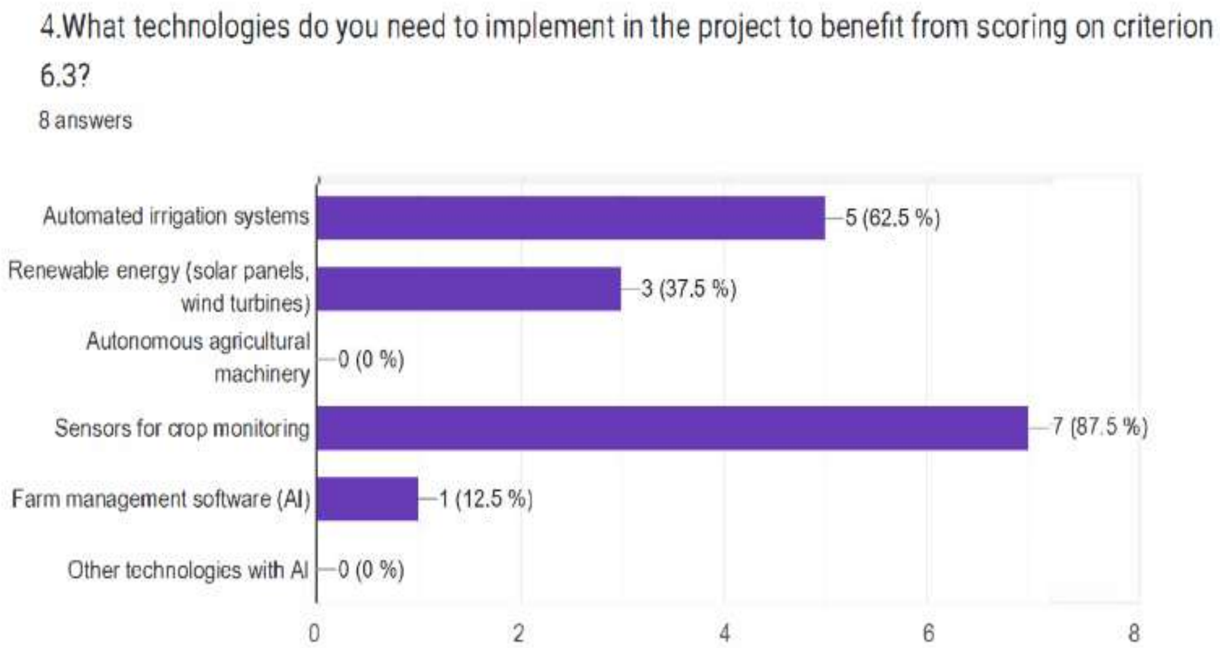

Fig. 4. Technologies to be implemented for criterion 6.3
Source: Own construction with google forms.

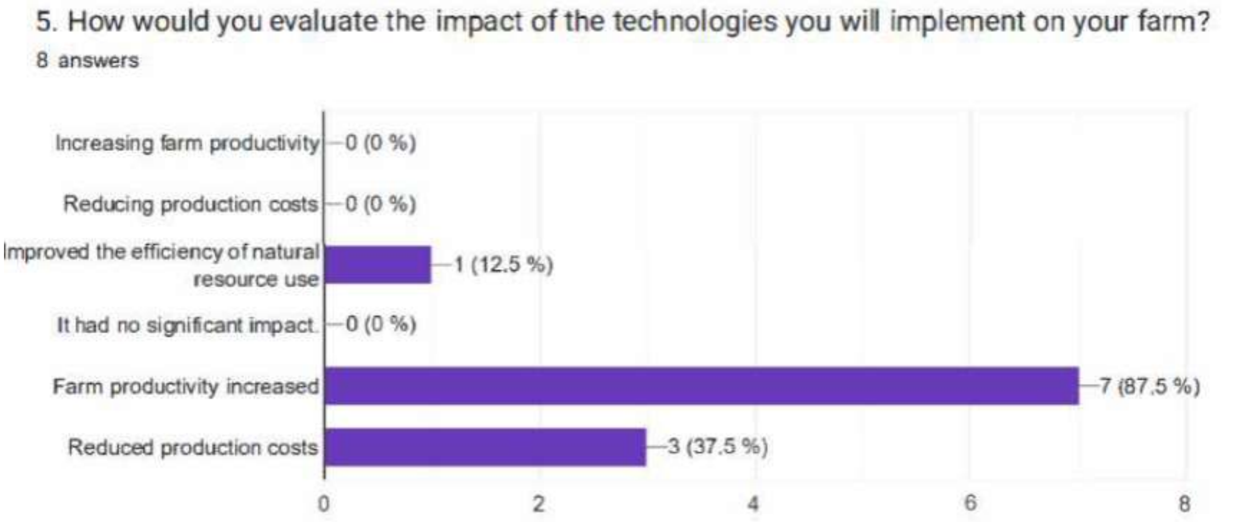

Fig. 5. The impact of the technologies that will be implemented
Source: Own construction with google forms.

Figure 5 shows the impact of the technologies to be implemented, that is, most farmers observed a positive impact, mentioning the following most frequently: Increased farm productivity (7 responses), reduced production costs (3 responses) and more efficient use of natural resources (1 response) are less common, which shows an untapped level of potential optimization.

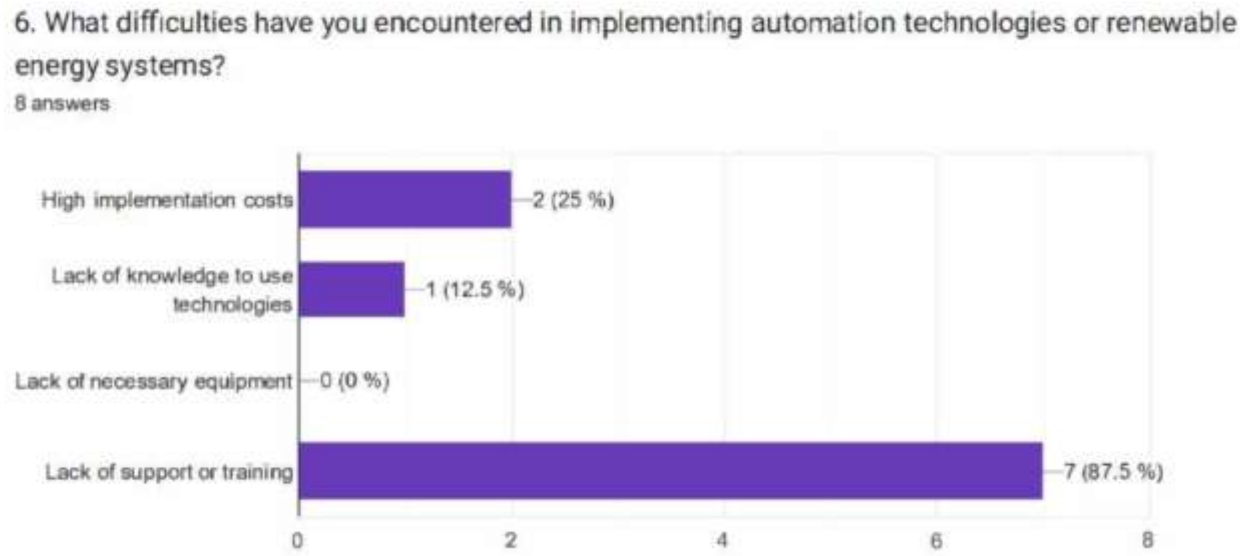

Fig. 6. Answers regarding the difficulties related to the implementation
Source: Own construction with google forms.

The main difficulties encountered in implementing projects are: Lack of support or training (7 responses), high implementation costs (2 responses), lack of knowledge for using technologies (1 response), this indicates a clear need for educational and technical support for farmers (Figure 7).

The most common reason for not implementing the project is administrative or bureaucratic problems (68.8%), which seem to be the main barrier. Other reasons include lack of additional financial resources (12.5%) and other priorities in farm management (18.8%) (Figure 7).

Farmers identified the following forms of support as the most useful: Continuous support from authorities (24 responses), training sessions and technical instruction (8 responses), other suggestions include specialized consultancy, additional funds and reduction of implementation costs, but are less common (Figure 8).

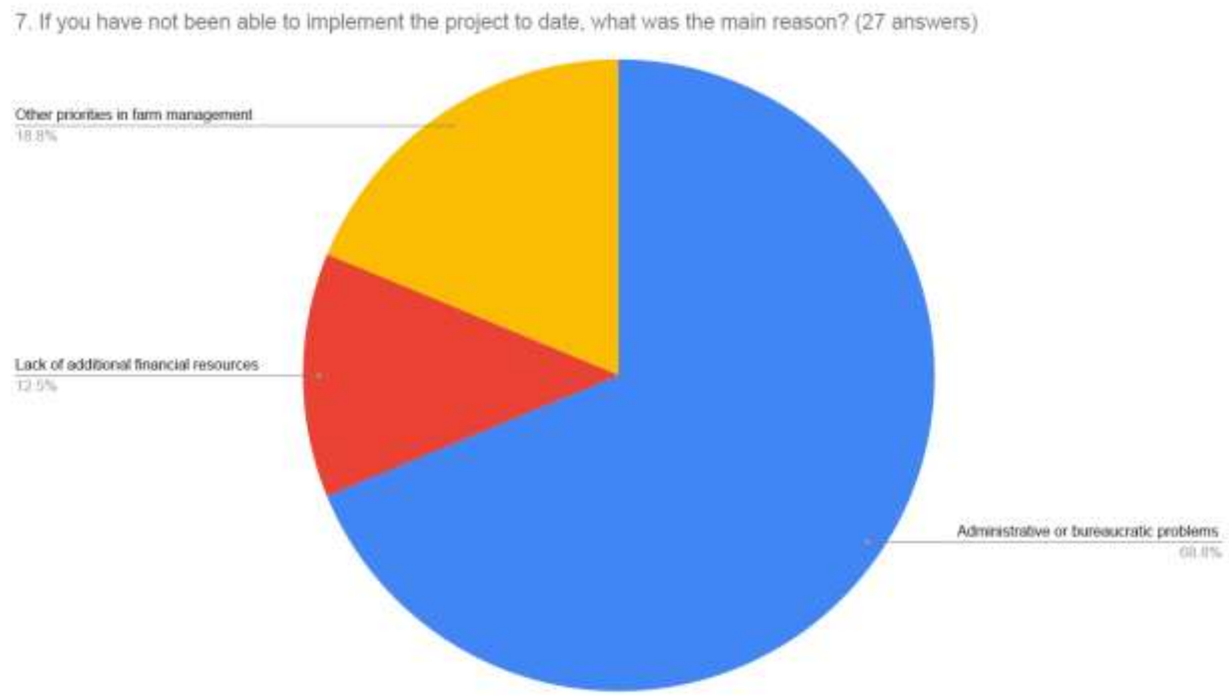

Fig. 7. Reasons why the project was not implemented on time
Source: Own construction with google forms.

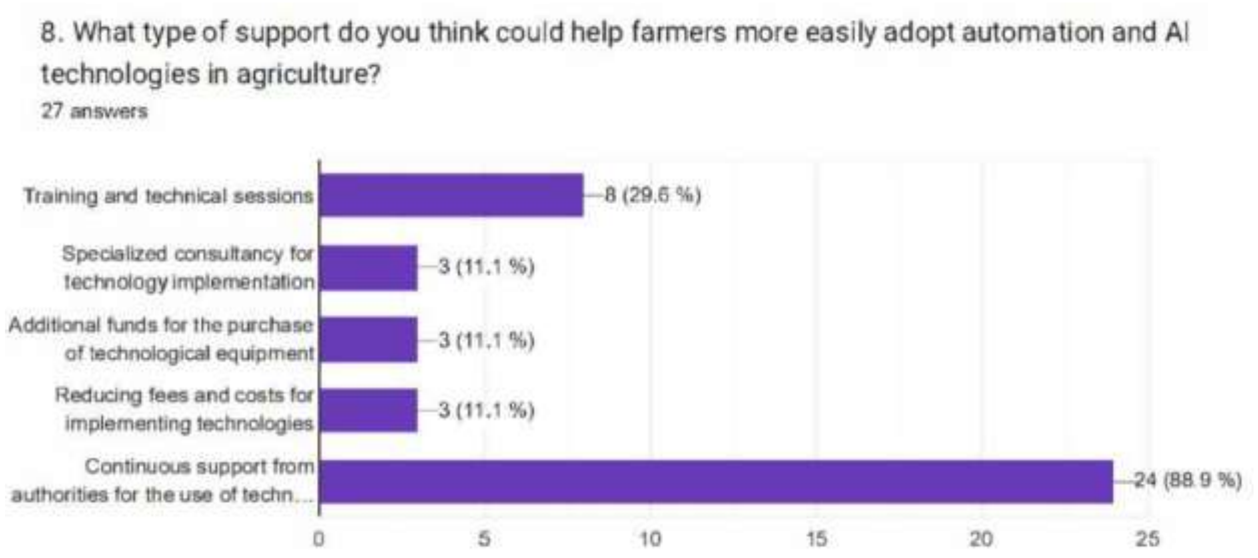

Fig. 8. Types of support needed by farmers to adopt automation and AI technologies?
Source: Own construction with google forms.

CONCLUSIONS

The descriptive analysis of the number of projects financed under the DR 30 measure shows an uneven distribution between development regions. Most projects were accessed in the North-West (1,612 projects) and South-Muntenia (422 projects), while Bucharest-Ilfov (45 projects) and Center (161 projects) had the fewest applications. The adoption of criterion 6.3 was significantly higher in regions with a lower number of projects, such as South-West Oltenia, suggesting that these regions were better informed or had more access to modern technologies.

Regional differences highlight the need for personalized support, especially for areas that have encountered difficulties in implementation, such as the North-East and the West. This support should include simplifying administrative processes and increasing the accessibility of technologies for good implementation, so that farmers can more easily access these projects.

The Chi-square test revealed a significant relationship between the development region and the application of criterion 6.3, with a p-value <0.00001, indicating that the distribution of projects that comply with this criterion is not random. Regions such as South-West Oltenia and North-West had large contributions to the Chi-square statistic, showing a high adoption of the technologies promoted by criterion 6.3, while the North-East, Center and Bucharest-Ilfov regions recorded low influences.

This regional disparity highlights the need for tailored policies, which specifically support regions with low adoption, through measures such as cost reduction and training programs for farmers. Thus, by introducing directives that help farmers, visible progress can be achieved.

A total of 3,306 projects were financed, of which only 48 opted to receive the additional score on criterion 6.3, representing a very low interest of farmers in this criterion (only 1.43% of farmers). However 40.7% of respondents applied for criterion 6.3, which highlights a limited interest in modern technologies.

The main barriers identified were bureaucratic problems (68.8%), lack of additional funds (12.5%), etc. The implemented technologies, such as monitoring sensors and automatic irrigation, brought clear benefits, including increased productivity. In order to increase the adoption of criterion 6.3, farmers require continuous support from the authorities and technical training sessions. Thus, most farmers observed a positive impact, most frequently mentioning: increased farm productivity (87.5%), reduced production costs (37.5%), and more efficient use of natural resources (12.5%) resulting in the use modern technologies means leading to higher productivity and lower costs.

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THE EFFICIENCY OF TRANSPORT COMPANIES FROM URBAN AND RURAL AREAS OF GIURGIU COUNTY, ROMANIA

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Abstract

The aim of the present work was to analyse the economic efficiency of transport companies in Giurgiu, a county in the south of Romania. Giurgiu County, while having one of the lowest road networks in Romania, has demonstrated significant economic potential, with remarkable growth in the number of transport companies, employees, and financial performance over the past decade. This study examines the business environment of road freight transport in Giurgiu County, focusing on companies active in 2021. An initial dataset of over 600 companies with CAEN code 4941 was refined by excluding those in insolvency, bankruptcy, or with incomplete financial records, resulting in a final sample of 447 firms. By analysing financial data and sectoral dynamics, this research provides insights into the economic contributions, challenges, and opportunities within the county's transport sector. The findings provide significant insights into the sector's resiliency and prospective expansion not with standing economic and logistical obstacles. In summary, the road transport sector is pivotal in the examined region, facilitating the movement of goods in a district that is both predominantly agricultural and a significant transport hub in the southern part of the country.

Key words: *transport, efficiency, turnover, net profit margin*

INTRODUCTION

The transport sector is essential for the economic development of a country [8], having a high capacity or adaptation at the level of supply chains [1] [7]. However, in recent years, inflation, energy and fuel prices, and, last but not least, the reduction in purchasing power have had a direct impact on the transport sector [13]. Added to these were the problems created by the pandemic, such as: the shortage of semiconductors in Europe; embargoes and customs restrictions; the lack of specialized labor force post-pandemic (from 2021 and 2022); the low level of wages compared to other sectors, etc.

In Romania, the contribution of the road freight transport sector to GDP was 2.57% in 2022, an increase of 0.08 percentage points compared to 2018 [12]. Road freight transport has a market value of approximately 16 billion Euros, an export value of 7.3 billion Euros and accounts for over 70% of total goods transported.

In summary, we can say that we hold "6th place in the European Union in road freight transport (in terms of market value)"; "3rd place in bilateral international road transport"; "3rd place in cabotage transport operated between two loading/unloading locations within another EU country"; and "4% of the EU road freight transport market" [11].

In 2022, it was stated that there is a shortage of drivers in the sector of over 70,000 people [12], while other sources reported that an approximate number of 173 thousand drivers will be used in the system in 2023 and a maximum of 188 thousand drivers in 2026 [10].

The estimations differ. A decline in the goods transport market is anticipated due to the driver issue, as well as other concerns including migration, environmental and mobility constraints, and rising costs or carbon footprints. Conversely, a projected increase of 0.8% in tonne-km volume and 8.3% in the value of the road freight sector is anticipated by 2030.

At present, however, road transport remains the most developed freight transport sector in Romania [3], being in continuous development even in conditions where road tolls, maintenance and repair costs, taxes, fuel prices, etc. have increased.

According to the National Institute of Statistics (NIS), in 2022 there were 37,214 active enterprises (mostly in the road transport sector), and about 87% of them had 0-9 employees [9]. The counties with the most active activity in road transport are Bucharest, Arges, Bihor, and Cluj. However, Giurgiu County presents a high development potential for the transport sector [4], with both the number of companies and the number of employees tripling in the sector in the last decade, which is why we chose it to analyze the potential of road freight transport in this area.

Giurgiu County has 1,188 km of roads, ranking last among the counties in this respect. However, it has almost 85% of moderated roads and a fleet of 3,034 freight vehicles (it is in the middle of the county ranking), of which 72.8% are trucks with a capacity of over 12 tons. The county is characterized by a fairly high dynamic in terms of economic results, showing: a 186% increase in the number of companies and a 140% increase in the number of employees (673 companies and almost 2000 employees); a 278% increase in the county-level turnover (876.3 million lei) and a 388.5% increase in net profit (about 700 million lei); labor productivity increased by 57% (about 440 thousand lei per employee).

The agriculture of Giurgiu County is well developed, being focused both on vegetal and animal production, contributing to food security of the local population, but also of the capital of Romania, Bucharest [2].

Agriculture becomes more and more extended from the rural area to the peri-urban area and even in the urban area. The connections between localities regarding the supply with raw materials and finished products are assured by the companies profiled on transport services which need a good endowment with adequate vehicles of various types and capacities and also with experienced drivers [6].

Seeds, fruits, vegetables, wines, milk, meat, eggs and other agro-food products require a large park of means of transportation of a corresponding capacity and equipped with refrigeration installations and not only to preserve the quality of products which are highly perishable.

A part of the transport companies have in their fleet even specialized machinery destined to support the farmers to carry out agricultural works of high quality and on time (tractors, combines etc).

In this context, the purpose of the paper is the analysis of the transport companies in Giurgiu County, regarding their dispersion by locality in the territory, and their financial performance in terms of turnover, profit, marginal profit, solvency and profitability.

MATERIALS AND METHODS

The paper analyzes the business environment in the road freight transport sector in Giurgiu County in the year 2021.

Table 1. Distribution of transport companies by locality

Localities	No. of companies	Localities	No. of companies
ROATA DE JOS	77	HERASTI	5
GIURGIU (city)	68	FRATESTI	5
VANATORII MICI	28	VARASTI	4
JOITA	27	CALUGARENI	4
BOLINTIN-VALE (city)	22	BANEASA	4
MIHAILESTI (city)	16	ISVOARELE	3
ULMI	15	GREACA	3
SABARENI	14	BULBUCATA	3
BUTURUGENI	14	BUCSANI	3
BOLINTIN-DEAL	14	SLOBOZIA	2
FLORESTI-STOENESTI	13	DAIA	2
OGREZENI	11	VALEA DRAGULUI	1
GRADINARI	11	STOENESTI	1
ADUNATII-COPACENI	11	PUTINEIU	1
HOTARELE	9	OINACU	1
CREVEDIA MARE	9	MIHAI BRAVU	1
GAISENI	8	MALU	1
COSOBA	8	IZVOARELE	1
PRUNDU	7	IEPURESTI	1
COMANA	7	GHIMPATI	1
SINGURENI	5	CLEJANI	1
MARSA	5		
TOTAL	447		

Source: Own calculation on the basis of data from listafirme.ro [5].

Initially, over 600 companies with the CAEN code 4941 Road freight transport were selected. For these, the data recorded on the basis of the balance sheet at the Ministry of Finance were verified, and companies in insolvency, bankruptcy, or that did not submit financial statements were eliminated, as well as those established in 2021, which did not have full activity in the respective fiscal year. The final analysis was carried out for 447 companies whose distribution by locality is shown in Table 1.

RESULTS AND DISCUSSIONS

The analysis carried out on 447 companies in could be analyzed based on various criteria.

The number of transport companies by localities in Giurgiu county is shown in Fig. From this figure we may identify that the most companies in Giurgiu County are found in the localities of Roata de Jos (77) and Giurgiu (68), these being followed by those in the localities of: Vanatorii Mici, Joita and Bolintin Vale with about 20-30 companies; Mihailesti, Ulmi, Sabareni, Buturugeni, Bolintin-Deal, Floresti-Stoenesti, Ogrezeni, Gradinari and Adunatii-Copaceni with about 7-9 companies. The rest of the localities have under 5 companies per locality with the CAEN code 4941.

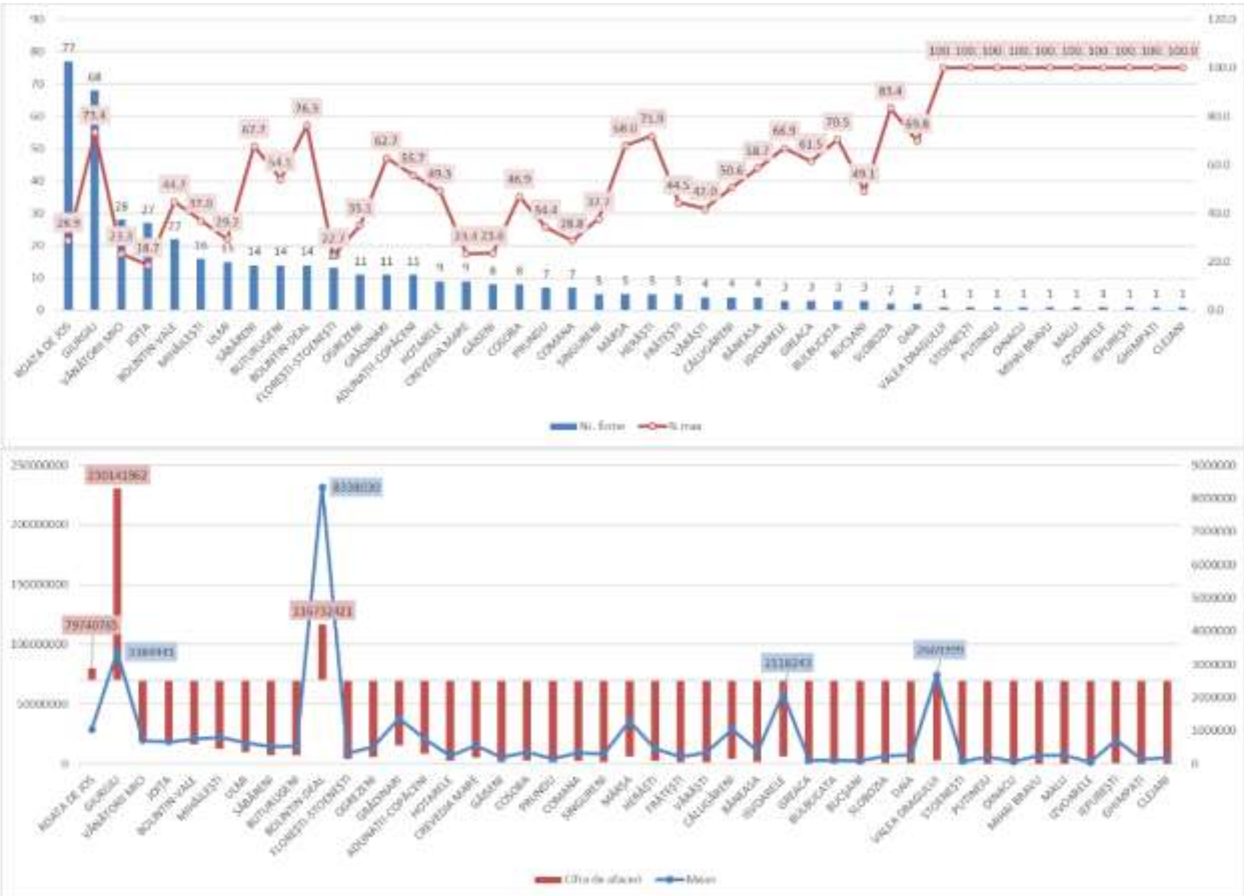

Fig.1. Number of companies, turnover and average turnover per locality
Source: Own calculation on the basis of data from listafirme.ro [5].

-Most companies are developed in localities near the city of Bucharest and on the border with Bulgaria;

-The highest turnover was recorded in the cities of Giurgiu and Bolintin-Vale and in the locality of Roata de Jos. These are distinguished by very high values compared to the other localities, respectively 2.3 billion lei, 116 million lei and 79.7 million lei. The next locality, Vanatorii Mici, has a turnover of only 2 million lei.

-A number of 117 companies out of the 447 had losses in 2021 (a total of 5.65 million lei);

the other 330 companies obtained a total profit of 61.5 million lei.

-Also, within the first localities there are companies that contribute over 50% to the local turnover of the sector. This is the case of the localities of Giurgiu (73.4%; one company out of 68 with a turnover of 168.9 million lei - BOLINTIS AGRO SRL), Bolintin-Deal (76.3%; one company out of 14 with a turnover of 89 million lei - KLG TRUCKING SRL), Sabareni (67.7%; one company out of 14 with a turnover of 4.8 million lei) or Gradinari (62.7%; one company out of 11 with a turnover of 9.5 million lei). However, although BOLINTIS AGRO SRL is in first place, it is not a company specialized in transport like KLG TRUCKING SRL which is in 49th place nationally with a fleet of almost 200 vehicles in 2023.

-The companies with the highest profit values were: from the localities of Bolintin-Deal (KLG TRUCKING SRL with 7.2 million lei), Roata de Jos (LAUR EURO DREAM S.R.L. with 5.8 million lei; STROMIH TRANS COM S.R.L. with 1.3 million lei), Giurgiu (DIRECT TRANSPORT RENT SRL with 4.5 million lei; CERONY SRL with 2.6 million lei), Gradinari (PREDI TRANS S.R.L. with 3.7 million lei) and Mihailesti (DOREL TRANS SRL with 1.7 million lei). As can be seen from the following graph, most companies have a profit below 260 thousand lei (406 companies), but about 34 companies with a profit between 260 thousand lei and 1.3 million lei can also be identified.

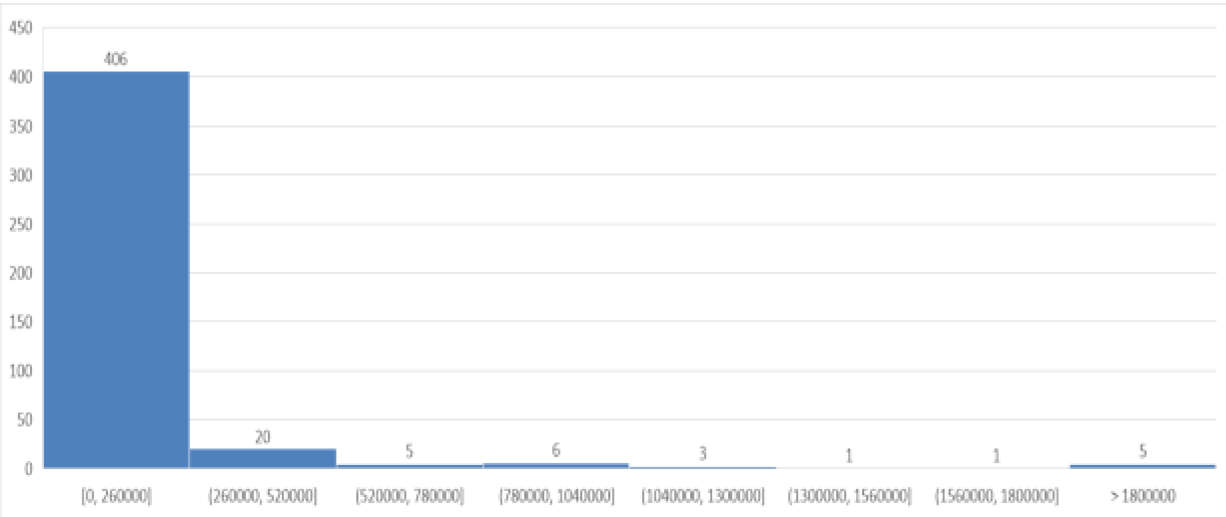

Fig. 2. Distribution of transport companies from Giurgiu County by profit value
Source: Own calculation on the basis of data from listafirme.ro [5].

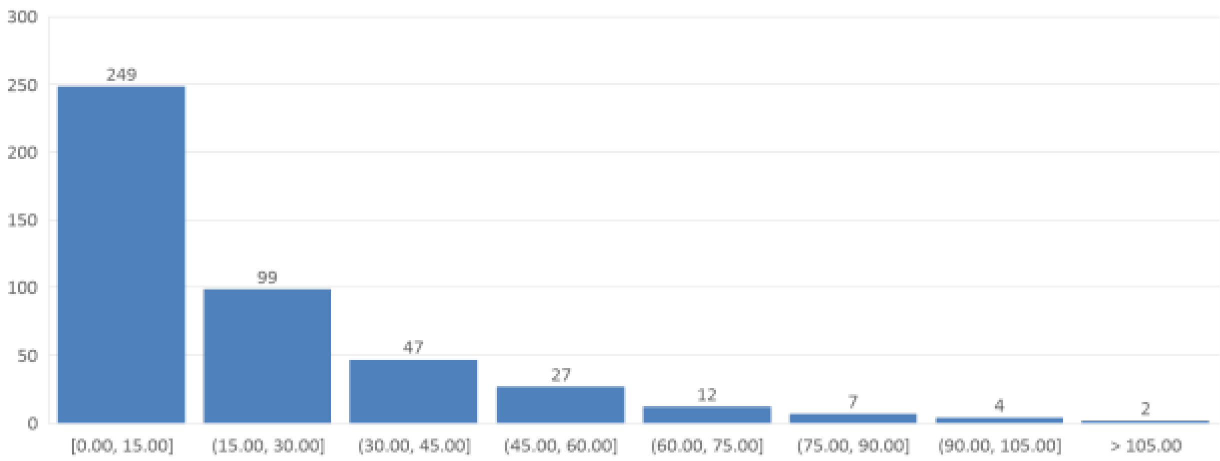

Fig. 3. Distribution of companies from Giurgiu County by profit margin
Source: Own calculation on the basis of data from listafirme.ro [5].

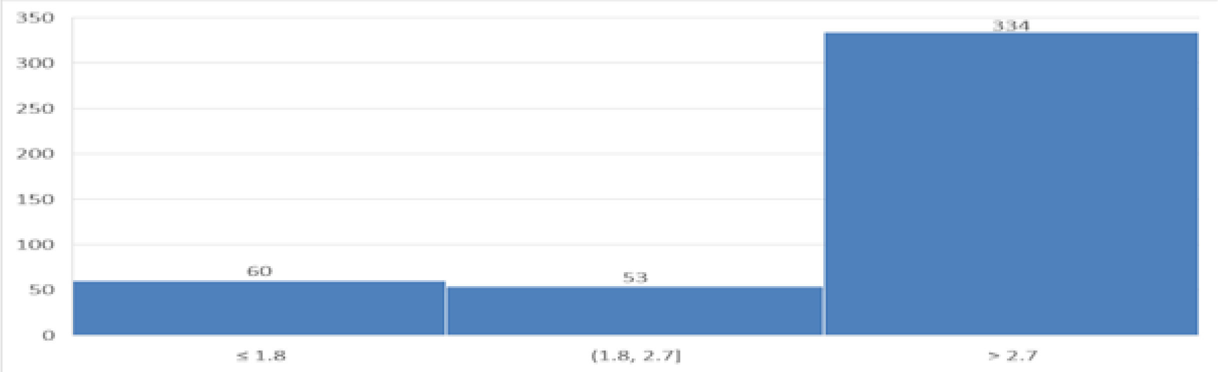

Fig. 4. Solvency of transport companies from Giurgiu County
Note: –Altman Z-Score meaning: High risk Z < 1.8, Medium risk 1.8 < Z < 2.7, No risk Z > 2.7
Source: Own calculation on the basis of data from listafirme.ro [5].

-If we analyze the profit margin, we notice a higher discrepancy between companies, about 249 having a profit margin below 15% (they have high operational costs, low prices or low efficiencies) and about 99 between 5% and 30%. However, 13 companies with profit margins above 75% are also identified (due to cost efficiency or advantageous prices).

Of course, there are more exceptions. For example, the two companies in the first places have a high profit margin due to undistributed profit, and other companies that have over 90% margin have very low expenses compared to revenue, which highlights that probably not all expenses are recorded in accounting.

-A number of 334 companies are not at risk of insolvency and 53 are at medium risk. About 60 companies have an unstable financial situation, and of these, over 25 have a negative score (high risk of bankruptcy) and 50 have recorded losses.

In terms of profitability, we identified two companies that stand out from the others with profit rate values exceeding 300-400% (PEDRO LOGISTIC TRANSPORT S.R.L. from Herasti and HOT TRANS ADIVAL S.R.L. from Varasti). In 2021, 116 companies did not record a profit, 2% have very high profitability (over 80%), and about 39% have a profit rate below 20%.

-If we compare urban with rural localities, we observe the following: in rural areas, a turnover of approximately 337.9 million lei was obtained, with an average per company of 990.8 thousand lei; in urban areas, a turnover of approximately 259.2 million lei was obtained, with an average per company of 2.5 million lei; in rural areas, a turnover of approximately 47.4 million lei was obtained, with an average per company of 139.1 thousand lei; in urban areas, a turnover of approximately 20.3 million lei was obtained, with an average per company of 191.5 thousand lei.

Table 2. Number of transport companies by profitability rank

	No	Percent
0	116	26.0
Under 20%	172	38.5
20-40%	98	21.9
40-60%	36	8.1
60-80%	14	3.1
80-100%	11	2.5
Total	447	100.0

Source: Own calculation on the basis of data from listafirme.ro [5].

Table 3. Descriptive statistics

	Turnover (Lei)		Profit (Lei)	
	Rural	Urban	Rural	Urban
No	341	106	341	106
Minimum	390	1,345	0	0
Maximum	89,022,079	168,954,737	8,383,084	4,588,609
Sum	337,872,069	259,195,217	47,433,029	20,300,757
Mean	990,827	2,445,237	139,099	191,516

Source: Own calculation on the basis of data from listafirme.ro [5].

Table 4. Profitability ranges by residence

	Urban		Rural	
	No	Percent	No	Percent
0	35	33.0	81	23.8
Under 20%	41	38.7	131	38.4
20-40%	21	19.8	77	22.6
40-60%	5	4.7	31	9.1
60-80%	3	2.8	11	3.2
80-100%	1	0.9	10	2.9
Total	106	100.0	341	100.0

Source: Own calculation on the basis of data from listafirme.ro [5].

There are no major differences by area of residence in terms of profitability, about 38-39% of companies have a profit rate below 20%. However, we can see that there are more companies in rural areas with a profit rate of over 60%.

CONCLUSIONS

The analysis of the business environment in the road freight transport industry, conducted among 447 enterprises in Giurgiu County, revealed the following findings: Presently, 85% of the roads are regulated, and there exists a fleet of 3,034 goods vehicles, positioning it approximately in the median of the county rankings; 32% of enterprises are concentrated in the localities of Roata de Jos and Giurgiu; from 2016 to 2022, the sector's value has doubled in workforce and tripled in turnover and profit. The results demonstrate that over 86% of the road transport sector in Giurgiu County is economically stable, although merely 73% are profitable. It is crucial to acknowledge that the existence of multiple firms in specific areas does not ensure their supremacy in regional revenue rankings. The road transportation sector in Giurgiu county, like in other counties of Romania is facing with various problems related to the insufficient capacity, higher and higher diesel price, high taxes and insurances, the need of more drivers and the reduction of pollution. The road transport sector is crucial in the examined region, facilitating the movement of goods in a county that is both predominantly agricultural and a significant transport centre in the southern part of the country.

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ANALYSIS OF FACTORS AFFECTING FARMERS' SATISFACTION WITH AGRICULTURAL ACTIVITIES AND MAIZE PRODUCTION: A CASE STUDY IN TÜRKİYE

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Abstract

The main purpose of this study is to reveal the satisfaction levels of farmers in the Izmir province of Türkiye from agricultural activities and maize production, to determine the factors affecting satisfaction and to analyze the future expectations of the farmers. The study data were collected from 93 farmers using proportional sampling and face-to-face survey method. In the analysis of the data, first the socio-economic characteristics of the farmers were examined, then the economic results of maize production were analyzed. The factors that can affect the satisfaction level of farmers were first prepared on a five-point Likert scale based on the literature and then factor analysis was applied to collect the variables that were correlated with each other into one category and obtain a smaller number of factors. According to the results of the study, the average maize yield in the farms was calculated as 14,523.99 kg/ha. The average net return obtained from maize was determined as 11,406.71 TL/ha. Farmers agree that maize has advantages such as easy growing, cost advantage, storability and providing good income. It was observed that the factor that farmers agreed the most in terms of satisfaction in maize production was the profitability factor. The factors affecting the satisfaction of farmers with agricultural activity in rural areas were determined as political, environmental, economic, rural infrastructure, social and personal factors. For farmers to sustain agricultural activities, socio-economic conditions in rural areas should be improved and living in rural areas should be made attractive.

Key words: *sustainable agriculture, satisfaction analysis, farmer satisfaction, farmer tendency, maize growing*

INTRODUCTION

The concept of satisfaction in the agricultural sector is expressed as the satisfaction of farmers with the agricultural activities they carry out and the fulfillment of their wishes, expectations or needs [3]. The tendency to sustain agricultural activities explains the tendency of farmers who are satisfied with the agricultural activities they carry out in terms of different parameters (social, economic, cultural, environmental, etc.). In Türkiye, researching the reasons why farmers who are currently active continue agricultural activities and the issues that may positively affect the decisions of young farmers to turn to agricultural activities can make significant contributions to the sustainability of agriculture. Therefore, first, it will be useful to determine the desire and tendency of farmers to sustain agricultural activities and the basic factors that will affect their decisions. The addition, the expectations of farmers that will be satisfied with sustaining agricultural activities should be examined at the regional level and within the scope of the research [32]. There are many factors that can directly affect the decisions of farmers to sustain agricultural activities and the reasons why young farmers turn to agriculture. Therefore, comparisons should also be made with other sectors in terms of social, economic or cultural indicators.

Most studies on the sustainability of agriculture in rural areas in Türkiye focus on rural migration, which is the movement from rural to urban areas [24, 33, 21,18, 17, 19, 6, 13, 20, 29, 30]. It is seen that some studies have been conducted in recent years on the tendency of farmers to stay in rural areas and sustain agricultural activities [11, 1, 22, 36, 37, 12, 2, 10, 31, 38, 35, 32]. However, it is necessary to reveal the satisfaction level of farmers and their tendency to sustain production based on production branches and in different regions.

On the other hand, maize is the most geographically widespread crop and the third largest crop in the world occupying 13% of the world's cultivated land [28, 16]. Maize is a very important crop also for Türkiye in terms of both its production and use. Maize, with its production as the first and second crop, has an important place in terms of the evaluation of the production area and labor force in rural areas, community nutrition, its use as an input in different sectors and the added value it creates. According to TURKSTAT data, 8.5 million tons of maize were produced in 911,885 hectares of land in Türkiye in 2022. The policies implemented by the Ministry of Agriculture and Forestry and Turkish Grain Board, the application of premiums and other supports, the use of certified seeds and the increase in mechanization in production have positively affected maize production. In 2022, 74% of the total maize production was obtained from main crop maize. Maize yield in Türkiye may vary from region to region. The average maize yield per hectare in Türkiye in 2022 was 9,320 kg [34]. In the same year, the world average maize yield was 5,721 kg/ha and Türkiye were well above this yield level [15]. However, Türkiye meets some of its maize needs through imports.

The public debate on whether GMO (Genetically Modified Organisms) maize is produced in Türkiye, the fact that ethanol can be produced from maize, the high water demand of maize and the effects of climate change on agriculture, and fluctuations in national and international prices necessitate scientific research to identify problems in terms of sustainability of maize production and to produce solution proposals [4, 5, 8]. With research to be conducted in this direction, the decisions of farmers and their tendencies to sustain production at the regional level can be analyzed to develop and increase maize production in Türkiye, and in this way, the necessary concrete data can be obtained to create the most appropriate policies. In addition, contributions can be made in terms of ensuring safe production for domestic and foreign markets, increasing Türkiye's competitiveness, controlling production costs and increasing farmer incomes.

One of the provinces of Türkiye with significant agricultural potential is Izmir province. In 2022, 96,007 tons of maize were produced in an area of 11,200 hectares in Izmir province. Maize (grain) production in Izmir province constituted 20% of the Aegean Region maize production and approximately 1.2% of Türkiye's total maize production [34].

The main purpose of this study is to reveal the satisfaction levels of farmers in the Izmir province of Türkiye from agricultural activities and maize production, to determine the factors affecting satisfaction and to analyze the future expectations of the farmers.

MATERIALS AND METHODS

The material of the study consists of data obtained through face-to-face surveys from maize farmers in the Menderes district of Izmir province. In addition, the results of previous studies were also used.

According to the data of the Izmir Provincial Directorate of the Ministry of Agriculture and Forestry, approximately 80% of the total maize production area and maize production in Izmir province are made up of the districts of Bergama, Menderes, Tire and Torbali. Menderes district alone provides approximately 20% of the maize production in Izmir province. Therefore, Menderes district was included in the scope of the study. Izmir province is in the west of Türkiye, and Menderes district is in the south of Izmir province. Mostly grain maize is produced in Menderes district.

According to the information received from the Menderes District Directorate of the Ministry of Agriculture and Forestry, approximately 90% of the maize production in the district is carried out in the neighbourhoods of Cileme, Tekeli, Cakaltepe, Karakuyu, Gölcükler and Develi. Therefore, these neighbourhoods were included in the scope of the study. The total number of farmers registered in the Farmer Registration System in these neighbourhoods was determined as 742. It was decided to include some of the farmers in the scope of the research by sampling method and the following Proportional Sample Size Formula was taken as basis [25].

$$n = \frac{Np(1-p)}{(N-1)\sigma^2{}_{px} + p(1-p)} \quad \text{......}(1)$$

In the formula:
n = Sample size
N = Total number of farmers
p = The ratio of farmers producing maize (0.5 was taken for the maximum sample volume)
σ^2px = The variance of the ratio.

In the study, calculations were made based on a 90% confidence interval and an 8% margin of error, and the sample size was determined as 93. In determining the number of farmers to be interviewed in each neighborhood, the shares of the neighborhoods in the total number of farmers were taken as basis. The farmers to be interviewed in the neighborhoods were determined using the random numbers table. Study surveys were conducted in March-April 2022. The study was found ethically appropriate with the decision of Ege University Scientific Research and Publication Ethics Committee numbered E.668908/2022.

In the analysis of data, farmers are divided into 3 groups according to the size of their maize land. The first group is farmers with maize land of less than 5.0 hectares (36 farmers), the second group is farmers with maize land of 5.0-9.9 hectares (27 farmers), and the third group is farmers with maize land of 10.0 hectares and more (30 farmers) were formed.

First, the socio-economic characteristics of the farmers were examined. At this stage, the age, education period, household size, land size, family labor utilization, capital availability and organizational characteristics of the farmers were determined.

In the study, the economic results of maize production were analyzed. Variable cost items in maize production; labor and machine costs, material (seed, fertilizer, pesticide, water, etc.) costs and interest on the total costs. Fixed cost items are land rent and management costs. Half of the interest rate (5%) applied by Ziraat Bank for subsidized crop production loans in 2021 was used in interest calculations. In calculating the management costs, 3% of variable costs was taken. Maize production costs consist of the sum of fixed and variable costs. Gross production value was determined by multiplying the production amount by the maize price. To calculate the net return obtained from maize, total production costs were subtracted from the gross production value [23].

In the study, satisfaction analysis was conducted to determine the satisfaction levels of producers from agricultural activities and maize production and the factors affecting this. Many factors (economic, social, cultural, geographic, environmental, structural, political, personal, organizational, etc.) can affect the satisfaction level of farmers. The factors that can affect the satisfaction level of farmers were first prepared on a five-point Likert scale based on the literature [36, 31, 35, 38, 32] and then factor analysis was applied to collect the variables that were correlated with each other into one category and obtain a smaller number of factors. With the satisfaction analysis, satisfaction factor tables were created for each sub-factor under each factor created to reveal the satisfaction levels of farmers from their agricultural activities. The average of the scores given by the farmers regarding their satisfaction level with agricultural production was taken with the Likert scale. The averages obtained for each factor group were ranked and it was determined from which factor group the farmers had higher expectations.

Factor analysis is a multivariate statistical technique that combines variables that are related to each other on many data to obtain a small number of unrelated variables. In factor analysis, since many observed variables are tried to be explained with a smaller number of factors, correlations between variables are primarily taken into consideration. Factor analysis is carried out in four basic stages. First, the suitability of the data for factor analysis is evaluated, factors are obtained, factors are rotated, and factors are named. Three methods are used to evaluate whether the data set is suitable. These are the creation of the correlation matrix, Kaiser-Meyer-Olkin (KMO) and Bartlett tests. In calculating the correlation matrix, a high correlation relationship is sought between the variables. Variables with a very strong correlation relationship will generally be in the same factor [26].

In determining the number of factors, the eigenvalue and scree test graphs are mostly used. In determining according to eigenvalues, factors with eigenvalues greater than 1 are derived. In the scatter diagram (Scree test) method, the eigenvalue graph is examined and the factors up to where the vertical line becomes horizontal are included in the solution. In the varimax method, which is the most widely used rotation process for better interpretation of factors, some factor loadings in each column are brought closer to 1, while the remaining many values are brought closer to 0. In this method proposed by Kaiser, rotation is performed in a way that ensures that the factor variances are maximized [14, 9].

RESULTS AND DISCUSSIONS

Socio-Economic Characteristics of Farmers

Information on the socio-economic characteristics of the farmers is presented in Table 1. The average age of the farmers was determined as 46.47 years, and the average education level was 7.81 years. The average experience of the farmers in maize production was 15.96 years. The average household size was 3.49 people, 50.7% of whom were men. The average family labour potential was found to be 2.46 male work unit and 738 male workdays. The family labour utilization rate was calculated as 45.72%.

The average land size in the farms was determined as 17.95 hectares. 64.27% of the lands are owned lands. The most important products grown in the farms other than maize are wheat, cotton, cucumber, tomato and olive, respectively. The average maize production area in the farms is 9.90 hectares. In farms, 97.27% of the average total active capital consists of land assets. 93.92% of passive capital consists of equity. 68.82% of farmers are partners in at least one agricultural cooperative. Most of these cooperatives are agricultural development cooperatives

Table 1. Socio-economic characteristics of farmers

Characteristics	Farm groups			
	Group 1 (<5.0 ha)	Group 2 (5.0-9.9 ha)	Group 3 (≥10.0 ha)	General
Age of farmer	46.31	48.48	44.87	46.47
Education period of farmer (year)	7.42	7.15	8.87	7.81
Maize production experience of farmer (year)	15.33	16.74	16.00	15.96
Household size	3.08	3.89	3.63	3.49
Family labor utilization rate (%)	30.59	42.56	65.41	45.72
Land size (ha)	9.34	11.20	34.37	17.95
Maize harvested area (ha)	2.99	6.98	20.84	9.90
Equity rate (%)	90.99	93.72	95.52	93.92
Cooperative participation rate (%)	75.00	55.56	73.33	68.82

Source: Results of this study.

Economic Aspects of Maize Growing

Information on the economic aspects of maize production in the farms examined is presented in Table 2. The average maize yield in the farms was calculated as 14,523.99kg/ha, and the average maize price received by the farmer was 2.71 TL/kg. The average gross production value was determined as 39,360.01TL/ha. The average maize production cost was calculated as 27,953.30TL/ha. 83.98% of the maize production costs were variable and 16.02% were fixed costs. The unit maize production cost was 1.92 TL/kg. The average gross margin and average net return obtained from maize were calculated as 15,885.16TL/ha and 11,406.71 TL/ha, respectively.

Table 2. Economic results of maize growing

Results	Farm groups			
	Group 1 (<5.0 ha)	Group 2 (5.0-9.9 ha)	Group 3 (≥10.0 ha)	General
Yield (kg/ha) (1)	14,701.78	14,325.32	14,539.32	14,523.99
Average maize price (TL/kg) (2) (*)	2.67	2.70	2.77	2.71
Gross production value (TL/ha) (3=1x2)	39,253.75	38,678.36	40,273.92	39,360.01
Variable costs (TL/ha) (4)	23,479.05	22,847.16	24,307.60	23,474.85
Production costs (TL/ha) (5)	27,975.12	27,291.77	28,803.53	27,953.30
Unit maize cost (TL/kg) (6=5/1)	1.90	1.91	1.98	1.92
Gross return (TL/ha) (7=3-4)	15,774.70	15,831.20	15,966.32	15,885.16
Net return (TL/ha) (8=3-5)	11,278.63	11,386.59	11,470.39	11,406.71

*1 US$ = 8.88 TL in 2021
Source: Results of this study.

Satisfaction Level of Farmers Regarding Maize Production and Affecting Factors

The level of participation of farmers in various factors that may affect their satisfaction in maize production was presented in Table 3. As can be seen, farmers agree that maize has advantages such as being easy to grow, cost advantage, storability and providing a good income.

Table 3**.** Opinions of farmers on factors affecting satisfaction with maize production

Factors	Participation level *
Maize production provides good income	4.10
High yield is obtained from maize	3.83
Maize production is promising	4.04
Maize has a high price advantage	3.84
Maize has a cost advantage	4.13
Maize growing is easy	4.26
It is easy to combat diseases and pests	4.35
Maize has easy marketing	4.04
It contributes to the purchase of new tools and machinery	3.92
It allows the increase of land size	3.81
Land size is suitable for production	3.87
Fertilizer needs can be provided	3.51
Tool and equipment need can be met	3.64
Maize production can be stocked	4.12
It can provide employment within and outside the farm	3.91
Large companies can create demand in the market	3.66
It is suitable for making long-term decisions	3.64
Contracted production can be done	4.07
There is government support for maize production	4.01
Average	3.94

*1. Strongly disagree, 2. Disagree, 3. Undecided, 4. Agree, 5. Strongly agree
Source: Results of this study.

In the study, factor analysis was used to collect the above 19 factors under fewer factors and to reveal which factors are more important to the farmers. According to the factor analysis results, eight factors with high eigenvalues (more than 1) were determined. The first factor explains 15.85% of the total variance, the second factor explains 11.08%, the third factor explains 10.07%, the fourth factor explains 9.12%, the fifth factor explains

7.43%, the sixth factor explains 6.16%, the seventh factor explains 5.97% and the eighth factor explains 5.63%. The cumulative variance amount explained by the eigenvalues is 71.31% of the total variance (Table 4).

Table 4. Results of factor analysis

Variables	Factors	Eigenvalue	Variance	Cumulative variance
Maize production provides good income	1	3.011	15.849	15.849
High yield is obtained from maize	2	2.106	11.082	26.931
Maize production is promising	3	1.913	10.068	36.999
Maize has a high price advantage	4	1.733	9.120	46.119
Maize has a cost advantage	5	1.411	7.428	53.547
Maize growing is easy	6	1.171	6.161	59.708
It is easy to combat diseases and pests	7	1.135	5.975	65.683
Maize has easy marketing	8	1.069	5.628	71.311
It contributes to the purchase of new tools and machinery	9	0.896	4.717	76.027
It allows the increase of land size	10	0.822	4.324	80.352
Land size is suitable for production	11	0.755	3.975	84.327
Fertilizer needs can be provided	12	0.610	3.211	87.538
Tool and equipment need can be met	13	0.547	2.881	90.419
Maize production can be stocked	14	0.506	2.666	93.085
It can provide employment within and outside the farm	15	0.441	2.322	95.406
Large companies can create demand in the market	16	0.350	1.843	97.249
It is suitable for making long-term decisions	17	0.212	1.115	98.364
Contracted production can be done	18	0.193	1.014	99.378
There is government support for maize production	19	0.118	0,622	100.000
Bartlett's Test of Sphericity:χ^2:494.140,df:171,p:0.000 Kaiser-Meyer-OlkinMeasure:0.566				

Source: Results of this study.

According to the factor analysis rotation results, factor 1 consists of large companies can create demand in the market, it is suitable for making long-term decisions and contracted production can be done. This factor was called the **“Marketing opportunities”.** Factor 2 consists of it is easy to combat diseases and pests, fertilizer needs can be provided, and tool and equipment needs can be met. This factor was called the **“Input demand”**. Factor 3 consists of maize production is promising, it contributes to the purchase of new tools and machinery and maize production can be stocked. This factor was called the **“Capital accumulation”**. Factor 4 consists of maize production providing good income, maize has a cost advantage and maize has easy marketing. This factor was called “**Profitability”**. Factor 5 consists of high yield obtained from maize and land size is suitable for production. This factor was called the **“Yield”**. Factor 6 consists of maize growing is easy and it can provide employment within and outside the farm. This factor was called the **“Growing technique”**. Factor 7 consists of maize having a high price advantage and it allows the increase of land size. This factor was called the **"Price"**. Factor 8 consists of government support for maize production. This factor was called “**Government support"** (Table 5).

When the values of the variables constituting the factors are considered and their averages are calculated, it is seen that the factor that farmers agree on the most in terms of satisfaction in maize production is the profitability factor, followed by the growing technique factor and capital accumulation factor (Table 6).

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Table 5**.** Rotation results of factor analysis

Variables	Factors							
	1	2	3	4	5	6	7	8
Maize production provides good income	0.166	-0.171	0.030	**0.676**	0.045	-0.442	0.050	-0.037
High yield is obtained from maize	0.184	0.122	-0.204	-0.025	**0.620**	0.319	0.045	-0.200
Maize production is promising	0.191	-0.057	**0.501**	0.112	-0.193	0.136	0.390	0.332
Maize has a high price advantage	-0.016	0.160	0.196	0.033	-0.114	-0.076	**-0.766**	0.099
Maize has a cost advantage	-0.014	0.179	0.005	**0.809**	0.039	0.058	-0.015	0.046
Maize growing is easy	0.189	-0.011	0.113	0.087	0.142	**0.662**	0.076	0.132
It is easy to combat diseases and pests	-0,245	**0.407**	0.273	0.181	0.176	-0.285	-0.153	-0.329
Maize has easy marketing	0.002	0.027	0.142	**0.662**	-0.369	0.301	0.077	-0.003
It contributes to the purchase of new tools and machinery	-0.002	-0.134	**0.682**	-0.004	0.226	0.243	-0.281	-0.093
It allows the increase of land size	0.083	0.207	0.063	0.070	-0.094	-0.075	**0.678**	-0.075
Land size is suitable for production	0.057	-0.098	0.137	-0.072	**0.816**	-0.121	-0.044	0.234
Fertilizer needs can be provided	0.096	**0.857**	-0.155	0.085	-0.061	0.011	0.146	0.064
Tool and equipment need can be met	0.050	**0.894**	0.080	-0.005	0.011	0.061	-0.059	0.079
Maize production can be stocked	0.027	0.076	**0.832**	0.068	-0.092	-0.185	0.003	-0.027
It can provide employment within and outside the farm	0.176	-0.051	0.243	0.043	0.253	**-0.607**	0.174	0.375
Large companies can create demand in the market	**0.927**	0.067	0.039	0.075	0.136	0.063	0.052	0.047
It is suitable for making long-term decisions	**0.900**	0.044	0.036	0.041	0.051	0.074	0.089	0.019
Contracted production can be done	**0.911**	0.007	0.008	-0.022	0.001	-0.030	0.007	-0.045
There is government support for maize production	-0.047	0.145	-0.047	0.026	0.094	-0.001	-0.199	**0.843**

Source: Results of this study.

Table 6**.** Factors affecting farmers' satisfaction with maize production

Factors	Variables	Participation level *
Factor 1 : Marketing opportunities	Large companies can create demand in the market	3.66
	It is suitable for making long-term decisions	3.64
	Contracted production can be done	4.07
	Average	**3.79**
Factor 2: Input demand	It is easy to combat diseases and pests	4.35
	Fertilizer needs can be provided	3.51
	Tool and equipment need can be met	3.64
	Average	**3.83**
Factor 3: Capital accumulation	Maize production is promising	4.04
	It contributes to the purchase of new tools and machinery	3.92
	Maize production can be stocked	4.12
	Average	**4.03**
Factor 4: Profitability	Maize production provides good income	4.10
	Maize has a cost advantage	4.13
	Maize has easy marketing	4.04
	Average	**4.09**
Factor 5: Yield	High yield is obtained from maize	3.83
	Land size is suitable for production	3.87
	Average	**3.85**
Factor 6: Growing technique	Maize growing is easy	4.26
	It can provide employment within and outside the farm	3.91
	Average	**4.08**
Factor 7: Maize price	Maize has a high price advantage	3.84
	It allows the increase of land size	3.81
	Average	**3.82**
Factor 8: Government support	There is government support for maize production	4.01
	Average	**4.01**

*1. Strongly disagree, 2. Disagree, 3. Undecided, 4. Agree, 5. Strongly agree
Source: Results of this study.

Satisfaction Level of Farmers Regarding Sustaining Agricultural Activities and Affecting Factors

The cumulative variance amount explained by the eigenvalues is 79.40% of the total variance. The level of participation of farmers with various factors affecting their satisfaction with living in rural areas and sustaining agricultural activities was presented in Table 7. As can be seen, farmers mostly stated that they were close to undecided or did not agree. Factors that may be close to the level of agreement are only farming activity can be of interest, climate conditions are suitable, and farming is a popular activity.

Table 7. Opinions of farmers on factors affecting satisfaction with agricultural activities

Factors	Participation level *
There is diversity of agricultural taxes, and their rates are low	2.44
Environmental pollution level is low	3.27
Young farmer supports are implemented	2.82
Government supports are sufficient	2.39
Agricultural insurance pool support is implemented	2.97
Farmer unions in the region work effectively	2.78
Climate conditions are suitable	3.73
Social security premium payment level is low	2.92
Life in rural areas is cheaper	2.92
Farmers can earn sufficient income	2.60
Farming is respected in society	2.70
Information about supports can be obtained	2.41
Infrastructure services in the region are sufficient	3.31
Small family farm support is implemented	2.38
Extension and consultancy support are implemented	2.44
Only farming activity can be of interest	3.81
Cooperative activities are effective	2.95
Farming is a popular activity	3.61
Government support diversity is high	2.34
Average	2.76

*1. Strongly disagree, 2. Disagree, 3. Undecided, 4. Agree, 5. Strongly agree
Source: Results of this study.

In the study, factor analysis was used again to collect the above 19 factors under fewer factors and to reveal which factors are more important to the farmers. According to the factor analysis results, six factors with high eigenvalues (more than 1) were determined. The first factor explains 32.20% of the total variance, the second factor explains 15.45%, third factor explains 10.76%, the fourth factor explains 9.53%, the fifth factor explains 5.81%, and the sixth factor explains 5.65% (Table 8).

The results of the factor analysis rotation were presented in Table 9. Factor 1 consists of there is diversity of agricultural taxes and their rates are low, environmental pollution level is low, young farmer supports are implemented, and government support is sufficient. This factor was called the **"Political conditions"**. Factor 2 consists of agricultural insurance pool support is implemented, farmer unions in the region work effectively, climate conditions are suitable, and social security premium payment level is low. This factor was called the **"Environmental conditions"**. Factor 3 consists of life in rural areas is cheaper, farmers can earn sufficient income, and farming is respected in society. This factor is called the **"Economic conditions"**. Factor 4 consists of information about supports can be obtained, infrastructure services in the region are sufficient, small family farm support is implemented, and extension and consultancy support are implemented. This factor was called the **"Rural infrastructure"**. Factor 5 consists of only farming activity can be of interest and cooperative activities are effective. This factor was called the **"Social conditions"**. Factor 6 consists of farming is a popular activity and government support diversity is high. This factor was called the **"Personal characteristics"** (Table 9).

Table 8. Results of factor analysis

Factors	Factors	Eigenvalue	Variance	Cumulative variance
There is diversity of agricultural taxes, and their rates are low	1	6.118	32.199	32.199
Environmental pollution level is low	2	2.936	15.450	47.649
Young farmer supports are implemented	3	2.045	10.764	58.414
Government supports are sufficient	4	1.811	9.532	67.946
Agricultural insurance pool support is implemented	5	1.105	5.814	73.759
Farmer unions in the region work effectively	6	1.073	5.645	79.405
Climate conditions are suitable	7	0.836	4.400	83.805
Social security premium payment level is low	8	0.731	3.849	87.653
Life in rural areas is cheaper	9	0.653	3.437	91.090
Farmers can earn sufficient income	10	0.501	2.637	93.727
Farming is respected in society	11	0.445	2.340	96.067
Information about supports can be obtained	12	0.309	1.624	97.691
Infrastructure services in the region are sufficient	13	0.155	0.814	98.506
Small family farm support is implemented	14	0.103	0.542	99.048
Extension and consultancy support are implemented	15	0.079	0.415	99.463
Only farming activity can be of interest	16	0.049	0.257	99.720
Cooperative activities are effective	17	0.030	0.159	99.879
Farming is a popular activity	18	0.016	0.087	99.966
Government support diversity is high	19	0.006	0.034	100.000
Bartlett's Test of Sphericity: χ^2:1765.100, df:171, p:0.000 Kaiser-Meyer-Olkin Measure:0.675				

Source: Results of this study.

Table 9. Rotation results of factor analysis

Variables	Factors					
	1	2	3	4	5	6
There is diversity of agricultural taxes, and their rates are low	**0.953**	-0.165	-0.002	-0.039	-0.022	0.015
Environmental pollution level is low	**0.947**	-0.164	-0.050	-0.019	-0.031	0.018
Young farmer supports are implemented	**0.937**	-0.168	0.029	-0.080	-0.030	0.047
Government supports are sufficient	**0.919**	-0.200	-0.104	0.022	-0.062	0.031
Agricultural insurance pool support is implemented	-0.154	**0.955**	0.129	0.028	0.055	-0.010
Farmer unions in the region work effectively	-0.170	**0.938**	0.147	0.007	0.074	0.015
Climate conditions are suitable	-0.170	**0.933**	0.199	0.038	-0.008	0.034
Social security premium payment level is low	-0.184	**0.928**	0.162	-0.001	0.118	-0.031
Life in rural areas is cheaper	-0.107	0.188	**0.931**	0.027	-0.008	-0.028
Farmers can earn sufficient income	-0.088	0.185	**0.910**	0.066	0.015	-0.048
Farming is respected in society	0.094	0.182	**0.831**	-0.052	-0.033	0.109
Information about supports can be obtained	-0.303	-0.044	0.044	**0.698**	0.050	0.040
Infrastructure services in the region are sufficient	-0.243	0.020	0.062	**-0.697**	0.322	0.043
Small family farm support is implemented	-0.215	0.202	0.243	**0.662**	0.276	0.089
Extension and consultancy support are implemented	-0.421	0.014	0.260	**-0.559**	0.191	-0.031
Only farming activity can be of interest	0.080	0.061	-0.345	0.042	**0.708**	0.037
Cooperative activities are effective	-0.148	0.101	0.222	-0.117	**0.694**	-0.085
Farming is a popular activity	-0.111	0.146	0.234	0.048	0.006	**0.825**
Government support diversity is high	0.266	-0.177	-0.275	0.026	-0.063	**0.646**

Source: Results of this study.

When the values of the variables constituting the factors are considered and their averages are calculated, it is seen that the farmers are stuck between being undecided and participating in terms of social and environmental factors in terms of sustaining agricultural activities by living in rural areas (Table 10).

Table 10. Factors affecting farmers' satisfaction with agricultural activities

Factors	Variables	Participation level *
Factor 1: Political conditions	There is diversity of agricultural taxes, and their rates are low	2.44
	Environmental pollution level is low	3.27
	Young farmer supports are implemented	2.82
	Government supports are sufficient	2.39
	Average	**2.73**
Factor 2: Environmental conditions	Agricultural insurance pool support is implemented	2.97
	Farmer unions in the region work effectively	2.78
	Climate conditions are suitable	3.73
	Social security premium payment level is low	2.92
	Average	**3.10**
Factor 3: Economic conditions	Life in rural areas is cheaper	2.92
	Farmers can earn sufficient income	2.60
	Farming is respected in society	2.70
	Average	**2.74**
Factor 4: Rural infrastructure	Information about supports can be obtained	2.41
	Infrastructure services in the region are sufficient	3.31
	Small family farm support is implemented	2.38
	Extension and consultancy support are Implemented	2.44
	Average	2.63
Factor 5: Social conditions	Only farming activity can be of interest	3.81
	Cooperative activities are effective	2.95
	Average	3.38
Factor 6: Personal characteristics	Farming is a popular activity	3.61
	Government support diversity is high	2.34
	Average	2.97

*1. Strongly disagree, 2. Disagree, 3. Undecided, 4. Agree, 5. Strongly agree
Source: Results of this study.

CONCLUSIONS

The agricultural sector in Türkiye sustains its importance in terms of its impact on labor and nutrition, the raw material it provides to the industrial sector, and its contribution to national income. However, farmers in the agricultural sector are gradually aging or moving to other sectors. Ensuring the sustainability of agricultural production depends on the effective and efficient use of production factors. The decrease in the share of production factors in income negatively affects the sustainability of agricultural production. Correct determination of the basic factors affecting the tendency of farmers to sustain agricultural production is extremely important in terms of ensuring food security for the future, ensuring the sustainability of agriculture, and ensuring the socio-economic sustainability of rural areas.

In this study, the tendency of farmers in Menderes district of Izmir province to sustain their agricultural activities and maize production in rural areas was determined. According to the results of the study, the average maize yield in the farms was calculated as 14,523.99 kg/ha. Maize yield may vary from region to region in Türkiye. The average maize yield was determined as 10,804.30 kg/ha in a study conducted in Kahramanmaras province, Türkiye [27] and

13,668.00 kg/ha in a study conducted in Konya province, Türkiye [7]. The average net return obtained from maize was calculated as 11,406.71TL/ha. The results of the study show that maize production can be done economically in the examined farms. Farmers agree that maize has advantages such as easy growing, cost advantage, storability and providing good income. It was observed that the factor that farmers agreed the most in terms of satisfaction in maize production was the profitability factor.

According to the study results, the factors affecting the satisfaction of farmers with agricultural activity in rural areas were determined as political, environmental, economic, rural infrastructure, social and personal factors. Similar results were obtained in another study [32]. However, some of the farmers state that they may not sustain agricultural activities in the future. They believe that especially the young population is not sufficiently encouraged for agricultural activities.

For farmers to sustain agricultural activities, socio-economic conditions in rural areas should be improved and living in rural areas should be made attractive. Agricultural industry investments should be increased in rural areas. In addition, comprehensive information should be provided, and incentive programs should be offered to the population who want to return to agriculture. Young people and women should sustain to be supported in terms of entrepreneurship.

In Türkiye, in addition to production, technology-focused and value-added policies need to be implemented. Reducing input costs and moving to economies of scale to produce products with high export potential and added value, and increasing profits and income in the agricultural sector will be effective in encouraging farmers to sustain agricultural activities. To ensure stability in the agricultural sector, moving to a planned production model based on demand according to domestic and international market research will prevent price fluctuations and prevent farmer grievances.

Most farmers find state support insufficient. Increasing the difference payment for maize production is one of the most important expectations of farmers. Support in this direction should be increased, and support payments should be planned in a timely manner. The Turkish Grain Board should announce the purchase guaranteed crop price early to support farmers, and the necessary financial opportunities should be created for the necessary payments to be made in a timely manner. The compliance of the prices with the international corn market prices should be determined and accordingly, support should be provided through the necessary channels for farmers' production. On the other hand, increases in input prices in maize production increase production costs. In fact, a different study has determined that the biggest problem of maize production is the excess of production costs [27]. For this reason, area-based input support should be increased. In addition, the reduction of taxes paid on input should continue. Maize is a crop that requires a lot of irrigation. Farmers have difficulty in covering water costs. Therefore, farmers should be informed about the use of alternative irrigation techniques and encouraged through financial methods.

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SYSTEMATIC ANALYSIS OF LITERARY SOURCES ON THE ISSUES OF TACIT KNOWLEDGE TRANSFER THROUGH INFORMAL INNOVATION NETWORKS

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Abstract

The paper explored the dynamics of researchers' interest in the scientific problem of transferring tacit knowledge, the main researchers/sources, significant problem areas and results. The main method of analysis is a systematic analysis of literary sources on the problems of the application possibilities of informal innovation networks in the transfer of tacit knowledge. The review covers 2,682 documents published in 1,806 sources indexed in the Web of Science database. The results of the review showed a growing interest in tacit knowledge transfer issues, identified specific areas of substantial application of tacit knowledge, significant organizational, social, and psychological factors, and mechanisms for sharing tacit knowledge.

Key words: *tacit knowledge, informal innovation networks, knowledge transfer, systematic analysis*

INTRODUCTION

This research presents a part of the results of a scientific study on "Formal and informal innovation networks", financed by the Bulgarian National Science Fund.
The purpose of the study is to establish, based on a systematic analysis of literary sources on the issues of the application possibilities of informal innovation networks in the transfer of tacit knowledge, what are the dynamics of the researchers' interest in this area, who are the main players in it and who are the most significant directions of interest to the authors.
The main research questions we asked are:
(1) What is the interest of researchers who have published their publications about tacit knowledge transfer through informal networks? How does this interest change over time?
(2)Who are the main players (authors, scientific journals, universities, etc.) working in the researched area, and have sustainable links and networks been established between them?
(3)What are the main problem areas explored in the publications and what are their specific features? As a result of the research, we conclude that the researchers' interest in the issues of the transfer of tacit knowledge through informal innovation networks is sustainable and growing.

MATERIALS AND METHODS

Due to the specificity of the research area and the research questions, we decided to conduct our research in two directions. First, we conducted an extensive systematic analysis of a sufficient and substantial number of literary sources published over an extended period [10, 5, 16], and then we continued with an in-depth analysis of selected literary sources [14].
We decided to start the systematic analysis by searching the Web of Science (WoS), database [40]. We consider it the most suitable one, due to the high degree of data structuring and good correspondence with the software we used running in the R environment. We created a search expression, that included keywords "tacit", "knowledge", "network", "networks", "informal", and "tacit knowledge". We searched the Topic and Title fields of the selected database. The search found publications from the period 1985-2024.

The selection of publications for in-depth analysis was based on a combination of factors.

First, up-to-date publications, indexed and referenced in the world's databases in the last 7 (seven) years are selected.

Secondly, publications should address specific problems related to the management of tacit knowledge, present new ideas regarding methods of tacit analysis and its transfer; achieve/receive interesting and significant results for theory and practice; identify significant factors influencing tacit knowledge flows; create useful models for studying, monitoring or managing the transfer of tacit knowledge; to have revealed connections and interdependencies in the transfer of tacit knowledge.

The publications were examined in terms of main results and ideas, using descriptive analysis, synthesis, comparative analysis, content analysis, grouping, summarization, graphical methods, and logical methods of finding similarity and contradiction.

RESULTS AND DISCUSSIONS

Bibliometric Analysis

A total of 2,682 documents published in 1,806 sources were found as a result of the WoS database search. The results obtained were processed using the Biblioshiny app [4].

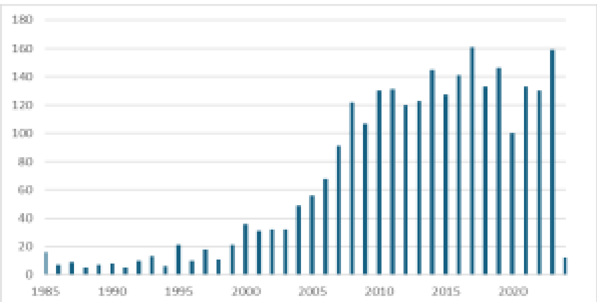

Fig. 1. Annual number of publications on the researched topic for the period 1985 – 2024
Source: Own calculation on the basis of data processed with Biblioshiny [39].

We distinguished three periods in the dynamics of publication activity in the researched area. The first was between 1985 and 2003 when relatively low and uniform activity was observed. The second period was 2004-2011 when there was an intense increase in activity. The third period 2012-2024 reported relatively constant but uneven activity (Fig. 1). The average age of the publications was 11.33 years.

Interest in the researched area could also be assessed according to the dynamics of the number of citations of literary sources (Fig. 2). We concluded that there was a significant difference in the average number of citations. However, for 1988-2003, it was significantly higher than for 2004-2024.

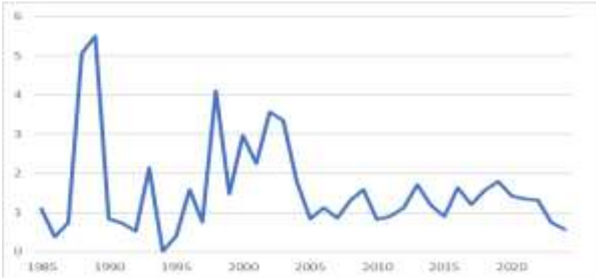

Fig. 2. Average number of citations per publication for the period 1985–2024
Source: Own calculation on the basis of data from Biblioshiny [39].

We directed the research to the publication sources. A large proportion of identified sources – 1,416 or 78% published only one paper, 233 or 13% published two papers, and 71 (4%) published three papers.

Table 1. Most actively publishing sources on the researched topic

Most Relevant Sources	No. of published articles
Journal of Knowledge Management	41
Gerontologist	21
Knowledge Management Research & Practice	21
Handbook of Research on Tacit Knowledge Management for Organizational Success	16
International Journal of Psychology	14
Sustainability	14
Vine Journal of Information and Knowledge Management Systems	14
European Planning Studies	11
Journal of Information & Knowledge Management	11
International Journal of Knowledge Management	10

Source: Own calculation on the basis of data processed with Biblioshiny [39].

The ten most actively publishing sources in the selected research area are presented in Table 1.

We revealed the authority of publication sources based on the number of citations to their publications. The analyzed publications cite a total of over 36,000 documents. A list of the most cited publications from those analyzed is presented in Table. 2.

Table 2. List of sources that published the most cited documents

Sources	Articles
Organization Science	1,701
Strategic Management Journal	1,539
Journal of Knowledge Management	1,364
Academy of Management Journal	1,059
Academy of Management Review	1,042
Administrative Science Quarterly	970
Research Policy	835
Journal of Knowledge Management	816
American Journal of Sociology	679
Management Science	636

Source: Own calculation on the basis of data processed with Biblioshiny [39].

The analyzed sources differ greatly in their impact on the development of scientific research. World practice uses several indices to assess the power of influence. Table. 3 presents the evaluation indices of the ten sources with the highest impact on the development of scientific research.

Table 3. Sources with the highest impact on the development of scientific research in the chosen field

Source	h_index	g_index	m_index
Journal of Knowledge Management	21	41	1.313
Knowledge Management Research & Practice	11	17	0.647
Journal of Economic Geography	9	10	0.409
Research Policy	9	9	0.333
International Journal of Information Management	8	9	0.333
Journal of Business Research	7	7	0.389
Organization Studies	7	7	0.219
European Planning Studies	6	11	0.261
International Journal of Knowledge Management	6	10	0.300
Technology Analysis & Strategic Management	6	7	0.207

Source: Own calculation on the basis of data processed with Biblioshiny [39].

The h-index score is “a standard scholarly metric in which the number of published papers, and the number of times their author is cited, is put into relation. Journals also have their own H-Index scores” [17]. In turn, the g-index is “the (unique) largest number such that the top g articles received (together) at least g^2 citations” [38]. M-index displays h-index per year since the first publication” [34].

The dynamics of the sources of the publications in the studied period were very different. Fig. 3 shows the dynamics of the publications of the five sources with the highest h-index.

Fig. 3. Dynamics of the number of publications (cumulative amount) on the researched topic of five sources with the highest h-index, 1985 – 2024
Source: Own calculation on the basis of data processed with Biblioshiny [39].

Another focus of this research was the authors with the highest publication activity in the studied field. An interesting comparison could be made here between the number of authors’ publications and the number of Articles Fractionalized. The second indicator quantifies the contribution of each of the authors, in the presence of co-authorship.

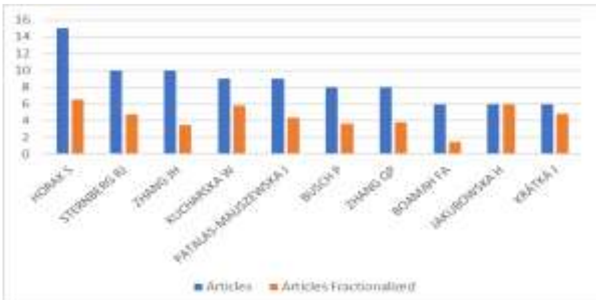

Fig. 4. Comparison between the number of publications and Articles Fractionalized of the ten authors with the highest publication activity in the researched area
Source: Own calculation on the basis of data processed with Biblioshiny [39].

In Fig. 4 a comparison was made between the publication activity of the ten authors with the

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most publications and their Articles Fractionalized. One can see that Horak S. was the author of the highest number of publications – 15. The same author has the highest value of Articles Fractionalized – 6.53. For one of the authors, the two indicators match – six. One could conclude that he had published six independent publications. Other authors, such as Sternberg RJ and Zhang JH. contributed to ten publications each, but their Articles Fractionalized values were 4.78 and 3.48, respectively. This meant their publications had more co-authors and their total contribution to publication activity was lower.

Not always the authors who publish the most actively had the highest contribution to the development of science in a certain field. Researchers prefer different approaches and methods for measuring the author's contribution and impact on the development of science. Indicators such as number of citations, h-index, g-index, m-index and others were very often used. Table 4 presents information on such indicators for the ten authors with the highest publication activity on the subject.

Table 4. Information on the impact of the ten authors with the highest publication activity in the researched area

Author	H index	G index	M index	Total Citations	Local Citations
HORAK S	7	15	0.636	328	70
STERNBERG RJ	8	10	0.200	711	134
ZHANG JH	4	5	0.250	29	9
KUCHARSKA W	7	9	0.778	101	27
PATALAS-MALISZEWSKA J	3	5	0.300	32	7
BUSCH P	3	8	0.125	140	32
ZHANG QP	2	2	0.100	6	0
BOAMAH FA	4	5	2.000	25	9
LEDENEVA A	5	6	0.313	177	19
KRÁTKÁ J	1	3	0.091	9	5

Source: Own calculation on the basis of data processed with Biblioshiny [39].

Total Citations reflected the number of author citations in the WoS database, while Local Citations were the citations in the population of 2,682 identified documents. The research showed that authors varied widely in their productivity. One document was published by 4,756 authors (or 88% of authors), two documents by 473 (or 87% of authors), and three documents by 111 authors (or 21% of authors). One author had published 15 papers. Our analysis confirmed to a high degree Lotka's law of the ratio between the number of authors, and the number of documents they published.

The research focused on the authors' affiliation. It turned out that there was also a significant difference between the number of publications from different affiliations. Table 5 presented information about the activity of the ten most actively published affiliations in the selected topic. Authors from the two most active institutions – University of Toronto and University System of Ohio- had published 23 papers each, and 1,366 institutions (or over 58%) had only one publication. Publishing activity increased over time.

Table 5. Publication activity of the ten most actively publishing affiliations in the selected topic

Affiliation	Articles
UNIVERSITY OF TORONTO	23
UNIVERSITY SYSTEM OF OHIO	23
HARBIN INSTITUTE OF TECHNOLOGY	21
UNIVERSITY OF LONDON	20
STATE UNIVERSITY SYSTEM OF FLORIDA	19
UNIVERSITY OF LONDON	18
STATE UNIVERSITY SYSTEM OF FLORIDA	18
UNIVERSITY SYSTEM OF OHIO	17
UNIVERSITY OF CALIFORNIA SYSTEM	16
UNIVERSITY OF MICHIGAN	15

Source: Own calculation on the basis of data processed with Biblioshiny [39].

The countries of the corresponding authors also differed in their publication activity. The most actively publishing countries were the USA (501 publications), China (364 publications), the United Kingdom (259 publications), Australia (103 posts), Canada (97 publications), Germany (83 publications), and The Netherlands (56 publications). Seventeen countries had only one publication each. The most actively publishing countries had the following number of citations: the USA – 16,727 citations (33.4 citations on average per article), China – 2,747 citations (7.5 citations per article), United Kingdom – 8,205 citations (31.7 citations per article), Australia – 1,512 citations (14.7 citations per article), Canada – 2,471 citations (25.5 citations per article), Germany – 1,206 citations (14.5 citations per article), and The Netherlands – 1,357 citations (24.2 citations per article).

The next direction of our research was the number of documents that fell within the scope of our research. There were 2,682 of them, distributed over time as follows (Fig. 5). There was an increase in the number of publications, which was most intense for the 2003-2017 period. Fig. 5 also presented the dynamics of the average number of citations per publication for the same period.

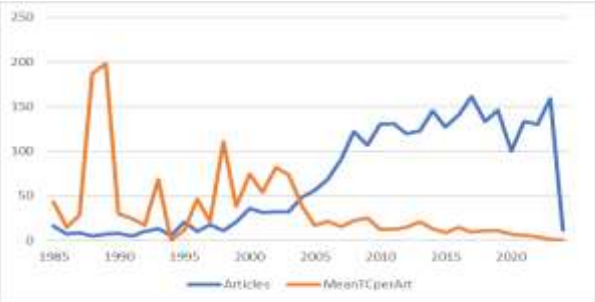

Fig. 5. Number of published documents and average number of citations per document by year, 1985 – 2024
Source: Own calculation on the basis of the data processed with Biblioshiny [39].

Initially, we analyzed the impact of the documents considering the number of citations, including global citations (all indexed in the WoS database) and local citations (within the studied set of documents). Table 6 presented the data for the first ten most cited documents.

Table 6. Number of local and global citations of the ten most cited documents in the research area

DOI/Document	Year	Local Citations	Global Citations
10.2307/41165946	1998	105	891
10.1287/orsc.1080.0412	2009	98	991
10.1111/1467-6486.00260	2001	82	352
10.1108/13673271011015615	2010	74	403
WAGNER RK, 1985, J PERS SOC PSYCHOL	1985	69	369
10.1093/jeg/3.1.75	2003	67	1133
10.1177/0170840600213001	2000	53	657
10.1016/S0090-2616(01)00026-2	2001	49	229
10.1037/0022-3514.52.6.1236	1987	48	148
10.1080/09537329608524237	1996	46	284

Source: Own calculation on the basis of data processed with Biblioshiny [39].

Keywords that appear in the identified posts were also of interest. We chose to analyze author keywords, considering that they highly reflected the author's ideas, as well as Key Words Plus, which gave a good idea of the actual content of the documents.

Table 7. Occurrences of Authors' Keywords and Key Words Plus in the studied set of documents

Words	Occurrences in Authors' Keywords	Occurrences in Keywords plus
tacit knowledge	690	73
knowledge management	211	7
knowledge sharing	106	N/A
social networks	97	54
knowledge transfer	81	10
innovation	70	146
explicit knowledge	68	12
tacit knowledge sharing	67	N/A
networks	64	33
knowledge	58	63
informal networks	56	N/A
social network analysis	55	1
social capital	52	N/A
informal learning	37	N/A
trust	30	92
social support	28	24
tacit knowledge transfer	28	N/A
organizational learning	23	N/A
social network	22	5
knowledge creation	20	1

Source: Own calculation on the basis of data processed with Biblioshiny [39].

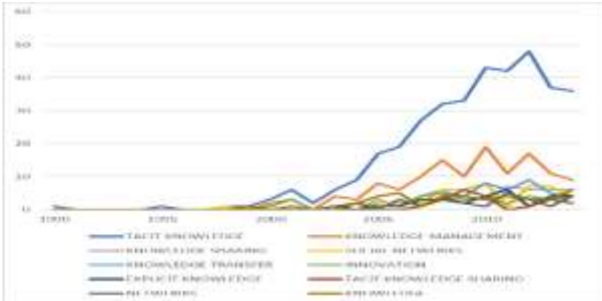

Fig. 6. Dynamics of the use of the ten most common Authors Keywords, 1990 – 2024
Source: Own calculation on the basis of data processed with Biblioshiny [39].

Key Words Plus were "words or phrases that frequently appear in the titles of an article's references, but do not appear in the title of the article itself" [12]. Table. 7 presented the twenty most frequent Authors' Keywords and the number of occurrences of the same words identified as Key Words Plus. Some of the Authors' Keywords do not appear as Key Words Plus at all.

The dynamics of the keywords used over time were also important. Figure 6 shows the dynamics of the use of the ten most common Authors' Keywords.

One can conclude that the use of the two most common keywords – tacit knowledge and knowledge management had increased intensively since 2002.

In-depth Analysis

The review of the publications made it possible to highlight several problem areas: a) the specifics/peculiarities in the application of the tacit knowledge; b) the key factors that have a significant impact on the transfer of tacit knowledge; c) the mechanisms and models for the implementation of the transfer of tacit knowledge.

The Specifics/Peculiarities in the Application of the Tacit Knowledge. Tacit knowledge arose and was enriched and developed more in certain economic and social activities than in others. The differences between these areas of its application were determined, on the one side, by the specifics of the particular area, by the environment in which the economic, social, organizational, and technological processes took place, and by the specific nature of the processes and activities themselves. This included actions and activities that were not typical, repetitive, routine, and therefore difficult to mechanize, automate, and codify. These were activities in situations that required quick decision-making of a specific nature, arising from circumstances that either couldn't be foreseen, were too rare and unusual to have ready-made recipes/instructions for action, or were just emerging and being observed/managed for the first time (e.g. in the field of emergency assistance, security, in the management of accidents, natural disasters, personal and international conflicts, etc.). On the other side, the individual areas of application of the tacit knowledge were related to the tacit knowledge itself, such as knowledge about the performance of specific human activities, knowledge related to the person and expressed in human capital (and in a broader aspect – in the social capital) – experience, routine, skills, competencies, morals, conscience, creativity, ingenuity, scientific activity, and innovations – everything that accumulated in a person during the performance of his occupational and social activities, and that was realized in them both consciously and unconsciously (intuitively).

Tacit knowledge was important in the field of **construction** activities [31]. The construction industry could be defined as highly knowledge-based [25]. The knowledge used was different – "soft" knowledge related to the human factor, which was mainly tacit knowledge, and "hard" or technical knowledge, which was mostly codified, with complex dependencies and complex interaction processes between the different types of knowledge [37]. Unlike implicit knowledge, tacit knowledge was expressed in individual relationships, experience, work skills, ability to communicate and work in a team, and had a direct relationship to the quality of work performed [2, 28]. Due to the nature of the activities in construction, tacit knowledge had a dominant role compared to technical knowledge [1], as the latter could be more easily reproduced or recovered. In contrast, tacit knowledge was extremely important for construction companies [36] as it was lost entirely or to a significant extent in staff turnover. For this reason, the transfer of tacit knowledge was key to the successful implementation of construction projects [27].

Tacit knowledge was a key factor in the field of **emergency medical care, crisis management, security management**, and the like, where quick and adequate decisions needed to be made for specific situations occurring in real time [11]. Having experience in dealing with similar situations in the past helped to adopt appropriate strategies with less effort and time, which could be key to saving a life. Security Operations Centers were concerned with monitoring, detecting, and responding to threats in company networks, and the interaction and coordination between people, technology, and processes were based on the ability to rank threats, accumulated experience, and competence, i.e. – of implicit tacit knowledge, which was often difficult to identify and, therefore, to share. New experts encountered difficulties in the absence of context, communication was prolonged or became incomprehensible in the initial phase of problem detection, which in turn slowed down the process of limiting the damage. Lack of experience could be only partially replaced by heuristics and "brute force", while experienced analysts could know the answer to threats almost immediately.

In **research and development**, knowledge was transferred over long distances through communication channels, some of which were suitable for sharing explicit knowledge, while others, such as human flows and relationships, were mainly related to the transfer of tacit knowledge [22]. Scientific work had a strong connection to tacit knowledge [6], with sharing tied to personal contacts and researcher mobility. The co-authorship of scientific articles was the result of personal contacts, work on joint scientific projects, and participation in mobilities, conferences, and seminars. Face-to-face meetings helped build relationships based on trust [7] and increased the potential for future joint publications.

The transfer of tacit knowledge was one of the main means of **sustainable organizational innovation** [35] because it stimulated the rapid growth of knowledge [13]. The sharing of tacit knowledge among members of a network through formal and informal communication channels led to its assimilation and application by other network participants, promoted knowledge innovation, and from the perspective of the entire network, increased the aggregate utility of existing tacit knowledge [33] and supported the generation of new, implicit and explicit knowledge [21].

Tacit knowledge was of critical importance in **open innovation** [32], as it was related to the complex process of creating new ideas [3]. Tacit knowledge transfer also faced additional difficulties, as, on the one hand, participants might not be aware of their knowledge or unable to express it [24], and on the other, they might be reluctant to provide it because they could lose competitive advantages [18]. Open innovation projects were not localized in an organization or in any central location, which made the exchange of explicit knowledge difficult and made tacit knowledge and its sharing even more essential [9], especially in the context of social relations that connect people with interdisciplinary competence from different places, across geographical and organizational boundaries.

Tacit knowledge was essential in the **development and implementation of software projects** [8]. It was related to the communication and understanding of the client's functional requirements in the design of the software modules. What the customer required, what the engineers who designed the software understood, and what was obtained as a final product in terms of functionality and interface, determined to a large extent the successful application of the software. The presence of tacit knowledge in the designers supported the correct specification of requirements, and structured communication, thus providing clear evidence of software development progress [20]. The ability of end-users to present requirements unambiguously and of engineers to interpret them correctly depended on personal contact, regular interaction, and trust [19], as such knowledge could only be shared in a specific context, for example when people were involved in the same social systems [26].

In **university education**, tacit knowledge plays an important role in the student’s successful acquisition of knowledge and skill development [15]. In the learning process, groups were formed based on personal qualities but also on the ability to solve the assigned tasks, and some students could play the role of sources of tacit knowledge, and others – of users. The tacit knowledge in this case was transmitted through the joint work of the students, through their practical activities, and not in a formal way. The awareness of having tacit knowledge, that was intuitively shared, was important for team building, working together, building relationships of trust and security, and complementing formal learning with informal connections, including through social networks.

The Key Factors That Have a Significant Impact on the Transfer of Tacit Knowledge. Many factors influenced the process of tacit knowledge transfer. Tahir et al. [31] conducted a detailed literature review and identified as many as 78 factors, some of them with overlapping scopes. According to Tahir et al. [31, p. 607], the factors can be reduced to 57, and after surveying 30 specialists in the field of architecture and construction, they found 19 important factors for the construction industry in developing countries. Those included: “*trust, personal contact and* *interaction, team composition, mutual reciprocity, peer relations, system of rewards, power and sense of ownership of knowledge, individual's agreeableness, individual knowledge/skills, teamwork and shared goals, expertise development, leadership commitment, strategic thinking, individual management of time, proactive management approach, communication, leadership structure, interpersonal skills, and self-efficacy*" [31, p. 612].

An important factor in the successful transfer of tacit knowledge between experts was **trust** [29], and in the specific case of security management centers [11, p. 42039], trust grew in previous work "face to face". Thus, factors such as an adequate working environment, accounting for the cultural aspects of the participants, and physical proximity of workplaces, incl. visual connection between experts, helped to overcome language barriers, enabled active and passive communication, increased the speed and productivity of work and the effectiveness of the transfer of tacit knowledge.

Jeck & Baláž [22] drew attention to the importance of the type of connectivity between actors, as flows of goods and patents transferred explicit knowledge, while mobilities of people – students, teachers, even travelers or migrants – contribute to a high degree to the transfer of tacit knowledge, which was based on informal social interactions [22, pp. 98, 107]. At the same time, despite the progress in the development of modern information and communication technologies, geography continued to play an important role in the transfer of tacit knowledge in two aspects: physical distance and cultural and linguistic boundaries. Tacit knowledge is shared more easily with already established and historically established commercial, cultural and linguistic ties between individual communities, with cooperation and shared historical heritage [22, p. 107].

Relationships between actors also mattered, particularly as measured by the symbiosis-competition scale [35]. The presence of a symbiotic interaction significantly supported the sharing of tacit knowledge, and this was further enhanced in symmetrical symbiotic relationships. Creating an appropriate working atmosphere, and increasing trust and cooperation between participants was more easily achieved in collaborative and mutually beneficial work, supported by an adequate organizational reward mechanism that stimulated knowledge sharing. At the same time, when knowledge was perceived as personal property ('*Knowledge-based psychological personal ownership*'), serious obstacles were created to its successful sharing between participants and interaction to achieve effective and sustainable transfer was difficult [35, p. 17].

The formalization of the transfer process gave an additional impetus to the sharing of tacit knowledge [8], and this was particularly evident in software development since the knowledge of customers often does not allow them to cope with the means of expression of programmers. Finding similar social constructions made it possible to identify certain dialogic reference points, interpret tacit knowledge and model the functional requirements of the commissioned software product [8, pp. 16-17].

The situation was special when the existence of tacit knowledge was not clear or was not realized by its holders. Its transfer then took place through collaborative practical work, intuitively [15]. The factors that determined its successful transfer were related to the size of work groups – small ones (2-4 people) were best suited, as they could be constantly reorganized for different tasks to increase the possibility of sharing between more people. The separation of groups – sources of knowledge, consumers of knowledge and intermediaries, accelerated the sharing of knowledge, but at the same time reduced the transfer of tacit knowledge [15, pp. 861-862].

Terhorst et al. [32] had a different view for the role of mediators. They were needed, at least in the initial stage of work, to build connections and help participants make sense of tacit knowledge. At a later stage, this necessity faded, increasing the importance of the autonomous motivation of participants to share and absorb tacit knowledge from others. In parallel, cultivating a work culture that fostered autonomy, competence, and connectedness led to building a positive attitude toward sharing tacit knowledge [32, p. 15].

According to Supanitchaisiri et al. [30], the factors that were central to the extraction of tacit knowledge were primarily organizational and were related to corporate policy, staff motivation, continuity in knowledge management, support for continuous and ongoing learning, supportive culture and organizational behavior. Other factors had to do with the individual qualities of the participants: preparation, knowledge and interpretation of tacit knowledge [30, p. 98].

The mechanisms and models for the implementation of the transfer of tacit knowledge. Tahir et al., [31] developed an SD (‘*System Dynamics*’) model in which they included 140 interrelationships between factors influencing the transfer of tacit knowledge in construction. They established a total of 6 loops, four of which were strengthening and two were balancing. The development of communication strengthened personal contacts and interaction between participants, thus consolidating teamwork and trust, and growing expertise and individual skills (effective self-learning). In parallel, the increase in trust reduced the sense of ownership of knowledge between individual participants and further contributed to effective sharing, enhancing communication. Model simulations showed a steady increase in tacit knowledge transfer over time.

In the field of security management centers, Cho et al. [11], used Nonaka's [26] 'SECI' model, in which there was a continuous transfer of tacit knowledge and its transformation into implicit, codified knowledge. According to them, in the separate phases, there were peculiarities caused by the specifics of the work in the crisis management centers. In the socialization phase, contacts were made and trust was built between the participants. The second phase covered the acquisition of tacit knowledge through the observation of the experts' work ('job shadowing'), application of the knowledge in simulations and a real work environment, discussion and commenting on the actions and filling in the noticed knowledge gaps. In the third phase of combining, the new knowledge was transformed into a document to serve other participants. In the final phase, junior analysts were ready for direct client action with the updated documentation [11, pp. 42034-42036].

Jeck & Baláž [22] pointed out that the transfer of tacit knowledge in scientific research was realized through the so-called ‘*connectivities*’, which were defined as specialized channels for communication and exchange of people, goods, and knowledge between countries [23]. In the scientific research sphere, however, the transfer of tacit knowledge manifested in the formation of two groups: core and periphery. The main part of the communication and sharing took place within the core, and concerning the periphery, there was minor intra-peripheral sharing. Over time, the sharing between the core and periphery increased [22, pp. 100, 106].

Xu et al. [35] considered the tacit knowledge transfer system in the organization as a dynamic ecosystem composed of four elements: knowledge provider, knowledge receiver, intermediary, and the organization as a whole. The sharing of heterogeneous tacit knowledge, which supported the organization's activity in a competitive environment, occurred in different forms of organization, with symbiotic ones providing significant advantages. Symmetrical relationships led to identical increases in the knowledge of participants who depended on each other to achieve their goals. Relationships were stable and led to both increased knowledge throughout the organization and sustainable organizational innovation [35, p. 18].

Dima & Vasilache [15] analyzed the mechanism of transfer of tacit knowledge in higher education, where the holders of tacit knowledge were often not aware of it. Its transfer was realized intuitively, as during their joint work the students constantly compared themselves and formed network relationships. Holders of tacit knowledge acted as experts or leaders who developed relationships with many more participants than users of tacit knowledge. When performing specific tasks, small groups or chains of trust were formed, in which the tacit knowledge of experts was transmitted in the process of practical work, sometimes without being fully aware of it [15, pp. 861-862].

In the field of open innovation, the sharing of tacit knowledge took place within a network composed of multiple organizations with different locations [32]. Sharing in this case differed from exchange between individuals, as it acquired a social context and was realized in the process of practical activity. Best suited for effective sharing were small groups, the presence of many and varied relationships, and last but not least – the presence of mediators. With participants of a similar level of education and experience, tacit knowledge was more easily shared. Formal communication channels played a role, and being in spatial proximity also supported transfer, especially when there was visual contact [32, pp. 12, 14].

The peculiar nature of tacit knowledge determined to a high degree the specific areas in which it has a significant or even a dominant, structure-determining role in the development of companies and the implementation of innovations. This is related to the role of the human factor in the accumulation of experience, knowledge, skills and competencies (tacit knowledge), its importance in the specific field and the importance of sharing it through personal contacts and face-to-face communication. At the same time, areas are identified in which tacit knowledge is not of essential importance and can be successfully combined or even completely replaced by codified (implicit) knowledge. These areas are not permanently defined but can change continuously, parallel to the continuous and natural process of transforming tacit into implicit knowledge (knowledge codification).

Summary of the factors made it possible to conclude that the authors outline three important groups of factors: external, organizational and personal, with external factors covering elements of the environment that are largely given and cannot be changed by the organization or individuals – geographical distance, historical, political and cultural heritage. Organizational factors describe the conditions that the organization creates or can influence, thereby facilitating or hindering the transfer of tacit knowledge – for example, a suitable work environment and physical proximity between participants, building symmetrical and mutually beneficial relationships, formalizing the knowledge-sharing process, creating a sustainable informal structure, etc. Personal factors are related to the individual qualities of the participants in the tacit knowledge transfer process and could be combined with the organizational factors or come into conflict with them, supporting or hindering the sharing of tacit knowledge – consciously or intuitively. This includes behavioral factors, motivation, communicativeness, competence, willingness to share knowledge, independence, team culture, etc.

Tacit knowledge transfer mechanisms always involve the creation of connectivity, communication channels and the building of trust. The lack of trust or an informal social structure necessitates the presence of intermediaries (brokers), at least until trust is strengthened. Physical proximity between participants is important because the sharing of tacit knowledge is often done through observation of work or through joint practical activity, where experience, knowledge and skills can be transferred even unconsciously, or intuitively.

CONCLUSIONS

The researchers' interest in the problems of the transfer of hidden (tacit) knowledge through informal innovation networks is growing. Many authors establish the importance of tacit knowledge and the difficulties in its transfer. Systematic analysis of literature sources on a specific chosen topic can be greatly facilitated with modern software products, such as those developed in the R environment. Through a systematic analysis of literary sources and their citations, the presence of clustering of researchers and research organizations, as well as the presence of informal research networks, can be established.

The sharing and, in a general sense, the management of tacit knowledge was important for specific areas of human activity associated with a high intensity of used knowledge (construction, crisis management, training, scientific research). As the complexity of knowledge, its diversity, and interdisciplinary content increased so did the importance of tacit knowledge and its transfer. The processes of sharing tacit knowledge were realized under the influence of numerous organizational, psychological, and socio-cultural factors, the main ones being related to trust, adequate communication (including face-to-face), motivation and culture for sharing knowledge (overcoming the stereotype of knowledge ownership as a source of competitive advantages).

Building adequate mechanisms for the transfer of tacit knowledge involved creating specialized communication channels based on symmetrical relationships, chains of trust and job shadowing thereby strengthening the participants' teamwork, trust, expertise and individual skills. There are rich opportunities for further research in the chosen research topic. An example of such directions is establishing the capabilities of modern social network analysis methods in quantitative analysis of established networks of researchers and research organizations to determine and exploit their network characteristics, such as centrality, transitivity, and modularity.

It is of significant interest to carry out a comparative analysis of the efficiency, speed and volume of the transfer of tacit knowledge in different branches of the economy, as well as to track regional differences, especially between territories with different levels of economic development. The use of different methods and models for sharing tacit knowledge and its gradual transformation into a codified one focused on the effectiveness of the various mechanisms, the possibilities for their combination and adaptation to the specifics of innovation networks, especially in the context of the internationalization of knowledge.

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PROVISION OF AGROECOSYSTEM SERVICES FROM FARMERS - EXTERNAL AND INTERNAL FACTORS

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Abstract

The purpose of this paper is to present an analysis of the motivating factors for the provision of agroecosystem services by farmers. Farmers are one of the main socio-economic actors on whom the provision or disruption of ecosystem services depends to a large extent. For this reason, a number of studies have focused on the motivating factors for promoting the provision of ecosystem services. In our study, we divided these factors into external and internal. We conducted interviews with 345 farmers in all Bulgarian districts. We observed that internal factors have a greater predominance for all three categories of ecosystem services, especially for the provisioning one. Among these, it appears that own beliefs are a prevailing factor among farmers. On the other hand, among the external factors, legal requirements and public subsidies predominate, while factors such as social pressure have a minor contribution.

Key words: *agro-ecosystem services, motivation factors, adoption behavior*

INTRODUCTION

Agroecosystems include the traditional understanding of ecosystem services, but with a focus on how agricultural activities modify natural functions. Agroecosystem services can be seen as a subtype of ecosystem services with all the natural functions and the resulting benefits for society, but subjected to the influence of farmers as decision-makers. Ecosystem services have been classified in four main categories by the Millennium Ecosystem Assessment (provisioning, regulating, cultural and supporting services). However, it should be noted that this classification serves mainly for our human understanding of natural processes. In the natural environment, these categories overlap and are completely interrelated. Agricultural ecosystems, by their very existence, provide material, supporting, regulating and cultural services to society. These services are strongly linked to the socio-economic demand of society, providing and satisfying our basic need for food. In most cases, agricultural ecosystems are considered primarily as territories related to the cultivation and production of food resources, with less consideration given to other ecosystem services that should be considered as an integral part of the agricultural ecosystem. The decision-making process in one farm holding has a direct impact on the capacity of the ecosystem to provide services. Thus, agricultural activities can lead to a deterioration in the state of various natural elements such as pollution of water sources, deterioration of soil health (including erosion processes, reduction of biogenic elements, etc.), reduction of biodiversity, among many. On the other hand, the farm is directly and economically dependent on the state of ecosystem functions. This reveals an interconnected system in which the way the farm is managed plays a key role in maintaining the provision of ecosystem services.

The main focus of this paper is what factors influence farmers’ decisions to provide agroecosystem services. A number of authors have investigated farmers’ motivations and attitudes towards implementing environmental measures. According to some authors [9], these attitudes are influenced by government policy and public pressure to improve the state of natural environment. Other authors examine the relationship between the implementation of environmental measures from the perspective of farmers’ perceptions of environmental problems, not only due to economic incentives [8, 5, 12, 1]. Attachment to the land can be a driving force for the conservation of natural systems [14]. The personal awareness of farmers can also be key in terms of undertaking specific conservation activities [7]. According to some researchers [11], awareness of the presence of soil erosion can have an effect on attitudes towards more environmentally friendly practices. According to other authors [6] social factors may be key to the pro-environmental attitude of farmers, rather than their awareness and information on environmental issues. Other studies address factors such as farm size [4, 15], receiving financial benefits such as government subsidies [3, 15]. By creating increased opportunities for state subsidies and promotion of environmental behavior of farmers in the European Union, there is a steady trend of increasing research interest in these issues. In Europe, research focuses on the participation of farmers in agri-environmental measures [7, 2, 13]. Similar studies have been conducted in Bulgaria, aiming to reveal the attitudes of farmers to participate in agri-environmental measures in order to provide ecosystem services [10].

In this context, the aim of the research is to analyze the motivating factors for the provision of agro-ecosystem services by farmers.

MATERIALS AND METHODS

To study the motives and attitudes of farmers towards the provision of agro-ecosystem services, a survey was conducted in 2024 among 345 producers from the six regions of Bulgaria. To reveal the attitudes, the following several motivating factors were identified: (i)Legal requirement, (ii) Social pressure, (iii) Receiving public subsidies, (iv) Requirement of a supplier or buyer, (v) Own conviction, (vi) Provision contract, (vii) Market benefits and (viii) Sustainable behavior.

The selection of factors is based on the author's own observations and literature review of similar studies. In addition to individual factors, the factors are grouped into external and internal (Fig. 1), which reveals a more in-depth view of the farmers' motivation.

The agro-ecosystem services that were selected for the study are divided into three categories. This classification is based on the methodology of CICES – Common International Classification of Ecosystem Services.

The categories and the agro-ecosystem services are as follows:

Provisioning:

- Use of recycled waste, composting
- Renewable energy use
- Preservation of traditional productions, varieties, breeds

Regulation and maintenance:

- Soil health
- Water conservation
- Biodiversity conservation
- Improving air quality and climate

Cultural:

- Preservation of traditional landscape
- Access to the farm territory by other persons
- Conservation and improvement of non-agricultural ecosystems

The division of factors influencing farmers' decisions are presented in Fig.1.

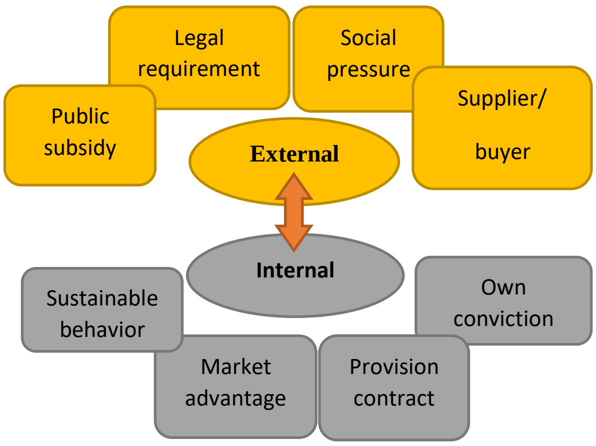

Fig. 1. Division of factors influencing farmers' decisions.
Source: Author's own work.

RESULTS AND DISCUSSIONS

In the next several figures (Fig. 2, 3, 4) we show the overall results regarding the factors that influence farmers' provision of agro-ecosystem services. The analysis follows the previous division of the services into three categories. Overall, it appears that the most common motives among the respondents are "own conviction", followed by "legal requirement" and "receiving public subsidies". To the least extent, respondents indicate "market benefits", "provider requirement" and "provision contract".

Provisioning agroecosystem services

Provisioning ecosystem services are directly related to the production of goods from the agricultural sector, which makes them easily appreciated and valued not only by the producers themselves, but also by consumers. Figure 2 presents the results regarding the factors influencing the provision of these services. For all three types of provisioning services, the factors "provision contract", "supplier/buyer requirement" and "social pressure" are the least important, whereas „own conviction" is the predominant factor.

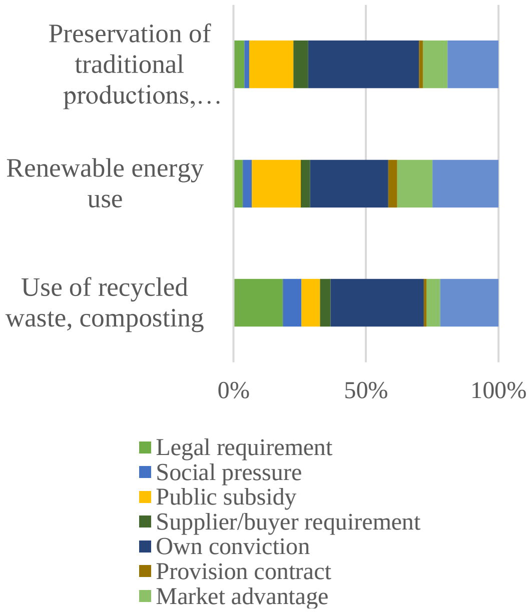

Fig. 2. Factors affecting the provision of provisioning agro-ecosystem services
Source: Author's own work.

Regulation and maintenance agroecosystem services

These are the services that are most difficult to perceive and evaluate by people, since their benefits to society often remain invisible (unlike provisioning ecosystem services like food and fiber). Similar to the previous category, the main focus is on several factors (Fig. 3).

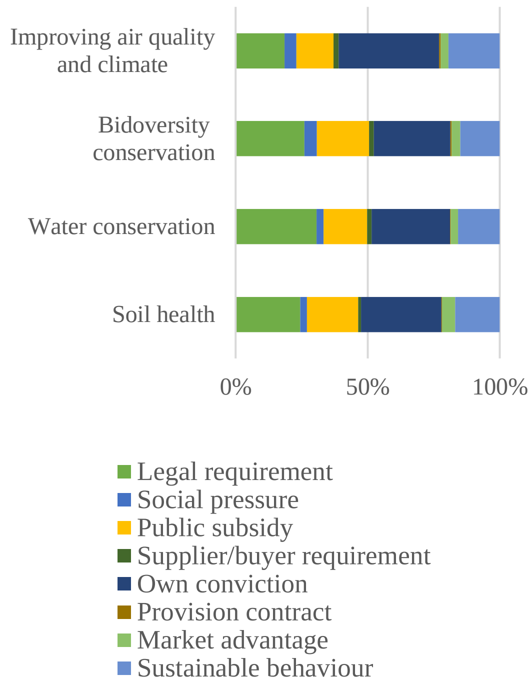

Fig. 3. Factors affecting the provision of regulation and maintenance agro-ecosystem services
Source: Author's own work.

First of all, the factors "legal requirement" and "own conviction" are most strongly represented in the respondents' answers, varying between 19-30% and 30-38% respectively. "Legal requirement" as a factor is strongly reported for water conservation service (30%), which stems from the long-standing state regulatory policy in this area. Again, the factors that have the least influence are "provision contracts", "social pressure" and "market benefits". "Public subsidy" has a steady share for all of the four type of services (ranging between 15-20%). This is a result of a long state support for conserving these natural functions.

Cultural agroecosystem services

In this category the motive "own conviction" is the most prevalent among respondents in relation to all three types of services included here (Fig.4). "Legal requirement" is significantly considered in the case of "preserving traditional landscape" (26%). For all three types of services the factors "provision contract", "supplier/buyer requirement" and "social pressure" are the least important, whereas "own conviction" is the predominant factor for all services.

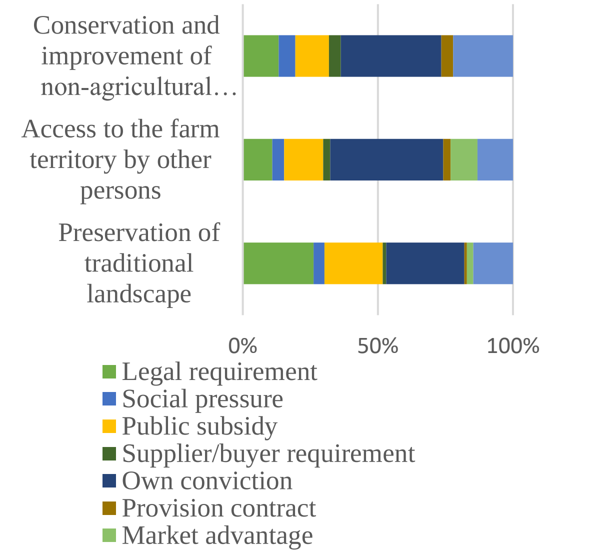

Fig. 4. Factors affecting the provision of cultural agro-ecosystem services
Source: Author's own work.

Division of factors affecting farmers' decisions to provide agro-ecosystem services – external and internal factors

This subsection presents the results of the survey regarding the factors that influence farmers' decisions to provide agro-ecosystem services from their farms, divided into two categories – external and internal (Fig. 5).

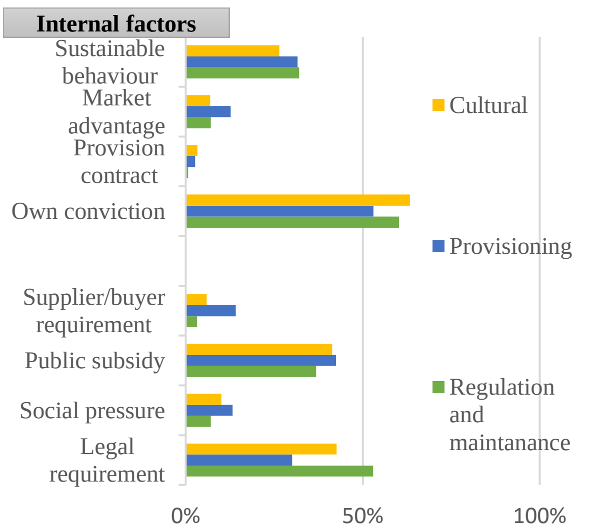

Fig. 5. Division of factors affecting the provision of agro-ecosystem services among the three categories of ecosystem services
Source: Author's own work.

Figure 5 shows how the two categories of factors (internal and external) are distributed among the three categories of ecosystem services.

Within the internal factors the predominant one is „own conviction" for all three categories of ecosystem services, followed by "sustainable behavior". "Market benefit" as a motive has the greatest weight in relation to provisioning services (13% of responses), while the "provision contract" represents a negligible percentage of all responses. Regarding the external factors, "legal requirement" and "public subsidies" are the types of factors that are predominant in all three categories of ecosystem services. "Supplier/buyer requirements" and "social pressure" seem to have limited influence.

CONCLUSIONS

The present study analyzed the factors influencing farmers' provision of agroecosystem services. For this purpose, a survey was conducted among 345 producers from the six regions of the country. The survey questions were aimed at revealing eight factors influencing the provision of eleven types of ecosystem services. The analysis included an assessment of these factors for each of the eleven agroecosystem services, and subsequently they were grouped into three categories. The factors were divided into internal and external in order to assess which of the two categories have greater importance. In general, it is observed that internal factors have a greater weight for all three categories of ecosystem services, especially for the provisioning ones. Of these, it turns out that "own conviction" and attitudes for "sustainable behavior" are predominant in the responses (between 85 - 93%) for all three categories of services.

In the case of external factors, "legal requirement" and the "public subsidy" prevail (between 72 - 89% of the responses), while factors such as "social pressure" and the "requirement of a supplier/ buyer" have a minor contribution. To the highest extent, the legal requirement as a factor is reported in relation to the ecosystem service "water conservation". "Social pressure" as a factor is reported to the highest extent in "conservation of biodiversity", and "public subsidies" is mostly associated with "conservation of soil health”.

It can be concluded that internal factors have a higher predominance for almost all of the agro-ecosystem services. The external factors increased their weight for services which are mostly perceived as public goods and where factors such as legal requirements and public subsidy can be driving forces for agro-ecosystem services provision.

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COMPETITIVENESS OF BULGARIAN FRUIT PRODUCTION IN THE WORLD MARKET

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Abstract

The purpose of the present study is to determine the competitiveness of the fruits sector in the world market after the accession of Bulgaria to the European Union, what is the state of fruits production, what are the challenges facing the sector and the opportunities for the development of the sector in the future. The development of the sector is determined by the demand of fruits on the world market and the traditional demand of local fruits on the national market. The novelty in this study is that the competitiveness in a static aspect is determined by the ability of agriculture in Bulgaria to expand its market share and preserve and increase the added value of production on a national and global scale. In this way, a comprehensive assessment of competitiveness is made of the fruits sector, combining both the production side and the value side. The data regard the period 2007-2022 and they have been collected from Bulgarian Ministry of Agriculture – Agro statistics, International Trade Center, FAOSTAT and National Statistical Institute of Bulgaria. In order to reveal the share of local fruits production in domestic and world consumption and the change in the gross value of Bulgarian production on a national and global scale, per capita in the article is used the total index of competitiveness. In this case, the assessment of competitiveness is expressed as a quantitative value and an index, taking into account the development of the sector through selected main fruit species, which occupy a dominant share not only in production, but also in the consumption of the population. In most years of the analysed period, the production component of competitiveness exceeded the value component, which is important from the point of view of making the country's market positions more sustainable. When the value component of competitiveness exceeds the production one, it means that the country achieves higher export prices of the production, which in a highly competitive market such as the agricultural one, can hardly be sustained in the long term. The expected variability of the environment in which fruit growing in Bulgaria will function under the changed conditions of the agrarian policy creates uncertainty among producers. In this aspect, the application of the general index of competitiveness is a means to develop and define appropriate policies and decisions applicable in the coming years.

Key words**:** *fruit, competitiveness, total index of competitiveness, Bulgaria*

INTRODUCTION

Competitiveness is a widely debated topic. There is still no generally accepted definition of competitiveness. The reason for this may be due to the different level of consideration of competitiveness – economy, sector or firm level. Historically, have different approaches to the study of competitiveness. A. Smith [18] examined her from the point of view of specialization and the absolute advantages of the countries. A. Smith proved that in a market economy, the needs of consumers can be satisfied and the resources in society can be used most efficiently [18]. D. Ricardo [17] studied competitiveness by supplementing it with the theory of the effect of comparative advantages and differences in the technologies of production of goods. In an OECD study of approaches to measuring competitiveness and efficiency in agricultural production, L. Lattrufe [11] notes that there is no generally accepted definition of competitiveness in economic theory, and that it can be defined as the ability to be successful when faced with competition. Bris and Caballero present their own holistic approach to the study of competitiveness by listing a further thirteen different definitions of competitiveness [1]. According to M. Porter's theory [16], a competitive advantage exists when the enterprise provides the same benefits to consumers as other firms, but at a lower price (price leadership) or when the utility of the company's product is greater than that of competing products (product differentiation).

From the review of the scientific literature on international competitiveness, it can be said that it is measured as the competitiveness achieved by individual nations. National competitiveness is seen as a synthetic indicator, uniting product, company and industry competitiveness. In the risky sectors of agriculture, such as fruit production, climatic conditions are of great importance due to the strong dependence from they. A significant role is also played by the country's agrarian policy. In this regard, the detailed analysis of the level of competitiveness and the competitive potential of the sub-sectors and sectors of agricultural production would give an opportunity to adequately determine the set goals and priorities of state agrarian policy.

In the their article, Slovak scientists pay attention to the competitiveness of Slovak fruits within the EU by highlighting and focusing (with the availability of production skills and traditions in fruit growing in Slovakia) on the crucial importance of building modern irrigation systems and introducing new sustainable varieties fruits [15]. Economic analysis of Slovak fruit production is based on yield per hectare, production systems, costs and performance targets. The total production of selected fruit species is analyzed in detail, and average yields are compared with those of EU producers. The analysis of the real costs for each type of fruit is done in order to find the most cost-effective fruit [15].

.In another study, Chinese scientists also analyzed the competitiveness of Chinese fruit products and its stability (for the period 2000-2016) by means of the Revealed Asymmetric Comparative Advantage (RSCA) Index [19].

Their results show that, for most fruit products, the competitiveness of the world market is greatly reduced, and that the level of comparative advantage of fruit products is far from the level at the beginning of the period. The competitiveness and overall comparative advantage of fruit products in China is gradually declining [19].

The overview of the presented research activity on the problems of the competitiveness of agricultural production in Bulgaria forms the opinion that there is a lack of a unified formulation regarding the essence of the concept. Most often, the competitiveness of agriculture and its sub-sectors is associated with the ability to maintain and expand the market share of the sector on the domestic and international market, based on the supply of goods at prices and with a quality better than those of other competitors, at the smallest opportunity costs to restore the value of the used resources [8]. As an economic activity, the development of which takes place in conditions of imperfect competition, agriculture is subject to a number of state interventions. The successful integration of political and economic priorities in the sector should be carried out against the background of the complex assessment of competitive positions, competitive potential and determinants of competitiveness in individual subsectors [8].

The evaluation of competitiveness in fruit growing in Bulgaria was made by the Institute of Agrarian Economics - Sofia, by calculating the competitiveness index of selected types of fruit, accepted as a reference group for the period 2007-2017 [9].

Unsatisfactory levels of competitiveness were found for the majority of fruits, including in the case of apples and pears (due to the significant lag behind the Bulgarian production of these fruits per head of the population compared to the world, lower sales prices, and hence lower added value) and a higher competitiveness in the rest, especially in the case of cherries, in which a higher market share in the world market stands out. Good levels and increasing competitiveness have been established for apricots and especially for peaches, whose competitiveness is defined as comparable to the average world levels [9].

In this context, the purpose of this research is to analyse the state of fruit sector in Bulgaria after its accession to the EU and to assess the competitiveness of the country in the international market emphasizing the challenges the sector is facing and the opportunities for its development in the future.

The paper is structured into two parts:

Part 1- The status of the Bulgaria fruit sector
Part 2- The calculation and interpretation of the competitiveness index.
Finally, the corresponding conclusions were drawn and important recommendations have been made for the future development of Bulgarian fruit sector.

MATERIALS AND METHODS

To conduct this research, the data were collected from FAOSTAT [3], Eurostat database [2], Agro statistics of the Ministry of Agriculture and Food of Bulgaria [12], as well as from the National Statistical Institute of Bulgaria [13] for the period 2007- 2022.
For analysing the status of Bulgaria's fruit sector ***in Part 1***, the following main indicators have been studied:
-The share of fruit production in crop output and agricultural production;
-The gross value added and its dynamics;
- The structure of agricultural gross output;
- Harvested areas in fruits sector;
- Fruit production value at producer's price;
- Fruits consumption.
- Share of apples and southern fruits in the total consumption of fruits.
The used methodology included:
- Dynamic analysis of the main indicators to identify the trends;
- Structural indices;
- Graphical representations;
- Comparison method to evaluate the changes in 2022 versus 2007.
For Part 2, it was determined the competitiveness in the fruit sector using the competitiveness index.
Competitiveness in a static aspect is determined by the ability of a specific production in Bulgaria to preserve and expand its local and market share and to maintain and increase the added value of its production on a national and global scale. Through this concept, through the analysis, an attempt is made to make a comprehensive assessment of the competitiveness of fruit growing by combining the production and value sides. If the market presence expresses the quantitative performance on the domestic and international markets, then the gross value of the output expresses the performance with the achieved economic results.
Based on this definition, a competitiveness index of fruit growing was compiled. A possible method for studying competitiveness was developed by [5] and tested by [7]. Competitiveness is equated per capita. The introduction of the per capita criterion enables a relative comparability, both to account for individual market sizes and to take into account resource security. Comparisons are made based on per person basis, taking into account the levels that exist in the markets where competitiveness is considered.
The **PICdc** component reveals the share of domestic production of the respective product in domestic and world consumption. This component has two variants depending on whether the country's level of self-sufficiency is secured or the country is non-self-sufficient.
In case the country is self-sufficient for the particular product, then the formula for calculating **PICdc** is:

$$PICdc = \frac{MPbg}{\mathrm{MCbg+MCwr+MEbg}} \ldots\ldots\ldots\ldots\ldots (1),$$

where:
MPbg – Bulgarian production of the specific product per person of population, expressed in quantity;
MCbg – local consumption of a specific product per capita;
MCwr – consumption of a product in the world per capita, in quantity;
MEbg – exportation of a product in quantity.
When the country is fully self-sufficient, then production is higher than consumption and the difference between production and consumption is destined for export. The exported quantities must be included in the denominator to preserve the property of the production component of the competitiveness index **PICdc** to be in the range from 0 to 1, because otherwise this would not be possible.
In the second variant **PICdc** has the expression:

$$PICdc = \frac{\mathrm{MPbg}}{\mathrm{MCbg+MCwr}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The denominator of the equation is without **MEbg** – export of the relevant product from

Bulgaria because in cases where consumption is higher than production, the denominator will always be greater than the numerator and the coefficient will be in the specified range from 0 to 1. In these cases, the calculation of **MEbg**is:

$$MEbg = MPbg - MCbg \quad \text{............ (3)}$$

This applies when self-sufficiency is at levels where production exceeds domestic consumption and surpluses are destined for export, with export quantities obtained by formula (3).

The consumption of the product, which is the object of competitiveness measurement, is calculated per person of the population, and the aim is to see what share forms the value of the production of Bulgarian sector within the world production. The range of this index component is from 0 to 1. In theory, the index takes a value of 0 whenever there is a lack of domestic production. A value of 1 can be reached when national production is the only one in the world.

When the value of the Bulgarian and world production is equal, the index takes a value of 0.5. In formula (1), the importation of the specific product was omitted and exportations have been included in the denominator to account for the possibility of re-exports. When calculating the indicators related to world production and consumption, the Bulgarian presence in volumes must be taken into account. This is done by subtracting Bulgarian production **(MPbg)** from the world production of the product or good, and related to consumption, the world production, excluding the part of local production, is divided by the number of the world population, which does not include the population of Bulgaria. The **VICdc** component represents the change in the gross value of Bulgarian production in the studied sector, and is expressed by the equation:

$$VICdc = \frac{\mathbf{MVbg}}{\mathbf{MVbg+MVwr}} \quad \text{......................(4)}$$

where:

MVbg - is the gross value of production in the national sector, per capita, and **MVwr** is the gross value of production of the corresponding production in the world, per capita.

In formula (4), the greater is the difference between the gross value of domestic production and its value in world production, the greater than 0.5 is the value of **VICdc.** The calculation is based on the export prices of the products in Bulgaria and the world, which reflects not only the production, but also the added value along the value chain. The composite index of competitiveness is calculated according to formula (5).

In our opinion, market share and value added are equally important in their presentation, therefore, the components are equally weighted:

$$VICdc = \frac{\mathbf{PICdc+VICdc}}{\mathbf{2}} \quad \text{............................(5)}$$

It can take values in the range from 0 to 1. In theory, it takes a value of 0 when the country in question has no such production, and a value close to 1, theoretically whenever the world market is dominated by the country under study [5, 6].

RESULTS AND DISCUSSIONS

Part 1. The status of fruit sector in Bulgaria in the period 2007-2022

Bulgarian fruit growing takes its place in the country's economy as a sub-sector from the agricultural sector. Despite the fact that Bulgaria traditionally has extremely favorable conditions for the development of a large number of fruit species, after the accession of the country into the EU, a sharp drop in the share is observed, both in crop production and in the agricultural sectoras a whole (Fig. 1) in order to beamong other sectors of Bulgarian agriculture, into the group of the so-called vulnerable sectors.

In Fig. 1. the dynamics in the share of total production from fruit growing to that from crop production and agriculture of the country after the accession to the EU are depicted.

A downward trend can be outlined in both indicators from 2007 to 2014. Thus, from 13.8%, the share of fruit plantations from the total crop growing has reached 4.6%, and similarly, as a share of agriculture has decreased from 7.1% to 3.1%. In the next few years until 2020, the trend has changed and the maximum for the remaining period has been reached in 2017, with the share of fruit growing from plant growing and from agriculture being 7% and 4.9%, respectively. In the last two years of the analyzed period, the lowest values were reported, and especially in 2022, namely 4% and 3.1%. All these dynamic changes in most cases negative for the sector, were observed against the background of the structural changes taking place between the two subsectors of crop growing and livestock growing [14].

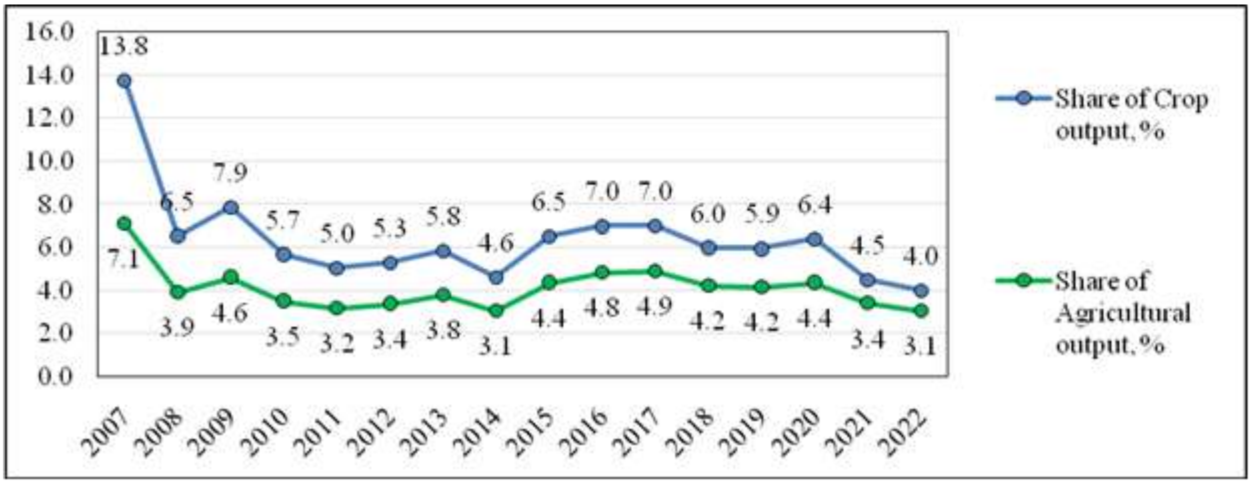
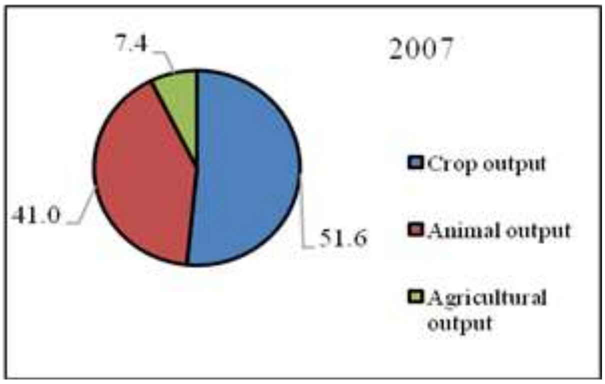


Fig. 1. Dynamics in the share Fruit output of Crop output and Agricultural output, %
Source: Eurostat and own calculations [2].

The significant changes that took place in the production structure of the agricultural sector from 2007 to the end of the period - 2022 are reflected in Fig. 2. The state of the gross output and of the gross added value in agriculture are a direct function of the production structure (Fig. 2), which in the considered period has significantly changed, the share of crop production has noticeably increased at the expense of animal production. In 2022 the crop growing forms almost 76.8% of GVA (thanks to the strong and progressive development of cereals and essential oil crops) in agriculture, and livestock production about 18.5%, the remaining 4.7% is created by the services in agriculture. Thus, sectors where the land is a direct productive force receive a greater incentive for development thanks to the subsidy policy implemented in the country, the support being based on area.



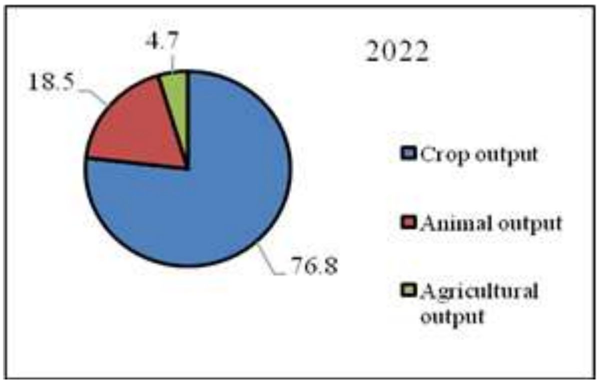


Fig. 2. Production structure of the gross output of agriculture, 2007 and 2022, %
Source: Eurostat and own calculations [2].

As for the impact of direct payments on area in fruit growing and especially as a share in the production value (Fig. 3), the impact of this support is not significant [10], since it cannot be assumed that that these payments affect the production cost. The main reason

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for this is the high production costs, reported on the technological map for the cultivation of the respective crop.

With one of the most labor-intensive fruit types, such as the apple, it is not serious to think that with a 5-6% share of subsidies from all production costs, a significant impact of this form of support could be expected. The picture is similar for the other structure-determining crops in Bulgaria. The lowest level of support is for peaches, apples, etc. [8].

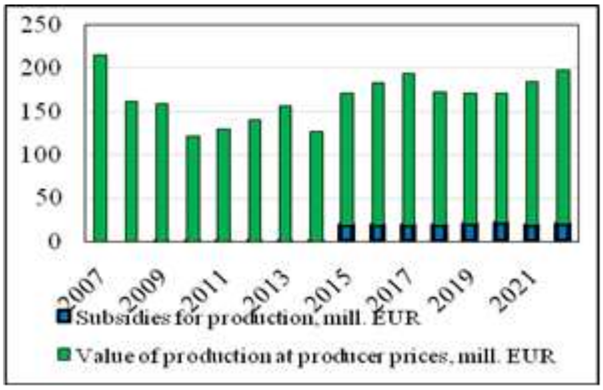

Fig. 3. Value of production from fruit growing at base prices (mill. EUR)
Source: Own design based on EUROSTAT data [2].

In terms of quantitative volumes, the total production of fruits in the country until the middle of the analyzed period shows significant fluctuations, which in the second half of the period, with the exception of 2020, maintain constant levels of total output, as for 2019 it amounts to at 234.6 thousand tons, and at the end of the period, respectively 222.2 thousand tons (Fig. 4).

It can be noted that the interest in fruit growing has gradually awakened in recent years, new plantations, as well as because of the aspiration to plant new fruit trees, (e.g. in 2022 the share of young plantations for plums was 12.5%, for peaches and nectarines - 10.2%, while for the apples it was 5.3%, and the same share was for apricots), part of the farms planning to diversify their activities. For the entire period, the areas increased more than 1.5 times, and the production more than 2 times (Fig. 4).

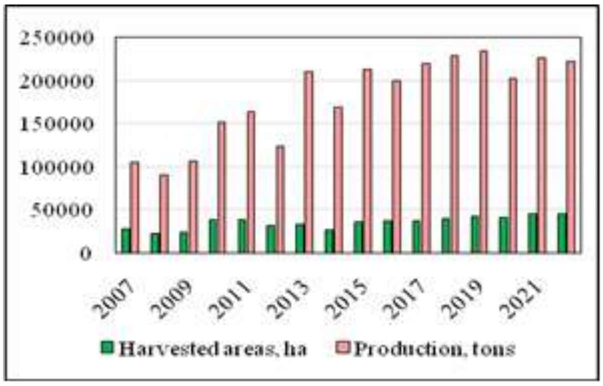

Fig. 4. Dynamics of harvested areas and production of fruit species in general for the country
Source: Own design based on the data from Ministry of Agriculture, Agro statistics, „Fruit production in Bulgaria“, 2008-2022 [12].

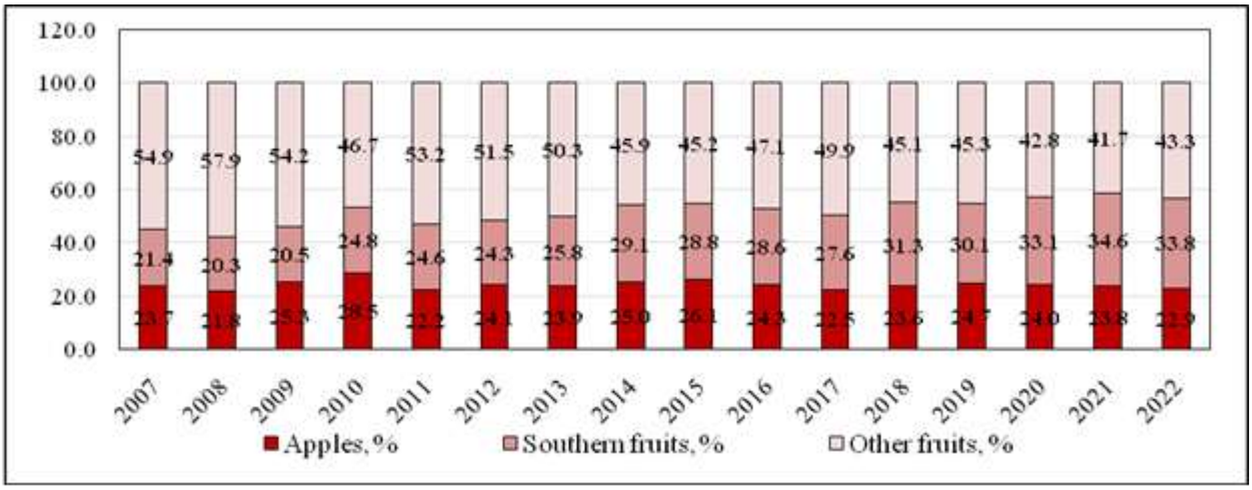

Fig. 5. Share of apples and southern fruits in the total fruit consumption on average per person from a household, %
Source: Own design based on the data from NSI, Household consumption of foodstuffs on average per person in households, 2007-2022 [13].

The dynamics of consumption of fresh and frozen fruit on average per person is shown in Fig. 5, from which it is clear that a significant part of the consumption per person is represented by southern fruits, and this consumption significantly increased as a share of the total fruit consumption from 21.4% in 2007 to 33.8% at the end of the period.

Part 2. The competitiveness of Bulgaria's fruit sector

The purpose of the analysis is to assess the competitiveness of the fruit sector in the country compared to its development in a global aspect. This assessment will determine both dynamically and in comparatively, the development of the production of fruit crops in the country compared to the trends in the world. In this case, competitiveness is understood as a result from production in value terms. The assessment of competitiveness can be expressed as a quantitative value and as an index, taking into account the development of the sector through selected main fruit species, which occupy a dominant share not only in production, but also in the consumption of the population.

The expected variability of the environment in which fruit growing in Bulgaria will function under the changing conditions of the agrarian policy creates uncertainty among producers. In this aspect, the application of the general index of competitiveness is a means to develop and define appropriate policies and decisions applicable in the coming years.

The application of the mentioned method for establishing competitiveness, developed by [6] makes it possible to calculate the competitiveness levels of Bulgarian fruit growing.

The indicators used for the calculations are the local and world production, as well as the local and world consumption of the main fruit crops selected in this case, which represent 92% of the produced quantities of fruit in Bulgaria in 2022, namely: apples, cherries, sour cherries, peaches, nectarines and plums. Due to the particularly large share of the preference and consumption of southern fruits by the population in the country (as shown in Fig. 5), the group of citrus fruits such as oranges, limes and lemons is also included in the study.

For commensurability and comparability in calculations, competitiveness is equated to per cap. The introduction of the per cap. criterion enables relative comparability, both to take into account individual market sizes and to take into account resource availability [13].

Changes in the number of the population have a significant impact on agricultural production, both through food consumption and as one of the factors of production - labor force. The country's population is constantly decreasing, and between 2007-2021 - by 9.4% and in 2021 it is estimated at about 6.84 million people, while the world population is constantly growing and in 2021

it reaches 7.9 billion people, and the increase compared to 2007 is 17.6% (Fig. 6).

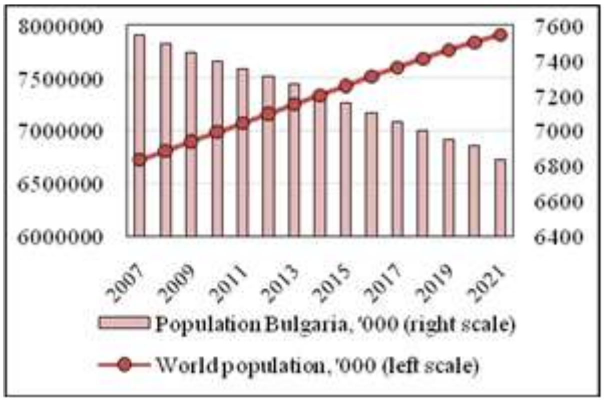

Fig. 6. Population dynamics in Bulgaria compared to the evolution of the world population (Thousand of people)
Source: Own design based on the data from FAOSTAT (2007-2021) [3].

The competitiveness index for fruit crops shows close values between the product and value components for 2009 and 2019 (Fig. 7). In the remaining years of the period, the production component is always of a greater value than the value component, which indicates lower prices of domestic production compared to the world one. With the exception of 2008, which is among the worst years in terms of production and yields for fruit crops in Bulgaria (IC - 0.28), in the remaining years of the analyzed period, the composite index (IC), which represents an arithmetic average between the two component, ranges between 0.30-0.49. According to the adopted methodology and criteria for interpreting the results of this index, in cases where the index is 0.30, this is an indicator of weak market positions on the global market, since according to the applied methodology [6] index values falling between 0.21-0.45 – competitiveness is low, the country is not only not a factor, but is also at a level lower than the average for the compared community. With the maximum value of the index for the analyzed period in this case - 0.49, according to the same methodology [6], values of the index within the range of 0.44-0.55 indicate an average level of competitiveness, giving equal positions with world levels of production and prices, as well as a competitiveness of the country, comparable to other competitors on the relevant market.

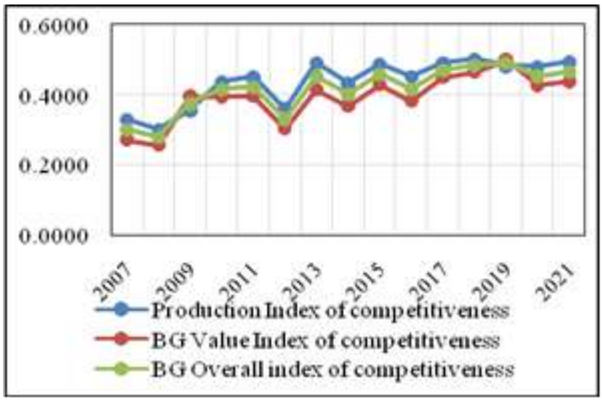

Fig. 7. Index of competitiveness of fruit in Bulgaria and the World
Source: Own calculations based on the data from FAO, NSI, ITC [3, 13, 4].

It is impressive that higher values and a relatively positive trend of the competitiveness index were reported after 2016 – from 0.45-0.49. This is largely due to the gradual recovery of production, which, thanks to coupled support and access to funding for the construction of new orchards, improves its competitive positions [6]. For some fruits, such as cherries, where the country has comparative advantages and production specialization, the competitiveness is high, which leads to production realization at good prices and to formation of good added value. In others, such as apples (which account for 23-25% of per capita fruit consumption by households), the country is at a low competitiveness level, where its presence in world markets is between the net importers and has lower indicators regarding the formation of the added value than the average world levels [6].

Discussions

The purpose of the current analysis is to establish the place of Bulgarian fruit production in the world fruit market, to trace the dynamic changes that have their impact on competitiveness in the years after its EU accession. The calculation of the levels of competitiveness in the fruit sector is carried out on the basis of data on national and global production, import and export, as well as on the per capita consumption of selected fruits.

According to the Ministry of Agriculture, in 2022 the production of fruit crops in the country was 222.2 thousand tons, which is nearly 2% less than in 2021 [12]. In this case, the largest quantities were produced from plums - 56.6 thousand tons, followed by cherries - 53.9 thousand tons.

In a comparative plan, the production of the selected fruits for the country and the world during the analyzed period according to [3] shows the following trends: growth in the production of the selected fruits, both in quantitative and value terms, as in the quantitative volumes for the country, the production has increased more than 2 times (which is mainly due to plums, cherries and sour cherries), while the world production has increased by 29% (due mostly to apples) (Fig. 8).

At the same time, the value of the production in Bulgaria has increased by 133.1%, and that of the world production value - by 51.8%.

Regarding the dynamics of production prices in Bulgarian production, although they increased at the end of the period, for all of the selected fruits except apples, they were significantly lower than the world ones, where an increase was also observed, with the exception of those from peaches and nectarines.

But comparing the production prices of Bulgarian fruits with those of the world in the last two years of the period, they are several times lower: for apples, cherries and sour cherries more than 2 times, for peaches and nectarines about 1.5 times and for plums - almost 4 times lower.

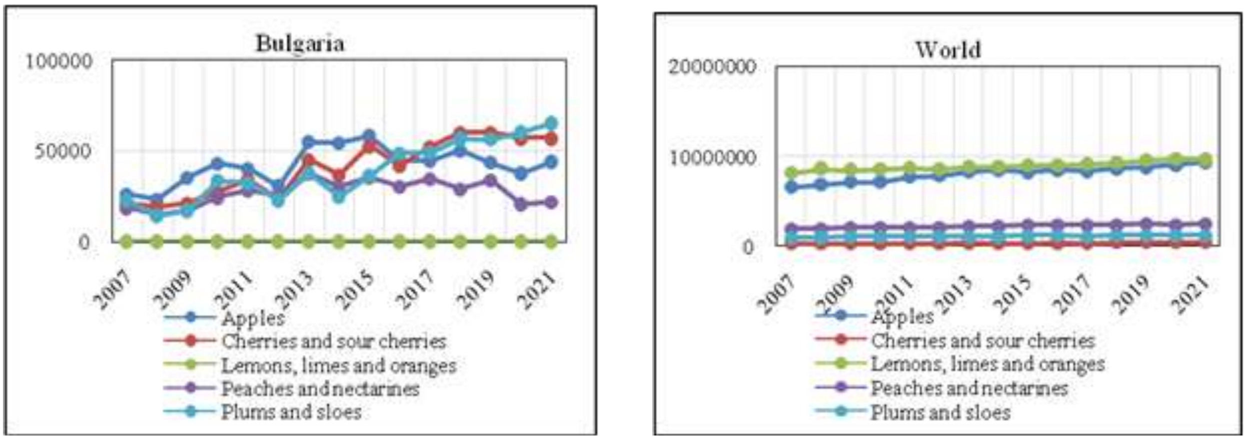

Fig. 8. Dynamics in the production of selected fruits (in relation to the applied methodology) in Bulgaria and the World (tons)
Source: Own design based on the data from FAOSTAT [3].

The average yields in the country and in the world show growth for all fruits, with the exception of apricots, which retain constant values in the world production and thus, in terms of average yields, the Bulgarian production is equal whit worlds. But what makes an extremely strong impression is that for all fruits, with the exception of plums, the country's average yields at the end of the period are below the level of the world's average yields in 2007 (Fig. 9).

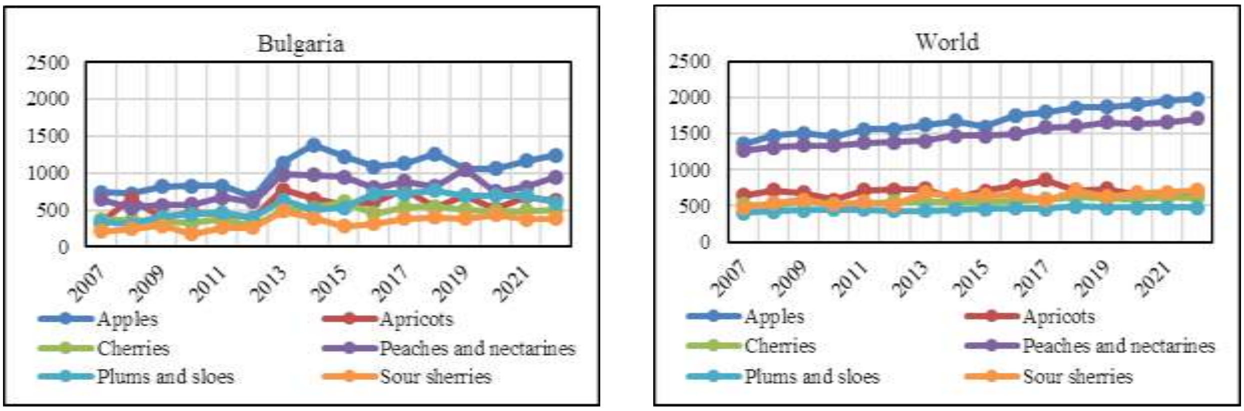

Fig. 9. Dynamics in the average yields of selected fruit species in Bulgaria andWorld (kg/dka)
Source: Own design based on FAOSTAT data [3].

In addition, the growth rate of average yields for Bulgarian fruits is much lower compared to the same ones in the world.

The reasons for these results are many, but at their core is the low productivity of the orchards and the poor condition of some of the plantations, along with a destroyed hydro-amelioration system leading to a strong dependence of Bulgarian fruit production on climatic factors and to unsustainable production through the years.

This put in the foreground the problem of irrigation and the almost destroyed irrigation system in the country.

The strong dependence of the manufactured product on the specific weather conditions brings to a great extent dependence and uncertainty among the producers.

In Fig. 10, it is reflected the average annual production of selected fruits in Bulgaria and the world but per person of the populationfor comparability to highlight the trends more clearly.

Bulgaria has better indicators than the average level for the world regarding the production of cherries and sour cherries, peaches and nectarines and especially plums as production in Bulgaria in 2021 is 9.5 kg/capita, but in the world this indicator is only 1.5 kg.

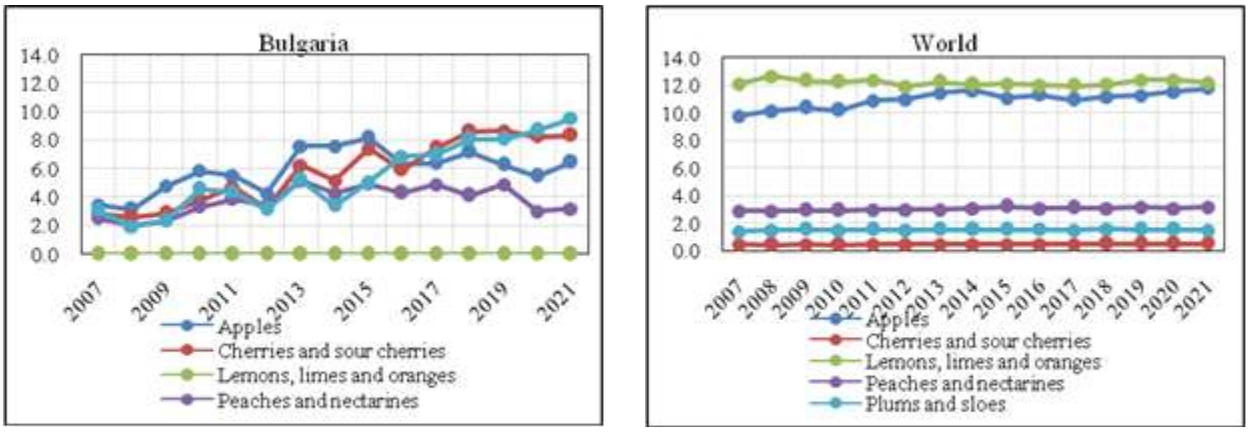

Fig. 10. Average annual production of selected fruit species per capita in Bulgaria and World (kg/capita)
Source: Own design based on FAOSTAT data [3].

The production of apples per capita in Bulgaria through 2021 is 6.4 kg which is significantly below the world average - 11.8 kg, and consumption per capita in the same year is 13.9, which is mainly from import (Fig. 11).

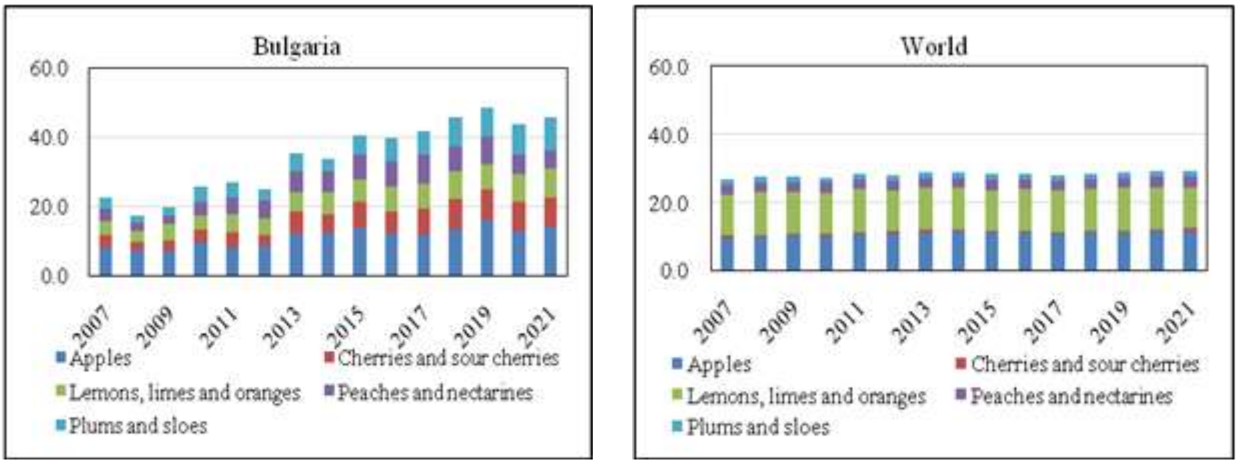

Fig. 11. Dynamics of the consumption of selected fruit species per capita in Bulgaria and World (kg)
Source: Own design based on FAOSTAT data [3].

Bulgaria is entirely a net importer of the citrus included in the study due to the lack of own production of these fruits. At the world output level, this indicator is the largest per person, followed by apples.

The listed citrus account for about 18% of the selected fruits average consumed per person per year in Bulgaria and this has the impact on the competitiveness of our fruit production.

Evaluation of the competitiveness of fruit sector in the country compared to development of the sector in the world depends on the quantity of the produced and exported products and its value is determined accordingly by the production and export prices of the products.

In Fig. 12, the main components are shown and compared which are important according to the applied methodology for establishing the level of competitiveness through the value component assuming that the greater is this value, the better the competitiveness result is.

The larger exported quantities per capita and the higher export prices are a prerequisite for reaching higher levels of competitiveness of the respective product.

Diminishing returns due to problems with productivity, finding the best prices, accessing the market and providing the production process with the necessary labour leads to an unsatisfactory ratio between gross incomes and production costs which makes specialized fruit production unattractive.

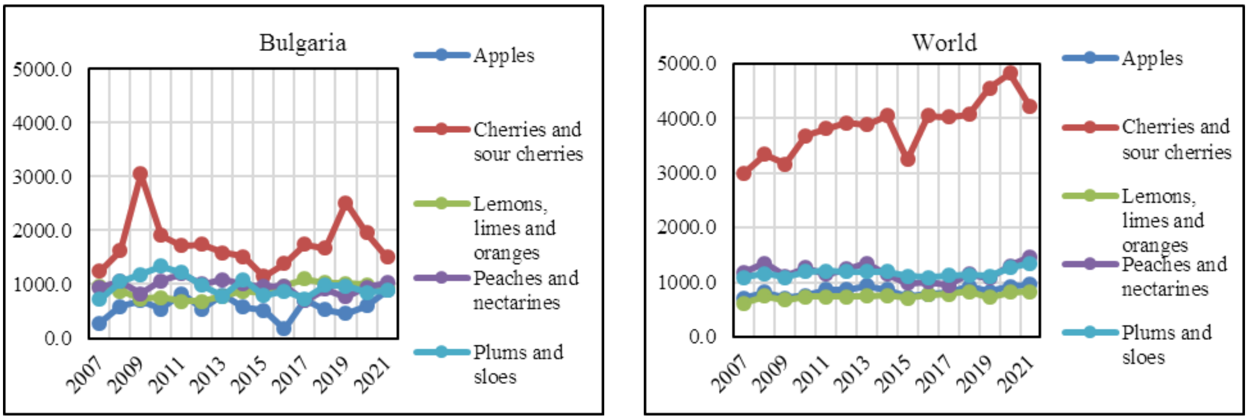

Fig. 12. Dynamics in export prices of selected fruit species for Bulgaria and World ($/ton)
Source: Own design based on FAOSTAT data [3].

The interest in recent years is to the possibilities of tied support as well as the access to use of investment funds under the Rural Development Program which should be aimed to increasing the result of these measures so as to increase the sustainability from the applied policy.

CONCLUSIONS

By researching the competitiveness of the fruit sector, the production and value growth of the market is established and what are the possibilities, ways and means for its improvement in relation to the scale determined by the methodology.

This is the starting point from which to start and to go in a direction of identifying and searching for the reasons and factors that determine this result.

Investigating the competitiveness of the fruit sector is establishing the production and value growth of the market and what are the possibilities, ways and means for its improvement in relation to the scale determined by the methodology. It is important in this case, which is also one of the advantages of the methodology, that the obtained competitiveness index be locked in the scale from 0 to 1.

Better levels of competitiveness can be achieved through higher quality production, and from there higher prices and, accordingly, better sales conditions, both on the domestic and foreign markets. This would also lead to a reduction of market risks for producers, which would be less possible when reaching higher levels of competitiveness.

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ANALYSIS OF GRAIN PRODUCTION IN THE REPUBLIC OF KAZAKHSTAN AND PROSPECTS FOR ENSURING FOOD SECURITY

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Abstract

The relevance of this study is due to the growing role of agriculture in the economic development of systems and the need to analyze and develop approaches to improving the efficiency of agriculture and ensuring food security of the each country. The object of this study is the grain production in Kazakhstan based on retrospective statistics and within the framework of the prospects for ensuring food security. To achieve this goal, the following methods were used: analysis, synthesis, comparison, historical and complex mathematical and statistical methods. The following can be cited as the main results of the study: at the end of 2022, Kazakhstan was not among the top ten leaders in the world's gross wheat harvest, possessing only 2% of the global figure, while it ranks 8th in exports with 3.4% of the world value. Retrospective dynamics of the gross grain harvest in Kazakhstan shows that until 1980 there was an increase in its levels, then a fall until 1998, which again changed to growth, but the levels reached during the Soviet period of development have not been exceeded at present. The main grain-producing regions are concentrated in the northern part of Kazakhstan, which is due to acceptable natural and climatic conditions and the presence of chernozems. Directions for modernizing Kazakhstan's agriculture are presented, which will ensure its food security.

Key words: *agricultural economics, processing industry, grain cluster, gross harvest, forecast*

INTRODUCTION

The relevance of this study is due to the growing role of agriculture in recent decades and the need to develop approaches to improving the efficiency of agriculture and ensuring food security at the level of all countries and regions. There are various national economies operating in the global economic space, which are constantly searching for their place in foreign trade relations. Trade flows of food products from and to a country are directly related to the issue of economic and food security [2; 12]. Cereals are very important for the sustenance of human populations and farm animals, grown for their important role in human diet, animal feed and biofuels [2; 4; 13].

Republic of Kazakhstan is no exception, which has significant weight in the post-Soviet space and makes a significant contribution to the Eurasian Economic Union [1; 7; 8; 24]. The transformation of the former Soviet Union countries' economic models after more than 30 years has led to the formation of sustainable systems that successfully resist the influence of external shocks and steadily increase the production of various goods and services. Despite the successes achieved, the country's food security is of concern, since the natural and climatic conditions are not favorable for crop production, while the country's population is constantly growing (20% or 3.3 million people for the1990-2022 period). These trends necessitate the study of the state and prospects of the grain production for ensuring food security.

It is worth noting the works devoted the grain production in the Republic of Kazakhstan [9; 10; 15; 22; 25], which provide an assessment of the effectiveness of this sector and identify its problems and prospects.

In turn, in our study, we will take into account the theoretical, methodological and practical developments of the presented authors. Evaluation of the identity of the results obtained by us and previously published studies by third-party authors will be carried out at the end of the article.

The object of this study is the grain production in Kazakhstan based on retrospective statistics and within the framework of the prospects for ensuring food security.

MATERIALS AND METHODS

To conduct the study, time series of indicators from international official statistical sources were used [16, 17, 18, 19; 23]. Three-letter country designations correspond to ISO 3166-1.

The research methodology of the grain and food cluster study based on the theoretical and methodological approaches outlined in [11]. It consists of three stages:

- formation of hypotheses and collection of statistical material;
- assessment of Kazakhstan's place and role in the global grain production and export;
- assessment of the state and prospects of development of the livestock complex in Kazakhstan.

At each stage of the study, various methods of scientific research were used.

Such general scientific methods as historical, comparison, analysis and synthesis were used at stage 1. Analysis and synthesis were used at stage 2, as well as the comparison method. The place and role of Kazakhstan in the world production and export of wheat were identified. At stage 3, mathematical and statistical methods were used, tabular and graphical (visualization of initial information and analysis results), coefficient (reflection of the structure, dynamics and ratio of parts), and correlation-regression (identification and measurement of relationships) in particular.

Next, we will move on to the results of testing the proposed methodology for studying the features of the functioning of the grain and food cluster of Kazakhstan.

RESULTS AND DISCUSSIONS

At the first stage of the study, let's turn to the data of the Statistics Division United Nations and analyze the dynamics of the structural transformation of the economic system of Kazakhstan (Table 1).

Table 1. The change in the specific weights of the GVA of types of economic activity in Kazakhstan, in % of the total GVA of all types of economic activity

Types of economic activity	1990	1995	2000	2010	2020	2022	2022 compared to 1990 (+/-)
ISIC A-B	31,8	12,9	8,6	4,6	5,7	5,7	-26,1
ISIC C-E	13,7	23,9	34,6	34,0	28,6	32,0	18,3
ISIC F	10,6	6,3	5,5	7,96	6,4	14,5	3,9
ISIC G-H	8,0	18,8	13,8	14,3	19,3	5,7	-2,3
ISIC I	8,8	11,1	12,3	11,5	9,7	18,8	10,1
ISIC J-P	27,2	27,0	25,3	27,6	30,3	8,8	-18,4

Source: compiled on the data from [21; 23].
Types of economic activity are presented according to the ISIC classifier.

In Table 1, we are primarily interested in the value of the share of agriculture and the fishing industry (ISIC A-B). In 1990, this industry in Kazakhstan accounted for 31.8% of the total GVA of all industries, which did not correspond to the global state, since on average the share of this type of activity in developed countries did not exceed 5%. This situation is typical for all post-Soviet countries, it clearly shows the differences between a planned economy and a market economy, in which agriculture played a prominent role.

It is worth noting that because of the transformation of the economic system and the formation of market institutions, the share of agriculture decreased, and as of 2022 in Kazakhstan it amounted to 5.7% (a decrease of 26.1 percentage points) [21].

This trend is inherent in all post-Soviet countries, since in a market economy the service sector and manufacturing industry come to the forefront (the growth of the industrial sector in Kazakhstan for the period 1990-2022 amounted to 18.3 percent points).

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Next, let's turn to the FAOSTAT data to assess the position of the post-Soviet countries (including Kazakhstan) in the world production of wheat (Fig. 1).

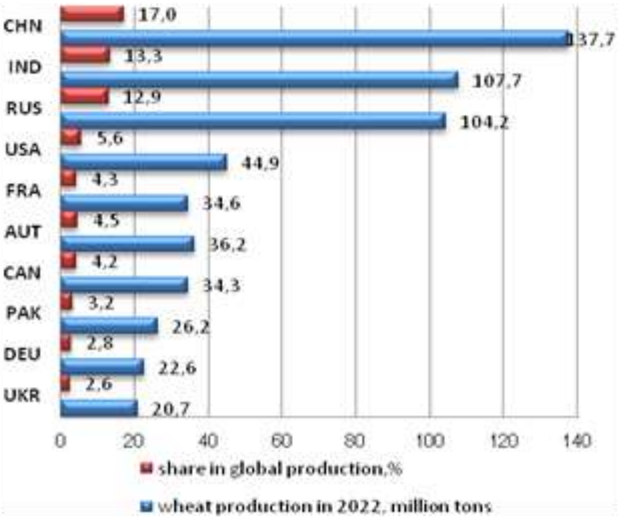

Fig. 1. TOP 10 countries in wheat production in 2022
Source: compiled on the data from [6].

According to the data shown in Figure 2, China occupies a leading position in wheat production, having produced 17.0% of the total world volume in 2022. India is in the second place with 13.3%. The leading placement of these countries is expected, since a significant part of the planet's population lives on their territory (in total, about 36% of the total population of the Earth). Accordingly, these states need to produce significant amounts of food (including grain) to ensure food security.

The Russian Federation is firmly entrenched in third place, but the reasons for the significant output in this case differ from the above countries. Russia produces grain for export, i.e. this direction is one of the key ones in the food export policy of this state.

The ten countries presented in Fig.1 in 2022 together produced about 70% of the total world volume.

In Kazakhstan, in 2022, 16.4 million tons of wheat were produced, which is 38.9% higher than the result of 2021, but at the same time, the volume of production in the reporting year amounted to only 2.03% of world production. Despite the insignificant value of the shares in wheat production, Kazakhstan occupies a significant place in the world production.

Obviously, wheat production will differ from its exports, so let's move on to the data shown in Fig. 2, which outlines the TOP 10 exporting countries of the product in question. According to the information given in Figure 3, the composition and positions of countries in terms of wheat exports differ from the values of the gross harvest. So, in the top three are Australia with 15.4% of all world wheat exports, USA with 11.2%, and France with 10.8%. As for Kazakhstan, at the end of 2022, the country ranks 8th in wheat exports, which is explained by the high values of the gross grain harvest (including wheat) that year.

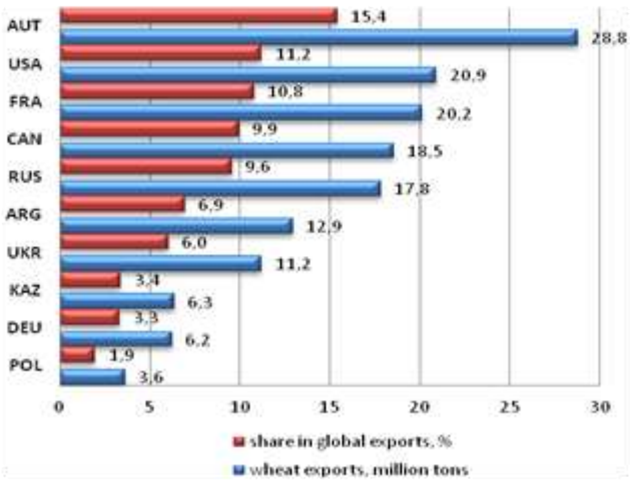

Fig. 2. TOP 10 countries in wheat exports in 2022
Source: compiled on the data from [6].

Next, based on the methodological approaches outlined by us in an earlier work [20], we will form a retrospective available time series of the gross grain harvest dynamics in Kazakhstan (Fig. 3).

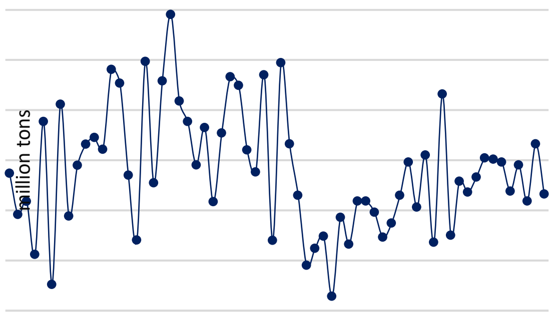

Fig. 3. Dynamics of the gross grain harvest in Kazakhstan in 1960-2023, million tons
Source: compiled on the data from [18, 19].

The following periods can be distinguished:

1) 1960 – 1978: the gross grain harvest increase by an average of 2.2% per year as a direct result of the virgin land development program. Before this program in 1949-1953 3.9 million tons per year were produced in Kazakhstan; while in 1954 – 1958 13.8 million tons were produced per year;
2) 1980s – mid-1990s: the gross grain harvest decrease due three global reasons for the decline: land degradation due to soil depletion of virgin lands; the crisis of the planned economy in the late 1980s; the transformation processes of the 1990s associated with the transition to a market economy.
3) 1998 – 2023: gross harvest is increased in the due to the development of food security policy and formation of the sustainable economic systems in Kazakhstan.

For the last stable period, we will conduct econometric modeling of the gross harvest dynamics of grain crops and construct a linear model with the following variables:

$$y' = 12.69 + 0.29 * t,\ t(b_0) = 9.13,\ t(b_1) = 3.21,\ R^2 = 0.40,$$

$$F(1,24) = 10.32$$

where:

- y' – model values of the gross grain harvest in Kazakhstan.
- t – discrete variable reflecting the belonging of the levels of the time series to a year.

As can be seen from the obtained results of the econometric model estimation, the regression equation was obtained statistically significant in general according to the F-statistic of Fisher, and the parameters are significant according to the Student's t-statistic. The coefficients for the variable t indicate annual absolute increases in the gross grain harvest. In Kazakhstan the increase was 0.29 million tons.

Since the resulting model is statistically significant, we will make a forecast based on it, for this we will substitute the numbers of the forecast periods into the regression equation (Table 2).

Table 2. Forecast values of the gross grain harvest in Kazakhstan in 2024-2026, million tons

Indicator	2024	2025	2026
Forecast value	20,0	20,3	20,6
Lower confidence limit of the forecast	17,7	17,9	18,0
Upper confidence limit of the forecast	22,3	22,8	23,2

Source: author's calculations in the STATISTICA program based on data from [16].

The calculation results demonstrate a further increase in the gross grain harvest, but the model does not take into account natural and climatic conditions, such as drought or untimely precipitation.

Table 3 presents data on the dynamics and structure of production of the main agricultural grain crops.

Table 3. Gross harvest of grain crops of all types farms in Kazakhstan in 1995-2023: dynamics and structure, thousand tons

Indicator	1995	2000	2010	2020	2023	Growth coefficient, 2023 to 1995
Cereals (including rice) and legumes	9,520	11,600	12,185	20,063	17,097	1.8
Cereals (excluding rice) and legumes	9,337	11,386	11,812	19,509	16,611	1.8
Winter and spring wheat	6,490	11,242	9,638	14,258	12,111	1.9
Corn (maize)	136	198	462	958	1,189	8.7
Winter and spring barley	2,208	2,265	1,313	3,659	2,614	1.2
Winter and spring rye	84	17	42	30	18	0.2
Oats	250	194	134	240	150	0.6
Millet	39	44	17	40	35	0.9
Buckwheat	53	16	27	40	83	1.6

Source: compiled on the data from [16].

The data presented in this table, clearly shows that over the reviewed period there has been an increase in the production of all grain crops, except for rye (a decrease of 80%), oats (a decrease of 40%) and millet (a decrease of 10%). The gross harvest of corn showed the greatest growth, which in 2023 increased by 8.7 times compared to 1995, which is due to the low base of comparison and crop growing demand for the domestic and world markets.

An analysis of the structure of grain production shows that wheat plays a key role in crop production in Kazakhstan; it occupies the largest share, and its share did not fall below 70% of the total volume.

For completeness, it is necessary to consider the balance of grain production and using (Table 4).

Table 4. Balance of resources and use of grain in Kazakhstan, thousand tons

Indicator	1995	2000	2010	2020	2021
I. RESOURCES					
Stocks at the beginning of the year	12,609.0	8,730.9	16,452.2	11,775.5	12,678.1
Production	9,505.5	11,565.0	12,185.2	20,065.3	16,375.9
Import	36.1	16.6	51.1	810.0	1,496.5
TOTAL RESOURCES	22,150.6	20,312.5	28,688.5	32,650.8	30,550.5
II. USAGE					
Industrial consumption, including:	11,160.5	2,063.6	6,787.8	5,938.5	4,931.9
livestock food	3,839.6	714.5	3,909.7	3,729.1	2,689.7
seeds	2,527.9	1,349.1	2,878.1	2,209.4	2,242.2
Processed for food purposes	4,288.6	2,616.9	5,035.8	4,447.3	4,025.5
Other industrial use	100.0	160.0	989.8	2,182.3	2,286.8
Losses	404.4	127.0	679.9	489.8	458.3
Export	4,083.3	5,683.5	5,552.8	6,556.6	6,851.1
Personal consumption	N/A	248.4	308.3	358.2	359.1
Stocks at the end of the year	6,906.8	9,413.1	9,334.1	12,678.1	11,637.8

Source: compiled on the data from [17].

Analysis of the data in the table demonstrates the high level of provision of the country's national economy with its own resources, exports tend to grow, grain imports are insignificant, reserves have minor fluctuations, and their variation is satisfactorily stable over time.

The structure of grain use is stable over time, so in 2021, 30% of production was used for industrial consumption, 25% for processing for food purposes, 14% for other industrial use, and only 2% for personal consumption.

Next, let's turn to regional data and assess the role of individual regions of Kazakhstan in the production of grain crops (Table 5).

Table 5. Dynamics of production of cereals (including rice) and legumes in the regions of Kazakhstan, thousand tons

Region	2010	2015	2020	2023	Structure, 2023, %
Kazakhstan	12,185.2	18,672.8	20,065.3	17,096.6	100
Abai	-	-	-	337.0	2.0
Akmola	2,141.9	4,434.7	5,093.9	3,215.5	18.8
Aktobe	64.4	164.9	498.6	421.5	2.5
Almaty	1,066.0	1,172.2	1,327.4	616.4	3.6
Atyrau	0.0	0.3	0.1	0.1	0.0
West Kazakhstan	76.3	95.4	279.3	310.8	1.8
Zhambyl	372.6	452.6	842.6	470.0	2.7
Jetisu	-	-	-	880.5	5.1
Karagandy	293.9	591.6	973.9	6,30.2	3.7
Kostanay	3,039.9	4,541.9	4,015.8	4,426.9	25.9
Kyzylorda	328.2	368.6	519.6	453.9	2.7
Pavlodar	232.1	575.5	750.4	407.5	2.4
North Kazakhstan	3,730.4	5,047.1	4,229.0	3,747.7	21.9
Turkistan	371.3	646.7	745.2	755.4	4.4
East Kazakhstan	467.7	713.0	773.9	386.8	2.3
Astana city	0.2	0.3	1.2	0.7	0.0
Almaty city	0.3	0.1	0.1	-	-
Shymkent city	0.0	0.0	14.3	12.0	0.1
Ulytau	-	-	-	23.6	0.1

Source: compiled on the data from [16].

The data presented in the table indicate that the production of grain in Kazakhstan is uneven across the territory. So there are three regions that contribute more than 65% to the country's production, these are: Kostanay Region - 25.9%, North Kazakhstan Region - 21.9% and Akmola Region - 18.8%. The current structure of the gross grain harvest is explained by natural and climatic conditions, since all three of these regions are located in the north of the country, on the border with the Russian Federation. These areas are characterized by lower spring and summer temperatures, which contributes to the vegetation of agricultural plants. Also in this area chernozems (black soil) are concentrated, which means land suitable for cultivation.

Next, we calculated the index of structural differences between the proportions of the number of people living in the regions of Kazakhstan with the shares of the gross grain harvest by region of the country. It is equal to 0.665, which indicates a high level of differences between the compared structures. Thus, the territories where grain is produced do not coincide with the places of residence of citizens, i.e. with consumers. This raises problems with harvest storage and the logistical problem of delivering grains and their derivatives to the end consumer, which undoubtedly affects the cost of the finished product.

The results obtained during the study allow us to compare them with earlier works of other authors. In the study of Zh. M. Omarkhanova we find an original approach, dividing the regions of Kazakhstan into two groups: "agricultural" and "non-agricultural" [10]. At the same time, these groups complement each other by transferring goods from one region to another, thereby ensuring the commodity and food security of the country. The statement deserves attention, but the topic of high storage and transportation costs remains open. The author also doesn’t consider the problem of price disparity between agricultural and industrial products.

The research team led by S. K. Mizanbekova, conducting a study of the grain economy of Kazakhstan, came to the following conclusion: "innovative activity, promising innovations for grain crop breeding and seed production systems, development of mechanization, land reclamation, chemical treatment, expansion and strengthening of transport routes, means of information support, management in the areas of grain production and market relations allow the formation of specialized grain zones" [9]. We are inclined to disagree with this statement, since the data we analyzed indicates natural and climatic factors, primarily weather conditions and soil composition, which led to the grain specialization of the three regions of the country.

Modern approaches to the determinants of economic processes are increasingly shifting the emphasis of policy towards interactions between actors of economic systems and the need to develop institutional interaction between them [5].

In the research of Derunova E. V. and the team, it is substantiated that directions for improving the activities of agricultural clusters are possible based on the development of an institutional approach and assessment of system efficiency [3, 4]. Limitations on extensive development and the transition to more intensive development in the grain cluster of Kazakhstan are possible not only through the use of innovative agricultural technologies, but also through increased interaction at all stages of production and logistics in agriculture.

The results of our study of the grain cluster in the Kazakhstan are relevant for many agricultural countries with a large territory. It is necessary to analyze the main components of agricultural systems and develop directions for its balanced development, taking into account spatial and strategic approaches both [14].

CONCLUSIONS

The statistical analysis of the dynamics and structure of grain production in Kazakhstan allows us to formulate several conclusions.

1. The leaders in world wheat production are China and India, which is due to the large population of these countries, which must be provided with food, thereby high production helps with food security. Kazakhstan, according to the results of 2022, was not among the ten leading countries, but its share is significant and amounts to 2% of world production. In turn, the leaders in exports are countries such as Australia, the USA and France. Obviously, these states cover the needs of citizens and production in this product, and want to get additional income from agriculture. In 2022, Kazakhstan ranks 8th among the ten main exporting countries, with a value of 3.4% of world wheat exports. Thus, the republic has a significant position both in world production and in the export of wheat.

2. The main share in the gross harvest of grain and legumes is wheat, in 2023 it accounted for 73% of overall grain and legumes gross harvest. The main regions where grain (including wheat) is grown are Kostanay Region, North Kazakhstan Region and Akmola Region, which together in 2023 grew more than 65% of the total crop. At the same time, the country's population is concentrated in other regions, i.e. there is a discrepancy

between production and consumption, which leads to the threat of loss of food security in the long term and an increase in prices for the final product due to logistical costs already at the present time.

3. The dynamics of the gross grain harvest in Kazakhstan for the 1960-2023 period shows a mixed trajectory, where several periods of development could be highlighted: firstly, until 1980, when there was an increase in production, which is explained by the program for the development of virgin and fallow lands; secondly, the decline that began in the 1980s and lasted until the mid-1990s, which is associated with soil degradation and the transformation of the economic system; thirdly, the modern stage, which began in 1998, is characterized by continuous growth.

These data allow us to predict further growth in gross harvest at a rate of 290 thousand tons per year, provided there is no impact of negative factors.

In order to ensure food security in Kazakhstan, further modernization of its agriculture is advisable. One of the reserves for increasing grain production is increasing yields, improving seed quality, and using advanced resource- and energy-saving technologies. It is also necessary to effectively organize the processes of dissemination and implementation of innovations and competent structural policies in relation to human, natural, climatic and other resources in relation of the agriculture system development in Kazakhstan.

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DYNAMICS OF SUSTAINABLE DEVELOPMENT AND ITS EFFECTS ON EDUCATION, AGRICULTURE AND ENVIRONMENTAL PROTECTION IN THE SOUTH EAST REGION, ROMANIA

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Abstract

The study aims to analyze the implementation of environmental policies in Romania's Southeast Region, taking into account the variations between counties that impact both the development and application of these policies, each component is evaluated through several environmental indicators at the level of all counties, by using Tempo online database. The analysis is structured around six key indicators, which have been ranked and prioritized. Throughout the research process, several secondary objectives were achieved, and initial hypotheses were formulated, which are later tested and validated in the concluding section of the article. The objective of the research falls within the current guidelines of PAM 8, which aims to analyze the performance of environmental policies in the region. In the analyzed period 2003-2023, the counties of the Southeast Region are ranked, based on the indicators environment, using the Spearman correlation coefficient. The results suggest the environmental performances achieved by each county, as well as the proposed measures for environmental management in the coming period.

Key words*: *Spearman, organic products, environmental policy, Romania

INTRODUCTION

The environmental policy promoted by the EU considers several components: economic-financial analysis, waste management analysis, greenhouse gas emissions analysis, energy efficiency analysis, and biodiversity analysis [4], [11], [15].

The environmental policies in force today worldwide have been achieved through a broad process of evolution, adoption and adaptation [1], [2]. In the European Union, the integration of environmental policies has been widely accepted as a principle in the development of European policies [6], [13]. Environmental problems are complex, they involve systemic interdependencies, which often accumulate over long periods and large spatial areas [3], [5].

Each component plays a crucial role in implementing coherent and effective policies aimed at achieving the sustainable development objectives set by each European Union Member State. This study explores environmental performance at the regional level as part of an ongoing research effort, designed to provide a clearer definition of "development" while offering certainty to key stakeholders and institutions. [10], [12].

The main objective of the research is to identify the degree of implementation of environmental policy in Romania, at the national and regional level, for a sustainable economic environment [7], [8]. To achieve this objective, an assessment is necessary by comparing territorial units in terms of: the application of environmental taxes in Romania; assessment of vocational education and training; analysis of sustainability and the environment; economic development of the economy and agriculture through the use of resources. Along with this, the research targets several objectives, presented below, in the form of O1-O5.

The research is current and aligns with EU strategies, the European Green Deal and the Circular Economy Action Plan, but also with national strategies in Romania regarding sustainability.

Starting from sustainable production and consumption in the EU and Romania, the objectives can be structured as follows:

O1.Reducing the number of technical high schools with an environmental protection profile through the formation of specialized human resources

O2. Determining the main factors leading to the increase in degraded and unproductive land areas

O3. Analyzing the impact of per capita GDP growth on rural development and the modernization of agricultural infrastructure.

O4. Evaluating how the reduction in natural fertilizer use affects soil quality and agricultural productivity.

O5. Determining the degree of adoption of sustainable agricultural practices and its correlation with the use of natural fertilizers.

For the South East Region, the specific objectives of the research include:

Os1. Developing the infrastructure for education and proposing solutions for their revitalization.

Os2. Stimulating green SMEs, the efficiency of ecological rehabilitation measures and their impact on affected lands[16].

Os3.Analysis of the correlation between the afforestation rate and the reduction of desertification risks;

Os4.Comparing the pace of economic growth in the counties of the Southeast region and identifying the factors that influence these differences[16].

Os5.Evaluating the impact of national and regional policies on economic growth in rural areas.

MATERIALS AND METHODS

To analyze the performance of environmental policies implemented in the South East Region, the Spearman coefficient method was used [9], [14]. This reserves for many statistical units used and classifies more territorially, based on a set of indicators.

The proposed set of indicators for assessingthe performance of environmentalpolicies in Romania over thepasttwodecades (2003-2023) consists of sixkeyindicators, as presented in Table 1.

Table1. Average values of environmental indicators in the counties of the South East Region from 2003 to 2023

	The growthrate of the number of technical high schools with an environmental protection profile (%)	The growth rate of areas with degraded and unproductive lands (%)	The growth rate of GDP/capita (%)	The growth rate of forested areas (%)	The growth rate of areas equipped with irrigation works (%)	The growth rate of quantity in natural agriculture (%)
România	-74.9	2.08	1618	3.8	-0.24	-51
SE Region	-73.3	1.99	1319	2.1	1.11	-57
Braila	-75	1.61	1302	18.2	-0.7	88
Buzau	-80	1.41	1316	1.2	-0.40	-74
Constanta	-62	3.27	1522	4.8	-0.36	-100
Galati	-66	0.8	1016	1.4	6.8	-100
Tulcea	-71	2.81	1595	3.2	4.7	-96

Source: Author's calculations based on Tempo online data [17].

It is about: growth rate of the number of technical high schools with an environmental protection profile, Growth rate of degraded and unproductive areas (%), Growth rate of area (%), Growth rate of growth of %) Growth rate of areas arranged with irrigation works (%), Growth rate of quantities of natural fertilizers in agriculture (%). According to this method, the place occupied by each territorial unit (in our case the respective county) is established compared to the rest of the territorial units (the other counties), taking into account the 6 interdependent statistical variables presented previously.

Thus, each statistical variable is assigned a rank according to its value (in ascending or descending order):

- if the indicator has a positive relationship with performance (e.g. Area occupied by degraded land, rank 1 is assigned to the minimum value).
- if the indicator has a positive relationship with performance (e.g. GDP/capita), rank 1 is assigned to the maximum value.

Table 2. Ranking of counties in the South East Region, based on environmental indicators, from 2003-2023

	Growth rate of the number of technical high schools with an environmental protection profile (%)	Growth rate of areas with degraded and unproductive lands (%)	Growth rate of GDP/capita (%)	Growth rate of forested areas (%)	Growth rate of areas equipped with irrigation works (%)	Growth rate of quantity in natural agriculture (%)
România	5	6	1	3	5	3
SE Region	4	5	4	5	4	4
Braila	6	4	6	1	8	1
Buzau	7	3	5	7	7	5
Constanta	1	8	3	2	6	7
Galati	2	1	8	6	1	8
Tulcea	3	7	2	4	2	6
Vrancea	8	2	7	8	3	2

Source: Author's calculations based on Tempo online data [17].

Calculation of the average rank for each county. The place of the territorial units (counties) is established based on the arithmetic mean of all ranks of the 6 statistical variables (Table 2).

Spearman coefficient analysis

The difference between the ranks of each pair of observations (d) and the square of the differences (d2) is calculated.

The Spearman correlation coefficient is calculated as follows:

$$\mathbf{r_s = 1 - \frac{6\sum d^2}{n\,(n^2-1)}} \qquad (1)$$

rs = Spearman's coefficient

n = number of observations

$\sum d^2$ = sum of squares of differences between ranks

Spearman correlation coefficients range from -1 to +1 and are interpreted as follows:

A value of +1 indicates a perfect positive correlation, meaning the two indicators are directly proportional—when one increases, the other increases proportionally.

A value of -1 signifies a perfect negative correlation, meaning the two indicators are inversely proportional—when one increases, the other decreases proportionally.

0 – indicates that there is no significant linear correlation between the two analyzed indicators. The results regarding the values of Spearman's correlation coefficients are presented in Table 3, which we present as follows:

The strongest negative correlation is between the growth rate of degraded lands and GDP/capita (ρ=−0.88), which suggests that counties with more degraded lands tend to have a lower GDP per capita. Between the growth rate of technical high schools and Growth rate of quantity in natural agriculture (ρ=0.79), there is an inverse relationship between the development of technical schools and the increase in production in natural agriculture. Moderate positive correlations emerged between GDP/capita and the growth rate of divided areas (ρ=0.48), which suggests that more administratively divided counties may have a higher GDP per capita. Between the growth rate of technical high schools and the growth rate of divided areas (ρ=0.43), it is indicated that counties with more technical high schools tend to be more administratively divided. Weak or almost non-existent relationships are noted between the growth rate of degraded lands and Growth rate of quantity in natural agriculture (ρ=0.12), which means that degraded lands do not seem to significantly influence production in natural agriculture.

Table 3. Spearman's correlation coefficients

	Growth rate of the number of technical high schools with an environmental protection profile (%)	Growth rate of areas with degraded and unproductive lands (%)	GDP/capita (%)	Growth rate of forested areas (%)	Growth rate of areas equipped with irrigation works (%)	Growth rate of quantity in natural agriculture (%)
Growth rate of the number of technical high schools with an environmental protection profile (%)	1	-0.47	0.26	0.42	0.33	-0.78
Growth rate of areas with degraded and unproductive lands (%)	-0.47	1	-0.88	-0.66	0.23	0.11
GDP/place (%)	0.26	-0.88	1	0.47	-0.16	-0.02
Growth rate of forested areas (%)	0.42	-0.66	0.47	1	-0.47	0.11
Growth rate of areas equipped with irrigation works (%)	0.33	0.23	-0.16	-0.47	1	-0.47
Growth rate of quantity in natural agriculture (%)	-0.78	0.11	-0.02	0.11	-0.47	1

Source: Author's calculations based on Tempo online data [17].

RESULTS AND DISCUSSIONS

From the analysis of Spearman correlations between the 6 analyzed indicators, the following values result:

1.Impact of the decrease in the number of technical high schools with an environmental protection profile:

Negative correlation with the area of degraded and unproductive land (-0.47) → The reduction in technical high schools with an environmental protection profile is associated with an increase in degraded land. This may indicate a decrease in specialists capable of implementing soil conservation solutions.

Negative correlation with the amount of natural fertilizers used (-0.78) → The reduction in the number of high schools may affect farmers' knowledge of organic farming practices, leading to a lower use of natural fertilizers.

Positive correlation with GDP/capita (0.26 → A smaller number of environmental high schools may mean less specialized education, which may affect the economic development of the region.

2. Correlation between degraded land and other indicators: Negative correlation with GDP/capita (-0.88)→ Regions with more degraded land tend to have lower GDP, indicating a negative economic impact of land degradation.

Negative correlation with forest area (-0.66)→ The increase in degraded areas is correlated with a decrease in forested areas, suggesting a lack of ecological rehabilitation measures through afforestation.

3. Correlation between GDP/capita and environmental factors Negative correlation with the area of land developed with irrigation works (-0.16) → A decrease in irrigated areas can harm GDP since irrigation is essential for agricultural productivity. Negative correlation with the amount of natural fertilizers (-0.22) → Decreased use of natural fertilizers can lead to soil degradation, affecting agricultural productivity and, implicitly, regional GDP.

4. Correlation between forested areas and agricultural sustainability

Negative correlation with the area of irrigated land (-0.47) → A conflict between afforestation and the expansion of irrigated areas suggests competition for land.

Negative correlation with degraded land (-0.47)→ Afforestation does not seem to be effective enough to reduce degraded areas.

5. Correlation between irrigated areas and natural fertilization Negative correlation with natural fertilizers (-0.47) → Regions with more irrigation tend to use less natural fertilizers, which could indicate a shift towards intensive agriculture and the use of chemical fertilizers.

By county, the Spearman correlation analysis can be summarized as follows:

In *Brăila County*, GDP/capita (+1302%) is increasing, but the number of environmental technical high schools has decreased (-75%); The forested area has increased significantly (+18.2%), which could have a positive impact on the stability of ecosystems; The area arranged for irrigation has decreased (-0.7%), which may affect agricultural productivity; Natural fertilizers have increased massively (+88%), which could indicate a trend towards more sustainable agriculture.

In *Buzău County*, results over the last 20 years show that GDP/capita has increased (+1316%), but the number of environmental technical high schools has decreased drastically (-80%); The forested area has increased very little (+1.2%), which suggests a lack of investment in this direction; The area arranged for irrigation is decreasing (-0.4%), affecting agricultural probability; Natural fertilizers used have decreased dramatically (-74%).

In *Constanța County*, the results show how GDP/capita (+1522%) has one of the highest increases, at the same time, the Forested Area increases (+4.8%), which shows the efforts for environmental protection. The irrigable area is decreasing (-0.36%), which can influence agricultural production, in the long term. Natural fertilizers have completely decreased (-100%), which suggests an agriculture based only on chemical fertilizers.

In *Galați County*, the results summarize how GDP/capita (+1016%) has the lowest increase among the counties, the Forested Area increases slightly (+1.4%); The irrigable Area Increases considerably (+6.8%), which shows investments in agriculture.

Natural fertilizers are decreasing massively (-100%), which indicates a more intensive agriculture.

In *Tulcea County*, the evolution of indicators shows how GDP/place (+1595%) is almost at the level of Constanța; The forested area has increased (+3.2%); The irrigable area has increased significantly (+4.7%); Natural fertilizers are decreasing (-96%).

The general conclusions for the South-East Region can be summarized as follows: The increase in GDP in all counties indicates a significant economic development;

The reduction in the number of environmental technical high schools (-73% in the SE Region) suggests a decrease in interest in environmental education;

Afforestation is increasing, but with differences between counties (Brăila +18.2% vs. Buzău +1.2%).

The irrigated area varies, with notable increases in Galați (+6.8%) and Tulcea (+4.7%), but decreases in other counties.

The use of natural fertilizers is decreasing sharply in most counties, except Brăila (+88%).

Environmental education is essential – The decrease in the number of technical high schools for environmental protection has negative effects on the sustainable use of natural resources and the economy.

➡A recommendation here includes investing in vocational training and promoting environmental education.

Land degradation affects the economy of each county – GDP is closely linked to the state of the soils, and the lack of rehabilitation measures can affect rural development.

➡ Recommendation includes an increase in forested areas and the promotion of sustainable agricultural practices.Afforestation and irrigation must be balanced – The expansion of irrigated agricultural areas must not negatively affect afforestation and land protection.

➔ A recommendation would be better-integrated management of agricultural and forest lands.

Natural fertilizers must be promoted – There is a trend towards reducing their use, which may affect soil quality and the sustainability of agriculture.

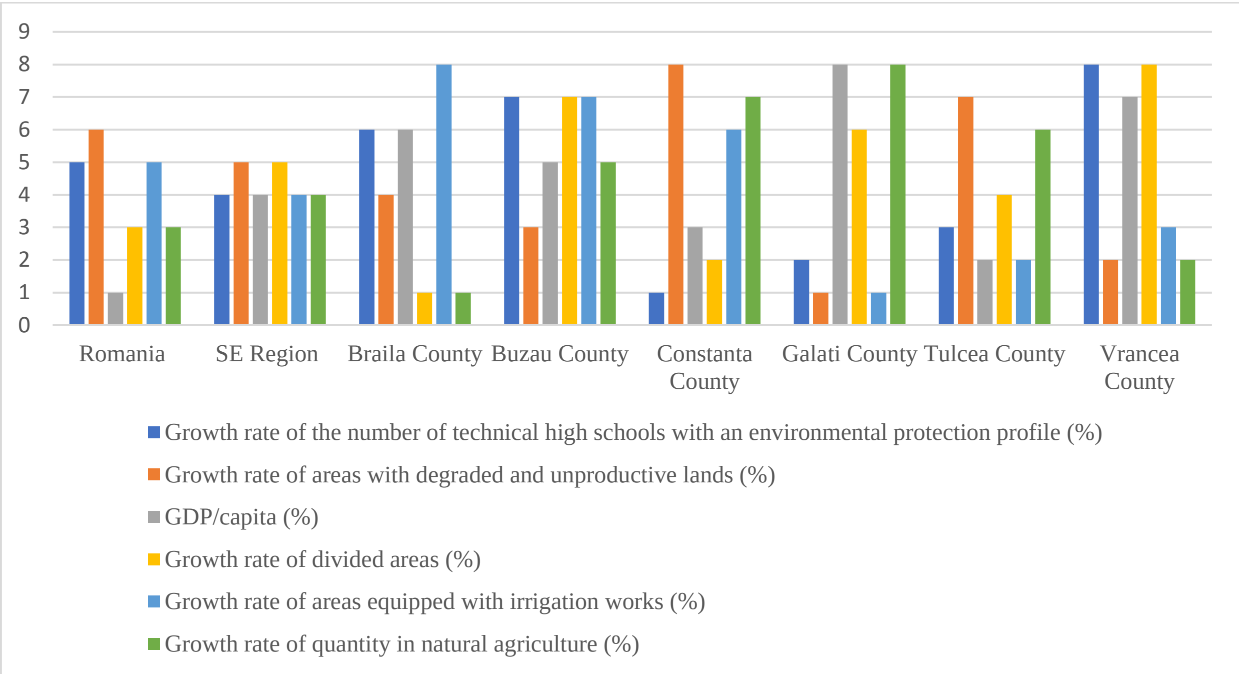

Fig. 1. Average ranks obtained by counties,in the South East Region during the period 2003-2023 (points)
Source: Author's calculations based on Tempo online data [17].

➔**Recommendation: Incentives for farmers using organic practices.**

CONCLUSIONS

The analysis of the implementation of environmental policy in the South East Region is summarized by county as follows:
Brăila County stands out for its accelerated GDP growth and a large increase in forested areas, but irrigation is in decline. On the other hand, the increase in natural fertilizers shows a possible interest in sustainability.
Buzău County records economic growth, but the lack of support for environmental education and the reduction in the use of natural fertilizers may raise issues regarding long-term sustainability.
Constanța County has a growing GDP and a positive trend in afforestation, but the complete abandonment of natural fertilizers may lead to soil degradation.
Galați County is investing in irrigation, which can help agricultural production, but the lack of natural fertilizers may be a problem in the long term. Over thepast 20 years, Tulcea County has experienced balanced development, marked by GDP growth and increased investments in irrigation. However, the significant decline in natural fertilizer use raises concerns about potential long-term impacts on soil fertility.

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DETERMINING FEASABILITY INDICATORS FOR CUCUMBERS AND ZUCCHINIS CROPS IN ORGANIC AND CONVENTIONAL SYSTEMS. CASE STUDY

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Abstract

Organic farming conversion is one of the main priority and challenges included in The Green Deal (EC, 2020), in order to achieve its mission, that of transforming Europe into the first climate-neutral region. According to the statistical data, Austria and Germany are fully converted to ecological agriculture and the others European states are in the conversion process. Nowadays, Romania's agricultural organic area measures 1,531,000 ha and 1,331,000 ha still remaining under transition from conventional agriculture to the ecological one. Global and European directives state that to be sustainable, the conventional agriculture sector must be converted to organic and to harm the environment at least at possible. Meanwhile, from the producer's perspective, practicing the agricultural activity is sustainable depending on the generated incomes level. The present paper aims to study several economic parameters (profit, operating risk rate, security index), both in the conventional and organic system, for cucumbers and zucchini. For the studied crops, the income and expenditure budgets were made differentiated according to the applied technologies, production factors, yields per surface unit cultivated in two cropping systems, conventional and ecological. For the economic analysis of the income and expenses budget, technical-economic indicators such as costs, profitability, costs and prices were used. The technologies were developed based on research within the ICDLF Vidra. The conclusions section reinforce the high importance of conversion from conventional to ecological agriculture system, at the farm level, in order to maintain a high production level on long term, indispensable for generating farmers revenues, but also to ensure the sustainability of natural resource and to facilitate the environment conservation.

Key words: *organic farming, sustainable food system, economic indicators, cucumbers, zucchini*

INTRODUCTION

In general terms, organic production is described by the European Commission as farm management that focuses on balancing the environmental good practice with biodiversity and natural resource protection, in order to increase both organic food supply and demand, using natural substances [3]. Among the latest European Commission's measures applied in encouraging organic food production directions it should be mentioned the organisation of "EU organic awards" competition, since 2022. Thus, by fulfilling the eligibility criteria, interested producers/institutions across the Europe can apply for different award category such as: "Best organic farmer (female/male)"; "Best organic region"; "Best organic "bio-district""; "Best organic food processing SME"; "Best organic food retailers"; "Best organic restaurant/food service" [5].

The European Commission strategy *From Farm to Fork Strategy* (EC, 2020) is the core of the main directions that a sustainable development of the agriculture sector should follow. Thus, between the main objectives of this strategy we can mention: *ensuring sustainable food production and food security, discouraging food waste, promoting sustainable food consumption for a healthier planet but also for the population health status* [4].

According to the author Willet W. (2019) [12], several category of food describe a food consumption healthy pattern: *vegetables, fruits, whole grains, nuts and pulses*. The present study addresses to the first category, presenting the economic efficiency for cucumbers and zucchini, both in conventional and organic production system. FAO recent statistical database update shows that comparative to the 2010 values, the a decrease of production level for cucumbers and zucchini, from 172,059 tons at 77,830 tons (cucumbers production), respectively, from 81,625 tons at 14,880 tons (zucchini production) [6].

In the Balkans area, vegetable production (cucumbers included) is practiced especially in Albania, Romania, Bulgaria, Greece and North Macedonia [2].

In this context, this paper aims to present the obtained results during the project "ADER 6.3.15 Integrated management for the control of pest agents in the main vegetable species grown in protected spaces in conventional and organic systems" [9], mirrored by the calculated values of some reference economic indicators for the domestic farmer, in order to determine the profitability of studied crops, both in organic and conventional system.

MATERIALS AND METHODS

In order to achieve this paper, a complex and diverse methodology was applied, both qualitative and quantitative, including but not resuming at literature overview, briefing European legislative framework, statistical data analysis, particularly for the level of production and consumption for cucumbers and zucchini crops, the calculation of relevant synthesis indicators regarding the economic efficiency for the analyzed crops and others.

It is mentioned that the primary data were estimated based on the previous results obtained within the "ADER 6.3.15 Integrated management for the control of pest agents in the main vegetable species grown in protected spaces in conventional and organic system".

Table 1 presents the following economic indicators which have been calculated and also their formulas: production level (to/ha), production value (lei/ha), variable and fixed production costs, producer price, labor force productivity (in value and non-value expression).

Table 1. Main economic indicators in order to determine the economic efficiency

Indicator	**Formula**
Sales revenue (CA)	CA = Q*P, Q - quantity sold P - sale price [8]
Profit (P_r)	**Pr** = CA – CT, CA = sales revenue CT = total costs [7]
Rate of return (RoR)	RoR = (Pr/CA) *100 [10]
Margin on variable expenses (MCV)	MCV = CA-CV, CV=variable costs [11]
Break even	The level of sales revenues when Pr = 0 [1]

Source: Authors' processing based on the specialized literature.

Also, starting from the initial situation regarding the feasibility of cucumbers and zucchini production both in organic and conventional system, 3 scenarios will be developed in order to simulate possible further evolutions of the economic parameters of interest:

-*Scenario 1* **(S1)**: the cucumbers/zucchini production value will increase by 20% compared to the initial situation;

-*Scenario 2* **(S2)**: the cucumbers/zucchini production value will decrease by 20% compared to the initial situation;

-*Scenario 3* **(S3)**: maintaining the initial result when the level of fixed costs is reduced by 10% of initial level.

RESULTS AND DISCUSSIONS

In this section it is presented the main results obtained regarding the cucumbers and zucchini cultivation feasibility, both in conventional and organic system.

Regarding the results presented in Table 2, we used several input variables, in order to calculate the economic efficiency indicators described in the methods section, like: average production, production costs, unit production cost and selling price. The fixed costs represents those expenses incurred by producer regardless of the level of production. For variable costs estimation, raw materials and materials costs (37,083 lei in organic system and 38,917 in conventional farming) and labor costs (estimated at 21,575 lei in conventional agriculture respectively 27,897 lei in organic farming) where included.

Starting from a lower crop yield in organic farming, it can be observed a lower cucumbers production value and a higher production cost, mirrored in a highest delivery price. However, the organic farming brings also economic advantages for farmer, through a lower level of variables costs, including those with labor force and raw materials.

Practicing organic farming shows in this case a higher labor productivity value and also a higher profit for each product unit (with 2.17% higher in organic farming case). Finally, the same level of RoR is obtained, both in conventional and organic farming, of 20%, for cucumber crops cultivation.

Table 2. Main economic indicators in order to determine the economic efficiency for cucumbers crop

Indicator/ Unit measure	**Organic farming**	**Conventional farming**
Average production (to/ha)	30	35
Production value (lei/ha)	120,681.3	137,797.2
Production costs (lei/ha)	100,567.8	114,831.0
Variable production costs (lei)	74,389.3	81,612.8
Fixed production costs (lei)	26,178.5	33,218.2
Unit production cost (lei/to)	3,400	3,300
Selling Price (lei/to)	4,022.7	3,937.1
Labor productivity in physical expression (to/man-hour)	60.4	62.9
Labor productivity in value expression (lei/man-hour)	66.6	62.6
CA (lei)	120,681	137,797
P_r / unit of production (lei/ha)	20,113.6	22,966.2
P_r / product unit (lei/to)	670.5	656.2
RoR (%)	20	20
MCV (lei)	46,292.1	56,184.4
MCV (%)	38.4	40.8
Break even (lei)	68,246.2	81,470.6
Break even (to)	17	20.7
Operating risk rate (%)	56.6	59.1
Is	0.4	0.4

Source: preliminary calculation obtained through ADER 6.3.15 project [9].

However, a slight difference regarding the profit express in production unit (lei/ha) can be observed (20,113 lei/ha in organic farming compared to 22,966 lei/ha in conventional system).

Initial economic situation for cucumbers crop in conventional and organic farming system

In Figure 1 it is illustrated the initial results of certain economic parameters, such as sales revenue, total production costs (fixed and variable), the profit and the optimal level for achieving the feasibility characteristics at the farm level activity. The data were calculated based on the input variables defined in Table 2.

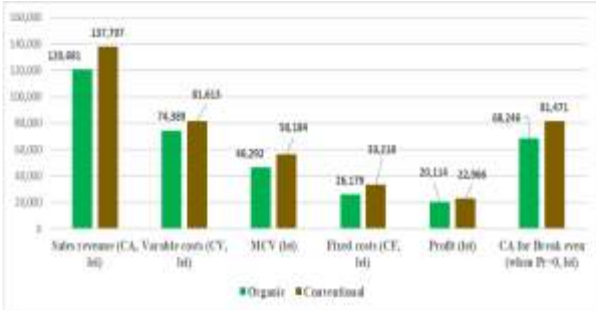

Fig. 1. Economic indicators for cucumber production in organic and conventional agriculture
Source: [9].

Simulations of possible scenarios. Cultivating cucumbers in solariums ecological and conventional system

Figure 2 shows the evolution of calculated economic parameters through the 3 scenarios presented in the "Materials and methods section".

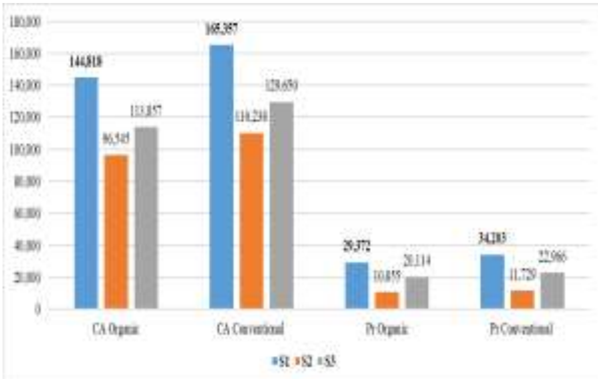

Fig. 2. Economic indicators for cucumber production in organic and conventional agriculture through S1, S2, S3
Source: [9].

Thus, it can be observed from Fig. 2 that Scenario 1, according to which increasing the level of production value is the optimal one, taking into consideration the profit level, in organic agriculture and also in conventional farming. Applying this type of strategy, the organic producers could increase their business profitability with 46% (from the initial value 20,114 lei to 29,372 lei). In conventional agriculture case, the profitability is also increasing, with a higher level compared to the organic agriculture case (49%), from 22,966 lei to 34,203 lei.

Regarding the results presented in Table 3, we used the same input variables like in previous presented crop.

Table 3. Main economic indicators in order to determine the economic efficiency for zucchini crop

Indicator/ Unit measure	Organic farming	Conventional farming
Average production (to/ha)	18.3	23.2
Production value (lei/ha)	130,111.6	85,118.1
Production costs (lei/ha)	108,426.3	70,931.8
Variable production costs (lei)	90,334.5	55,126.5
Fixed production costs (lei)	18,091.8	15,805.3
Unit production cost (lei/to)	5,900	3,100
Selling Price (lei/to)	7,125.9	3,661.2
Labor productivity in physical expression (to/man-hour)	50	38.9
Labor productivity in value expression (lei/man-hour)	142.4	113
CA (lei)	130,111.6	85,118.1
P_r / unit of production (lei/ha)	21,685.3	14,186.4
P_r / product unit (lei/to)	1,187.6	610.2
RoR (%)	20	20
MCV (lei)	39,777.1	29,991.7
MCV (%)	30.6	35.2
Break even (lei)	59,178.7	44,856.4
Break even (to)	8.3	12.3
Operating risk rate (%)	45.5	52.7
Is	0.5	0.5

Source: preliminary calculation obtained through ADER 6.3.15 project [9].

For variable costs estimation, raw materials and materials costs (63,757 lei in organic system and 39,691 in conventional farming) and labor costs (estimated at 12,454 lei in conventional agriculture respectively 13,004 lei in organic farming) where included.

As in cucumbers case, although the calculations starts from a lower crop yield in organic farming (18.3 to/ha in organic farming compared to 23.2 ton/ha in conventional agriculture), it can be observed a higher zucchini production value produced in organic system (130,112 lei compared to 85,118 lei). The higher level of organic zucchini production is explained by a significant difference regarding the selling price (7,126 lei/ton in organic case compared to 3,661 lei/ton case of conventional production). However, the organic farming brings also economic disadvantages for farmer, through a higher level of variables costs, including those with labor force and raw materials. Practicing organic farming shows in this case a higher labor productivity value and also a higher profit for each product unit (with 53% higher in organic farming case). Finally, the same level of RoR is obtained, both in conventional and organic farming, of 20%, for zucchini crop cultivation.

Initial economic situation for zucchini crop in conventional and organic farming system

Figure 3 illustrates the initial results of certain economic parameters, such as sales revenue, total production costs (fixed and variable), the profit and the optimal level for achieving the feasibility characteristics at the farm level activity. The data were calculated based on the input variables defined in Table 3.

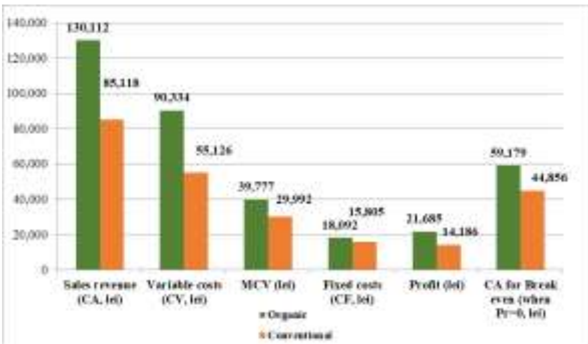

Fig. 3. Economic indicators for zucchini production in organic and conventional agriculture
Source: [9].

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Simulations of possible scenarios

Cultivating zucchini in solariums ecological and conventional system

Figure 4 shows the evolution of calculated economic parameters through the 3 scenarios presented in the “Materials and methods section “, as in the previous studied crop, cucumbers.

Thus, it can be observed from Fig. 4 that Scenario 1, according to which increasing the level of production value is the optimal one, same situation with the previous analyze, at cucumbers crop, taking into consideration the profit level, in organic agriculture and also in conventional farming.

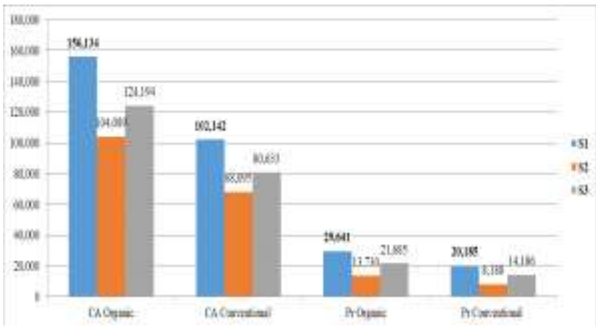

Fig. 4. Economic indicators for cucumber production in organic and conventional agriculture through S1, S2, S3

Source: [9].

The lowest level is presented through S2, according to which the production value will decrease with 20% compared to the initial level presented in Table 3.

CONCLUSIONS

This paper offers a synthetic presentation of the main results obtained within the ADER 6.3.15 project, entitled “Integrated management for the control of pest agents in the main vegetable species grown in protected spaces in conventional and organic systems” (First stage). The objectives of the current research are related with the European Green Pact main ambition, to facilitate the transfer from the current production and consumption models to the organic one, thus ensuring the sustainability of environmental resources and encouraging a healthy lifestyle of population. Starting from European specific legislation and policies, the zucchini and cucumbers crops were selected for the foundation of the specific economic indicators calculation, in order to establish the economic feasibility characteristic of the agriculture activity, both in organic and conventional system. Although related in terms of identified crops characteristics, the presented simulations demonstrate different results. Thus, from the farmer perspective, a highest level of income is obtained practicing organic farming, in cucumber crop study case. Meanwhile, in zucchini case, a highest level of income is registered within the organic farming, due to the possibility of setting a higher recovery price compared to the conventional agriculture products. This explanation can also be accompanied by the changes in consumer preferences and the type of demand registered for the reference products, the fluctuations in consumer behavior. This research also tests 3 types of scenarios, regarding cucumber and zucchini production in organic and conventional systems, in order to determine the optimal case for farmer’s wellbeing: the cucumbers/zucchini production value will increase with 20% compared to the initial situation (S1); the cucumbers/zucchini production value will decrease with 20% compared to the initial situation (S2); and maintaining the initial result when the level of fixed costs is reduced by 10% of initial level (S3).

The results of this research confirm the results of previous field research: the best way to increase the farmer revenues is to increase the level of production value. In order to ensure the sustainability of the agricultural business, farmers need to produce more, or to maintain the initial production level but capitalize on it at competitive prices, specific to a superior quality production.

Regardless of the producer’s decision in the agricultural sector, the conversion from the conventional farming to organic farming is the main challenge for each entrepreneur.

By producing in organic system, the farmers will bring their contribution to a better natural resource conservation management, a mandatory condition for ensuring the sustainability of the agriculture sector but also for the food safety and security, a primary need for the entire population.

ACKNOWLEDGEMENTS

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ECONOMIC AND SOCIAL DIMENSIONS OF AGRI-FOOD SECTOR IN THE SLOVAK REPUBLIC

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Abstract

The aim of the paper is to analyse selected economic and social aspects of the agri-food sector in the Slovak Republic. The source of data was the Statistical Office of the Slovak Republic as well as the National Agricultural and Food Centre Branch: Research Institute of Agriculture and Food Economics. A typical feature of Slovakia is that its territory is mainly dominated by rural areas, of which agriculture is an integral part, fulfilling not only an economic but also a social role. According to the latest Structural Farm Survey, there are 25658 farms in Slovakia, owned by legal and natural persons, which manage 1,889,819 ha of utilised agricultural land. The largest group is made up of registered and unregistered natural persons (87.8 %) and the smallest group is made up of legal persons (12.2 %). The situation is reversed in terms of the size of the land farmed, with legal persons farming 80.0 % of the agricultural land and natural persons farming only about 20 %. The number of persons employed in agriculture is 46.46 thousand and the remuneration of employees is lower than in other sectors of the national economy. In terms of status, employees account for 87.4% and entrepreneurs 12.6%.

Key words**:** *agriculture, food industry, utilised agricultural land, rural areas, employment*

INTRODUCTION

According to a study on income situation in the agricultural sector [4], which examined the differences in income per worker between the new EU-12 and the former EU-15 countries and considered the costs of land (rent), labour and capital as factors driving income differentials, the labour force declined by up to 25% between 2000 and 2009.

[7] and [9] state that "labour force transference is a pivotal strategy for enhancing farmers' income. Cross-regional labour mobility contributes to increasing farmers' income levels and reducing the income disparity between urban and rural populations to a notable extent".

Important factor that impacts farmers' income is the value of commodities. Increases in the prices of agricultural and side-line products bolster farmers' earnings [2] and [13]. Additionally, state subsidies are also crucial factors influencing farmers' income [8]. Several scholars argue that "various factors, including farmers' educational level, health status, physical capital, labour force quantity and quality, cultivable land area, geographic location, access to bank loans, and willingness to transfer land, significantly influence farmers' income. Additionally, social capital has garnered increasing scholarly attention as a crucial determinant" [6].

The social aspect of agriculture and food production is understood, according to [1, 11], as employment, wage level, labour reproduction, and educational level. Agriculture plays a less important role in job creation than other sectors of the national economy. The development of agricultural population has undergone a degressive trend over the last decades and is heading towards potential complications for the reproductive base of the agricultural labour force. Another persistent obstacle is ensuring the stabilization of a sufficiently educated workforce, which is one of the prerequisites for economic growth and innovative development of this sector.

The modernization of agricultural enterprises ensures an increase in work efficiency and at the same time replaces live labour and reduces labour costs, which is reflected in their efficiency and competitiveness. The competitive success of the agrarian sector is also influenced by the technical and technological equipment of production and the efficiency of the use and annual renewal of fixed assets of agricultural enterprises [5].

Production efficiency and support policies are crucial factors influencing the income situation and economic stability of agriculture [12]. Other determinants include the optimal structure of production, cost-effectiveness with an impact on employment, renewal of fixed capital and assured marketing of production. Recent years have been characterised by a preference for crop production over livestock production, with a different development in the scale and intensity of production (lagging behind neighbouring countries) and a loss of the status and production potential of livestock production (a decline in the number of animals, especially cattle). In the business structure, the share of commercial companies is growing, and the share of agricultural cooperatives and self-employed farmers is decreasing [3].

[10] annually produce a publication called "Panorama of the food industry", which states that in terms of the macroeconomic position, the production of food, beverages and tobacco products in the Czech Republic in 2020 contributed 2.19% to the gross value added in current prices and 2.59% to employment. Nevertheless, this sector is one of the major employers, as in the whole EU. In terms of the number of employees (including the amount of personnel costs), the strongest group was "Manufacture of bakery, confectionery and other flour products", which is related to the need to supply fresh bakery products to the market network on a daily basis throughout the territory of the Czech Republic. This group employed 34.4% of the employees in the food industry. The production of flour products, including the production of meat products (24.4%) and dairy products (9.6%), employs a total of 68.4% of the food industry's workforce.

MATERIALS AND METHODS

The analyses were carried out using data from the Statistical Office of the Slovak Republic, in particular the Structural Farm Survey (formerly called the “Agricultural Census of Farms”), which uses the same methodological procedure for all EU Member States to ensure compatibility and possible comparison within EU countries. The latest data from the 2020 Farm Structural Survey were published in 2022. The survey included all agricultural enterprises - farms engaged in crop or livestock production, regardless of the scale of production, as well as households that reached one of the threshold values set for farms in the Slovak Republic.

Monitoring employment in agriculture is quite complex due to the existence of multiple sources, namely the "enterprise method", the Labour Force Sample Survey and the Structural Farm Census. The volume of work, expressed in terms of the number of workers, is considerably underestimated in agriculture because seasonal fluctuations in labour consumption are considered in enterprise reporting under the heading “services to agriculture - contract work for agriculture” (i.e., contracted labour) and are not reflected in labour costs.

Data for the food industry were used from the Statistical Office of the Slovak Republic. The macroeconomic situation of agriculture and food industry in terms of socio-economic aspects was expressed by the participation of these sectors in the national economy during the period 2013-2020. This concerned the development of the share of agricultural and food industry indicators in indicators of the national economy of Slovakia, gross value added and employment.

The data were processed using common standard research methods such as analysis and synthesis, comparisons, sorting of enterprise sets and graphical representation of the development of selected indicators over a period of time.

RESULTS AND DISCUSSIONS

Characteristics of Slovakia's territory and social aspect of the countryside

The territory of the Slovak Republic covers an area of 4 903434 ha. Of this, non-agricultural land accounts for 51.4% and agricultural land for 48.6% (Table 1). The largest share of the area of non-agricultural land is forest land (41.3%). Agricultural land occupies almost half of the total area (48.6%) and arable land accounts for 28.8% of the territory of the Slovak Republic.

Table 1. Structure of Slovak republic land area in 2020 (in ha)

Land area in the SR	ha	%	Share of the area	ha	%
Agricultural land	2 385 328.1	48.6	Arable land	1,409,777.9	28.75
			Hop plants	510.5	0.01
			Vineyards	26,266.5	0.54
			Gardens	76,205.7	1.55
			Orchards	16,685.2	0.34
			Permanent grass lands	855,882.2	17.45
Non-agricultural area	2 518 106.5	51.4	Forest lands	2,022,522.3	41.25
			Water areas	95,257.1	1.94
			Built-up areas and courtyards	236,281.1	4.82
			Other area	164,046.0	3.35
Total	4 903 434.6	100.0		4,903,434.6	100.00

Source: Statistical office of the Slovak republic; National Agricultural and Food Centre Branch: Research Institute of Agriculture and Food Economics.

Since Slovakia's accession to the EU, the term subsidized utilized agricultural land (1 910654 ha) has been used, which is 20% less than the total agricultural land of the Slovak Republic (Fig. 1). Trends in the development of agricultural land document that since 2007 there has been a slight decrease in utilised agricultural land and a gradual slight increase in forest land. Arable land has maintained the same level, except for small fluctuations in 2009 and 2010.

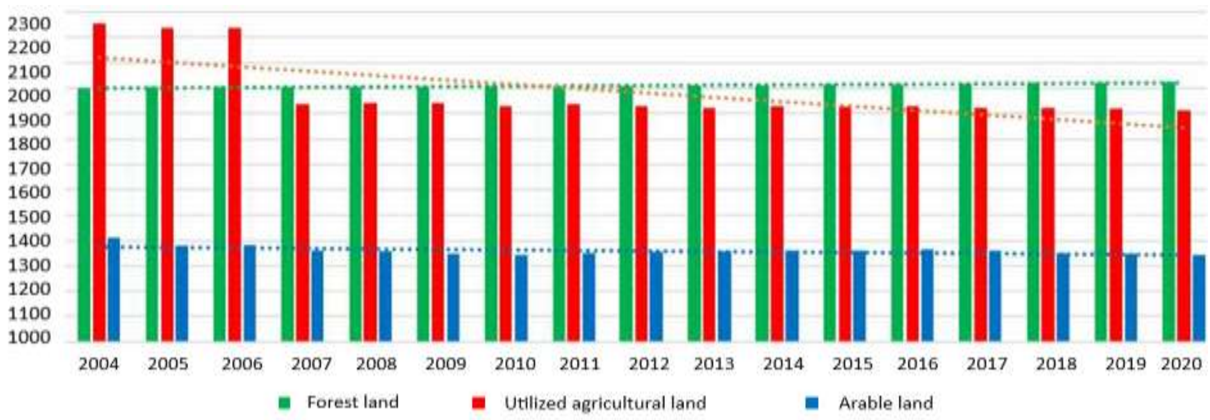

Fig. 1. Development of utilized agricultural land (in thousands of ha)
Legend: BA – Bratislava region, TT – Trnava region, TN – Trenčín region, NR – Nitra region, ZA – Žilina region,
Source: Statistical office of the Slovak republic.

Rural areas

Slovakia is dominated by rural areas, an integral part of which is agriculture and its associated productive efficiency, which as one of the key elements influences the economic and social level of its inhabitants. Despite the application of the Common Agricultural Policy to reduce regional disparities after EU accession, significant regional disparities persist in Slovakia. Rural areas, which are characterised by their agriculturally disposable land, represent an untapped potential for at least partially solving the unemployment problem and developing the rural settlement structure.

Slovakia has a total population of 5.5 million inhabitants with an average population density of 110.5 inhabitants per 1 km^2. The degree of

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rurality of a territory, determined on the basis of the Eurostat methodology, is expressed as the proportion of the population living in rural municipalities. In terms of the share of total area of Slovakia, rural regions predominate, together with the transition regions, which together cover almost the entire territory of the Slovak Republic (95.8%). Predominantly urban regions make up a small part of the Slovak Republic, accounting for 4.2% of the country's total area (Table 2). People with permanent residence in municipalities classified as "transition regions" make up half (50.9%) of the total population of the Slovak Republic. Together with people from "predominantly rural regions" (37.5%), they make up 88.4%. The smallest share of permanently living people is in predominantly urban areas, namely 11.7%.

Table 2. Structure of Slovak Republic land area in 2020 (in ha)

Region	**Area in km²**	**Share on the SR area in %**	**Population of the region**	**Populationshares in the SR in %**
Mostly urban regions	2,053	4.2	633,288	11.7
Transitional regions	24,409	49.8	2,759,546	50.9
Predominantly rural regions	22,573	46.0	2,033,418	37.5
SR in total	49,035	100.0	5,426,252	100. 0

Source: Statistical office of the Slovak republic; National Agricultural and Food Centre Branch: Research Institute of Agriculture and Food Economics.

Farm Structural Survey and labour force development in agriculture

The business structure in Slovakia consists of commercial farms (based on the principle of trading companies and agricultural cooperatives) and farms of natural persons. According to the 2020 Farm Structure Survey, there were 25,658 farms owned by legal entities and natural persons in Slovakia, managing 1,889,819 ha of agricultural land. In terms of numbers, the majority group consisted of natural persons' enterprises, both registered and unregistered, with a share of 87.8 %, and the minority group consisted of legal persons' enterprises with a share of 12.2 % (Table 3).

Table 3. Structure of Slovak Republic land area in 2020 (in ha)

Agricultural enterprises	**2013**				**2016**				**2020**			
	Number	Share in number (%)	Area (ha)	Share in area (%)	Number	Share in number (%)	Area (ha)	Share in area (%)	Number	Share in number (%)	Area (ha)	Share in area (%)
Legal persons	2,276	9.3	1,529,083	80.7	2,666	11.3	1,531,331	80.5	3,139	12.23	1,511,949	80.0
Trade companies					2,094		826,139		2,465		836,586	
Agricultural cooperatives. State estates. State enterprises					572		705,192		674		675,363	
Natural persons	22,187	90.7	366,417	19.3	20,900	88.7	370,283	19.5	22,519	87.77	377,870	20.0
Registered	6,008		316,370		5,469		311,580		5,996		307,551	
Unregistered	16,179		50,047		15,431		58,703		16,523		70,319	
Legal and natural persons in total	24,463	100.0	1,895,500	100.0	23,566	100.0	1,901,614	100.0	25,658	100.0	1,889,819	100.0

Source: Ministry of Agriculture and Rural Development of the Slovak Republic; National Agricultural and Food Centre Branch: Research Institute of Agriculture and Food Economics.

In terms of size of the cultivated land, the situation is reversed, with 80.0% of agricultural land being cultivated by legal entities and approximately 20% by natural persons. Compared to 2013, there has been a decrease in the area of legal entities (1.1%, 17 thousand ha) and an increase in the area of natural persons (3.1%, 12 thousand ha). A large number of small farms cultivate a small share of the total agricultural area, while a relatively small number of large farms have a predominant share of the total agricultural area. The size structure of farms was significantly differentiated (Table 4). Most farms (47.3%) operated on an area of less than 5 ha. 9.6 % of the total number of farms operated on an area of more than 100 ha, which is crucial for production and for maintaining the rural agricultural landscape in good condition. Of these, only 2.2 % of farms were operating on more than 1,000 ha.

Table 4. Structure of farms of legal and natural persons in Slovakia according to intervals of agricultural land size in 2020

Groups of enterprises according to farmed land (ha)	Enterprises in total				Enterprises of legal persons- trade companies				Enterprises of legal persons - agricultural cooperatives. state estates. state enterprises				Enterprises of natural persons				Unregistered enterprises of natural persons			
	Number		Area		Number		Area		Number		Area		Number		Area		Number		Area	
	abs.	%	ha	%	abs.	%	ha	%	abs.	%	ha	%	abs.	%	ha	%	abs.	%	ha	%
0	2,286	8.9	22	0.0	93	3.8	0	0.0	5	0.7	0	0.0	144	2.4	0	0.0	2,044	12.4	22	0.0
0 - 5	12,124	47.3	29,448	1.6	224	9.1	635	0.1	12	1.8	25	0.0	1,283	21.4	3,564	1.2	10,605	64.2	25,224	35.9
5 - 10	3,537	13.8	25,448	1.3	219	8.9	1,679	0.2	21	3.1	153	0.0	957	16.0	7,159	2.3	2,340	14.2	16,458	23.4
10 - 50	4,370	17.0	94,365	5.0	571	23.2	14,761	1.8	65	9.6	1,575	0.2	2,236	37.3	52,434	17.0	1,498	9.1	25,595	36.4
50 - 100	941	3.7	66,920	3.5	261	10.6	18,871	2.3	31	4.6	2,231	0.3	619	10.3	43,852	14.3	30	0.2	1,966	2.8
100 - 500	1,399	5.5	331,061	17.5	603	24.5	158,501	18.9	103	15.3	30,972	4.6	688	11.5	140,533	45.7	5	0.0	1,054	1.5
500 - 1,000	446	1.7	325,303	17.2	234	9.5	171,020	20.4	163	24.2	122,631	18.2	49	0.8	31,653	10.3	0	0.0	0	0.0
1,000 - 1,500	256	1.0	310,938	16.5	127	5.2	151,487	18.1	112	16.6	138,919	20.6	17	0.3	20,532	6.7	0	0.0	0	0.0
1,500 - 2,000	135	0.5	233,239	12.3	58	2.4	100,047	12.0	76	11.3	131,311	19.4	1	0.0	1,881	0.6	0	0.0	0	0.0
2,000 - 2,500	69	0.3	151,868	8.0	30	1.2	67,005	8.0	38	5.6	82,839	12.3	1	0.0	2,024	0.7	0	0.0	0	0.0
2,500 - 3,000	33	0.1	88,306	4.7	14	0.6	37,483	4.5	19	2.8	50,822	7.5	0	0.0	0	0.0	0	0.0	0	0.0
3,000 - 3,500	26	0.1	84,569	4.5	14	0.6	45,882	5.5	12	1.8	38,687	5.7	0	0.0	0	0.0	0	0.0	0	0.0
3,500 - 4,000	16	0.1	59,307	3.1	8	0.3	29,566	3.5	7	1.0	25,824	3.8	1	0.0	3,917	1.3	0	0.0	0	0.0
over 4,000	19	0.1	89,024	4.7	9	0.4	39,649	4.7	10	1.5	49,375	7.3	0	0.0	0	0.0	0	0.0	0	0.0
Total	25,658	100.0	1,889,819	100.0	2,465	100.0	836,586	100.0	674	100.0	675,363	100.0	5,996	100.0	307,551	100.0	16,523	100.0	70,319	100.0

Source: Statistical office of the Slovak republic; National Agricultural and Food Centre Branch: Research Institute of Agriculture and Food Economics.

In terms of production importance and rural employment, corporate enterprises are crucial. Out of a total of 3,139, a significant share is represented by trading companies (78.5%), which manage 55.3% of the agricultural land of legal entities. Agricultural cooperatives and state-owned enterprises accounted for 21.5 % of total and managed 44.6 % of the legal entities' land. The periods between the two structural censuses document the growing importance of small family farms, especially in less productive areas of Slovakia, where there are less job opportunities in other sectors. While the numbers of registered natural persons have remained stable, except for small fluctuations, the number of unregistered natural persons has increased. These are mostly small backyard farms with production for own consumption, only in specific cases production intended for the market.

The average farm size in Slovakia differs significantly from the average farm size in most EU Member States. For legal entities, the average area is approximately 1,287 ha. For all entities, including unregistered ones, the average farm area was 73.65 ha, of which the average area of cultivated land per farm was 79.03 ha. There are almost 16,523 unregistered individuals in Slovakia with very small land area, but their total land size is not significant in terms of production. The average area of legal entities' farms is decreasing and the average area of registered natural persons - self-employed farmers is increasing. This process also has a significant impact on the social structure of the countryside.

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Structural survey of farms by region

Between 2016 and 2020, the number of farms increased by 8.9%, both legal (16.5%) and natural (7.9%) persons, to a total of 2,092, which was reflected in most regions, except the Žilina region. However, the highest number was in the Nitra region (an increase of 623 farms).

Significant changes compared to the Structural Census of Farms between 2013 and 2016 also occurred in employment per 100 ha of agricultural land, especially of legal entities, which decreased on average from 5.6 to 4.7 employees, i.e., by almost 1 employee (Table 5). This can be explained by the decline in agricultural land for other purposes, cost-saving measures, the onset of mechanisation of work activities, but also by lower interest in working in agriculture, given the remuneration and job opportunities in other sectors.

Table 5. Agricultural enterprises according to numbers. area of agricultural land and employment in regions in 2020

Indicator / Region	BA	TT	TN	NR	ZA	BB	PO	KE	SR
1.Legal persons in total									
Number	148	427	236	548	313	608	474	446	3200
Area in ha	63,849	225,397	115,049	327,910	134,095	224,810	217,925	202,913	1,511,949
Number of employees per 100 ha	4.3	5.3	4.9	6.0	4.3	3.7	4.6	4.5	4.7
2. Natural persons in total									
Number	735	2,387	1,400	3,915	3,809	4,238	3,041	2,933	22,458
Area in ha	13,055	40,993	18,738	85,856	29,393	69,678	49,091	71,066	377,870
2.1. Registered natural persons									
Number	186	577	341	871	973	1,268	975	744	5,996
Area in ha	10,386	31,826	13,592	72,214	21,321	56,599	41,046	60,568	307,551
Number of employees per 100 ha	0.6	0.6	0.4	0.8	0.2	0.4	0.4	0.8	0.5
2.2.Unregistered natural persons									
Number	549	1,810	1,059	3,044	2,836	2,970	2,066	2,189	16,523
Area in ha	2,669	9,167	5,147	13,642	8,072	13,079	8,045	10,499	70,319
Legal and natural persons in total									
Number	883	2,814	1,636	4,463	4,122	4,846	3,515	3,379	25,658
Area in ha	76,904	266,390	133,788	413,766	163,488	294,488	267,016	273,979	1,889,819

Legend: BA – Bratislava region, TT – Trnava region, TN – Trenčín region, NR – Nitra region, ZA – Žilina region, BB – Banská Bystrica region, PO – Prešov region, KE – Košice region, SR – Slovak republic

Source: Statistical office of the Slovak republic; National Agricultural and Food Centre Branch: Research Institute of Agriculture and Food Economics.

Agricultural land decreased by 0.62%, a total of 11,795 ha, most in the Bratislava region (20,491 ha) and less in the Košice (11,753 ha) and Žilina (7,069 ha) regions. On the other hand, the area of agricultural land increased most in the Prešov region (11,482 ha), less in the Banská Bystrica region (5,313 ha), the Trenčín region (5,287 ha) and the Nitra Region (5,107 ha). However, the total gain did not compensate for the total loss of land in the Slovak Republic.

Regionally, the western Slovak regions experienced the largest decrease in number of workers, especially legal entities, which can be explained by better job opportunities in other sectors in this region, as well as accessibility of the Slovak capital. The situation was similar in Žilina region, where the decrease in agricultural land was mainly due to changes related to the establishment of non-agricultural enterprises (automotive industry). In the Bratislava and Košice regions, the decrease in agricultural land was caused by interest in individual construction.

Legal entities

From the results of the Structural Farm Survey of Legal Persons between 2013 and 2020, it can be deduced that in 2020:

-legal persons are the decisive group of producers of agricultural products for the food industry in Slovakia, they are predominant in terms of production, area of cultivated agricultural land and employment,

-in terms of the breakdown of legal entities, commercial companies (Ltd, JSC) managed 836,586 ha of agricultural land, which was 23.8% more than cooperatives (675,363 ha of agricultural land),

-the number of agricultural enterprises increased by 40.6% (924 enterprises) in almost all regions, with the highest number in the Banská Bystrica (221) and Košice (154) regions, mainly due to the increase in commercial companies,

-the total area of agricultural land in Slovakia decreased by 17,134 ha. The largest decrease was in the Bratislava region (17,006 ha), less in the Žilina (8,702 ha) and Košice (8,222 ha) regions.

This is documented by the significant dispersion of business entities and the segmentation of farms of legal entities was more evident in less productive agricultural areas of Slovakia.

-The decrease in cultivated land of legal entities, especially in the north-eastern regions of Slovakia, was compensated by high increases in cultivated land of registered natural persons in these areas. The decrease in area of large business entities (legal entities) was thus compensated by an increase in cultivated areas of registered natural persons.

-The increase in agricultural land of legal entities occurred in the Nitra region (12,633 ha) and less in the Trnava region (3,739 ha), but this was not sufficient to compensate for the overall decrease:

-significant changes also occurred in employment. The number of employees in relative terms, i.e., per 100 ha of land, decreased from 6.7 in 2010 to 4.7 in 2016.

Natural persons

Registered natural persons

-According to the structural survey, in 2020 up to 5,996 farms were registered as natural persons, their number increased by 11.3% compared to 2013, except for the Bratislava region in all regions, most of them in northern parts of Slovakia, i.e., in the Trenčín, Žilina, Prešov and Banská Bystrica regions, in most of which the cultivated land also increased, i.e., these are the less productive areas of Slovakia. The average area of cultivated land per farm of registered natural persons was 17.96 ha.

-In productive agricultural areas, the number of registered farms of natural persons almost stagnated. These areas are dominated by legal entities - large farms in terms of area. In all regions of western Slovakia, the area of agricultural land of this group of farms has decreased. In relative terms, i.e., per 100 ha of agricultural land, employment has not changed significantly, with an average decrease of only 0.1 worker.

Unregistered natural persons

In 2020, there were 16,523 farms of unregistered natural persons managing 70,319 ha of agricultural land. The number of unregistered farms has increased by 7.1% since 2016 and agricultural land by 19.8%. These are more or less self-sufficient farms, (households), which are a complementary activity of the rural population, and also represent a certain rural lifestyle in almost all regions of Slovakia, but their significant increase is not expected in the future.

Employment in agriculture and food industry

Agriculture in Slovakia has undergone many changes over the past decades, and this has been reflected in employment. Crop and livestock production have declined, and the number of cooperatives has gradually decreased. During the transition process, many cooperatives have disappeared or have been transformed into trading companies. The restructuring of enterprises and the gradual optimization of cost factors and work procedures have led to considerable unemployment in agriculture. With Slovakia's accession to the EU in 2004 and the adoption of conditions of the single European market, the possibilities of obtaining financial support from EU funds have expanded and the situation has partially stabilised.

Macroeconomic aspects of the socio-economic situation of agriculture and food industry

After 2011, the share of agriculture in the economic performance of Slovakia has had a fluctuating development in individual years.

While in 2011 the share of gross value added of agriculture in the gross value added of the national economy reached 3.20%, in 2020 it was only 2.43%. It peaked in 2017 at 3.38%, when it also exceeded the level of the base year 2011. This development was also reflected in the social sphere - employment (Table 6).

Table 6. Development of the participation of agri-food sector indicators on the economy (in %)

Indicator/sector	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Agriculture										
on gross value added (current prices)	3.20	2.53	2.07	2.55	2.69	2.99	3.38	2.67	2.69	2.43
on employment	2.47	2.34	2.24	2.18	2.12	2.25	2.15	2.10	2.01	1.96
on average wage	75.92	75.58	75.55	77.86	78.26	75.97	76.11	74.18	76.97	76.42
Production of food, beverages and tobacco products										
on gross value added (current prices)	1.83	1.68	1.61	1.55	1.55	1.41	1.51	1.41	1.40	1.43
on employment	2.24	2.20	2.11	2.05	2.02	1.95	1.89	1.91	1.93	1.96
on average wage	91.04	91.45	90.77	89.19	90.09	88.93	89.83	89.01	89.64	88.08

Source: Statistical office of the Slovak republic; National Agricultural and Food Centre Branch: Research Institute of Agriculture and Food Economics.

In addition to its national importance, agriculture in the Slovak countryside has in the past fulfilled an important social function, especially in terms of employment. It was the main employer and often the only one in rural areas. A significant decline in the workforce occurred in the early years of the agricultural transformation and later because of technological progress under subsidy support from the Rural Development Plan 2007-2013. Although the rate of reduction in employment has slowed down in recent years, the share of average number of registered employees in agriculture in the total number of employees in the national economy has decreased from 12.00 % in 1990 to 1.96 % in 2020. Since 2011, the share of agricultural employment in total employment in the country has ranged from 1.96% to 2.47%.The development of employment in agriculture since 2011 has been variable, with a gradual slight decrease from 55.6 thousand in 2011 to 46.6 thousand in 2020 (16.2%). There has been a slight stabilization of employment in the last two years (Table 7).

Compared to other sectors of the national economy, the remuneration of employees in agriculture is still lower. According to average monthly wages, agricultural workers are among the most socially disadvantaged group of employees, with a tendency towards a significant deterioration in their income status. Average wages in agriculture have been at 74 % of the national average for a long time.

Table 7. Development of employment in agriculture and food industry (in thousands of persons)

Sector	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Agriculture, forestry and fisheries	81.8	77.6	73.1	73.0	70.6	73.9	72.4	73.4	72.5	72.3
- out of which agriculture	55.6	51.5	48.6	48.1	46.8	49.2	47.7	47.7	46.7	46.6
Production of food, beverages and tobacco products	43.6	41.9	39.9	39.8	38.6	37.1	36.9	38.2	39.7	41.0

Source: Statistical office of the Slovak Republic.

The contribution of the food industry to the gross value added of the national economy is lower than that of agriculture. The macroeconomic situation in the food sector has been more stable after 2008, although its trend in value added as a share of the national economy has been degressive, from 1.83% in 2008 to 1.43% in 2017. The decline in the share has been continuous and has taken place gradually every year since 2011. This trend has continued until now, due to the liberalization of trade, the pressure exerted by retail chains on their suppliers and the high import of food products that can be produced in Slovakia. This resulted in a decrease in food production in individual sectors and an increase in imports of finished foreign products. On the other hand, the low competitiveness of Slovak products on the domestic and foreign markets is reflected in the high negative balance of foreign trade in food products.

This trend subsequently also affected employment, as the share of employment in the food industry in the national economy fell from 2.24% in 2011 to 1.96% in 2020. Although the number of employees decreased between 2011 and 2020 (6.0%), employment in the food industry had a more moderate decline than in agriculture, from 43.6 thousand in 2011 to 43.6 thousand in 2020. The remuneration of workers in the food industry was higher than in agriculture by about 15-20% and the share of the average wage in this sector reached almost 90% of the average wage in the national economy.

Development of the structure of agricultural workers in terms of status

In terms of status of persons in agriculture, employees accounted for a decisive share of the total number of workers in agriculture (Table 8). The steady to slightly increasing share of entrepreneurs, except for 2015 and 2016, confirms the established trend, with an annual increase of 5.8% in 2017.

Table 8. Development of agricultural workers structure in terms of status (in %)

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Employees	91.9	89.8	88.1	86.4	92.4	93.5	87.7	86.6	88.8	87.4
Entrepreneurs	8.1	10.2	11.9	13.6	7.6	6.5	12.3	13.4	11.2	12.6

Source: Statistical office of the Slovak Republic.

Educational structure of agricultural workers

The educational level in agriculture has improved since 2011 and is currently characterised by two equal groups (Table 9), i.e., secondary education, with the share of workers falling from 55.8% (2011) to 41% (2020, vocational education), and complete secondary education, with the share rising from 23.4% (2011) to 42% (2020).

Table 9. Development of educational level of agricultural workers (in thousands of persons)

Education/year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Index 2020/2011	Index 2020/ Ø2011-2019
Primary education	10.4	9.6	6.5	5.2	5.3	4.6	4.7	4.8	2.8	2.3	22.1	38.4
Secondary education (vocational)	39.6	35.6	28.8	25.8	28.8	24.8	25.5	26.1	25.8	19.9	50.3	68.7
Complete secondary education	16.6	15.4	16.5	14.9	17.3	18.6	22.9	21.8	20.4	20.4	122.9	111.7
University education	4.4	4.9	4.5	5.4	3.9	4.9	5.6	5.3	3.6	5.9	134.1	124.9
Total	71.0	65.5	56.3	51.3	55.3	52.9	58.7	58.0	52.6	48.5	68.3	83.7

Source: Statistical office of the Slovak republic; National Agricultural and Food Centre Branch: Research Institute of Agriculture and Food Economics.

Low-skilled and marginalised groups of workers have found employment mainly in specialized production areas. The increasing efficiency of the production process results from the growing pressure of the market environment and has also been carried out through the minimisation of manual labour using of modern, innovative technologies. This trend places higher demands on the technical skills required to operate the equipment in production as well as on the managerial skills of managers of individual farm managers.

Evolution of the structure of workers in the food industry in terms of status, age and education

In terms of employment status, employees account for a decisive share of the total

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number of workers in the food industry (Table 10), accounting for 96.2% in 2020. The share of entrepreneurs ranged from 2.7%-7.6% between 2011-2020 and reached 3.6% in 2020. The development of the share of entrepreneurs varied significantly, while the share in the number of employees was more stable. The share of entrepreneurs fluctuated significantly in 4-5-year intervals. The highest decline occurred in 2016 and 2020.

Table 10. Development of food production workers structure in terms of status (in %)

Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Employees	97.5	96.2	95.8	92.2	93.8	96.7	96.0	93.3	92.5	96.2
Entrepreneurs	2.7	3.8	4.2	7.6	5.6	2.8	4.2	6.5	7.4	3.6

Source: Statistical office of the Slovak Republic.

Development of the educational structure in the food industry

In terms of educational level in the food industry in 2020, the largest share of workers in 2020 had a complete secondary vocational education (36.4%) and a secondary vocational education without graduation exam (34.3%). These two educational groups dominate the shares of long-term workers, but education without graduation exam was predominant (Table 11).

The share of workers with primary education reached 5.1% in 2020 and the share of those with a university degree reached 10.3%, both groups with continuous growth over the last three years.

Table 11. Development of educational level of food production workers (in %)

Education/year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Primary education	6.6	4.7	5.1	5.8	5.1	6.4	2.4	2.8	3.1	5.1
Secondary vocational education without graduation exam	46.5	47.9	47.0	45.4	46.8	39.5	45.8	45.4	41.0	34.3
Complete secondary education - vocational education with graduation exam	7.5	6.0	7.3	4.2	3.7	5.7	7.0	5.6	6.8	7.3
Complete general secondary education	3.0	2.3	2.8	5.3	5.8	2.9	2.8	3.2	4.8	3.6
Complete secondary vocational education	30.9	33.1	31.1	29.0	30.3	36.4	31.7	34.8	33.1	36.4
Higher vocational education	0.2	0.3	0.8	0.2	-	0.2	0.4	-	-	0.6
University education – bachelor's degree	0.2	0.7	0.2	0.7	1.0	0.7	1.4	0.7	1.3	2.2
University education – master's degree	5.2	5.0	5.7	9.4	7.3	8.2	8.6	7.5	9.2	10.3
Total	6.6	4.7	5.1	5.8	5.1	6.4	2.4	2.8	3.1	5.1

Source: Statistical office of the Slovak republic; National Agricultural and Food Centre Branch: Research Institute of Agriculture and Food Economics.

CONCLUSIONS

The sustainability of economic life in rural areas is largely influenced by the presence of agriculture and its productive performance. There are significant regional differences in this field. In the most agriculturally productive regions, agricultural activity generates a significant share of employment and the rural economy. In other areas, particularly in heavily industrialised areas, agriculture is a complementary element in the use of available productive resources, especially labour. Future employment prospects in agriculture will thus depend on an increase in the productive efficiency of agriculture, the intensity of modernisation of the sector, the improvement of the quality of the workforce and the diversified use of the internal development potential of the rural economy.

Slovakia is dominated by rural areas, an integral part of which is agriculture and its associated productive efficiency, which as one of the key elements influences the economic and social level of its inhabitants. Agricultural land occupies almost half of the entire territory (48.6 %), arable land accounts for 28.8 % of the territory.

In Slovakia, there were 25,658 farms of legal and natural persons managing 1,889,819 ha of agricultural land in 2020. In terms of numbers, the majority group consisted of natural persons' enterprises, both registered and unregistered, with a share of 87.8 %, and the minority group consisted of legal persons' enterprises with a share of 12.2 %

In terms of size of the cultivated land, the situation was reversed, with 80.0% of agricultural land being cultivated by legal entities and approximately 20% by natural persons.

The average area of farms in Slovakia for all entities, including unregistered ones, is 73.65 ha. In the case of legal entities, it is 1,287 ha. The economically and productively decisive part of the enterprises is made up of legal entities with a large-scale production character, with a predominance of rented land and with a low degree of diversification of activities beyond agriculture. There were 16,523 unregistered individuals with a very small area of land, but their total land size is not significant in terms of production.

Regionally, the western Slovak regions experienced the largest decrease in number of workers, especially legal entities, which can be explained by better job opportunities in other sectors in this region, as well as accessibility of the Slovak capital. The situation was similar in Žilina region, where the decrease in agricultural land was mainly due to changes related to the establishment of non-agricultural enterprises (automotive industry). In the Bratislava and Košice regions, the decrease in agricultural land was caused by interest in individual construction.

The number of persons employed in agriculture was 46.46 thousand and the remuneration of employees was lower than in other sectors of the national economy. In terms of status, employees account for 87.4% and entrepreneurs 12.6%.

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THE CONTRIBUTION OF THE BIBLIOMETRIC ANALYSIS TO THE UNDERSTANDING OF TRENDS IN THE SUSTAINABLE DEVELOPMENT OF TOURISM

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Abstract

In the contemporary context of economic development and environmental conservation, sustainable tourism is an important field of research that significantly impacts local communities and natural resource management. The need to reconcile the growth of the tourism industry with the preservation of ecosystems and cultural heritage while producing long-term financial rewards makes this topic vital. Given the difficulties posed by climate change, the rise of mass tourism, and its effects on the environment and society, there is a growing interest in discovering efficient tourist management solutions. This desire led to the selection of this issue. Using a bibliometric method, the study sought to identify the most influential works, authors, journals, and international collaborations by analyzing the structure and development of the scientific literature on sustainable tourism. The bibliometric methodology was used in the study, and the associations between publications, authors, and nations were shown using the VOSviewer software and the Scopus database. Concept maps and collaborative networks were generated to demonstrate major trends in the field, and analysis focused on co-citation relationships, keyword co-occurrence, and bibliographic coupling. The results obtained indicated that sustainable tourism is an expanding field, with an exponential increase in publications over the last two decades. The most influential works are centered on destination management, environmental impact of tourism, sustainability strategies and tourist behaviour. In terms of the geographical distribution of research, a dominance of developed countries such as the United States, the United Kingdom, China, Australia and Spain has been observed, while emerging countries, although present, have a smaller impact. The analysis also highlighted a strong interconnection between sustainable tourism and other fields such as economics, ecology and development policies. However, the study highlighted several gaps in current research, including the lack of in-depth studies on the integration of new technologies in sustainable tourism, the long-term economic impact of tourism on local communities, regional disparities in the adoption of sustainability strategies, the influence of tourists' behavior on the implementation of responsible tourism and the need for standardized methods to evaluate the effectiveness of applied strategies. We believe that future research perspectives should focus on promoting interdisciplinary approaches and international collaborations for the development of sustainable models applicable on a global scale.

Key words: *tourism, sustainable, responsible, management, bibliometric analysis*

INTRODUCTION

Sustainable tourism has become a central topic in contemporary research, having the role of balancing economic development with environmental protection and ensuring the well-being of local communities. This idea developed out of the necessity to counteract the detrimental impacts of mass tourism and to guarantee the sustainability of travel destinations in the future [7, 8, 18]. Sustainable tourism, as defined by the World Tourism Organization, is a form of travel that takes into account both the immediate and long-term economic, social, and environmental ramifications in order to meet the needs of travelers, businesses, the environment, and host communities.

[22]. This definition emphasizes the need for a balance between the different components of tourism, which requires the adoption of clear management and regulatory strategies.

The main objectives of sustainable tourism include environmental protection, cultural heritage conservation, equitable economic development and the active involvement of local communities in the management of tourist destinations [22]. However, the achievement of these objectives is often hampered by the challenges of increasing tourist numbers, pressure on local resources and the lack of clear regulatory policies [10].

In many regions of the world, unsustainable tourism has led to overcrowding, which has damaged fragile ecosystems, increased pollution, and raised the cost of living for local residents [13]. Also, the effect of "showcase tourism" has been observed in many cultural destinations, where the authenticity of traditions has been affected by the need to meet the expectations of tourists [23]. Another challenge is excessive economic dependence on tourism, which can make local communities vulnerable, especially in crisis situations, such as the COVID-19 pandemic.

Despite these challenges, sustainable tourism brings many benefits, such as stimulating the local economy, protecting biodiversity and increasing the quality of life for host communities [6, 22, 27.]. By taking steps like using renewable energy, cutting waste, and encouraging environmentally friendly transportation, sustainable strategies can help lessen their negative effects on the environment [16]. The creation of steady jobs, local entrepreneurship, artisanal industries, and traditional cuisine are all facilitated by sustainable tourism [23, 30]. Community tourism is a tangible illustration of the advantages of sustainable tourism, since it provides locals with the chance to actively engage in the tourism industry by providing lodging, guides, and traditional goods [25]. The preservation of cultural identity and equitable distribution of tourism revenue are two benefits of this kind of travel [22].

On the other hand, the sustainable management of a tourist destination requires the implementation of clear policies that prevent environmental degradation and optimize the tourist experience without negatively affecting the local community. Destination Management Organizations play an essential role in this direction, being responsible for planning, regulating and promoting tourism in a responsible manner [30].

Among the most effective strategies adopted are: Establishing tourist load capacity, which mimics the number of visitors to prevent overcrowding and negative environmental impact [8]; Development of sustainable infrastructure that includes ecological transport, intelligent waste management and efficiency of energy resources [14, 20], Educating and raising awareness among tourists through information campaigns, being encouraged to adopt responsible behavior towards the environment and communities [20]; Intersectoral collaboration that involves the involvement of local authorities, NGOs and the private sector in defining coherent policies.

In order to better understand the evolution of research in this field, we considered that bibliometric analysis, which represents an important tool, which allows the identification of predominant themes in scientific literature, influential authors and international collaborations, offering a clear vision of trends and gaps in the field [23], represents a valuable methodological tool.

MATERIALS AND METHODS

Thus, in this study, a bibliometric approach was used to analyze the scientific literature related to the sustainable development of tourism, using the Scopus database as the main source of information and the VOSviewer software for data processing and visualization. The methodology was designed to highlight major trends in sustainable tourism research, identify networks of scientific collaboration, and examine the conceptual evolution of the field.

The scientific articles included in the analysis were extracted from the Scopus database, one of the most extensive and prestigious platforms for indexing scientific literature, frequently used in bibliometric analyzes to identify academic trends and the impact of research on a specific field [28]. Scopus provides an extensive coverage of academic publications, including articles from renowned journals, international conferences and relevant books, making it an ideal source for analyzing scientific trends in sustainable tourism [5].

The consultation was carried out on February 16, 2025. The search was carried out using three main terms: "Sustainable tourism development", "Tourism management" and "Sustainable destination management", which reflect the most relevant aspects of sustainable tourism. Articles published in the period 1991-2025 were selected, in order to gain a perspective on the evolution of research in this field. Only articles published in recognized scientific journals were included, excluding conference papers, book chapters and articles that had not undergone the peer-review process. Also, only articles published in English were analyzed to ensure data comparability and international accessibility.

Following the application of these filters, a total number of 2,028 articles were selected for bibliometric analysis. After the first term used "Sustainable tourism development" a number of 21,177 articles resulted, and after applying the second term "Tourism management" the number of articles was 7,683. For data processing and visualization, VOSviewer was used, a specialized software for the analysis of bibliometric networks that allows mapping the relationships between publications, authors and key concepts, facilitating the identification of thematic clusters, co-citations and international collaboration networks.

The bibliometric methodology was based on two main approaches:

Analysis of co-authorship networks that allowed the identification of collaborations between researchers and institutions, highlighting academic centers of excellence in the field of sustainable tourism [21]; Keyword co-occurrence analysis that was used to identify the most important research themes and see how they evolved over time [2].

Through this technique, the main research directions in sustainable tourism were highlighted, such as destination management, the economic and social impact of sustainable tourism, and strategies to reduce negative environmental effects [19].

RESULTS AND DISCUSSIONS

Starting from the 2,028 articles published in the period 1991-2025, it can be seen that the subject of sustainable management of the tourist destination was addressed for the first time in 1991, subsequently gaining more and more importance. Thus, the number of articles reached almost 200 in 2021 and 2022 and 350 in 2024, which proves the importance of this subject for the scientific environment (Figure 1).

Regarding the number of published scientific articles/countries, we found that China is in first place, with 243 publications, followed by Spain with 191 scientific articles, the United Kingdom with 149 scientific articles and the United States with 140 scientific articles. Romania, with a number of 55 articles, ranks 13th among countries concerned with this subject (Figure 2). We found that countries with a developed tourism sector or with significant challenges in managing sustainability are the most active in research in the field, but there is an uneven distribution of scientific production, with a dominant influence of countries with strong academic infrastructures.

Although Romania's contribution to research in the field can be considered significant, we consider that there is a need to intensify international collaborations and funding for research projects focused on the sustainable management of tourist destinations, given that tourism has a strategic importance in the national economy, but also the existence of challenges related to the sustainability and international competitiveness of Romanian destinations. Additionally, Romania has a lot of potential for tourism, and in order to prevent the negative effects of mass tourism—like crowding, damage to natural resources and cultural heritage, increased strain on local infrastructure, and an adverse effect on host communities—sustainable management of tourist destinations is crucial. Scientific research is crucial in this regard for creating policies that strike a balance between the requirement for long-term resource protection and economic growth.

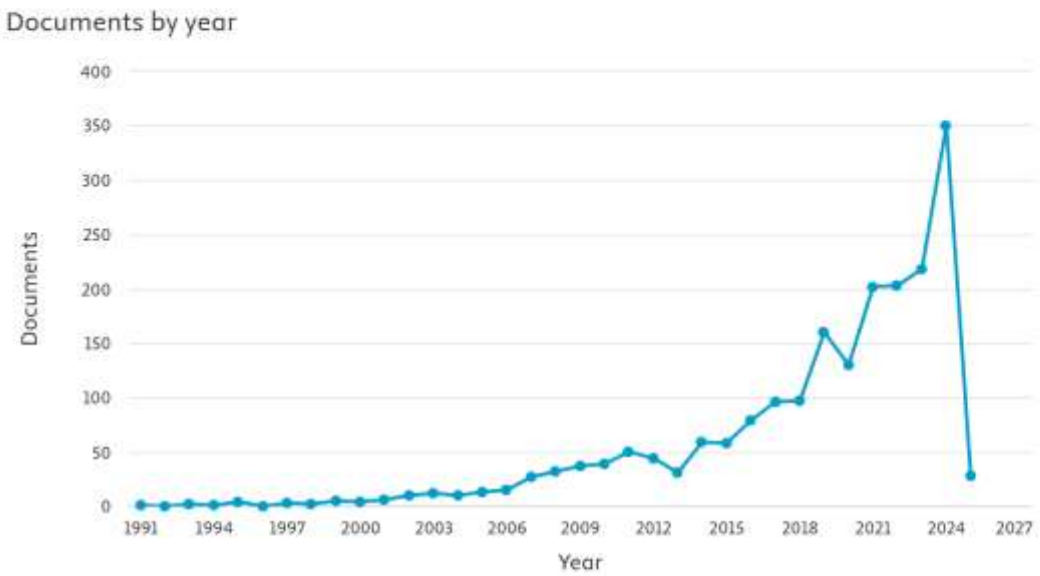

Fig. 1. The development of scholarly works about the sustainable administration of the tourism destination between 1991 and 2025
Source: own processing [24].

On the other hand, compliance with international standards for eco-friendly travel, especially the EU's goals for the travel industry's ecological expansion. The ability to conduct research and provide efficient destination management models are key requirements for obtaining European funding for the development of green infrastructure, digitization of destinations, and ecotourism projects.

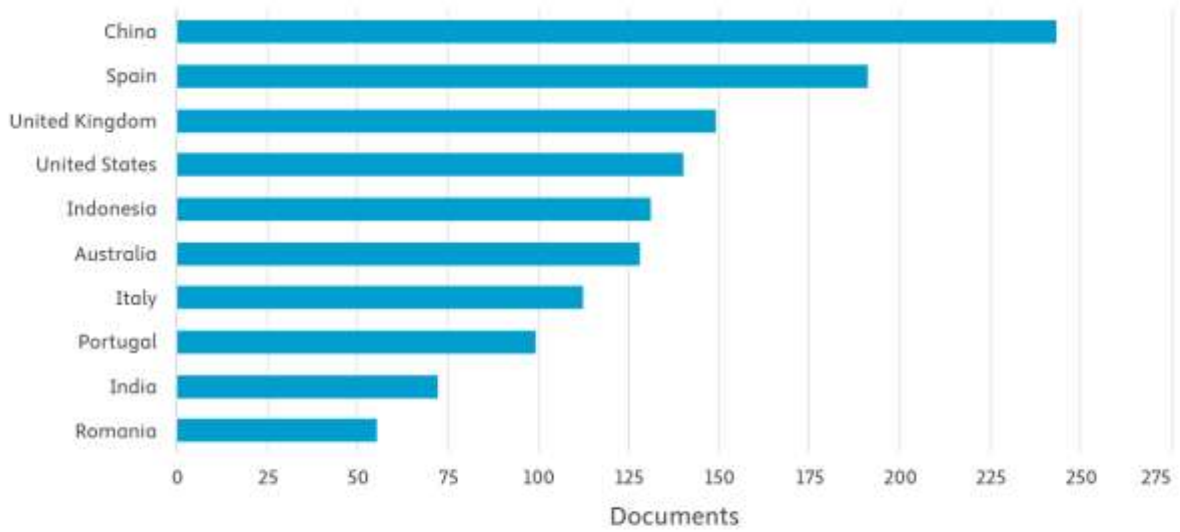

Fig. 2. Dissemination of scholarly works on the international level of sustainable tourism destination management
Source: own processing [24].

The results of the examination of the conceptual maps produced by VOSviewer indicate that there are three main areas of study in the field of sustainable tourism: responsible tourism implementation strategies, the effects of sustainable tourism on the economy and society, and sustainable destination management. Eight idea maps were developed for the study, each of which concentrated on a distinct aspect of sustainable tourism, such as co-authorship networks, keyword co-occurrence analysis, and the historical evolution of the sector.

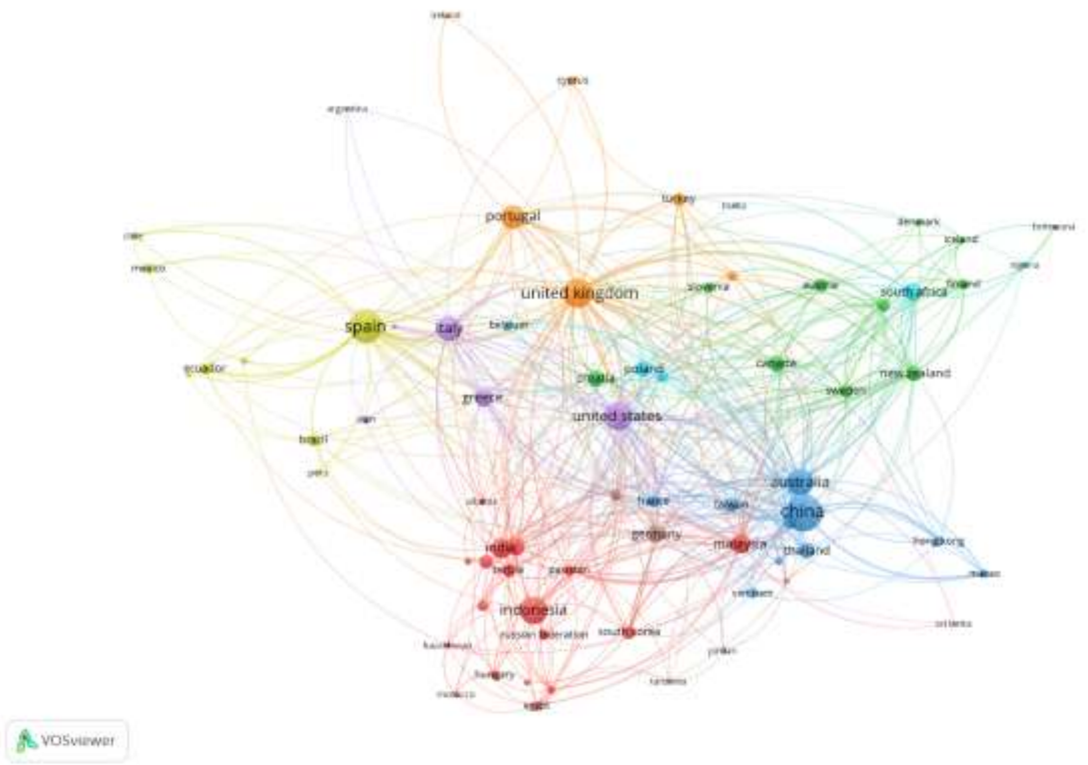

Fig. 3. International collaboration networks in sustainable tourism research
Source: own processing [29].

Based on the data analysis presented in Figure 3, the main hubs of the network are the United States, China, and the United Kingdom, with the strongest connections to other countries. This implies that they are at the forefront of sustainable tourism research and collaborate closely with international partners. The UK has a central position, with close links to Spain, Portugal and Italy, reflecting strong cooperation between the European institutions. A balanced distribution of research between North America and other developed regions is evident. China and Australia form a distinct cluster, having significant interactions with Southeast Asian countries such as Malaysia, Thailand and Indonesia, which reflects the interest of these states in sustainable tourism, which is due to the economic and environmental importance of this sector. At the bottom of the network, a cluster consisting of India, Indonesia and the countries of South Asia and North Africa is noted, highlighting the collaboration of these countries that have limited access to the global scientific networks dominated by Europe and North America. Similarly, Northern European countries such as Sweden, Finland and Denmark are closely linked and collaborate on specific sustainability issues, given the region's high interest in advanced environmental policies. Another important aspect is the presence of Latin American countries such as Brazil, Mexico and Ecuador, which connect mostly with Spain and Portugal, which reflects the linguistic and historical links between these regions. However, Latin America and Africa are relatively under-represented in global collaborative networks as a result of their limited access to funding and academic resources.

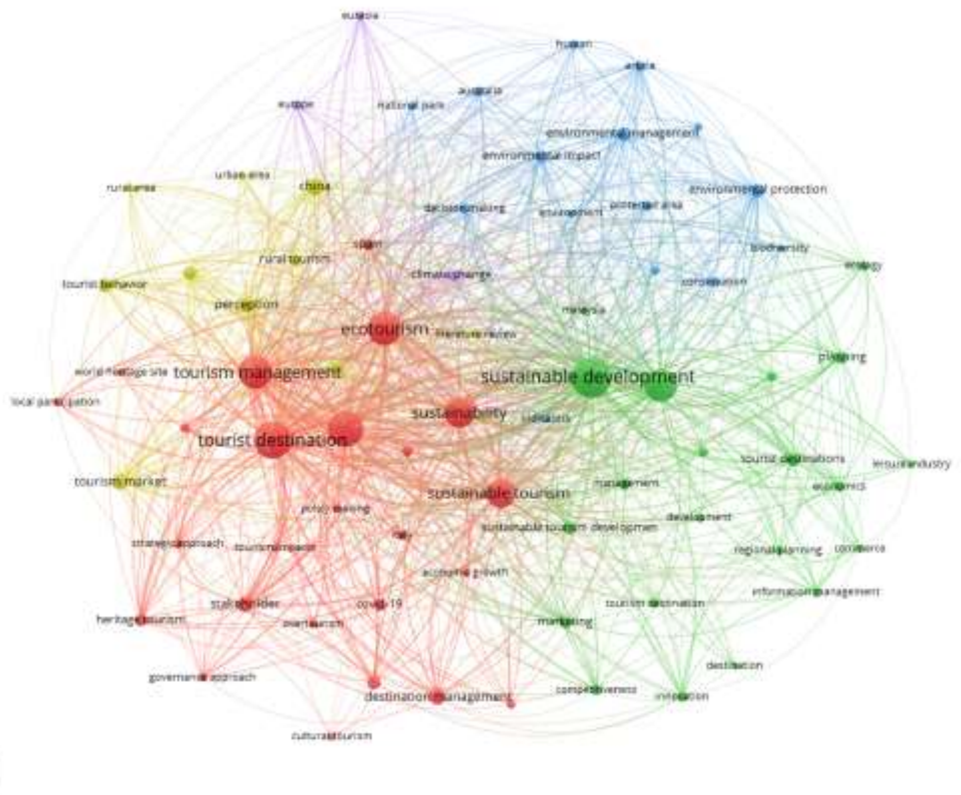

Fig. 4. Conceptual networks in sustainable tourism management research
Source: own processing [29].

Figure 4 highlights four major research directions. The first is sustainable development and tourism economics, where terms such as "sustainable development", "sustainable tourism", "destination management", "economics" and "marketing" emphasize the importance of economic and competitiveness strategies in the sustainable management of tourist destinations. This research direction reflects the concern for optimizing the economic impact of tourism on the host regions and the implementation of innovative solutions for resource management. The second major direction is tourism destination management and tourist behaviour, where terms such as 'tourism management', 'tourist destination', 'stakeholder', 'over-tourism' and 'policy making' indicate the challenges of destination management and regulation of mass tourism. This cluster shows that research addresses both the social and economic impact of tourism and the strategies needed for effective public policy planning. The links with the terms "heritage tourism" and "cultural tourism" demonstrate an important concern for the protection of heritage sites and the integration of cultural tourism in sustainable planning. A third research direction identified is ecological impact and environmental management, where terms such as "environmental protection", "climate change", "biodiversity", "conservation" and "environmental management" highlight the growing concern for the relationship between tourism and environmental protection. This cluster highlights how crucial it is to analyze how tourism affects biodiversity and protected areas and incorporate ecological regulations into tourist initiatives. The close links between the terms "decision making", "environmental impact" and "policy making" show that more research is being done on the creation of regulations to lessen the adverse environmental consequences of tourism. The last direction highlighted by the conceptual map is ecotourism and rural tourism, where terms such as "ecotourism", "rural tourism", "local participation" and "tourist behavior" indicate a significant interest in the integration of local communities in the development of tourism and the promotion of ecotourism as an environmental conservation strategy. The connection with the terms "perception" and "tourist behavior" shows that researchers analyze how tourists perceive sustainability and how this aspect influences their travel behavior and choices.

Therefore, sustainable tourism management is a multidisciplinary field, combining tourism economics, destination management, environmental protection and the involvement of local communities. The four major clusters reflect the main research directions, and the interconnection of terms shows that sustainable tourism development cannot be approached separately from economic and ecological aspects.

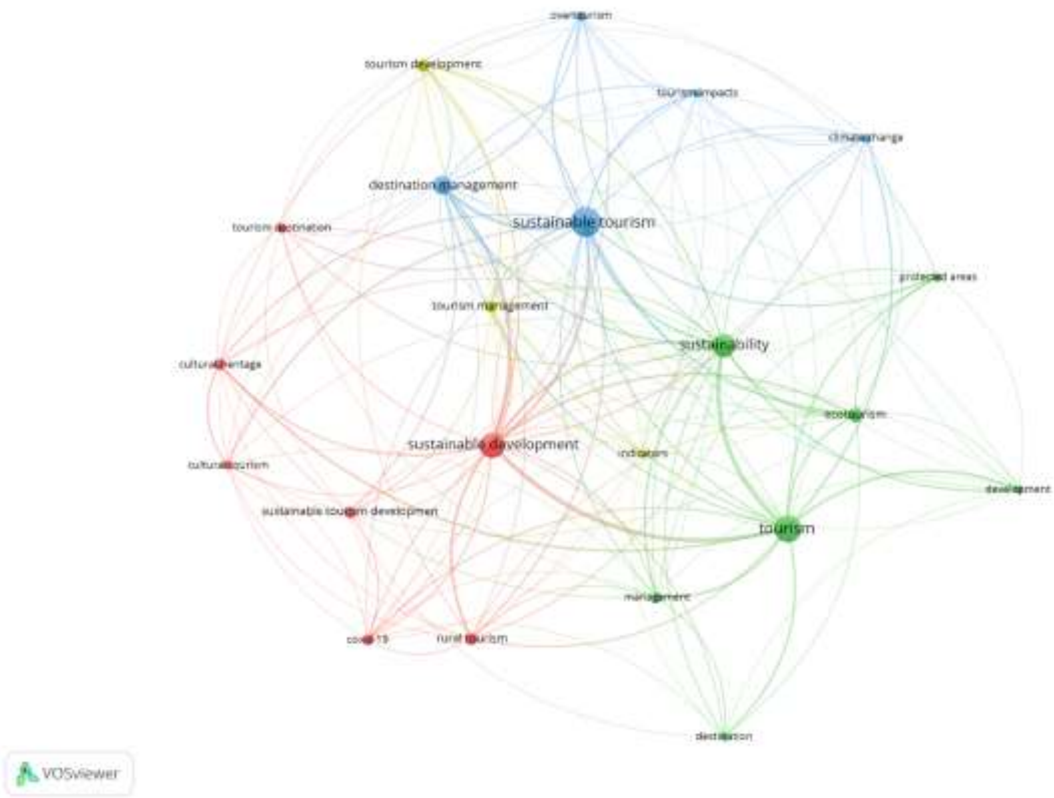

Fig. 5. Conceptual network of term co-occurrence in sustainable tourism research
Source: own processing [29].

Based on the information in figure 5, three major clusters can be distinguished that structure the field of sustainable tourism. The green cluster is centered around the concept of "sustainability", being associated with terms such as "tourism", "ecotourism", "protected areas" and "development". This group highlights the researchers' concern for the sustainable management of tourist destinations, with a particular focus on environmental conservation, protecting natural areas and integrating ecotourism practices. The strong connections between the terms "indicators" and "management" demonstrate a high interest in the development of sustainability measurement systems in tourism, which indicates a trend towards the development of evidence-based strategies to optimize tourism impact. The red cluster revolves around the term "sustainable development", highlighting the relationships between sustainable development, cultural tourism, rural tourism and the impact of COVID-19 on the tourism sector. This group of concepts reflects a concern for the impact of tourism on local communities, the economics of rural tourism and global crisis management. The term "cultural tourism" is strongly connected with "cultural heritage", it shows that sustainable tourism is often approached through the lens of preserving cultural heritage, which underlines the need for effective policies to protect and promote local identities. The blue cluster focuses on the sustainable management of tourist destinations, with the central terms "sustainable tourism", "destination management", "tourism impacts" and "overtourism". This grouping suggests that the field's study focuses on ways to manage tourist flows, lessen the negative effects of excessive tourism, and develop rules to maintain the balance between economic growth and environmental preservation. The link between "tourism impacts" and "climate change" suggests that concerns about how climate change is influencing travel are becoming more prevalent, a topic that has recently attracted attention from academics.

As a result, we discover a multifaceted framework for sustainable tourism research, wherein destination management, environmental preservation, and economic development are all interrelated. According to the connections between the terms, current research trends are focused on integrating sustainable strategies into tourist development, optimizing destination management, and assessing the impact of tourism on the environment and local populations.

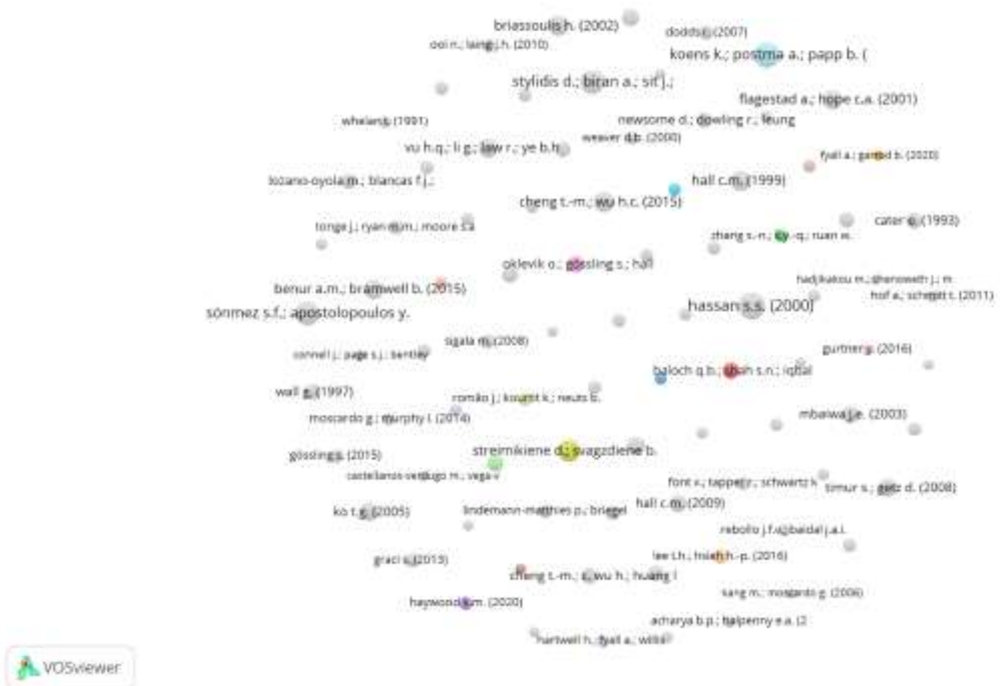

Fig. 6. Citation network in sustainable tourism research
Source: own processing [29].

A selection criterion of 100 citations per article is used, and Figure 6 shows the correlation between the quantity of citations obtained and scientific papers. Based on the sub-themes of sustainable tourism, a number of groups of significant studies are discernible. The works that have had the biggest influence on this field of study, including Hall C.M. (1999, 2009) [9, 10], Gössling S. (2015), [11, 12], are the most cited. These authors have addressed issues like the environmental impact of tourism, sustainable destination management, and sustainability legislation, all of which have significantly advanced the idea of sustainable tourism. Publications that study the relationship between tourism, the economy, and local development, such as Bramwell B.

(2015) [1], Sönmez S.F., and Apostolopoulos Y. [26], represent another important category: studies on how tourism affects local communities and the economics of sustainable tourism. These studies are essential for developing balanced models of economic growth in the tourism sector and for comprehending how sustainable policies can help host communities. Important studies in the fields of ecotourism and environmental protection are highlighted at the top of the graph. For example, Weaver D.B. (2001), Lindemann-Matthies P., Briegel B., and Castellanos-Verdugo M. [17, 31] are examining the connections between tourism, biodiversity, and natural resource preservation. These studies highlight the significance of ecotourism as an environmental effect and sustainable development approach. A small number of reference works dominate the field of sustainable tourism, according to the citation network analysis, which had a big impact on the future course of the study. The connections between the articles prove that the major topics of sustainable tourism are interconnected, including sustainability policies, environmental impact, economic development and destination management.

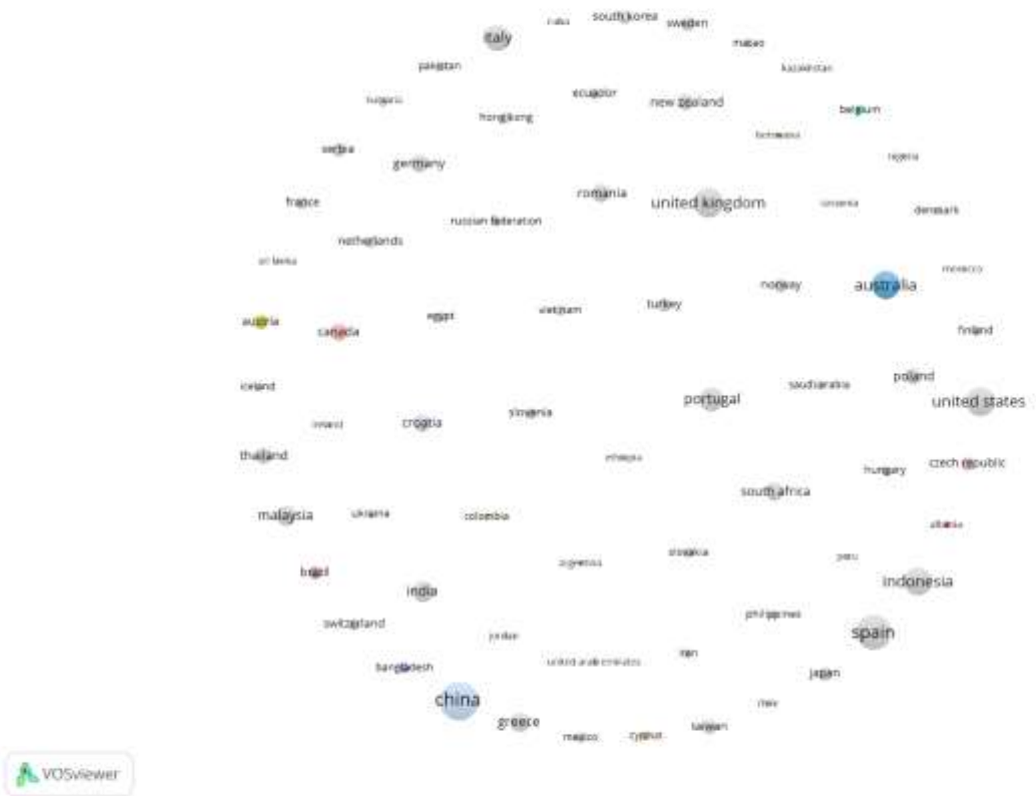

Fig. 7. Cross-country citation network in sustainable tourism research
Source: own processing [29].

Figure 7 shows the distribution of citations among countries contributing to sustainable tourism research, providing insight into each nation's academic influence.

It is observed that China, the United Kingdom, the United States, Spain and Australia are the dominant centers in the citation network, indicating that these countries have a significant impact on the scientific literature in the field of sustainable tourism. China is the largest node in the diagram, which demonstrates that papers published by Chinese researchers have been extensively cited internationally, reflecting the country's growing influence in sustainable development studies. The United Kingdom and the United States are also well represented, confirming their role as leaders in scientific production and generating theoretical frameworks relevant to sustainable tourism. Spain and Australia appear as important points of reference, due to their high interest in managing tourist destinations and implementing sustainability strategies in their tourist regions. However, while being part of the network, Central and Eastern European nations like Romania, Poland, and the Czech Republic have smaller nodes, which suggests that their academic influence is lesser based on the quantity of citations. However, the presence of these states demonstrates a growing contribution to the specialized literature. Southeast Asian countries such as Indonesia and Malaysia are found in the network, indicating a development of research in this area. The data reveals the disparity in the distribution of scholarly influence on sustainable tourism, with citations predominating in nations with a strong academic infrastructure and research traditions. At the same time, emerging countries are joining international academic networks more frequently, which suggests that research on sustainable tourism is becoming more globally integrated.

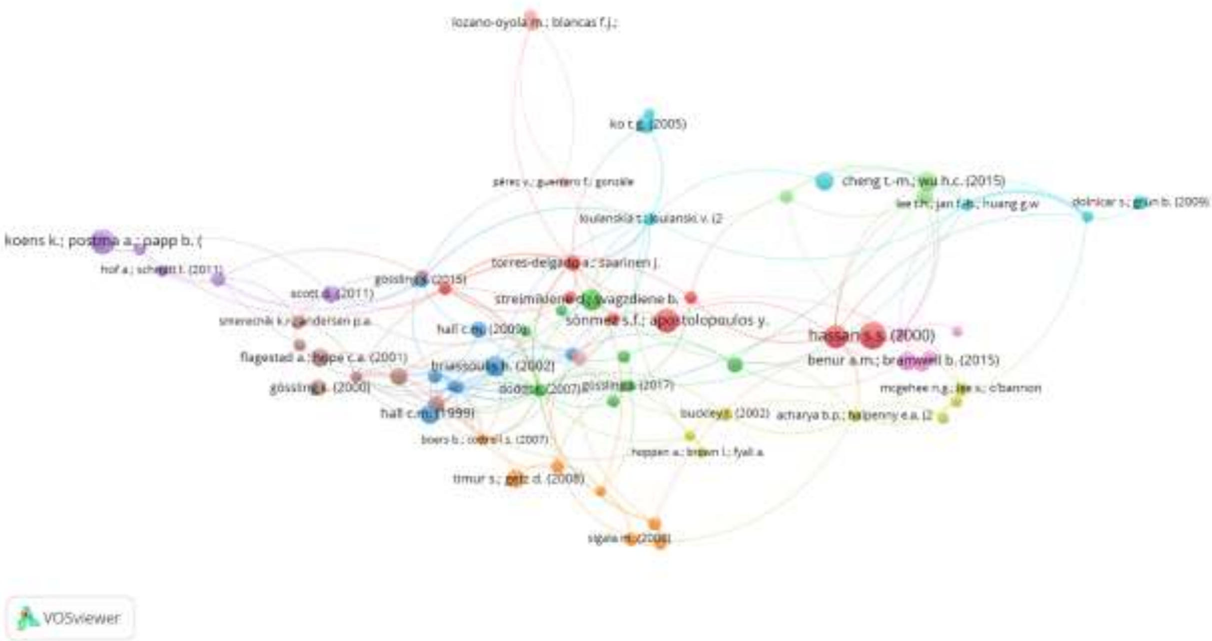

Fig. 8. Network of papers with bibliographic links in research on sustainable tourism
Source: own processing [29].

Figure 8 shows the bibliographic coupling network, which reflects the relationships between scientific articles that share common bibliographic sources, providing insight into the conceptual coherence of the field and the knowledge structures that have influenced the development of sustainable tourism research.

Several major groups of works can be distinguished. A central cluster, consisting of works signed by authors such as Hall C.M. (1999, 2009), Gössling S. (2000, 2015) and Hassan S.S. (2000) [9, 10, 11, 12], show that these studies represent the theoretical foundation of sustainable tourism. These papers address essential topics such as the impact of tourism on the environment, sustainability policies and the development of destination management.

Another important cluster consists of the works of Sönmez S.F. and Apostolopoulos Y. [26], which focuses on the interaction between tourism, the economy and local communities. This group indicates that researchers have actively explored how sustainability strategies can influence the economic development and social protection of tourism regions.

The research group represented by the studies of Ko T.G. (2005) [15], Cheng T.M. and Wu H.C. (2015) [3] have a strong connection with the analysis of tourists' behavior and the perception of sustainability. These papers highlight how tourists' perceptions influence the adoption of sustainable practices in tourism, highlighting the need for visitor education to reduce negative impacts on destinations. The cluster formed around the authors Dolnicar S., Grün B. (2009)[4] demonstrates the concern for the segmentation of the tourist market and the development of sustainable marketing strategies. This body of work explores how sustainable tourism can be adapted to different consumer profiles and what measures can be implemented to promote responsible tourism.

We thus find that sustainable tourism research is structured along several major directions, including sustainability policies, economic impact, tourist behavior and destination management strategies. The bibliographic coupling network shows that these fields are not isolated but deeply interconnected, emphasizing the need for a multidisciplinary approach to effectively understand and implement the principles of sustainability in tourism.

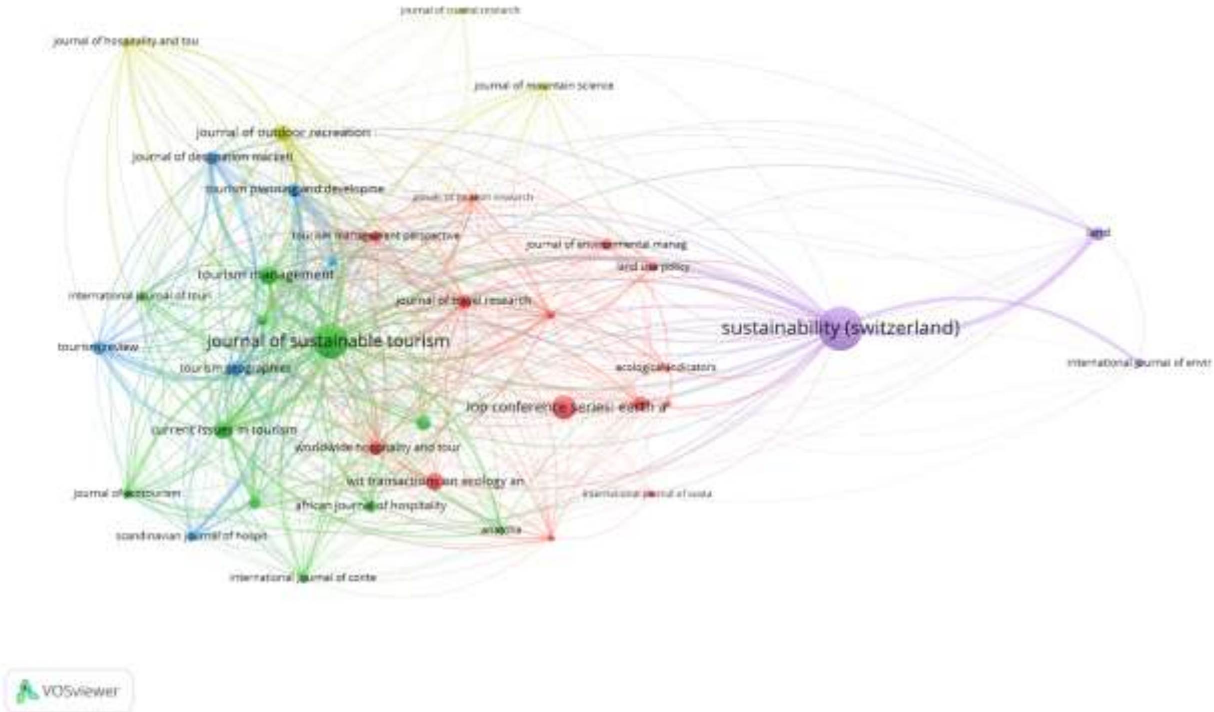

Fig. 9. A network of sources with bibliographic links for research on sustainable tourism
Source: own processing [29].

A key resource for sustainable tourism research, the "Journal of Sustainable Tourism" is the network's most important and core node. Figure 9 uses bibliographic coupling to illustrate the relationship between the scientific sources used in studies on sustainable tourism. Its close ties to other tourism journals, including "Tourism Management," "Tourism Geographies," "Journal of Travel Research," and "Annals of Tourism Research," demonstrate that sustainable tourism is a prominent subject in the literature and is approached from a number of perspectives, including destination management, the effects of tourism on the environment, and sustainable planning of the tourism industry. Another major cluster is that represented by 'Sustainability (Switzerland)', which is an important reference point with strong connections to environmental and sustainability policy journals such as “Land”, “Journal of Environmental Management” and “Ecological Indicators”, highlighting a close link between sustainable tourism research and the general sustainability literature, indicating that tourism studies are based on environmental science theories and methodologies. The cluster of journals such as "IOP Conference Series: Earth and Environmental Science" and "WIT Transactions on Ecology and the Environment", which focus on ecology, environmental policies and the impact of economic development on natural resources, demonstrate that sustainable tourism researchers are collaborating and borrowing concepts from the environmental sciences to study the impact of tourism on ecosystems.

Journal clustering shows that, although sustainable tourism is a well-defined field, it is strongly influenced by general trends in sustainability and environmental protection.

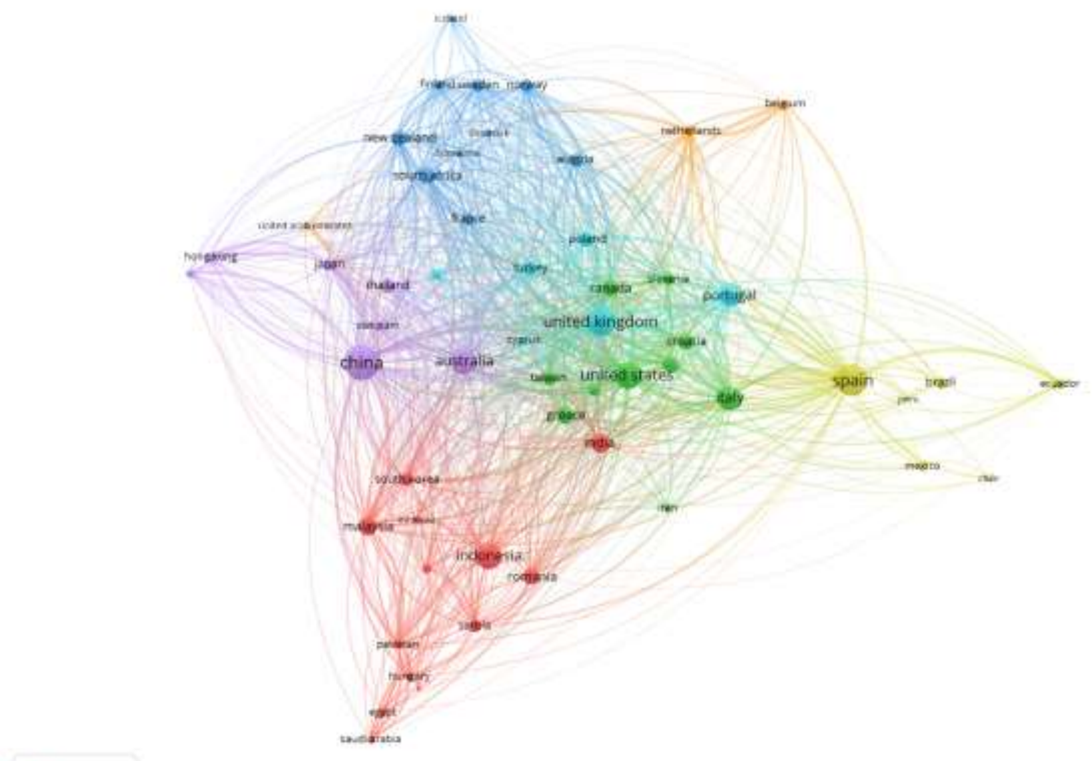

Fig. 10. Cross-country bibliographic linkage network in sustainable tourism research
Source: own processing [29].

Figure 10 demonstrates the bibliographic coupling relationship between countries that contribute to sustainable tourism research, based on a minimum threshold of 100 citations per country.

The network highlights several geographic and thematic clusters, which suggest dominant research centers and international academic partnerships. The three primary academic hubs—the United States, the United Kingdom, and China—are at the core of the network and have the most links, suggesting that they have a big impact on the body of research on sustainable tourism worldwide. The blue cluster comprises Northern and Central European countries such as the United Kingdom, Germany, France, Sweden, Norway and Finland, which collaborate strongly with each other, reflecting a common interest in sustainability policies and strategic tourism planning. The green cluster, dominated by the United States, Italy, Portugal and Canada, highlights the interplay between research focused on tourism management and the economic impact of sustainability. The red cluster is dominated by China, Indonesia, Malaysia and India, reflecting a large volume of research on the environmental impact of tourism in Asian regions and strategies for ecotourism. The yellow cluster, led by Spain, Brazil, Mexico and Ecuador, identifies a strong link between Latin American and Southern European research focused on the sustainable development of tourism in cultural and natural destinations. Another interesting aspect is the position of some emerging countries, such as Romania, Serbia and Pakistan, which, although they have a lower number of publications and citations, are connected to larger research centers, suggesting a progressive integration into international collaborative networks.

Relations between countries show that sustainable tourism is a multidisciplinary and global field, where academic collaboration plays an essential role in developing effective strategies for environmental protection and responsible tourism management.

CONCLUSIONS

This study provides a clear and structured perspective on the evolution of research in sustainable tourism, identifying the most influential papers, journals and international collaborations. By using the bibliometric analysis, the research highlighted the main scientific trends, identified the research gaps in order to propose future directions for the development of the field.

Thus, one of the gaps identified in the literature is the integration of new technologies in sustainable tourism, finding the existence of a small number of studies that analyze the use of artificial intelligence, big data and blockchain in the management of tourist destinations and the reduction of ecological impact. There is also a dearth of research on the long-term economic repercussions of sustainable tourism; most studies concentrate on the short-term advantages rather than closely examining how it affects the socioeconomic structure and quality of life of the host communities. Regional variations in the adoption of sustainable tourism are also poorly understood because the majority of study focuses on developed countries, ignoring the opportunities and problems in developing regions like Eastern Europe, Africa, or Latin America. Furthermore, a deeper understanding of how visitor behavior contributes to the shift to responsible tourism is desperately needed, especially with regard to the psychological and motivational elements that influence travelers' decisions to adopt sustainable travel practice.

We think there is still room for improvement in the evaluation of sustainable tourism policies' effectiveness through the use of standardized indicators and clear evaluations of their impacts on the environment, locals, and the economy. The lack of research on the effects of climate change on tourism and the capacity of sensitive places to adapt to extreme weather events makes it difficult to develop effective resolution strategies.

Even while sustainable tourism is frequently marketed as a means of fostering economic growth, little is known about how it relates to social justice and economic equity. More thorough research is necessary to fully understand the fundamental socioeconomic injustices caused by tourism, income distribution, and vulnerable groups' access to tourism resources. We believe that covering these gaps could considerably improve the efficiency of sustainable tourism strategies, allowing the development of innovative and equitable models. Future research should integrate interdisciplinary approaches and promote international collaborations to gain a broader perspective on tourism sustainability globally.

From a practical perspective, we consider that this study can provide information to public authorities, decision makers in the tourism industry and researchers interested in the implementation of effective sustainability policies. For political decision-makers, the obtained results can contribute to guiding tourism development strategies by highlighting the most effective models of destination management, adopted in countries with advanced research in this field. For tourism operators, the study provides information on international trends, highlighting key aspects that should be integrated into the development and promotion of tourist destinations. For the academic community, the study is essential because it identifies the most cited papers and journals, facilitating access to the most relevant sources of information and encouraging international collaborations. The study also highlighted disparities in research between different regions, which could motivate research investments and international collaborations to integrate emerging countries into the global debate on tourism sustainability.

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STUDY ON THE IMPACT OF RURAL EDUCATIONAL INFRASTRUCTURE ON TEACHERS' SATISFACTION IN THE PRACTICAL TRAINING OF THE STUDENTS IN VOCATIONAL AND TECHNICAL EDUCATION IN ARGES AND VALCEA COUNTIES OF ROMANIA

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Abstract

The quality of educational infrastructure and material resources influences teachers' perceptions of the effectiveness of practical training for students in vocational and technical education, especially in rural areas, where resources are often limited. The study analyzes the relationship between teachers' perceptions of the curriculum, educational infrastructure and continuing training and examines the extent to which these variables are associated with the adequacy of students' training to the demand of the labor market. The research used a quantitative methodology, applying a structured questionnaire to a sample of 272 teachers from two counties in Romania - Argeș and Vâlcea. Data analysis was performed using Pearson correlation and t-test for independent samples, investigating three objectives: assessing the relationship between the curriculum and the perception of graduates' employability, analyzing the impact of infrastructure on teachers' satisfaction and examining the effect of continuing training on the perception of the quality of education. The results indicate a weak correlation between perceptions of the curriculum and estimates of graduate employability, suggesting that teachers' perceptions are not a clear predictor of students' professional integration. In contrast, the analysis highlights a strong association between the quality of infrastructure and teachers' satisfaction with students' practical training, suggesting that the endowment of educational institution splays a major role in the evaluation of the training process, with significant implications in rural areas. The independent samples t-test does not indicate a significant difference between teachers who participated in in-service training and those who did not, raising questions about the real impact of these programs on perceptions of the quality of education.

Key words: *vocational and technical education, educational infrastructure, teacher satisfaction, continuing education, graduate employability*

INTRODUCTION

The low number of qualified school leavers in various fields does not reflect the real needs of the economy, and the qualitative aspect regards the low degree of satisfaction from the part of employers concerning the competences of the graduates of the professional education.
This is a reason that technical and vocational education to be a priority for any Government strategy for assuring the labour market with a high skilled young generation of qualified specialists [11]
Education is among the EU priorities because it provides knowledge and practical competences and skills as required by labor market according toot the principles of equity and inclusion. However, the structure of the educational system varies from an European country to another taking into account its specific needs [3].
In Romania, Law no.1/2011 [4] and completed with OM No.5733/2022 [7] establishes the legal framework for the development of technological and professional education.
According to these legal documents in Romania, the high school technological and vocational education assures qualifications and skills according the labor market according to the National Register of Qualifications. At the regional, county and local level, there are set up strategies for planning the offer of the future students in the high schools profiled in this field of education [4, 8].

Besides the Governemnt strategy in teh filed of education, locally the School Insperctorates of the counties assures the offer for admittance and enrollment in the technical and vocational education. An example is given by the two inspectorates of Valcea and Arges counties of Romnaia where this research is running [9, 10].

In the Republic of Moldova, important studies on technical and vocation education were made by [5, 6].

Among the main important aspects regarding vocational and technical education (VET), we could mention the way in which teachers percept the curriculum and how educational infrastructure influences the quality of the educational process and the preparation of students for the labor market.

Specialized studies emphasize that a well-structured curriculum adapted to the current demands of the labor market facilitates the transition of graduates to jobs appropriate to their qualifications [8].

In rural technical and vocational education institutions, educational infrastructure is not only a logistical support, but also a determining factor in the efficiency of the practical training process. Schools in rural areas frequently face problems related to the condition of workshops and laboratories, the lack of adequate equipment and limited access to modern technology. These deficiencies can significantly influence teachers' motivation and their ability to provide students with relevant practical training. Studies show that, in the absence of adequate equipment, teachers in rural areas are forced to resort to alternative training methods, which can reduce the quality of practical training and affect the transition of graduates to the labor market.

The quality of educational infrastructure plays a decisive role in the efficiency of practical training of students in TVET. Properly equipped training spaces and modern equipment not only enhance the learning experience, but also contribute to the development of practical skills needed in various technical fields [6].

Continuous teacher training is a key variable for updating knowledge and adapting to new educational and technological trends. Participation in professional development programs allows teachers to improve their pedagogical skills and implement innovative teaching methods, having a positive impact on student performance, as demonstrated in recent research [2].

The active involvement of teachers in the design and updating of the curriculum ensures a better correlation between the educational content and the real needs of the labor market. This collaboration leads to the development of study programs that meet the requirements of employers and facilitate the professional insertion of graduates [1].

Investigating teachers' perceptions of curriculum, infrastructure and continuing training offers valuable insights for improving the quality of TVET education and adapting it to labor market dynamics.

In this context, this paper studied teachers' perceptions of the curriculum, educational infrastructure and continuing training in order to assess in what measure these variables are associated with a coorresponding students' destined to meet the demand of the labor market. The study case was made In Arges and Valcea counties, Romania

MATERIALS AND METHODS

Through this research, we aim to investigate the perceptions of teachers in vocational and technical education (VET) in Argeș [10] and Vâlcea [9] counties, Romania, focusing on the relationship between curriculum, infrastructure, continuous training and adequacy to labor market requirements. To achieve the proposed objectives, a quantitative methodology was adopted, using structured questionnaires as the main data collection instrument.

The group included 272 teachers of which: from Argeș (n=192, 70.6%) and Vâlcea (n=80, 29.4%) counties. Most of the participants came from educational institutions such as Costești Technological High School (n=30, 11%), Bistrița Special Vocational School (n=25, 9.2%), Mărăcineni Technological High School No. 1 (n=23, 8.5%), Maria Teiuleanu Economic College and Călimănești Technological High School of Tourism (each with n=21, 7.7%). Regarding the teaching degree, 214 teachers (78.7%) hold the teaching degree I, 23 (8.5%) the degree II, 22 (8.1%) the permanent one, 8 (2.9%) are beginners, and 3 (1.1%) are substitutes.

Research objectives:

1. Assessing the correlation between teachers' perception of the TVET curriculum and the degree of adequacy to labor market requirements.
2. Analysis of the relationship between the quality of infrastructure and material resources and teachers' satisfaction with students' practical training.
3. Determining the impact of continuous training of teachers on their perception of the efficiency of the educational act in TVET.

Assumptions :

1. H1: There is a significant positive correlation between teachers' perception of the adequacy of the TVET curriculum and the assessment of graduates' chances of finding a job in the field studied. (Tested by Pearson correlation between variables related to the curriculum and perception of employment opportunities)
2. H2: Teachers who have participated in continuing education programs in the last two years will have a significantly more positive perception of the effectiveness of the educational act compared to those who have not participated. (Tested by t-test for the difference between the means between two groups: participants vs. non-participants in continuing education and their perception of the quality of education in TVET)

The questionnaire included both questions with answers on a Likert scale from 1 to 4 (from "not at all" to "to a great extent") and multiple-choice questions, allowing for a detailed analysis of teachers' perceptions and experiences.

Data collection was carried out between 01.07.2024-01.09.2024, by distributing questionnaires in physical and electronic format. For physical distribution, the questionnaires were sent to the selected educational units, and teachers were asked to complete them and return them in sealed envelopes, ensuring the confidentiality of the responses. The electronic version was distributed by e-mail, using secure online platforms. Participation was voluntary, and respondents were informed about the purpose of the research and ensuring the confidentiality of the data provided.

RESULTS AND DISCUSSIONS

The first objective aimed at evaluating the correlation between teachers' perception of the vocational and technical education curriculum and its degree of adequacy to the labor market requirements. To verify the relationship between teachers' perception of the vocational and technical education curriculum and its degree of adequacy to the labor market requirements, we used Pearson correlation analysis. This allows quantifying the relationship between two variables measured on an ordinal scale, converted into numerical variables in order to be analyzed statistically.

The data used in the analysis were obtained through two specific items of the questionnaire. The first item assessed teachers' perceptions of the extent to which the curriculum covered general technical knowledge, specific technical skills, general and socio-emotional skills. The second item concerned teachers' estimates of students' chances of obtaining a job in the field studied. Both variables were measured on a scale from 1 to 5, where higher scores indicated a more favorable perception.

Before applying the Pearson correlation test, we evaluated its statistical premises. We analyzed the data distribution to assess whether there is a linear relationship between the variables, as the Pearson correlation test is appropriate for variables that meet this condition. We also excluded the existence of extreme values that could have influenced the result.

Table 1 presents the correlation results.

The Pearson correlation coefficient calculated between the two variables is **$r = 0.16$**, which shows a weak positive association. The positive direction of the coefficient suggests that as teachers perceive the curriculum to have a higher degree of coverage of general technical knowledge, specific skills and socio-emotional competences, their estimates of graduates' employment opportunities tend to be more optimistic.

Table 1. Correlation between teachers' perception of the TVET curriculum and the degree of adequacy to labor market requirements

Item	To what extent does the TVET curriculum cover general technical knowledge, specific technical, general and socio-emotional skills?	What chances do you think your students will have, after graduating, of finding a job in their field of study?	P-value
To what extent does the TVET curriculum cover general technical knowledge, specific technical, general and socio-emotional skills ?	1.0	0.16	0.374
What chances do you think your students will have, after graduating, of finding a job in their field of study?	0.16	1.0	0.374

Source: Own results.

p -value = 0.374 provides additional information on the robustness of this relationship. A p-value greater than the conventional significance threshold of 0.05 indicates that this association could be influenced by random variation in the sample, which raises questions about the extent to which this relationship can be generalized to the entire population of vocational and technical education teachers.

On the one hand, teachers' perceptions of the curriculum are influenced by factors such as their teaching experience, access to pedagogical resources and familiarity with current employer requirements.

On the other hand, the assessment of graduates' employability is likely to reflect both the knowledge and skills acquired during their studies, as well as local socio-economic conditions, job availability and the degree of collaboration between educational institutions and the private sector.

A low correlation coefficient does not imply the absence of a relationship between the two variables, but rather suggests that the link between curriculum perception and employment opportunity estimates could be influenced by other factors not measured in this study. Aspects such as the structure of internship programs, the involvement of economic agents in vocational training, or the individual characteristics of graduates probably have an impact on the analyzed relationship, requiring further investigation.

Next, we asked teachers about the extent to which they believe that the vocational and technical education curriculum covers different types of competencies needed to prepare students. These competencies were structured into four distinct categories: general technical knowledge, specific technical and practical skills, general skills, and socio-emotional skills.

For each category, respondents were ableto rate the degree of curriculum coverage using an ordinal scale ranging from “a little” to “a lot.” The results are presented in Figure 1.

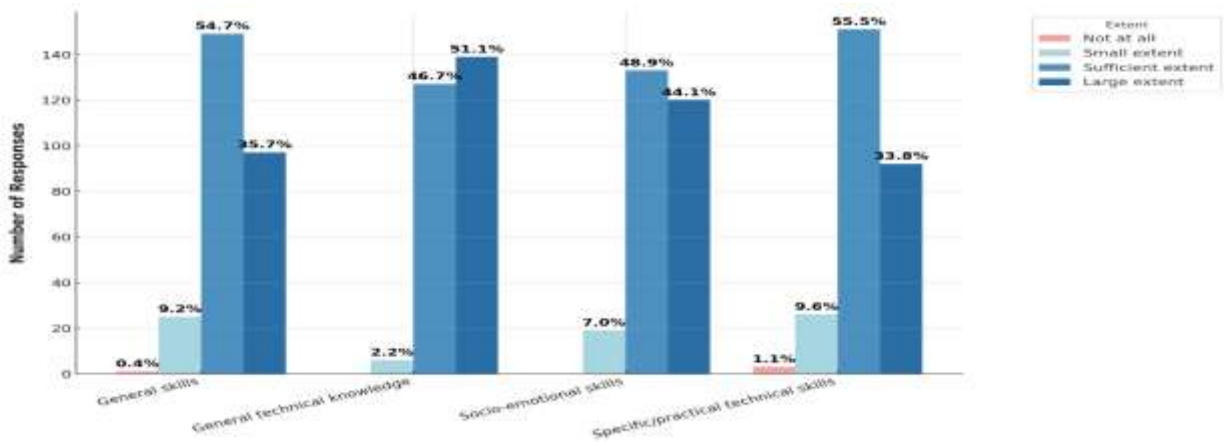

Fig. 1. Teachers' assessment of theextenttowhichthe curriculum coversdifferentaspects
Source: Own results.

Figure 1 illustrates the distribution of teachers' perceptions of the extent to which the vocational and technical education curriculum covers four types of competences: general, general technical, socio-emotional and specific technical or practical. The data indicate a variation in responses, suggesting that perceptions of the curriculum are not uniform and may be influenced by several educational and professional factors.

For general competences, the largest proportion of teachers consider that they are covered to a largeextent (35.7%) or sufficient (54.7%). Only a small percentage of respondents consider that these competences are covered to a small extent (9.2%), and an insignificant percentage considers that they are not included in the curriculum at all (0.4%). This type of competence, which includes skills such as writing a report or approaching a problem, is considered to be present in the curriculum, but the perception of the extent to which they are covered varies. A possible explanation may be related to the differences between the training areas and the way in which these skills are integrated into the subjects taught.

Regarding general technical knowledge, 51.1% of teachers consider it to be covered to a large extent and 46.7% to a sufficient extent. A small proportion of 2.2% state that it is covered to a small extent, which suggests that most teachers consider that the curriculum provides students with a solid theoretical basis in the technical field. The high degree of agreement can be explained by the structure of the educational programs, which emphasize theoretical knowledge as a foundation for practical training.

Socio-emotional skills are considered by 44.1% of teachers to be covered to a large extent, and by 48.9% to be covered to a sufficient extent. The percentage of those who consider that these skills are covered to a small extent is 7%, which indicates a generally positive perception of the integration of these skills into the curriculum. Teamwork, perseverance and conflict management are elements that can be developed both through explicit curriculum and through pedagogical methods that promote interaction and collaboration. However, different perceptions may be influenced by the distinct approaches that teachers have within the educational process.

For specific technical and practical skills, 33.8% of teachers consider them to be covered to a large extent, and 55.5% to a sufficient extent. In contrast, 9.6% of respondents believe that these skills are integrated to a small extent, and 1.1% state that they are not included at all. This distribution indicates a greater variation in perceptions compared to the other categories of skills, which may reflect differences between vocational training areas or unequal access to adequate resources and infrastructure for carrying out practical activities. Teaching practical skills requires the existence of up-to-date equipment and technologies, and discrepancies between educational institutions may influence teachers' perceptions of how these skills are taught.

The second objective aimed to analyze the relationship between the quality of infrastructure and material resources and teachers' satisfaction with students' practical training.

The results are presented in Table 2.

In the study, the variable related to the quality of infrastructure and material resources was defined based on item 12 of the questionnaire, which included three dimensions: the condition of the workshops, the equipment used in the educational process and the availability of materials necessary for carrying out practical activities.

Table 2. Correlation between the quality of infrastructure and material resources and teachers' satisfaction with students' practical training.

Item	Quality of infrastructure and material resources	Teachers' satisfaction with students' practical training	P-value
Quality of infrastructure and material resources	1.0	0.722	0.00015
Teachers' satisfaction with students' practical training	0.722	1.0	0.00015

Source: Own results.

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The responses were coded using an ordinal system, where "Very good" received a score of 3, "Good" a score of 2, and "Poor" a score of 1. This approach allowed the aggregation of an average score for each respondent, reflecting the general perception of the resources existing in the educational unit.

The variable corresponding to teachers' satisfaction with students' practical training was constructed based on item 13, which evaluated four aspects: coverage of general technical knowledge, development of specific technical skills, training of general skills necessary for professional activity, and stimulation of socio-emotional skills.

To test the relationship between the two variables, Pearson correlation was used, justified by treating the scores as continuous variables. The coefficient obtained was 0.18, indicating a weak positive association between the perception of infrastructure and material resources and satisfaction with practical training. The p-value for this coefficient was 0.352, suggesting a high probability that the observed relationship is the result of random fluctuations in the analyzed sample.

The Pearson correlation coefficient calculated between the quality of infrastructure and teachers' satisfaction is 0.722, which suggests a strong positive relationship between the two variables. As teachers evaluate the infrastructure and material resources more favorably, their satisfaction with students' practical activities also increases. This association can be explained by the fact that access to modern equipment and adequate materials facilitates more efficient practical training, reducing the difficulties that teachers may encounter in organizing teaching activities. The p value = 0.00015 indicates the probability that this relationship occurred by chance in the analyzed sample. In a statistical context, such a small p value suggests that the observed association between the two variablesis consistent and can be interpreted as a stable trend among the teachers included in the study. The third objective refers to determining the impact of continuous teacher training on their perception of the efficiency of the educational act in TVET. To begin with, we were interested in the share of teachers who benefited from continuing education programs in the last 2 years. The results are presented in Figure 2.

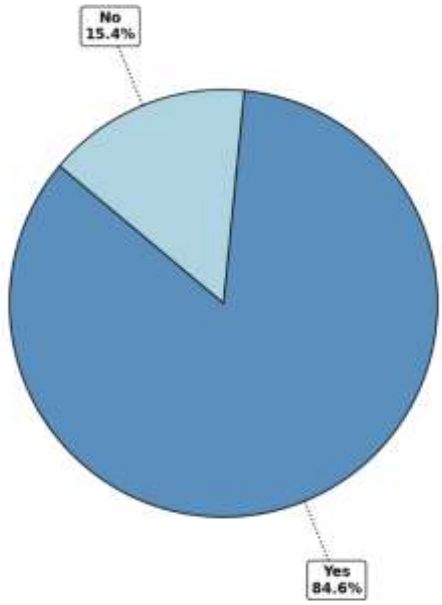

Fig. 2. Share of teachers who have benefited from continuous professional training programs in the last 2 years
Source: Own results.

The data in Figure 2 reflect the participation of teachers in in-service training activities organized by public or private providers in the last two years. The proportion of teachers who declared that they participated in such programs is 84.6% (n=230), while 15.4% (n=42) stated that they were not involved in any in-service training activities during this period.

This distribution suggests that continuing education is a common practice among teachers in vocational and technical education. A high participation rate can be explained by the requirements of the educational system, which requires periodic updating of professional skills. Also, engagement in advanced training programs is influenced by the opportunities available at local or national level, the accessibility of courses and the specific requirements imposed for the evolution of the teaching career.

To achieve our third objective and test the second hypothesis, we used the independent samples t-test. The hypothesis assumes that teachers who have participated in in-service training programs in the last two years will have a significantly more positive perception of the effectiveness of the educational act compared to those who have not participated. We tested the hypothesis by t-test for the difference between the means between two groups: participants vs. non-participants in in-service training and their perception of the quality of education in TVET.

Table 3. T-test for the difference between means between two groups: participants vs. non-participants in continuing education and their perception of the quality of education in TVET

Test	Test statistics	df	p	The difference between the environments	95% Confidence Interval (Lower)	95% Confidence Interval (Upper)
Levene	0.245	-	0.622	-	-	-
T-Test (Assumed Equality)	-1.129	58	0.263	-0.133	-0.292	0.025
T-Test (Unassumed Equality)	-1.129	29.0	0.263	-0.133	-0.297	0.03

Source: Own results.

Before applying the t-test, we checked the homogeneity of variances using the Levene test. The value of the Levene statistic is 0.245, and the associated p-value is 0.622, which indicates that the variances of the two groups are homogeneous. Thus, the standard t-test can be used, with the assumption of equality of variances.

The result of the independent samples t-test indicates a t-statistic value of -1.129 for the variant with the assumed equality of variances and the same value for the variant in which the equality of variances is not assumed. The degrees of freedom (df) are 58 in the first variant and 29.0 in the second. The p-value obtained in both cases is 0.263, which indicates the probability that the observed difference between the means is generated by random fluctuations in the sample.

The difference between the means is -0.133, which shows that the perception of the quality of education among those who participated in continuing education is, on average, slightly lower than among those who did not participate. The 95% confidence interval for this difference is between -0.292 and 0.025 in the version with the equality of variances assumed and between -0.297 and 0.03 in the version without this assumption. The fact that this interval includes the value 0 indicates that the difference between the two groups is not sufficiently clearly defined to beconsidered significant.

The interpretation of these results must be made in the context of the dynamics of continuous training and the way in which teachers perceive the effectiveness of the educational act. A possible explanation for the lack of a significant difference may be that training programs are not always designed to provide a real added value in terms of teaching quality.

In some cases, teachers may perceive these programs as administrative requirements rather than genuine opportunities for professional development.

This result can be analyzed through the lens of the theory of cultural capital formulated by Pierre Bourdieu, according to which the accumulation of formal skills and certifications does not always translate into a perceptible change in the way a profession is practiced [12].

In this case, even if teachers participate in continuous training, their perception of the quality of education may not changes ignificantly, either because of the content of these programs or because of other contextual factors that influence the educational act, such as the available material resources or the level of student involvement.

Another aspect that deserves attention is the possibility that the perception of the quality of education is influenced bys ubjective factors, independent of participation in continuous training.

The accumulated professional experience, the teaching conditions in each school unit and the socio-economic context of the students can contribute to the way in which teachers evaluate the quality of the educational act.

If these variables are not taken into account in the research design, the real effect of continuous training on teachers' perceptions may be diluted or masked by other factors.

CONCLUSIONS

The first objective aimed to evaluate the correlation between teachers' perception of the curriculum and its degree of adequacy to the labor market requirements.

Hypothesis H1 assumed that the perception of the curriculum correlates positively with the assessment of graduates' chances of finding a job in the fields tudied. Testing this hypothesis by Pearson correlation indicated a coefficient of 0.16, which suggests a positive association of low intensity between the two variables. The direction of the correlation suggests that, as teachers perceive the curriculum as having a higher degree of coverage of technical and socio-emotional skills, the general tendency is to estimate higher employment chances for graduates. However, the p value = 0.374 shows that this relationship is not statistically significant, which suggests that teachers' perceptions of the curriculum are not a strong enough predictor of graduates' professional success.

The second objective was to analyze the relationship between the quality of infrastructure and material resources and teachers' satisfaction with students' practical training. The results of the Pearson correlation indicated a coefficient of 0.722, which suggests a strong positive relationship between these variables. The p value = 0.00015 shows that this association is statistically significant, which shows us that teachers who perceive the infrastructure and material resources as being of quality are more satisfied with students' practical training.

The third objective was to determine the impact of in-service training of teachers on their perception of the effectiveness of the educational act.

Hypothesis H2 assumed that teachers who participated in in-service training in the last two years will have a significantly more positive perception of the quality of education compared to those who did not participate. The t-test for independent samples did not indicate a statistically significant difference between the two groups, the p value = 0.263 showing that the perception of the quality of education is not clearly influenced by participation in in-service training.

The results suggest that teachers' perceptions of curriculum, infrastructure and in-service training are shaped by multiple contextual variables. While educational infrastructure has a clear influence on teachers' satisfaction with students' practical training, the relationship between curriculum and graduate employability, as well as the impact of in-service training on teachers' perceptions of educational quality, are less clearly defined. These aspects can be analyzed in more detail by future studies that include additional factors, such as employers' perspectives, students' performance in practical activities and the actual impact of in-service training on teaching skills.

The results of the study suggest that rural teachers' perception of the educational infrastructure is significantly more negative compared to that of urban teachers. The lack of investment in the modernization of workshops and the provision of equipment relevant to the labor market leads to a decrease in teachers' satisfaction with the practical training process. In addition, rural teachers face additional difficulties, such as the lack of continuous training opportunities in the vicinity of their localities, which may limit access to advanced training programs adapted to the current demands of the labor market.

Another aspect that differentiates rural and urban vocational education institutions is their limited access to partnerships with relevant economic agents. In many rural areas, the lack of industrial or manufacturing companies reduces internship opportunities for students, which affects both practical learning and the integration of graduates into the labor market. Unlike urban institutions, where collaborations with employers are more frequent and better structured, rural schools need to make additional efforts to ensure relevant internships for students.

In order to reduce the gaps between urban and rural areas in terms of educational infrastructure, investments are needed to equip workshops and laboratories in rural vocational and technical education units. It is also important to develop continuous training programs accessible to teachers in rural areas, either through online learning solutions or through regional training centers. Last but not least, closer collaboration between authorities, educational units and the private sector can facilitate the development of internship programs adapted to the economic specificities of each rural region.

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PRODUCTIVITY AND PROFITABILITY OF SHORT GRAIN CROP ROTATION DEPENDING ON TILLAGE SYSTEMS

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Abstract

Tillage systems have significant impact not only on soil properties, but also on general productivity of cultivated crops and, consequently, on the economic efficiency of agriculture. This study's primary goal was to assess the effects of various tillage techniques used in short-grain crop rotation"grain corn – winter rapeseed – winter wheat – soybeans", on the resulting yields and profitability of crop production. The study was conducted at the Institute of Climate-Smart Agricultureon the irrigated trial fields in Ukraine between 2021 and 2023. Tillage systems, embraced in the study, were represented by differentiated moldboard plowing, differentiated chiseling and differentiated disking with soil slitting. Crop yields were accounted after harvesting at technical ripeness of grain. Economic efficiency was assessed by calculating the figures of gross product value, expenditures, profits, production costs, profitability and recompensating terms. As a result, it was established that the best economic output is provided by differentiated disking with soil slitting, where general profitability reached 73.5% owing to the highest average yields of the crops studied and general yields of grain (7.66 t/ha) and forage (8.31 t/ha) units. The shortest recompensating term of 1.4years was also recorded for the disc tillage system.

Key words: *corn, economic efficiency, production cost, rapeseed, recompensating term, soybeans, wheat*

INTRODUCTION

Nowadays, mankind is facing the challenge of the global food crisis, which is aggravated by dramatic climate change. Global warming has led to increased frequence of adverse meteorological events worldwide, including hurricanes, extensive drought, hailstorms, extreme heating, instability in water income, etc., which in turn have detrimental effects on agriculture in general and crop production in particular [6]. Adverse meteorological phenomena are resulting in crop losses and deterioration of crop products quality [20]. The latter contributes to food distribution inequality, as well as inequality in access to high-quality products because of increasing prices. Ongoing military activities in Ukraine and the Middle East, as well as ongoing COVID-19 pandemic, just add fuel to the fire of global food crisis and malnourishment, making crop products prices even higher than expected because of destruction of powerful crop production systems and disturbed logistics [14,19]. If earlier mainly African countries were considered to be vulnerable to food crisis, today even the developed countries with powerful economy such as, for example, Germany and the United States, suffer food insecurity [1, 13]. Therefore, a major task of modern agriculture is to provide solutions for achieving the highest economic efficiency of crop production at the expense of minimizing expenditures, in addition to satisfying the sustainable development of agro-ecosystems on the basis of climate-smart and environmentally friendly technologies.

In this regard, an important role is played by tillage systems, which have significant effects on both soil fertility preservation, soil physical and chemical properties, climate resilience, growth and development of agricultural plants and, as a result, shaped general economic efficiency of crop production [8, 11, 16]. It has been proved that optimal tillage technology is decisive for proper water resources management in agriculture, as well as proper plant residues management and general efficiency of natural resources usage [7]. This is especially true for the cultivation of crops in semi-arid and arid climates [17], to which almost all the South of Ukraine belongs.

Therefore, the main goal of this study was to establish the best tillage system for economically efficient grain production on the irrigated lands of the South of Ukraine in short crop rotations to facilitate qualitative crop products at the minimal costs.

MATERIALS AND METHODS

The study was conducted on the irrigated experimental fields of the Institute of Climate-Smart Agriculture of NAAS, located in the Kherson region of Ukraine, close to the village of Naddniprianske. The experimental area's soil-climate conditions are typical of Ukraine's Southern Steppe region. The weather conditionscan be classified as semi-arid [9], the soil is represented by dark-chestnut middle-loamy soil with slightly increased salinity and sodium contents.Generally, the zone of the experiment conduction belongs to the zone of so-called risky agriculture [15]. The research was performed during the period 2021-2023 with strict accordance to common standards and procedures of the experimental work in irrigated agriculture.

Table 1. The Scheme of the Stationary Field Experiment on Tillage Systems in Short Grain Crop Rotation and Their Effects on the Crops Productivity and Economic Efficiency

No	Tillage system	Crops of the crop rotation, depth of tillage			
		corn	wnter rapeseed	wnter wheat	soybeans
1	Differentiated plowing	28-30	14-16	20-22	23-25
2	Differentiated chiseling	28-30	14-16	20-22	23-25
3	Differentiated disking with soil slitting	10-12 + 38-40	12-14	14-16	10-12

Source: Own study.

The scheme of the stationary field experiment on tillage systems in the short grain crop rotation is presented in Table 1.

Standard agricultural machines and tillage means of the national Ukrainian manufacturer were used in the experiment. Cropcultivars, cultivated in the experiment, were as follows: corn variety Skadovskyi,soybeans variety Diona,winter wheat varietyKonkaand ChornyiVeletenvariety of winter rapeseed. Irrigation was carried outby the means of sprinkler overhead machine DDA-100-MA when soil moisture level decreased to 70% of the field water-holding capacity. Crop yields were established after direct harvesting with a self-propelled combine harvester at the full technical ripeness of grain, and then recalculated to the standard moisture content in the kernels (14% for corn, wheat and soybeans, and 15% for rapeseed). General grain and forage unit yields were also evaluated. The economic efficiency of the used agro-technologies was estimated using common economic indices, namely: production costs, expenditures, profit, profitability, and recompensating term [18]. All the calculations were performed in EUR/ha considering current currency exchange rates (dated October 2024, 1 EUR = 45.0 UAH).

RESULTS AND DISCUSSIONS

According to the study's findings, the chisel tillage system produced the worst results among the options examined, even falling short of the traditional moldboard plowing system. In contrast, the highest yield of each crop in the short grain crop rotation was harvested under differentiated disking with soil slitting (Table 2).

The highest yield of the studied crops was 6.31 t/ha for winter wheat, 12.79 t/ha for grain corn, 2.53 t/ha for winter rapeseed, and 3.60 t/ha for soybeans, respectively. The difference with the lowest yields was 6.1% for winter wheat, 11.7% for corn, 6.3% for winter rapeseed, and 13.2% for soybeans, respectively. Thus, it could be concluded that among the studied crops winter wheat and winter rapeseed had the least susceptibility to tillage options, while soybeans provided the strongest reaction on tillage changes within the crop rotation.

As for the profits and general profitability rates, it was established that winter wheat was, surprisingly, the most profitable crop among the studied, while soybeans are the least commercially attractive crop. This is mainly because of higher production costs for soybeans, compared to other crops, which is strongly related to more frequent irrigation and higher expenditures for plant care.

The same is also true for recompensating terms, which were the shortest for winter wheat, and the longest for soybeans, respectively. As for comparison between the studied tillage systems, the best average profitability rate of the crop rotation was recorded for differentiated disking tillage, as well as the shortest period of recompensation. As for chiseling and plowing, profitability rates were close enough (the difference of just 1.6%), as well as recompensating term duration (the difference of just about 0.2 years).

Table 2. The economic efficiency of the irrigated short grain crop rotation depending on the tillage system (averaged data for the period 2021-2023, prices dated October 2024)

Economic indices and parameters	Crops				Average per 1 ha of the crop rotation
	Winter wheat	Corn	Winter rapeseed	Soybeans	
Differentiated plowing					
1. Yield. t/ha	6.08	11.85	2.45	3.32	-
2. Yield of forage units. t/ha	7.78	15.76	2.86	4.81	7.80
3. Yield of grain units. t/ha	6.08	11.85	4.90	5.97	7.20
4. Gross value. EUR	803.9	1,540.5	680.6	1,010.8	1,008.9
5. Expenditures. EUR	470.2	969.2	407.9	778.1	656.3
6. Profit. EUR/ha	333.8	571.3	272.7	232.6	352.6
7. Profitability rate. %	70.9	58.9	66.8	29.9	56.6
8.Production cost. EUR/t	77.3	81.8	166.5	234.4	140.0
9. Recompensating terms	1.4	1.7	1.5	3.4	2.0
Differentiated chiseling					
1. Yield. t/ha	5.95	11.45	2.38	3.18	-
2. Yield of forage units. t/ha	7.61	15.23	2.78	4.61	7.55
3. Yield of grain units. t/ha	5.95	11.45	4.76	5.72	6.97
4. Gross value. EUR	786.7	1,488.5	661.1	968.1	976.1
5. Expenditures. EUR	454.8	961.2	395.2	774.3	646.4
6. Profit. EUR/ha	332.0	527.3	265.9	193.8	329.8
7. Profitability rate. %	73.0	54.8	67.3	25.0	55.0
8.Production cost. EUR/t	76.4	84.0	166.0	243.5	142.5
9. Recompensating terms	1.4	1.8	1.5	4.0	2.2
Differentiated disking with soil slitting					
1. Yield. t/ha	6.31	12.79	2.53	3.60	-
2. Yield of forage units. t/ha	8.07	17.01	2.96	5.22	8.31
3. Yield of grain units. t/ha	6.31	12.79	5.06	6.48	7.66
4. Gross value. EUR	834.3	1,662.7	702.8	1,096.0	1,074.0
5. Expenditures. EUR	441.7	948.3	379.5	757.2	631.7
6. Profit. EUR/ha	392.6	714.4	323.3	338.8	442.2
7. Profitability rate. %	88.8	75.3	85.2	44.7	73.5
8.Production cost. EUR/t	70.0	74.2	150.0	210.4	126.1
9. Recompensating terms	1.1	1.3	1.2	2.2	1.4

Source: Own results.

In addition to being a sign of sensible resource management in agriculture, fuel consumption is one of the most important factors influencing production costs under various tillage schemes.

It was determined that the plowing system had the highest energy costs of all the tillage systems, followed by the disking and chiseling systems (Table 3). It has to do with the crop rotation's highest average fuel costs per hectare of arable land. Remarkably, in all tillage scenarios, grain corn was found to have the greatest average fuel expenditures, rather than soybeans, the commodity with the highest production cost.

Tillage minimization resulted in a great economy of financial resources, which reached 19.4% in case of chiseling and plowing comparison, and 75.5% in case of plowing and disking comparison, respectively.

Table 3. Fuel costs in the irrigated short grain crop rotation vary according to the tillage regimes (averaged data for 2021-2023, prices dated October 2024)

Indices and parameters	Crops				Average by the crop rotation
	Corn	Winter rapeseed	Winter wheat	Soybeans	
Differentiated plowing					
Tillage depth.cm	28-30	14-16	20-22	23-25	-
Fuel expenditures.L/ha	25.4	20.6	23.8	24.7	23.6
Fuel costs. EUR/ha	31.33	25.40	29.36	30.47	29.13
Energy of fuel. MJ/ha	1,211.6	982.6	1,135.3	1,178.2	1,126.9
Differentiated chiseling					
Tillage depth. cm	28-30	14-16	20-22	23-25	-
Fuel expenditures. L/ha	21.2	18.2	19.4	20.3	19.8
Fuel costs. EUR/ha	26.16	22.44	23.93	25.04	24.40
Energy of fuel. MJ/ha	1,011.2	868.1	925.4	968.3	943.3
Differentiated disking with soil slitting (on 38-40 cm once per the crop roatation)					
Tillage depth. cm	10-12	12-14	14-16	10-12	-
Fuel expenditures. L/ha	18.0	12.0	12.4	11.4	13.5
Fuel costs. EUR/ha	22.20	14.82	15.29	14.07	16.60
Energy of fuel. MJ/ha	858.6	572.4	591.5	543.8	641.6

Source: Own results.

Energy efficiency of fuel usage was also almost twice better in the variant of discing tillage than moldboard plowing. Thus, tillage minimization resulted in all-round improvement of economic efficiency of crop production, manifested in decreased production costs, increased profitability, fuel economy and better management of energy resources in general.

Our results find sufficient support in other studies. For instance, less tillage significantly lowered the energy expenses of growing sugar beets in Pannonia, improving crop production's economic and energetic efficiency [12]. Our findings are consistent with those of Romanian researchers who investigated the effects of various tillage strategies on winter wheat yields, soil characteristics, and the financial viability of agricultural production. Cociu (2011) claimed that all the conservation tillage options, namely, chisel tillage, disc tillage and zero tillage, provided more benefits for soil health (especially mechanical and physical properties), winter wheat yields and increased economic efficiency of crop cultivation. The greatest income and the least production costs among the tillage options were attributed to disking tillage, as in our study, while the highest costs and expenditures were recorded for traditional plowing tillage [5].

An extremely valuable improvement in economic efficiency of winter wheat production was registered in the study, devoted to the comparison of no-till and conventional tillage systems. Yield difference was insignificant (just about 35 kg/ha of wheat grain), while technological expenditures reduction, owing to cutting fuel costs down, reached 19.2% [3]. Apart from economic benefits, no-till system provided environmental benefits because of facilitating soil structure, properties and fertility preservation, and better water regime formation.

As for corn crops, it was also established that minimal tillage is not significantly inferior in yields compared to moldboard plowing, but provides great fuel economy and therefore, results in the best economic efficiency of corn grain production. The only drawback of tillage minimization was observed in higher weediness of crops [4]. However, rational use of selective herbicides can be suggested as a solution for this issue.

The study, devoted to sweet corn cultivation economic efficiency determination in the irrigated conditions of the Southern Steppe zone of Ukraine revealed that decreased tillage depth even under traditional moldboard tillage system provides better yields and increases crop profitability. The only

condition when deep plowing is superior to minimized tillage is nutritional stress [10].
However, some studies claim different results. For example, Zhichkinaet al. (2021) stated that the best yields of soybeans were obtained under conventional plowing tillage in comparison to minimized tillage options. The authors admitted higher fuel and general costs for soybeans production in the variant of moldboard plowing, however, the total income because of significantly higher crop yield was better in this variant than in the variants with minimal tillage [21]. But another study provided evidence for better economic efficiency in minimal strip tillage system for soybeans cultivation, which provided higher profitability under the lower production costs [2]. Thus, it could be concluded that most scientific evidence favors tillage minimization to achieve the highest possible economic efficiency of crop production at the expense of cutting down fuel costs and labor expenditures.

CONCLUSIONS

The study's findings, which were recorded in 2021–2023, on dark-chestnut soil in the semi-arid environment of southern Ukraine, showed that the most cost-effective crop rotation strategy in the conditions of irrigation with average profit of 442.2 EUR/ha, and profitability rate of 73.5% under the highest yield of grain (7.66 t/ha) and forage (8.31 t/ha) units were provided by the differentiated disc tillage system with one soil slitting on the depth 38-40 cm per the crop rotation. Moldboard plowing and chiseling provided close economic outcomes, but chisel tillage saved more energy and fuel. Further investigations will be directed on no-till systems research.

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MARKETING RESEARCH ON CONSUMER PREFERENCES FOR CRAFT BEER

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Abstract

This paper aims to explore customer preferences for craft beer through a questionnaire-based survey, analyzing key factors influencing purchasing decisions. The research focuses on aspects such as taste, aspect, alcohol content, and price sensitivity to understand the motivation behind the customer choices. The study collected responses from diverse samples of craft beer consumers, examining demographics influences on preferences. The results of the survey show that most respondents are familiar with craft beer, which they consume occasionally, usually in pubs. The bitter taste and fullness of craft beer are appreciated, they also prefer a beer made from quality ingredients with golden color, clear and glossy having a low content of alcohol packed in a glass bottle.

Key words*: *craft beer, customer, survey

INTRODUCTION

In recent years, the craft beer market has experienced rapid expansion as a result of consumer interest in authentic, artisanal products [3,10]. Craft beers are often not pasteurized or not filtered and, for these reasons, they are products rich in healthy compounds, but with a reduced shelf life [2] As a consequence, the price is higher compared to a regular beer, and its consumers forms a market niche, targeted with specific strategies.

According to the USA Brewers Association [18], global craft beer market size was valued at USD 102.15 billion in 2023. The craft beer industry is projected to grow from USD 108.8 Billion in 2024 to USD 275.76 billion by 2032, exhibiting a compound annual growth rate (CAGR) of 12.33% during the forecast period (2024 - 2032). The European craft beer market reached USD 37.7 billion in 2023, expecting a growth rate (CAGR) of 6.57% in the period 2024–2032 [6].

In Romania, the beer production sector recorded 102 economic agents with a turnover of 5.2 billion RON, a profit of 213 million RON and 3,420 employees. The main producers are Ursus Breweries SA, Heineken Romania SA, United Romanian Breweries Bereprod SRL, with turnovers of 5.04 billion RON, profit 206 million RON and 1,703 employees [17].

Romanian National Institute of Statistics shows in latest report that beer consumption (per capita) has been decreased by 2.9 liters in 2023 compared to 2022 [13]. Traditional mass-produced beer brands have seen a drop in sales due to shifting consumer preferences, health conscious trends and competition from other alcoholic beverages. Despite of this slightly contraction of beer market volume, Romanian brewing companies have chosen to increase their investments against the previous year by almost 50%.

However, craft beer has managed to develop a strong and loyal customer base appealing to those who value quality, unique flavors [19, 12.

To adapt their strategies, producers rely on research on consumer behavior, therefore, this article aims to explore the main trends and factors that underpin the decision to buy craft beer. This article aims to answer the question of who the average craft beer consumer in Romania is, starting from the following hypotheses.

Hypotheses and objectives of the research

Q1. How familiar are you with craft beer concept? Known / Very well-known / Very little known / Little known / Totally unknown.

O1: Identification of consumers' knowledge regarding craft beer; identifying the profile of the craft beer consumer by gender groups, age, background, education.

H1: Consumers are little familiar with the concept of craft beer and the knowledge is directly related to their background, gender, age and education [5].

Q2: How often do you drink craft beer? Not at all/ Several times a year/ 1 time a month/ Weekly/ Every day/ Other.

O2: Identification of the craft beer consumer profile. Determining how often craft beer is consumed.

H2: Consumers' preferences for craft beers vary according to gender, age, education. Most respondents consume craft beer occasionally, and the frequency is correlated with personal preferences, lifestyle [9].

Q3. What do you appreciate about craft beer? Taste & Fullness / Color / Personality / Design & Label / Others

O3: Identification of characteristics preferred by consumers in craft beer.

H3: Drinking craft beer is perceived as a multisensory experience. Most respondents value taste as the main reason for choosing this type of beer [7].

Q4. Where do you usually drink craft beer? Home/ Pub/Breweries/ Restaurant/ Fairs/ Others

O4: Determining the preferred places to drink craft beer.

H4: Craft beer is consumed in a variety of places, depending on the context, personal preferences and availability of the product. It is expected that respondents will prefer to consume craft beer in pubs/breweries, in different social contexts. Craft beer is consumed in bars and restaurants [2].

Q5. How do you prefer craft beer to taste? Bitter/ Fruity/ Sweet/Floral/ Other

O5 Identify preferences regarding the taste of craft beer.

H5 Craft beer consumers place great emphasis on the uniqueness and complexity of taste [1]. The various flavors give authenticity, the most appreciated are those that contribute to the bitter and fruity taste.

Q6. Do you prefer craft beer versus industrially produced beer? I prefer craft beer/ I prefer industrial beer/ I don't have a preference.

O6 Establishing consumer preferences for craft beer versus industrially produced beer.

H6 Consumers' preferences for craft beer differ according to gender, age, education. We expect significant influences to have age and education. Young consumers are attracted to the social and exploratory aspect of craft beer [3].

Q7. What is the reason/reasons why you choose to consume craft beer? Atypical & Premium Ingredients/ Desire to Try New Drinks/ Different Taste/ Other

O7 Identify the reasons that lead to the choice of craft beer.

H7 Respondents choose to consume craft beer out of the desire to try new drinks, out of the desire to experiment with different tastes [3].

Q8. What is the amount you are willing to pay for a 500 ml craft beer? 5-10 Ron/ 11-15 Ron/ 16-20 Ron/ +20 Ron

O8 Identification of the price that consumers are willing to pay for 500 ml craft beer.

H8 The price that consumers are willing to pay for 500 ml bottle of craft beer is between 11-15 lei RON.

Q9. What is the source of information that will help you choose a certain type of craft beer? Internet/ Social Media/ Family/Friends/ Other

O9 Determining the source of information that influences the choice of a certain type of craft beer.

H9. Craft beer consumers get their information from a variety of sources; social media plays a key role in the choice made, being the preferred source of information [15].

Q10. What type of packaging do you prefer? Pet/ Dose/ Bottle/ Keg & Draft

O10: Identifying consumer preferences for the type of packaging used in craft beer bottling.

H10: Craft beer consumers prefer to drink the beverage from a glass bottle, the packaging design playing an important role in the choice made in terms of beer packaging, more environmentally committed consumers, who are usually focused on sustainable consumption [8], value glass bottles over cans [14].

Q11. How do you prefer beer, considering the amount of alcohol it contains? 0% Alcohol/ 2-3% Alcohol/ 5% Alcohol/ '+ 5% Alcohol

O11 Establishing preferences according to the amount of alcohol contained in craft beer.

H11 Alcohol content is important for craft beer consumers. Craft beer consumers choose a moderate alcohol content of 5% because they want to enjoy complex flavors without alcoholic strength. The production of beer with low alcohol content is a fast-growing segment in the world market [16].

Q12. How do you prefer beer, considering the color? Gold/ Copper / Light Yellow/ Brown & Black

O12 Identification of beer color preferences as a differentiating element between different types of beer.

H12 Color influences expectations about the beer taste, that's why it plays an important role in the choice of craft beer. Light colors, especially gold, are at the top of the preferences of craft beer consumers [4].

Q13. How do you prefer beer to be considering appearance? Very clear, without opalescent and sediment/ Clear, without sediment, with characteristic gloss/ Slightly opalescent, with yeast sediment/ Opalescent, with sediment from yeast deposition

O13 Identification of consumer preferences regarding the appearance of beer.

H13 The degree of clarity or opalescence is a visual aspect that attracts attention and provides clues regarding the manufacturing process and certain taste characteristics. Craft beer consumers are attracted by the slightly opalescent aspect.

Q14. What do you think about the following types of beer? Indian Pale Ale, Wheat Beer, Stout, Dark Lager, Pilsener – I Don't Know, I Dislike, Neutral, I Like

O14: Determine the degree of knowledge of different types of beer as well as identify preferences related to these types of beer.

H14 The most popular beer is represented by the Pilsener type beer [2]. The consumption pattern and consumer loyalty differ according to gender, age and education.

Starting from these hypotheses and considering the fulfillment of these objectives and the situation on the beer market in Romania, it becomes necessary to study the preferences of beer consumers, an approach conducted in this research. The paper is divided into five parts. After introduction, the research methodology is presented, then the results are analyzed. Finally, during the discussions, the hypotheses are verified, and the main ideas that resulted from the market research are highlighted in the conclusions.

MATERIALS AND METHODS

The sources of information used to conduct this study are external, primary. For the collection of information, the structured quantitative survey was used [11]. The tool used for data collection was the self-administered questionnaire, disseminated online.

The research was limited to a certain segment of the total community, sample, and the results can be extrapolated to the level of the entire community. The sample, consisting of 280 people, was calculated by mathematical methods, with an error of 5.8%. The accuracy of the application of the quota method as a sampling method can be seen in Tables 1 to 3.

The independent variables considered are gender, age, background and occupation.
Table 1 Sample structure by gender, compared to the resident population of Romania aged over 18 years.

Table 1. Sample structure by gender, compared to the resident population of Romania aged over 18 years.

Variable	Total population		Sample population	
Gen	Absolut (persons)	Relative (%)	Absolut (persons)	Relative (%)
Masculine	7,581,036	48.34%	129	46.07%
Feminine	8,102,639	51.66%	151	53.93%
Total	15,683,675	100%	280	100%

Source: calculations based on statistical data (Tempo online database, 2020) and survey results [13].

The sample consists of 53% women and 46% men, shares similarity with the total population (Table 1).
In terms of age, the majority of the sample consists of younger people, aged between 18 and 25 years, and mature people, aged between 36 and 45 years. Elderly people have low shares in the sample, compared to the shares of the total population (Table 2).

Table 2. Sample structure by age compared to total population

Variable	Total population		Sample population	
Age	Absolut (persons)	Relative (%)	Absolut (persons)	Relative (%)
18-25	1,617,753	10.31%	89	31.79%
26-35	2,473,022	15.77%	49	17.50%
36-45	2,917,238	18.60%	74	26.43%
46-55	2,849,749	18.17%	58	20.71%
≥56	5,825,913	37.15%	10	3.57%
Total	15,683,675	100%	280	100%

Source: calculations based on statistical data (Tempo online database, 2020) and survey results [13].

Depending on the rural-urban classification, 75% of the respondents live in urban areas, and about 25% in rural areas, the explanation being that the research refers to the population of the Bucharest-Ilfov metropolitan region, where the main sales of craft beer are concentrated. This product is less present in rural areas.

Table 3. Sample structure by urban- rural classification compared to the total population

Variable	Total population		Sample population	
Urban/Rural Classification	Absolut (persons)	Relative (%)	Absolut (persons)	Relative (%)
Urban	8,484,868	54.10%	211	75.36%
Rural	7,198,807	45.90%	69	24.64%
Total	15,683,675	100%	280	100%

Source: calculations based on statistical data (Tempo online database, 2020) and survey results [13].

RESULTS AND DISCUSSIONS

Data analysis is done on two levels: primary and secondary. The primary level of analysis consists in the elaboration of frequency distribution tables, analyzing the response in correlation with the number of people who formulated the respective response. The secondary level of analysis consists in the elaboration of frequency distribution tables with multiple inputs, analyzing the response in relation to the socio-economic characteristics of the subjects, as well as to other factors.
At first question " *How familiar are you with craft beer concept?*" 42% of respondents answered that they are familiar with the concept of craft beer and for 29% of them this concept is "little known" (Fig. 1).

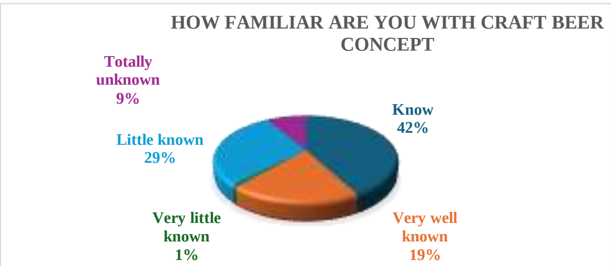


Fig. 1. Respondents' answers to the question: How familiar are you with craft beer concept?
Source: Survey results.

Answers to question "How often do you drink craft beer?" segregate more than half of the respondents, 53%, in occasional consumers, people who consume craft beer only a few times a year. Moderate consumers (13%) drink craft beer weekly and are good connoisseurs of this type of drink (Fig. 2).

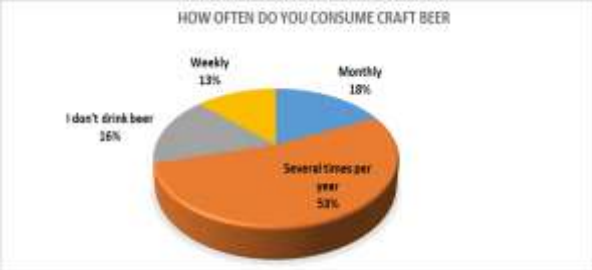


Fig. 2. Respondents' answers to the question: How often doyou consume craft beer?
Source: Survey results.

When asked "What do you appreciate about craft beer?" most respondents (62%) appreciate the taste and fullness. These attributes of craft beer are followed in preferences by another characteristic, the personality of beer (in 14% of respondents), a concept that also translates into taste, being represented by the flavors that give authenticity and uniqueness to these drinks. For 11% of respondents, packaging is an attractive element for consumers, who appreciate the interesting design, the story conveyed by the name and the visual aspect (Fig. 3).

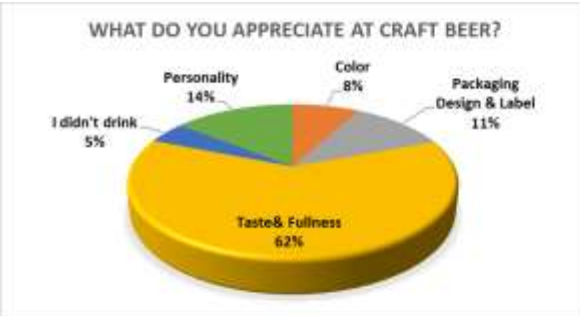


Fig. 3. Respondents' answers to the question: What do you appreciate at craft beer?
Source: Survey results.

To the question "Where do you drink craft beer?" we notice that two answers stand out: Pub - 44% and Home - 38%.
Pubs dedicated to craft beer offer the opportunity to experiment with new selections together with colleagues and friends.
A smaller percentage, 38%, is represented by people who prefer to enjoy craft beer at home, without the pressure of a social environment (Fig. 4).

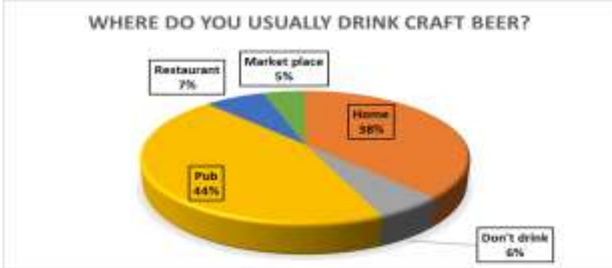


Fig. 4. Respondents' answers to the question: Where do you usually drink craft beer?
Source: Survey results.

When asked "How do you prefer the taste of craft beer" 41% of respondents prefer the bitter taste, 24% prefer the sweet taste. Diverse aromas, fruity notes (appreciated by 29% of respondents) and floral notes (preferred by 9% of respondents) add to the complexity of the taste and contribute to the entire multisensory experience (Fig. 5).

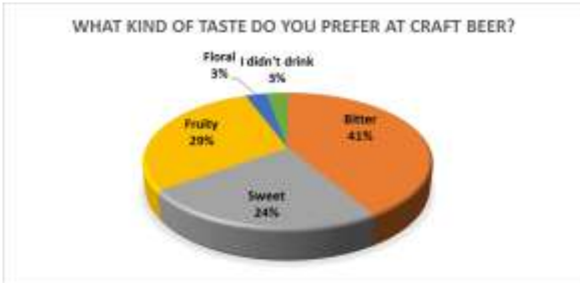


Fig. 5. Respondents' answers to the question: What kind of tase do you prefer at craft beer?
Source: Survey results.

The answers given to question number 6 clearly show the preference of the interviewees for craft beer (55%) to the detriment of beer produced at industrial level (29%) (Fig. 6).

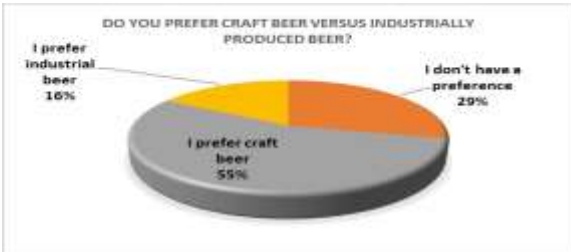


Fig. 6. Respondents' answers to the question: Do your prefer craft beer versus industrially produced beer?
Source: Survey results.

The reasons why craft beer is preferred can be found in the answers of question number 7: different taste (32%), desire to try new drinks (29%).

They consider craft beer a premium product (34%) as a result of using quality ingredients in artisanal process (Fg. 7).

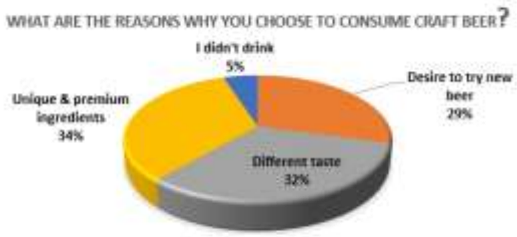


Fig. 7. Respondents' answers to the question: Which are the reasons why you choose to consume craft beer?
Source: Survey results.

Question 8: The amount of money that respondents are willing to spend for 500 ml bottle of beer is found in the range of 11-20 RON, more precisely: 39% would pay between 11-15 RON, and 28% would pay between 16-20 RON. Only 7% of respondents would pay more, over 20 RON.
At the opposite pole are 26% of respondents, who would prefer to pay between 5-10 RON. (Fig. 8).

Fig. 8. Respondents' answers to the question: Which is the amount you are willing to pay for a 500 ml craft beer?
Source: Survey results.

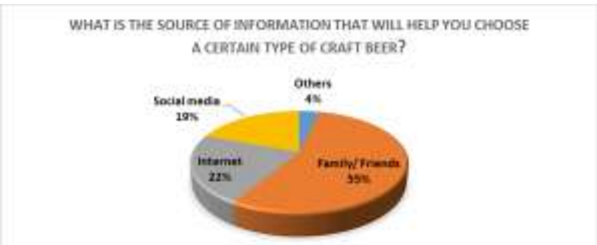


Fig. 9. Respondents' answers to the question: Which is the source of information that will help you choose a certain type of craft beer?
Source: Survey results.

Question 9: Before choosing a particular type of craft beer, consumers get information from a variety of sources. Family and friends (55%) are the source of trust according to the survey.
Online reviews and specialized applications, 19% and 22% respectively, contribute to the prior information of the tasting of craft beer (Fig. 9).
According to the survey (question 10), the preferred packaging remains glass (76%), followed by Keg & Draft (16%), cans (5%) and PET packaging (3%) (Fig. 10).

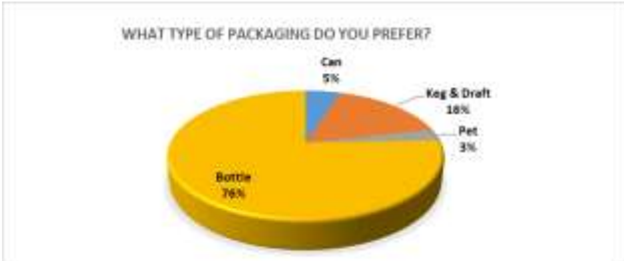


Fig. 10. Respondents' answers to the question: What type of packaging do you prefer?
Source: Survey results.

Question 11: "How do you prefer beer considering the amount of alcohol, 0% alcohol/ 2-3% alcohol/ 5% alcohol/ 5% alcohol/ 5% alcohol/ '+ 5% alcohol?' The answers rank the respondents' preferences as follows: 49% prefer the concentration of 5% alcohol; 27% of respondents go out for a lower amount of alcohol, 2-3%. An important percentage (14%) places beer with a percentage of more than 5% alcohol on the 3rd place in preferences. Non-alcoholic beer is also appreciated by an important percentage of respondents, 10% (Fig.11).

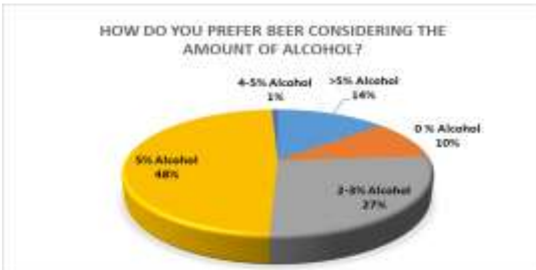


Fig.11. Respondents' answers to the question: How do you prefer beer considering teh amount of alcohol?
Source: Survey results.

To question 12: "How do you prefer beer to be considering the color? Gold / Copper / Light Yellow / Brown & Black"
Color plays an important role in the choice of craft beer, as it creates a visual connection

with taste expectations. The golden color is preferred by 54% of respondents, suggesting a light, fresh beer with a defined taste. Copper is preferred by 21%, light yellow color is appreciated by 14% of respondents, and dark beer, brown & black, ranks on the last places in preferences, with a favorability percentage of 11% (Fig. 12).

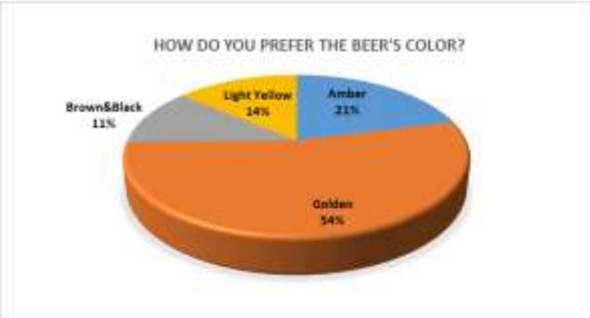


Fig.12. Respondents' answers to the question: How do you prefer the beer's color?
Source: Survey results.

Question 13: "How do you prefer beer considering the appearance?
Clear, without opalescent and sediment/ Very clear, without sediment, with characteristic luster/ Slightly opalescent, with yeast sediment/ Opalescent, with sediment from yeast deposition"
The appearance of the beer is an indicator of the beer production process.
A clear beer suggests clear aromas, filtration or prolonged maturation.
The opalescent appearance is perceived as natural, artisanal, with little or no filtration.
From the analysis of the answers, it results that very clear, sediment-free beer, with characteristic glossy is appreciated in a proportion of 41%, immediately followed by clear, clear beer with 37%.

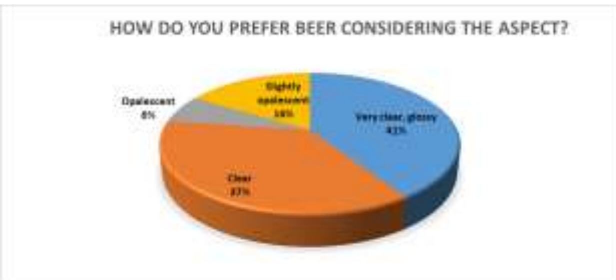
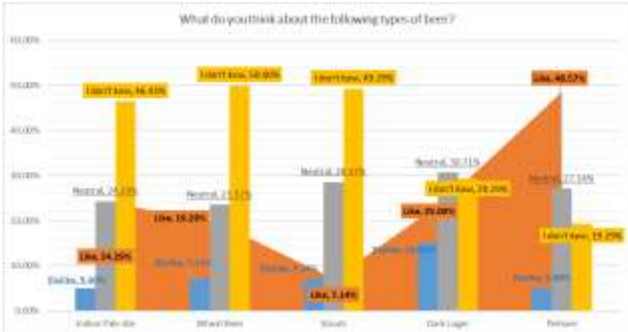


Fig. 13. Respondents' answers to the question: How do you prefer beer considering the aspect?
Source: Survey results.

Craft beer with a slightly opalescent appearance (16%) and the one with an opalescent appearance (6%) are less appreciated (Fig.13).
Question 14*:* What do you think about the following types of beer? Indian Pale Ale. Wheat Beer, Stout, Dark Lager, Pilsener – I Don't Know, I Dislike, Neutral, I Like.
The most famous beer, Pilsener beer, is also the most appreciated beer (48.57%). Dark Lager ranks second in the top of preferences (25%), with a small difference from Indian Pale Ale, which obtains a score of 24.29%, with the mention that the percentage of the "Dislike" factor for the Indian Pale assortment is 5%, compared to 15% for Dark Lager. Next is the "Wheat Beer" beer, which is appreciated by 19.29%, and in the last place is the "Stout" beer with 7.14%.
From the respondents' answers, it can be seen that almost half of them do not know the varieties of beer such as Indian Pale Ale (46.43%), Wheat Beer - 50%, Stout - 49.29%.
23-31% of respondents are neutral, not having a formed opinion about these types of beer (Fig. 14).



What do you think about the following types of beer?	Indian Pale Ale	Wheat Beer	Stouts	Dark Lager	Pielsner
Dislike	5.00%	7.14%	7.14%	15.00%	5.00%
Like	24.29%	19.29%	7.14%	25.00%	48.57%
Neutral	24.29%	23.57%	28.57%	30.71%	27.14%
I don't kow	46.43%	50.00%	49.29%	29.29%	19.29%

Fig.14. Respondents' answers to the question: What do you thik about the following types of beer?
Source: Survey results.

Among the objectives of the research is to identify the profile of the craft beer consumer, an approach carried out in this section. Also, the initially established premises will be verified, comparing the results of the survey with the research hypotheses. It can be seen that some hypotheses have been validated, others have not.

H1: Consumers know little about the concept of craft beer and is directly related to their background, gender, age and education.

Partially validated hypothesis, craft beer is known among consumers and is directly related to the urban-rural classification, gender, age and education. The survey shows that craft beer is better known to males, from urban areas with age between 36-45 years, predominantly higher education.

H2: Consumers' preferences for craft beers differ according to gender, age, education. Most respondents consume craft beer occasionally, and the frequency varies with personal preferences, lifestyle.

Validated hypothesis, craft beer is consumed occasionally, several times per year and is preferred by males, with higher education, in urban areas.

H3: Drinking craft beer is perceived as a multisensory experience. Most respondents appreciate taste as the main criteria in choosing this type of beer.

Hypothesis validated, the results of the research show that 62% of respondents appreciate taste and consider it as the main attribute that leads to the choice of a certain type of beer.

H4: Craft beer is consumed in a variety of places, depending on the context, personal preferences and availability of the product. Respondents prefer to consume craft beer in pubs/breweries, in different social contexts.

Hypothesis validated, the result of the survey (44%) shows a preference for drinking craft beer in pubs/breweries.

H5 Craft beer consumers place great emphasis on the uniqueness and complexity of taste. The various flavors give authenticity, the most appreciated are those that contribute to the bitter and fruity taste.

Hypothesis validated. The results of the research show that bitter flavors (41%), followed by fruity ones (29%), are at the top of preferences in terms of taste.

H6 Consumers' preferences for beer differ according to gender, age, education. We expect significant influences to have age and education. Young people are attracted by the social and exploratory aspect of craft beer consumption.

Partially validated hypothesis. The results of the research show that craft beer is preferred by the 18-25 year old age segment, female people, with higher education (13%), followed, at a short distance, by male people, 36-45 year old segment, higher education graduates (12%).

H7 Respondents choose to consume craft beer driven by desire to try new drinks and experiment different tastes.

The hypothesis is partially validated, respondents choose craft beer because they consider it a quality beer, made from premium ingredients (34%), which offers a different experience in terms of taste (32%).

H8 The price that consumers are willing to pay for 500 ml bottle of craft beer is between 11-15 RON.

The hypothesis is confirmed, the respondents chose, with a frequency of 39%, the price variant between 11-15 RON, followed by the price variant between 16-20 RON (28%).

H9. Craft beer consumers get their information from a variety of sources; Social media plays an important role in the choice made by being the preferred source of information.

The hypothesis is not confirmed. The result of the study shows that the preferred source of information, based on which the consumption decision is made, is represented by recommendations from family and friends (55%), followed by social media (22%)

H10: Craft beer consumers prefer glass bottle, the packaging design plays an important role in the choice made

The hypothesis is validated. The preferred packaging is the glass bottle, the frequency of favorable responses being 76% of respondents, who appreciate the glass bottle for its ability to preserve the taste and aromas of beer.

H11 Alcohol content is important for craft beer consumers. Craft beer consumers choose a moderate alcohol content of 5% because they want to enjoy complex flavors without alcoholic strength dominating the experience.

The hypothesis is validated, the result of the survey shows that beer with an alcohol content of 5% obtained the highest frequency of favorable responses (48%), followed by beer with alcohol content of 2-3%, which is preferred by 27% of respondents.

H12 Color influences expectations about the taste of beer, which is why it plays an important role in the choice of craft beer. Light colors, especially gold, are at the top of the preferences of craft beer consumers.

Hypothesis validated. The result of the survey shows that the golden hue of beer is important for respondents, obtaining the highest frequency of favorable responses (54%).

H13 The degree of clarity or opalescent is a visual aspect that attracts attention and gives clues about the manufacturing process and taste characteristics. Craft beer consumers are attracted by the slightly opalescent aspect.

Hypothesis invalidated. The results of the study show that respondents choose to consume a clear, bright (41%) or very clear (37%) beer. Only 16% of the answers indicate a preference for a beer with a slightly opalescent appearance, and 6% for an opalescent appearance.

H14 The most popular (pleasant) beer is represented by the Pilsener beer. The consumption pattern and consumer loyalty differ according to gender, age and education.

Hypothesis confirmed. Pilsener beer is the most pleasant beer. Wheat Beer, Stout, Indian Pale Ale are unknown to almost half of the respondents (50% Wheat Beer, 49.29% Stout, 46.43% Indian Pale Ale). Dark Lager ranks second, after Pilsener with a percentage of 25%. Stout beer is the least pleasant beer, with a percentage of 7.14%. Preferences differ according to gender, age and education.

Craft beer consumer profile

The profile of the craft beer consumer is represented, for men, by a person aged between 36-45 years, and for women, by a person aged between 18-25 years, both genders have graduated from higher education and live in urban areas.

These results are in line with other ones, showing that the average consumer is predominantly male, in his thirties, having higher education and earning quite averagely [8].

CONCLUSIONS

The article researched the preferences of Romanian consumers towards craft beer, in order to identify the main consumption trends, the information collected being used by producers to substantiate marketing decisions and develop strategies for product, price, promotion and placement of craft beer.

From the research, there are some important conclusions: most respondents know craft beer, they usually find out about it from friends or family. Craft beer is occasionally consumed, usually in pubs. Respondents appreciate the taste and fullness of a craft beer and prefer the bitter taste, the golden color, the characteristic clarity and gloss, a low alcohol content and the glass packaging. They are willing to pay 11-15 lei for 500 ml of craft beer.

Limits of research

The structure of the sample by age does not respect the structure of the total population, with the distribution of frequencies being higher in the 18-25 age segment and lower in the 56 years plus age segment. These differences are justified, however, by the fact that the questionnaire was administered online, and people over 56 years of age use the computer less, compared to younger people. A consequence of the same fact is the non-compliance with division in case of the sample structure by occupational status, pensioners having a higher share in the total population compared to the sample, and students a lower share in the total population compared to the sample.

Exceeding the maximum error accepted by statistics for extrapolating the results, 5.8% (current survey) versus 5%, is also a limitation of the research; the results obtained being valid for Bucharest metropolitan area, a center of social and economic polarization.

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