

BEEKEEPING: ECONOMIC AND SOCIAL IMPORTANCE, GLOBAL TRENDS AND DEVELOPMENT STRATEGIES IN EUROPE AND ROMANIA

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Abstract

Beekeeping plays an important role in the economies of European Union countries, with specific programs to support the beekeeping sector implemented in all member states. However, the sector faces challenges such as the lack of predictive market information, competition in the global market, changing consumer preferences, the introduction of modern technologies, and more. This article explores the basic economic parameters of honey production, consumption, export and import at national, European, and global levels. It forecasts trends in the growth of bee populations, honey production, and consumption using data from relevant sources (FAO, Eurostat, National Institute of Statistics-NIS) through a forecasting model. Furthermore, it discusses strategic development directions in Europe and Romania. The research highlights the sector's potential and the need for integrated policies that support both bee health and beekeepers' incomes.

Key words: beekeeping, socio-economic importance, trends, directions

INTRODUCTION

Beekeeping, or apiculture, has a significant economic and social impact, contributing to the development of communities and environmental protection through biodiversity conservation. This activity provides direct economic benefits through the production of honey and other valuable bee products, and indirect benefits through the essential role of bees in pollinating agricultural crops. Additionally, in rural areas, beekeeping is a vital source of food and income, reducing poverty and providing economic stability (Adjare, S.O., 1990)[3].

Pollination performed by bees is indispensable for agricultural production, contributing to maintaining stable agricultural yields, supporting food security, and enhancing the competitiveness of the agri-food sector (European Commission, 2022) [10]. According to FAO (2021) [13], approximately 75% of global food crops and 35% of total agricultural production depend on pollination. This includes oilseed crops (rapeseed, sunflower), fodder plants (alfalfa, clover), vegetables, and fruits, as well as high-value

crops such as almonds, coffee, and citrus, essential for dietary diversity and local economies (Klein, A. M., et al., 2007; Potts, S. G., et al., 2010; FAO, 2021) [18, 29, 14]. The global value of pollination services exceeds USD 200 billion annually (FAO, 2021)[14].

Beekeeping plays a significant role in the global and local economy through the revenues it generates. Bee products, including honey, wax, propolis, and royal jelly, had a global market estimated at USD 9.3 billion in 2023 (Bee Culture, 2023) [4]. Major honey-exporting countries include China, Argentina, Ukraine, and India, while the European Union and the United States are among the largest importers (FAO, 2021) [14]. Romania is one of the largest honey producers in the European Union (European Commission, 2022; FAO, 2021) [10, 14], with over half of its honey destined for export, beekeeping contributes to the rural economy and bolsters the country's reputation as a producer of high-quality honey (MADR, 2021) [23]. With relatively low investments, beekeeping can generate supplementary income, contributing to the financial stability of small-scale farmers and marginalized communities, thereby reduce

poverty and food insecurity, by increasing household resilience to economic shocks (Abro, Z., et al., 2022; Popescu A., et al., 2024, Prodanović, R., et al., 2024) [1, 26, 30].

The interdependence between beekeeping, ecosystems and agricultural production profoundly impacts food availability, accessibility and security, not only by increasing the production of fruits, vegetables and oilseeds but also by providing a nutrient-rich food product (Bogdanov, S., et al., 2008; Akanda, M. K. M., et al., 2024) [5, 2]. Honey is a natural energy source, widely used in many cultures as a traditional sweetener and functional food (Kumar, K. S., et al., 2010) [19]. Additionally, bee products have a long history of use in natural medicine and cultural practices. In many parts of the world, honey is used to treat wounds, colds, and digestive issues, reflecting its social and cultural value (Crane, 1999) [8].

Beekeeping activities often involve women and youth, contributing to social inclusion and reducing unemployment. In many rural communities, women participate in honey production and processing, gaining economic independence (Prodanović, R., et al., 2024) [30].

Beyond its economic and social dimensions, beekeeping plays an essential role in biodiversity conservation and sustainable environmental management through agroecological practices that minimize synthetic inputs and chemical treatments. These practices help preserve soil fertility, water quality and the overall integrity of natural ecosystems (Pocol et. al., , 2021; Prodanović, R., et al., 2024) [25, 30]. Sustainable beekeeping supports biodiversity, especially in regions with threatened habitats (IPBES, 2019) [17]. By providing these ecosystem services and conserving the genetic diversity of plant populations, beekeeping helps mitigate the impact of climate change. Moreover, creating income sources less exposed to climatic risks contributes to the resilience of rural communities (Prodanović, R., et al., 2024) [30].

Beekeeping plays a crucial role in the economies of European Union countries, with the EU being a major player in the beekeeping

market and Romania is among the leading honey producers in the EU. Programs to support the beekeeping sector are implemented in EU member states. However, the sector faces challenges such as the lack of predictive market information, global market competition, changing consumer preferences, lack of international import standards and regulation and more (Popescu A., et al., 2020, 2021, Róžański, K., 2022) [27, 28, 31]. Addressing these issues requires a nuanced understanding of global beekeeping trends and targeted strategies to enhance its sustainability. This article explores the basic economic parameters of honey production, consumption, export and import at national, European, and global levels. It forecasts trends in the growth of bee populations, honey production and consumption using data from relevant sources (FAO, Eurostat, NIS) through a forecasting model. Furthermore, it discusses strategic development directions in Europe and Romania.

The research highlights the sector's potential and the need for integrated policies that support both bee health and beekeepers' incomes.

MATERIALS AND METHODS

The research is based on the processing and analysis of secondary data sourced from statistical databases (FAO, EUROSTAT, NIS) and Romania's National Strategic Plan (PNS). The indicators used for analyzing the economic importance of beekeeping include the number of bee families, the number of beekeepers, the number of bee families per beekeeper, honey production, annual honey consumption per person, honey imports, honey exports, and the national balance of honey import and export.

To establish the evolution and determine the dispersion degree of the indicators over the analyzed period, fixed-base indices and the coefficient of variation were used, calculated as:

$$Cvar (\%) = (Standard\ deviation / Mean) * 100$$

To identify trends in the analyzed indicators, the annual growth rate was calculated using the formula:

Growth rate (%) = $\left(\frac{\text{Geometric mean (analyzed period)}}{\text{analyzed period} - 1} \right) * 100$

To determine the significance of the difference between calculated means, the t-test was employed, interpreted for probabilities of 95%, 99%, and 99.9% ($t_{cal} > t_{theoretical}$) (Savoiu Gh, 2011) [32].

To establish trends in the analyzed indicators, a second-degree equation of the form $ax^2 + bx + c$ was used. Quadratic regression (or second-degree regression) is a non-linear regression model used to analyze the relationship between variables and estimate trends that are not directly proportional, i.e., when the relationship between variables forms a curve.

This type of regression is often used to analyze long-term consumer trends, especially when there are seasonal, economic, or consumption behavior-related fluctuations that do not exhibit linear evolution.

In the field of beekeeping, indicators such as honey production, the number of bee colonies, or other variables may exhibit a non-linear evolution over time.

For instance, an initial fast increase in production can be followed by stagnation or decline due to ecological, economic or climatic factors. The quadratic model allows for identifying such an evolution (e.g., in the form of a parabola that shows growth followed by decline).

Once the mathematical relationship is identified, the trend can be extrapolated for future years.

This is useful for estimating future values of the indicators, providing guidance for strategic planning. For example, farmers or decision-makers can plan resources or support measures based on the predictions.

The quadratic model enables the identification of a maximum or minimum point, depending on the parameters of the equation. In beekeeping, this point might indicate the moment when production reaches a peak and begins to decline (e.g., due to reduced biodiversity or climate changes).

If the actual trends of beekeeping indicators are curvilinear, a linear model may overestimate or underestimate future values.

The quadratic model provides greater accuracy, better reflecting real fluctuations. Quadratic regression can also include the effects of other independent variables, such as investments in beekeeping or the impact of climatic factors, forming more complex models.

For honey production, if data shows an increase in production in recent years followed by stagnation, quadratic regression can model this evolution, providing an estimate for when production might begin to decline.

Similarly, for bee colonies, if the number initially increases but then decreases due to bee mortality (e.g., the colony collapse disorder phenomenon), quadratic regression can help quantify the rate of decline and estimate the critical point.

By extrapolating into the coming years, scenarios regarding the evolution of the beekeeping sector can be created, aiding in informed decision-making for agricultural policies or economic interventions.

Quadratic regression is, therefore, a valuable tool for understanding and predicting the evolution of the beekeeping sector in the context of complex trends.

RESULTS AND DISCUSSIONS

Evolution of the number of bee families, honey production, and international honey trade balance at the global level and in some EU countries.

Despite the numerous challenges facing the sector (climate change, pesticide use, and habitat loss) and warnings about their effects on colony trends (IPBES, 2019) [17], the number of bee colonies increased in all regions between 2010 and 2022 (Table 1).

With higher growth rates compared to the global average, recorded in Oceania and Europe, their share improved relative to 2022, driven by a decline in the share held by Africa and America. Asia and Europe together account for approximately 70% of the world's bee families.

Table 1. Evolution of the number of bee colonies in the EU and on the continents during the period 2010-2022

Year	MU	UE27	Africa	America	Asia	Europe	Oceania	Worldwide
2010	mil bee col.	12.35	16.08	11.02	35.93	16.85	0.76	80.65
2011	mil bee col.	12.76	15.92	10.95	36.56	17.28	0.69	81.40
2012	mil bee col.	13.02	16.62	10.93	37.73	18.11	0.71	84.10
2013	mil bee col.	13.12	16.42	11.12	39.15	18.27	1.01	85.97
2014	mil bee col.	13.76	16.80	11.28	40.52	19.01	1.06	88.66
2015	mil bee col.	14.14	16.94	11.32	41.70	19.66	1.04	90.66
2016	mil bee col.	14.67	17.14	11.25	41.99	20.23	1.19	91.80
2017	mil bee col.	15.14	17.70	11.15	42.17	20.63	1.40	93.05
2018	mil bee col.	16.91	18.31	11.61	42.65	22.34	1.58	96.50
2019	mil bee col.	17.67	17.93	11.66	43.38	23.29	1.65	97.91
2020	mil bee col.	18.58	18.08	11.55	43.75	24.04	1.46	98.88
2021	mil bee col.	19.67	17.17	11.67	44.67	24.90	1.43	99.85
2022	mil bee col.	19.88	17.46	11.71	45.34	25.12	1.36	101.00
2022 Vs 2010	mil bee col.	7.53	1.38	0.69	9.41	8.27	0.60	20.35
	%	161.0	108.6	106.3	126.2	149.1	178.1	125.2
Annual rhythm	%	4.05	0.69	0.51	1.96	3.38	4.93	1.89
2022 structure	%	19.68	17.29	11.59	44.89	24.87	1.35	100

Source: FAOSTAT, 2024, <https://www.fao.org/faostat/fr/#data/QCL> [15].

From Table 1, it can be observed that globally, the number of bee colonies increased by over 20.35% between 2010 and 2022. The dominant continent in terms of the number of bee colonies is Asia, followed by Europe, Africa, and America, a hierarchy that remained consistent throughout the analyzed period

(Figure 1). Interestingly, in Oceania, although the number of bee colonies is much smaller due to unfavorable climatic conditions, the number of colonies increased by 78.1% from 2010 to 2022. Europe also experienced significant growth, with an increase of 49.1% in 2022 compared to 2010.

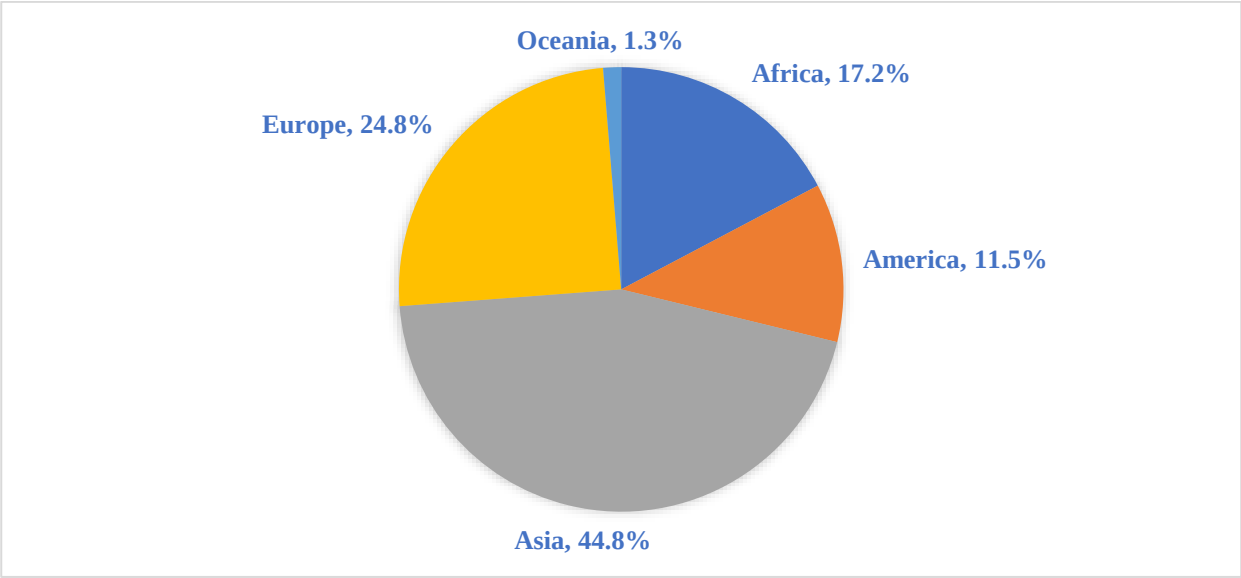


Fig. 1. Share of the bee colonies' number by continents in 2022 (%)

Source: FAOSTAT, 2024, <https://www.fao.org/faostat/fr/#data/QCL> [15].

According to FAO data, global honey production increased from 1.4 million tons in 2000 to over 1.9 million tons in 2023. Asia (China, India, Turkey) dominates global production, followed by Europe and South America (FAO Reports on Apiculture, 2023) [14]. The highest production is recorded in Asia, accounting for approximately 49% of global

production, with a significant increase (27.9%) during the analyzed period. Asia is also the only continent where increases in average honey production per bee colony were recorded during the same period (Table 2). In Europe and the EU, although some of the highest growth rates in bee colony numbers were recorded during the analyzed period, this trend is not fully reflected in honey production.

The average yield per bee colony decreased during the period analyzed (Table 3).

Table 2. Evolution of honey production in the EU and continents during the period 2010-2021

Year	MU	EU 27	Africa	America	Asia	Europe	Oceania	Worldwide
2010	Th. to	202	167	362	678	353	28	1587
2011	Th. to	217	156	373	732	376	20	1657
2012	Th. to	186	166	381	773	350	23	1692
2013	Th. to	203	169	363	787	378	32	1730
2014	Th. to	202	194	354	816	373	32	1769
2015	Th. to	250	214	320	832	424	33	1824
2016	Th. to	224	199	335	910	387	33	1863
2017	Th. to	239	184	334	914	406	27	1866
2018	Th. to	246	191	357	829	424	32	1834
2019	Th. to	228	150	350	825	397	37	1759
2020	Th. to	230	152	339	840	404	40	1775
2021	Th. to	216	152	346	867	384	33	1781
Average	Th. to	220	175	351	817	388	31	1761
	Th. to	14	-15	-16	189	31	5	194
2021 vs 2010	%	106.9	91.0	95.6	127.9	108.8	117.9	112.2
Annual rhythm	%	0.6	-0.9	-0.4	2.3	0.8	1.5	1.1
2021 Structure	%	12.13	8.53	19.43	48.68	21.56	1.85	100.00

Source: FAOSTAT, 2024, <https://www.fao.org/faostat/fr/#data/FBS> [15].

The continents of Africa and America recorded declines in honey production during the analyzed period. However, overall, global honey production increased by 12.2% during the analyzed interval.

An increase in the number of bee colonies does not automatically guarantee a proportional increase in honey production. While the number of colonies may grow, honey production can be affected by external factors such as climate, pollution, bee health, and the availability of food sources (flowers and plants). For example, during periods of drought or unfavorable weather conditions, even if the number of bee colonies increases, honey production may remain constant or even decrease (FAO, 2018) [11].

A bee colony can produce less honey in a year, even if the total number of colonies increases. Factors influencing efficiency include bee health, diseases, and parasites that affect productivity. In a study by Brodschneider and Crailsheim (2010), it was demonstrated that poor bee health can significantly reduce the amount of honey produced [6].

Moreover, bees are not always active in honey production throughout the year (especially in areas with cold winters), which can limit annual honey production, even if the bee population grows.

Honey production is also influenced by economic conditions and the demand for honey

in the market. Even if the number of bee colonies increases, this does not immediately translate into a corresponding increase in honey production. For instance, honey prices can fluctuate, and beekeepers may choose to sell honey at higher prices or focus on other factors, such as increasing bee colonies to support crop pollination.

In certain regions (e.g., Europe or America), despite an increase in the number of bee colonies, honey production has not grown at the same pace due to factors such as climate change, pollution, or agricultural practices that reduce the availability of nectar for bees.

Table 3 reveals a significant decline in honey production per bee colony in Europe and Oceania, where the percentage decreases are the most pronounced. Conversely, regions in America and Asia experienced more stable trends with moderate increases.

Africa recorded a greater increase in honey production per bee colony, although levels remain below those of other regions.

China is the largest honey exporter, while the United States and the European Union are the main importers.

The global honey market reached a value of USD 9.3 billion in 2023, according to a Bee Culture report (2023) [4].

Table 3. Evolution of honey production per bee colony in the EU and on continents during the period 2010-2021

Year	MU	EU27	Africa	America	Asia	Europe	Oceania	Worldwide
2010	kg	16.4	10.4	32.8	18.9	20.9	36.8	19.7
2011	kg	17.0	9.8	34.1	20.0	21.8	29.0	20.4
2012	kg	14.3	10.0	34.9	20.5	19.3	32.4	20.1
2013	kg	15.5	10.3	32.6	20.1	20.7	31.7	20.1
2014	kg	14.7	11.5	31.4	20.1	19.6	30.2	20.0
2015	kg	17.7	12.6	28.3	20.0	21.6	31.7	20.1
2016	kg	15.3	11.6	29.8	21.7	19.1	27.7	20.3
2017	kg	15.8	10.4	30.0	21.7	19.7	19.3	20.1
2018	kg	14.5	10.4	30.7	19.4	19.0	20.3	19.0
2019	kg	12.9	8.4	30.0	19.0	17.0	22.4	18.0
2020	kg	12.4	8.4	29.4	19.2	16.8	27.4	18.0
2021	kg	11.0	8.9	29.6	19.4	15.4	23.1	17.8
2021 vs 2010	%	67.1	85.2	90.3	102.9	73.6	62.6	90.6

Source: Own calculation based on data from FAOSTAT, 2024, <https://www.fao.org/faostat/fr/#data/FBS> [15].

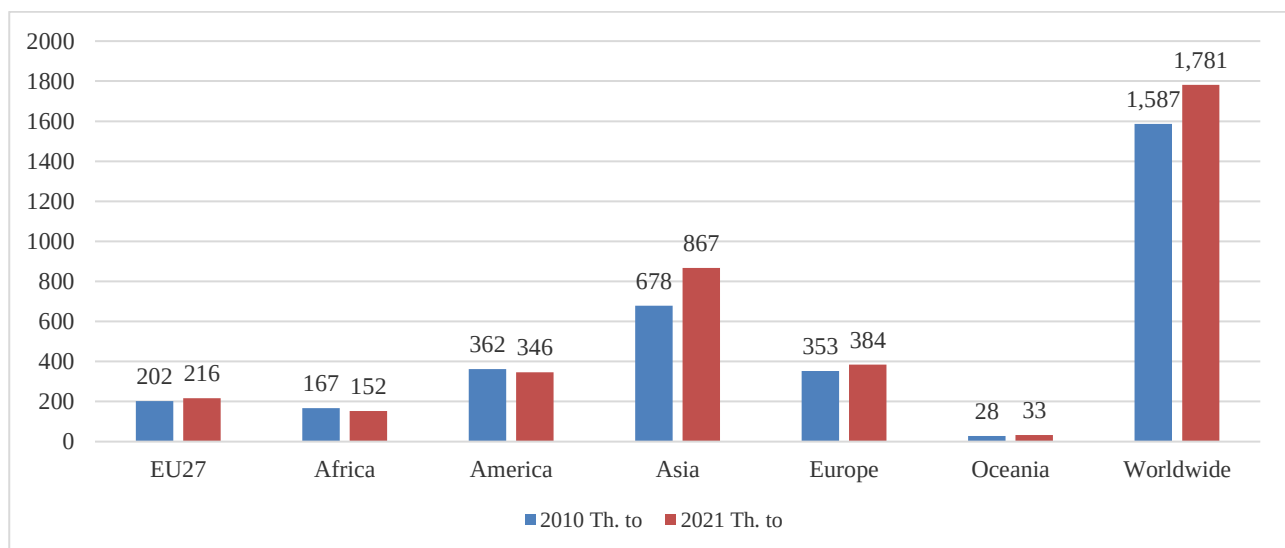


Fig. 2. Evolution of honey production in the EU and on continents, 2010 and 2021

Source: FAOSTAT, 2024, <https://www.fao.org/faostat/fr/#data/FBS> [15].

Regarding the balance of honey trade and its evolution during 2010–2021, the balance was negative throughout the analyzed period for

Europe (average of -124.7 thousand tons) and Africa (-6.8 thousand tons).

Table 4. Evolution of the international honey trade balance in the EU27 and on continents during the period 2010-2021

Year	MU	EU 27	Africa	America	Asia	Europe	Oceania
2010	Th. to	-99	-3	34	71	-136	10
2011	Th. to	-104	-3	35	83	-139	7
2012	Th. to	-101	-7	32	87	-128	8
2013	Th. to	-109	-5	7	106	-129	11
2014	Th. to	-119	-7	-8	127	-123	6
2015	Th. to	-131	-5	-21	148	-134	5
2016	Th. to	-128	-7	11	103	-109	4
2017	Th. to	-143	-8	-34	126	-118	4
2018	Th. to	-141	-9	-1	124	-140	5
2019	Th. to	-131	-7	-36	120	-122	7
2020	Th. to	-132	-10	-22	131	-101	9
2021	Th. to	-132	-11	-58	195	-117	9
Average	Th. to	-122.5	-6.8	-5.1	118.4	-124.7	7.1
2021 vs 2010	Th. to	-33.0	-8.0	-92.0	124.0	19.0	-1.0

Source: FAOSTAT, 2024, <https://www.fao.org/faostat/fr/#data/FBS>, [15].

In America, the trade balance was positive in the initial years of the analysis but turned

negative in 2017 (average of -5.1 thousand tons) (Table 4).

Oceania (average of +7 thousand tons) shows a positive balance, while Asia is the continent

with an average of +118.4 thousand tons, increasing from 71 thousand tons in 2010 to 195 thousand tons in 2021 (Table 4, Fig. 3).

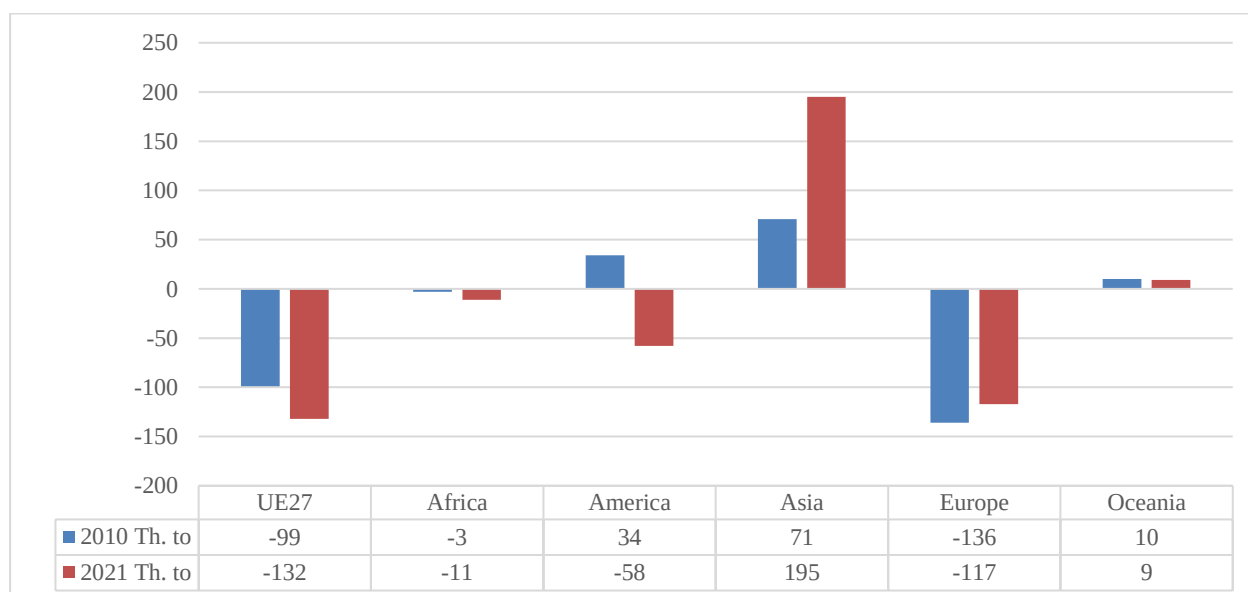


Fig. 3. The difference in the international honey trade balance in EU27 and continents between year 2010 and year 2021

Source: FAOSTAT, 2024, <https://www.fao.org/faostat/fr/#data/FBS>, [15].

The differences in honey trade balances between 2010 and 2021 are illustrated in Figure 3.

Asia's dominance in honey trade is well-documented (Market Research Future, 2021) [22], driven by economic, geographical, and cultural factors. Asia, particularly China, India, Turkey, and other regional countries, plays a major role in global honey production and exports due to unique advantages (FAO, 2020) [12].

For example, China, the leading honey exporter, produces vast quantities at relatively low costs due to diverse climates, abundant natural resources, and inexpensive labor. According to the Food and Agriculture Organization of the United Nations (FAO), China contributes over 20% of global production. Other Asian countries, like India and Turkey, have developed large-scale beekeeping practices, combining modern technologies with traditional methods (FAO Reports on Apiculture, 2021) [15]. Another contributing factor to Asia's surplus trade balance is the variety of ecosystems that support diverse honey production, including rare and sought-after varieties. For example,

Asia's vast monocultures (e.g., rapeseed or sunflower fields) support intensive beekeeping focused on efficiency.

Although there are frequent criticisms of the quality of honey produced in some Asian regions, particularly accusations of adulteration or the addition of syrups, and Mouriquand (2023) [21] note that European and American markets have imposed restrictive measures to limit imports of Asian honey. Despite this, its competitive prices remain attractive. Eva Crane, in her work *The World History of Beekeeping and Honey Hunting* (1999), emphasizes Asia's long-standing beekeeping traditions and their impact on global markets. According to Honey Market Reports (2023), exports from Asia have continued to grow despite stringent regulations in Europe and North America [16].

The commercial strategy of Asian countries, which includes the export of not only raw honey but also processed apiculture products such as pollen, propolis, and beeswax, also explains their strong position in international markets.

Evolution of honey consumption worldwide and in certain European Union countries

Honey consumption per capita varies significantly across continents and countries, influenced by factors such as cultural traditions, the accessibility of apiculture products and dietary habits. As shown in Table 5, some of the highest per capita consumption levels have been recorded in Africa, Europe,

and Oceania. Asia, on the other hand, registers the lowest per capita honey consumption. Analyzing the averages over two periods, there are noticeable negative declines in some regions, contrasted with significant positive growth in others, particularly in America (Figure 4).

Table 5. Evolution of honey consumption per capita by continents, during the periods 2010-2014 and 2015-2021

Area/MU	2010	2014	Average 2010-2014		St Dev	Rhythm	2015	2021	Average 2015-2021		St Dev	Rhythm	Average 2015-2021 vs Average 2010-2014		
	kg/cap/year	kg/cap/year	kg/cap/year	TOP	kg/cap/year	%	kg/cap/year	kg/cap/year	kg/cap/year	TOP	kg/cap/year	%	kg/cap/year n	%	Signific.
Africa	1.49	1.47	1.370	1	0.103	-0.3	1.56	0.98	1.21	1	0.224	-7.5	-0.260	113.2	***
America	0.34	0.31	0.340	4	0.017	-2.3	0.3	0.37	0.32	4	0.029	3.6	0.010	106.3	***
Asia	0.14	0.15	0.150	5	0.005	1.7	0.15	0.14	0.15	5	0.010	-1.1	0.000	100.0	000
Europe	0.63	0.62	0.640	2	0.018	-0.4	0.63	0.58	0.6	2	0.021	-1.4	-0.020	106.7	000
Oceania	0.62	0.62	0.600	3	0.025	0	0.62	0.58	0.6	3	0.045	-1.1	-0.020	100.0	000

Source: FAOSTAT, 2024, <https://www.fao.org/faostat/fr/#data/QCL> [15].

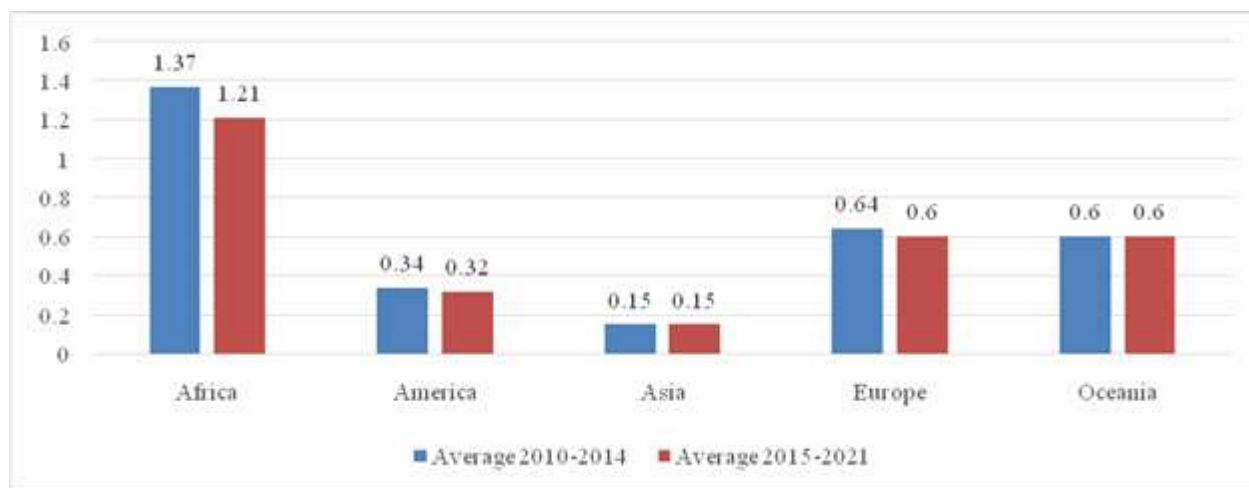


Fig. 4. Average honey consumption (kg) per capita by continents during the periods 2010-2014 and 2015-2021

Source: FAOSTAT, 2024, <https://www.fao.org/faostat/fr/#data/QCL> [15].

Table 6. Evolution of honey consumption per capita in some European Union countries during the periods 2010-2014 and 2015-2021

Area/MU	2010	2014	Average 2010-2014		Stdev	Annual rhythm	2015	2021	Average 2015-2021		Stdev	Annual rhythm	Average 2015-2021 vs Average 2010-2014		
	kg/cap/year	kg/cap/year	kg/cap/year	TOP	kg/cap/year	%	kg/cap/year	kg/cap/year	kg/cap/year	TOP	kg/cap/year	%	kg/cap/year	%	Signific.
UE	0.64	0.65	0.64	7	0.022	0.4	0.68	0.66	0.67	8	0.018	-0.5	0.02	95.5	***
Austria	1.15	1.25	1.18	1	0.042	2.1	1.12	1.1	1.09	1	0.094	-0.3	-0.16	108.3	00
Belgium	0.59	0.63	0.62	8	0.017	1.7	0.63	1.03	0.62	10	0.194	8.5	-0.01	100.0	N
Bulgaria	0.23	0	0.08	13	0.102	-43.5	0.13	0.48	0.15	12	0.154	24.3	0.15	53.3	**
Germany	1.13	1.02	1.04	3	0.059	-2.5	1.02	0.81	0.99	2	0.085	-3.8	-0.03	105.1	***
Finland	0.51	0.51	0.51	11	0.002	0	0.51	0.9	0.63	9	0.163	9.9	0.12	81.0	N
France	0.59	0.61	0.58	10	0.026	0.8	0.67	0.59	0.68	6	0.074	-2.1	0.07	85.3	**
Poland	0.12	0.11	0.12	12	0.004	-2.2	0.11	0.28	0.13	13	0.064	16.8	0.02	92.3	N
Romania	0.57	0.6	0.62	9	0.049	1.3	0.8	0.79	0.8	5	0.041	-0.2	0.20	77.5	***
Slovenia	1.19	1.04	1.15	2	0.301	-3.3	1.18	0.92	0.98	3	0.182	-4.1	-0.06	117.3	000
Slovakia	0.86	0.86	0.86	4	0.003	0	0.86	0.64	0.86	4	0.108	-4.8	0.00	100.0	N
Spain	0.66	0.7	0.69	6	0.053	1.5	0.71	0.62	0.68	7	0.057	-2.2	-0.02	101.5	000
Sweden	0.75	0.8	0.79	5	0.033	1.6	0.8	0.34	0.6	11	0.202	-13.3	-0.20	131.7	N

FAOSTAT, 2024, <https://www.fao.org/faostat/fr/#data/QCL> [15].

There is a great diversity in honey consumption patterns across European Union countries (as shown in Table 6).

Austria holds the top spot for honey consumption per capita, with an average of 1.18 kg per capita during the 2010–2014 period, followed by a significant decrease to 1.1 kg per capita in the 2015–2021 period, representing an annual decline of -0.3%.

Germany, close behind Austria, ranked third during the first period and rose to second place during 2015–2021, with an average consumption of 0.99 kg per capita.

Romania ranked ninth during the first period but rose to fifth place during the second, with an average consumption of 0.8 kg per capita. Poland and Bulgaria consistently recorded the lowest honey consumption per capita in both periods (Fig. 5).

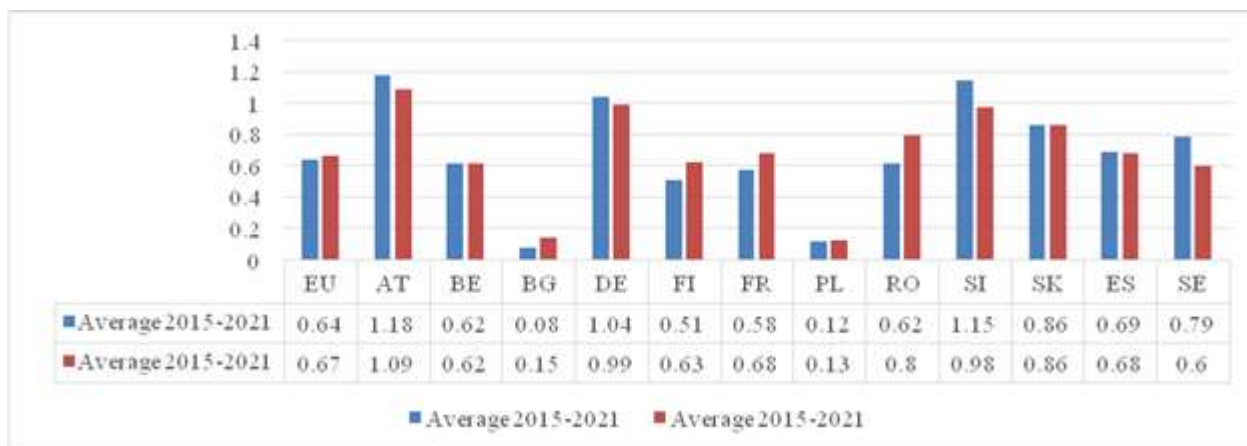


Fig. 5. Average honey consumption (kg) per capita in some European Union countries during the periods 2010–2014 and 2015–2021

Source: FAOSTAT, 2024, <https://www.fao.org/faostat/fr/#data/QCL> [15].

Determining trends in beekeeping indicators and projections for 2023–2030

The trend in the growth of bee colonies worldwide was calculated using the equation:

$$Y(\text{global bee colonies}) = -0.0441x^2 + 2.416x + 77.437 \quad (R^2 = 0.993, r = 0.996) \quad (\text{Fig. 6}).$$

Globally, based on projections using the second-degree trend equation, the adjusted average number of bee colonies is expected to reach 108.7 million by 2030, compared to 80.6 million in 2010. This projection is bounded by a 95% confidence interval, with a lower limit of 104.4 million colonies and an upper limit of 113 million colonies.

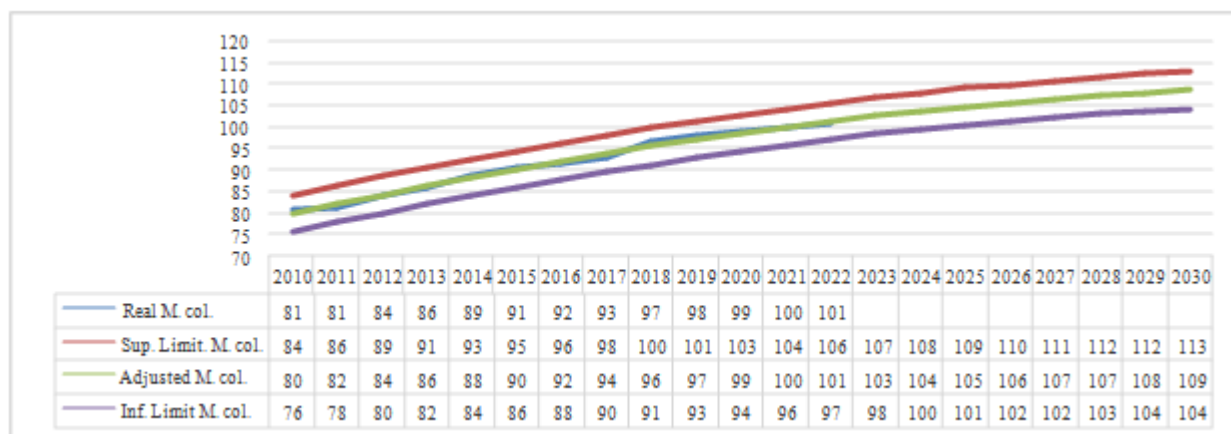


Fig. 6. The trend in the number of bee colonies, worldwide during the period 2023–2030 and the 95% confidence limits ($t = 2.17$; $DL = 12$)

Source: Own calculations.

Trend in the Growth of Bee Colonies within the EU-27 was calculated using the equation:

$$Y(\text{EU bee colonies}) = 0.0411x^2 + 0.1006x + 12.221 \quad (R^2=0.985, r=0.992) \quad (\text{Fig. 7}).$$

The trend in the number of bee colonies within the European Union (EU-27) was calculated, showing significant growth projected between 2023 and 2030. By 2030, the number of colonies is expected to reach 34.1 million, with confidence limits ranging from 30.3 million to 32.5 million colonies.

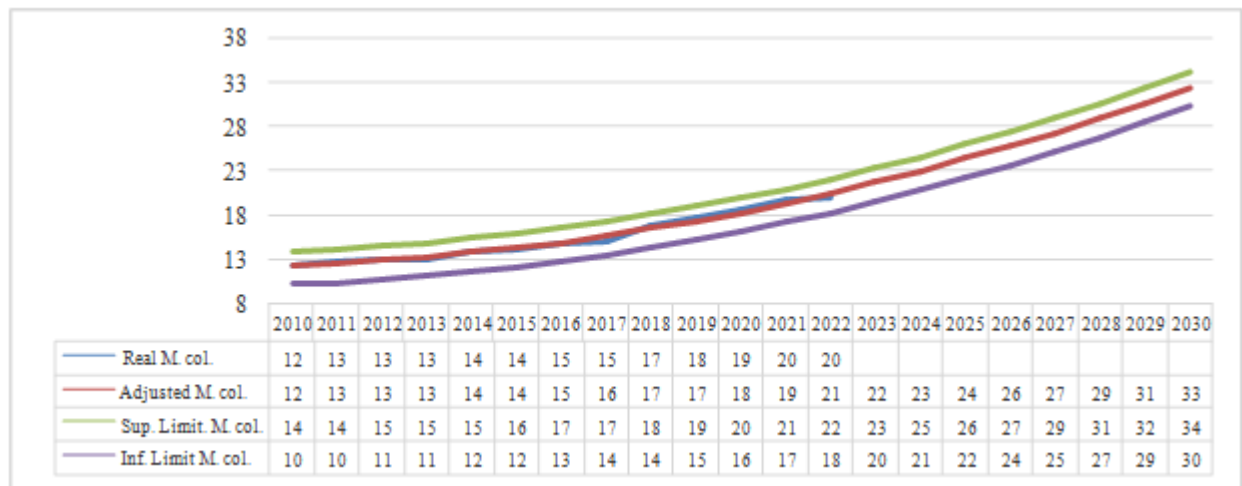


Fig. 7. The trend in the number of bee colonies in the European Union during the period 2023–2030 and the 95% confidence limit
Source: Own calculations ($t = 2.17$; $DL = 12$).

Projection of Annual Honey Consumption per Capita in the EU

At the European Union level, the projected annual honey consumption per person, based on the trend given by the regression equation:

$$Y(\text{kg/person/year}) = -0.0002x^2 + 0.0066x + 0.6289 \quad (R^2 = 0.3322, r = 0.576)$$

It will range between 0.68 kg/person/year and 0.71 kg/person/year, with a 95% probability. This indicates a stagnation compared to the year 2021 (Fig. 8).

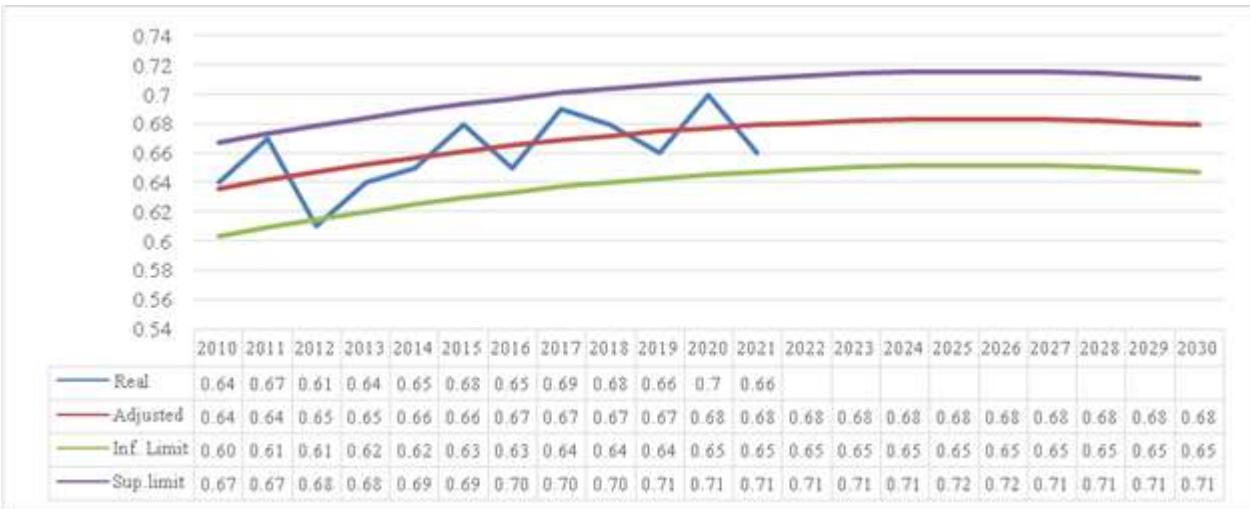


Fig. 8. The trend of the honey consumption per capita in the European Union during the period 2023–2030 and the 95% confidence limits
Source: Own calculations ($t = 2.17$; $DL = 12$)

Programs and development directions for beekeeping at the European and Romanian levels

Programs supporting the development of beekeeping

In EU member states, the beekeeping sector has been supported through the instruments of the Common Agricultural Policy (CAP) since the second half of the 1990s. Until the end of 2022, this support was implemented through voluntary National Apiculture Programs [23], developed and executed by each EU member state. Starting January 1, 2023, beekeeping support is provided through sectoral interventions, a component of the CAP Strategic Plans for the 2023–2027 period. These plans are designed at the national level and define how each EU country will direct support to achieve the economic, environmental, and social objectives of the CAP.

According to EU Regulation 2021/2115, seven types of interventions are available to member states, funded by the European Agricultural Guarantee Fund (EAGF). Member states select the most suitable interventions based on the specific characteristics of their national beekeeping sector.

a) Beekeeping Sectoral Plan in Romania's National Strategic Plan

For the 2023–2027 period, Romania's National Strategic Plan for the beekeeping sector includes the following measures:

- Advisory services, technical assistance, training, information dissemination and the exchange of best practices;
- Acquisition of equipment by associative organizations for wax processing to produce artificial combs, as well as equipment for honey packaging;
- Combating hive pests and diseases, especially varroosis;
- Rationalization of transhumance;
- Repopulation of hives, including bee improvement programs;
- Support actions for apiculture product testing laboratories, aimed at reimbursing physical-chemical and residue analyses to certify honey quality—this serves as a protective measure against the recent influx of low-quality honey imports;

0Promotion, communication, and marketing, including market monitoring activities.

Each EU member state benefits from specific funds for implementing these measures, and projects are monitored at the national level to ensure their efficiency and impact (European Commission, 2022) [10]. For the 2023–2027 period, the total amount allocated to the Romanian beekeeping sector through these interventions is estimated at €60,816,300 (National Strategic Plan 2023–2027).

b) In addition to the support provided under CAP Pillar I, complementary measures funded through the European Agricultural Fund for Rural Development (EAFRD) under Pillar II aim to strengthen beekeeping operations.

These include:

- Investments for small-scale agricultural holdings practicing beekeeping;
- Establishment and strengthening of operations run by young farmers in the beekeeping sector;
- Investments to develop livestock farms, where beekeeping subsector investments are eligible;
- Investments in processing, conditioning, and storage of agricultural products;
- Establishment of producer groups.

c) Research and Innovation Projects

The European Union funds research projects in the field of beekeeping, aimed at:

- Bee health and disease prevention.
- Development of innovative technologies for hive monitoring and production improvement.
- Studies on the impact of climate change on bees and pollinators.

These research projects are implemented through programs such as Horizon Europe, which support innovation and the sustainable growth of the beekeeping sector (FAO, 2021) [14].

2. National Beekeeping Development Programs

a) The National Beekeeping Program (PNA) in Romania was established in 2008 as part of a broader plan to support the national beekeeping sector. Over the years, the program has been adjusted and expanded, and since 2021, the measures and funds allocated for beekeeping have been included in the National Strategic Plan (PNS) for the 2023–2027 period [23].

The PNS includes support measures and subsidies for beekeepers:

- Support for improving bee colony health and disease control.
- Subsidies for organic beekeeping and best beekeeping practices.
- Investments in beekeeping equipment and infrastructure.
- Continuous professional training for beekeepers.

These measures aim to strengthen Romania's beekeeping sector, increase competitiveness, and protect the environment (Ministry of Agriculture and Rural Development, 2023) [23].

b) Subsidies for Bees and Pollinators' protection

Under its national environmental policy, Romania has implemented support measures for pollinators' protection, including bees' protection. These measures include:

- Promoting the use of bee-friendly pesticides.
- Creating protected habitats for pollinators as part of national environmental and rural development programs.

These initiatives are essential for preserving biodiversity and ensuring sustainable agricultural production (Ministry of Environment, 2022) [24].

Development Directions

Apiculture is undergoing continuous development, with its future shaped by the need to address global challenges while leveraging the economic and ecological opportunities of the sector. At both European and national levels, clear trends and strategies are emerging, focusing on modernization, sustainability, and increased efficiency in beekeeping.

The European Union is concerned with both beekeeping and the marketing of honey. Article 55 of Regulation (EU) No. 1308/2013 stipulates that each member state must have a national program covering up to 50% of hive-related expenses. Directive (EU) 2024/1438 introduces strict requirements for honey labeling, mandating the clear specification of both the floral and geographical origin of honey to increase transparency for consumers [9]. This directive amends Directive 2001/110/EC to combat the practice of

blending honey from various sources without proper disclosure. Efforts are also underway to harmonize regulations across the EU, ensuring better protection for local producers. At the same time, Regulation (EU) 2017/625 establishes measures to control and combat honey adulteration by producers within and outside the EU. Additionally, a platform has been launched to exchange data on bee health (CAgr, 2024)[7].

Considering the role of beekeeping in economic sustainability and biodiversity, development proposals aim to strengthen the sector's resilience and competitiveness at both European and Romanian levels.

Development of sustainable and organic beekeeping. There is a growing demand for organic beekeeping products in Europe, making organic apiculture a significant opportunity. The European Union supports this type of beekeeping through funding and regulations promoting sustainable production methods (e.g., initiatives like the *EU Pollinators Initiative*) (European Commission, 2022) [10]. European beekeepers are encouraged through integrated measures to adopt practices that minimize environmental impact, avoid pesticide use, and protect local biodiversity. Thus, stimulating the acquisition of modern equipment, certified organic beehives, identifying and protecting regions with high biodiversity, creating a national brand for Romanian organic honey, promoting the benefits of organic honey to consumers, etc. would support organic production and contribute to raising beekeepers' awareness of this market opportunity.

Certification of organic beekeeping products is becoming increasingly important. Financial support measures to cover costs associated with organic certification, including inspections and required documentation, as well as simplifying the certification process, would encourage more beekeepers to adopt organic practices. This would provide beekeepers with the opportunity to access broader international markets with higher prices for organic products (Kumar et al., 2024) [20].

Digitalization and innovation in beekeeping. Modern beekeeping increasingly relies on

digital technology. Across Europe, many beekeepers are adopting hive monitoring systems, which include sensors for temperature, humidity, and bee movement. These technologies enable beekeepers to monitor hive health and respond quickly to problems. Research projects, such as “BeeProtect”, exemplify the implementation of smart technologies in apiculture (Bee Culture, 2023) [4]. Investment support measures in beekeeping that encourage the adoption of IoT devices, artificial intelligence systems, big data, blockchain, remote sensing, and mobile applications would provide Romanian beekeepers with the tools needed to improve efficiency and competitiveness, both locally and internationally.

The automation of honey harvesting and other apicultural processes reduces costs and increases efficiency. The use of modern equipment, such as automatic centrifuges and machines for wax extraction, is growing. These innovations enable beekeepers to enhance their productivity and improve the quality of their products.

Professional training and apicultural education. In Europe, many countries offer training and education programs for beekeepers. These programs should focus on adapting to modern technologies, utilizing digital tools and implementing sustainable beekeeping practices to address ecological and economic challenges. Additionally, supporting apicultural education initiatives to prepare beekeepers to tackle climate change and other risks is vital (European Commission, 2022) [10].

Support for apicultural research is another crucial aspect of the sector's development. The European Union funds research projects aimed at improving bee health, the quality of apicultural products, and pollination methodologies. The participation of beekeepers' associations alongside universities and research institutions in such initiatives is essential for identifying practical solutions to challenges such as diseases and the decline in bee populations (FAO, 2021) [13].

Market development for apicultural products. At both European and global levels, there is growing interest in high-quality honey

and apicultural products with proven health benefits, such as royal jelly and propolis. Romania has significant potential to become an important exporter of organic honey and other apicultural products to international markets. These products are increasingly valued for their health benefits and are in high demand, especially in markets such as Asia and North America (Bee Culture, 2023) [4].

Within the European context, beekeepers are encouraged to invest in marketing their products by promoting the unique characteristics of honey and other apicultural goods (e.g., promoting honey and apicultural products with protected geographical indication (PGI)). Increasing visibility in international markets and educating consumers about the benefits of these products is essential for boosting demand (Kumar et al., 2024) [19].
Sustainability, bee protection, and diversity. The European Union has implemented policies to reduce the use of harmful pesticides and support initiatives to conserve bees' natural habitats. These measures include ecological protection zones and awareness programs for both beekeepers and farmers (FAO, 2021) [14].

Another important direction for the development of apiculture is the promotion of diversity in beekeeping practices. Romania has immense resource potential that could be harnessed through integrated measures to encourage: expanding the range of products (e.g., propolis, royal jelly, wax, pollen, and bee venom), developing innovative, high-value-added products (e.g., dietary supplements, natural cosmetics), protecting and conserving local genetics, as well as integrating beekeeping with other agricultural activities, such as agritourism, diversifying beekeeping practices and promoting more resilient bee species can help maintain hive health and reduce risks associated with diseases and climate change (IPBES, 2019) [17].

The development directions of beekeeping are oriented towards sustainability, innovation and environmental protection. In Europe and in Romania, beekeeping can benefit from support through favorable European policies, education and continuous training, and beekeepers can exploit modern technologies to

improve production and access wider external markets. It is essential that the beekeeping sector responds to global challenges and contributes to sustainable development, while protecting biodiversity and supporting local economies.

CONCLUSIONS

Beekeeping significantly contributes to agricultural production through pollination, which is estimated to be worth over \$200 billion annually. It supports ecosystem stability and rural economies, playing a strategic role in food production and biodiversity conservation. Analyses indicate a global increase in the number of bee colonies and honey production, although there are regional variations. Asia leads both in production and exports due to floral diversity and favorable economic conditions, supported by low per capita honey consumption. In Europe, steady growth is observed, largely due to legislative support.

Stress factors such as climate change, habitat loss, pesticide use, and diseases affect bee health. Approximately 40% of pollinator species are threatened, necessitating targeted support policies.

Directive (EU) 2024/1438 introduces strict standards for honey labeling, requiring the disclosure of floral and geographical origins. Additionally, national and European programs support bee health, organic beekeeping, and technological innovation, including the digital monitoring of hives.

By 2030, trend models predict a continuous increase in the number of bee colonies and honey production, while per capita consumption in the European Union will stagnate. This stabilization highlights the need for market diversification and the promotion of apicultural products.

The integration of organic beekeeping, digitalization of operations and continuous beekeeper training are necessary. Establishing a strong legislative framework and educating consumers about the benefits of apicultural products are priorities for ensuring sustainability.

The analysis shows the need for an integrated approach to protect bees, modernize

beekeeping and respond to global challenges. Legislative support and technological innovation will be essential to increase the sustainability and competitiveness of the beekeeping sector.

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