RESEARCH INSTITUTE FOR AGRICULTURE
ECONOMY AND RURAL DEVELOPMENT
Bucharest, Romania

INTERNATIONALSYMPOSIUM AGRICULTURE ECONOMY AND RURAL DEVELOPMENT – TRENDS AND CHALLENGES

"Agriculture and rural economy between tradition, innovation and sustainability"

16th Edition

November 2025
Bucharest

ISSN 2972-1741
ISSN – L 2972-1741
To be cited: Scientific papers "Agriculture Economy and Rural Development – Trends and Challenges", Volume 16, Issue 2025

RESEARCH INSTITUTE FOR AGRICULTURE ECONOMY AND RURAL DEVELOPMENT

in collaboration with:
INSTITUTE FOR AGRICULTURAL ECONOMICS, ROMANIAN ACADEMY, BUCHAREST, ROMANIA

NATIONAL INSTITUTE FOR ECONOMICS RESEARCH, ACADEMY OF SCIENCE, CHISINAU, REPUBLIC OF MOLDOVA

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CONTENT

THE RELEVANCE OF THE ACTIVITY OF THE AGROPENSION "VINĂRIA POIANA" IN THE DEVELOPMENT OF WINE TOURISM IN THE REPUBLIC OF MOLDOVA

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Abstract: *At the current stage of economic globalization and the development of the world economic system, the tourism sector is one of the most promising, perspective, very profitable and dynamic in its development. The Republic of Moldova is a country with a developed wine industry, being considered one of the leaders in this field. Moldovan wines, divins (brandy), sparkling wines have won gold, silver and bronze medals at the most prestigious international competitions and exhibitions. All these factors formed the basis for the development of wine tourism in the Republic of Moldova. The essence of wine tourism is familiarization with the production, consumption traditions, tasting and purchasing wines directly from the producer, at the winery. A characteristic feature of wine tourism is that it is not limited to wine consumption, but also has its own multiplier effect. Thus, winemakers and restaurant owners offer tourists not only visits to wineries and wine tasting, but also food services, accommodation, purchase of souvenirs (most often related to grapes and wine) and various food products. The study focused on the assessment and analysis of the level of development of tourist services provided by the agro-pension "Vinăria Poiana", the assessment and analysis of the number of tourists/visitors in the period 2019-2024, as well as the development of the questionnaire and the conduct of an opinion poll among tourists.*

Keywords: *agritourism, winery, wine management, tourist services*

JEL classification: Z320

INTRODUCTION

Tourism occupies a leading position in international economic relations and is recognized as one of the fastest growing and most profitable sectors of the world economy. This branch accounts for approximately 30% of world trade in services and 10% of world gross domestic product, which makes it one of the leading sectors of the global economy. In the Republic of Moldova, tourism has become a key factor for socio-economic progress.

The Republic of Moldova is a country with a developed wine industry, being considered one of the leaders in this field, exporting its wines to over 60 countries around the world. The successful combination of tourism and the wine industry, according to the study conducted by Bounce's Wine Lover's Index 2023, in 2023 allowed it to hold 2nd place in the top 10 world countries in the field of wine tourism. Wines and traditional local cuisine act as decisive factors in forming the core of tourist destinations and attracting visitors. In the National Tourism Development Program "Tourism 2025" (610/2020) and the National Tourism Development Program "Tourism-2028" this type of tourism is part of the priority projects, for which it is expected to attract investors, with full government support. (PNDT-2025), (PNDT -2028). The characteristics and development opportunities of wine tourism constitute a trigger for the development of the tourism cluster, which includes tourism infrastructure, training organizations, educational and research institutions, which involves the promotion and innovative development of the territory as a whole. In our country, the development of wine tourism clusters is in its early stages.

Since 2020, the “Moldova Wine Route” has become part of the Iter Vitis network, offering authentic wine experiences and wine tourism itineraries that encourage tourists to discover the precious elements of the old European wine culture, but also the vibrant revival of wine traditions, supported by a new generation of winemakers. The wine routes of the “Moldova Wine Route” offer guests the opportunity to explore the land of 28 wine producers, of which 11 are small wineries, 2 are world-renowned underground cellars and 15 famous wineries. The route is constantly developing, always adding new wineries and wine tourism experiences. (Government Decision No. 554/2004)

A component part of the “Moldova Wine Route” is the “Codru” wine region, located in the central part of Moldova, occupying an area of about 60 thousand hectares. It is a region with a protected geographical indication (PGI) "Codru". The route of the "Codru" region includes 14 wineries and wineries, including the "Vinăria Poiana" agri-pension. (Gaina B., 2004)

MATERIAL AND METHODS

The study focused on the evaluation and analysis of the level of development of tourist services provided by the "Vinăria Poiana" agri-pension, the evaluation and analysis of the number of tourists/visitors during the period 2019-2024, as well as the development of the questionnaire and the conduct of an opinion poll among tourists.

RESULTS AND DISSCUSION

The agro-pension "Vinăria Poiana" is a private property located in the middle of the Codri in the heart of Moldova. The motto of the agro-pension "Vinăria Poiana" is "We maximize the potential that grapes give us naturally. The wine of "Vinăria Poiana" is taste and passion." (Vinăria Poiana).

The wines are obtained from grapes carefully selected by hand from internationally known varieties: Cabernet Sauvignon, Merlot, Chardonnay, Sauvignon Blanc, Traminer, Pinot Gris, Aligote, Muscat, Saperavi, but also from valuable Romanian varieties, such as Feteasca Alba, Feteasca Neagra, Feteasca Regală, Tămâioasă.

The main type of activity is - the manufacture of grape wines, and in the field of tourism: tourism activity as well as passenger car transport, including taxis.

The interest in wine tourism after the 2000s influenced the emergence of wineries with a modern architectural appearance. An example is the "Poiana Winery", the innovative element being that all the functional elements (production and tasting rooms, restaurant, hotel, shop) are located in the same building (Figure 1).

Figure 1. The agro-pension complex "Vinăria Poiana"

The agro-pension "Vinăria Poiana" is identified by numerous elements with a defining role in ensuring a certain qualitative level of tourist services. The main offer of the agro-pension "Vinăria Poiana" is the varied assortment of white, rosé, red and sparkling wines, which during its activity have been mentioned countless times with gold, silver, bronze medals and diplomas of mention.

The next complementary offer to the main one are excursions – "Wine Tour", which are very varied. Orders are made online. The minimum number is two people.

• ***Pack #1*** - Excursion + 3 wines - includes a guided tour and tasting of 3 types of wine. The tasting includes: cheese, mineral water.

• ***Pack #2*** - Excursion + 5 wines - includes a guided tour and a tasting of 5 types of wine paired with a mixed snack platter - Tapas Menu.

• ***Pack #3*** - Wine & Food at Poiana Winery - includes a guided tour and a tasting of 7 types of wine, a mixed snack platter - Tapas Menu, a choice of a main course, and a dessert.

In the hotel "Vinăriei Poiana", whose windows offer a panoramic view of the area, natural light and beautiful views throughout the year.

The offer includes: Accommodation for 1 night, Breakfast, Mini Bar, Excursion through 3 sections of the Winery and Tasting of 3 Types of Poiana Wine, free Wi-Fi. All benefits are for two people. The accommodation offers the knowledge of the most picturesque places of the area and the endless view of the Forests. Currently, three boutique mini-hotels are under construction, located in the heart of the vineyards. These mini-hotels include two bedrooms, a living room and a fully equipped kitchen. Guests have the option of cooking for themselves or eating in the agri-pension's restaurant.

In addition to the wine offer, "Wine Tour" packages and accommodation, the diversity of tourist offers also includes:

The "Vacation with Winegrowers" offer - includes assistance and participation of tourists in the grape harvest followed by a meal in the bosom of nature.

The "National traditions and handicrafts related to grapes and wines" offer. Sometimes it takes place simultaneously with the annual celebration of "Wine Day" and at the end of the grape harvest from the winery's vineyards, events are organized with the invitation of musicians and folk craftsmen.

The "Forester's House" offer. There is a cart trip through the forests surrounding the "Poiana Winery" with stops in the forest and a visit to the "Forester's House" where souvenirs and objects carved in wood, as well as freshly baked bakery products, are exhibited.

The "Architecture, vineyards and lakes" offer. The concept of the "Poiana Winery" is the combination of native nature and modern architecture, which was successfully achieved. Tourists staying at the hotel can have the opportunity to fish in the lake and go cycling around the winery.

"Wine Collection" offer. Tourists can have the opportunity to get acquainted with the impressive collection of white, rosé and red wines with tasting.

"Wine Shop" offer. Tourists can have the opportunity to buy the wines tasted in advance.

"Helicopter flight services" offer - here tourists can have the opportunity to take a flight over the region.

"Children's playground" offer - here the little ones can have the opportunity to play in a complex consisting of slides, houses, a swing, a ladder, a climbing wall, sand. All these elements of the "Poiana Winery" infrastructure make it one of the most visited wineries in the Republic of Moldova.

On the Independence Day of the Republic of Moldova (27.08.25), a joint visit was made by French President Emmanuel Macron, German Chancellor Friedrich Merz and Polish Prime Minister Donald Tusk. The country's President Maia Sandu invited the guests to the agri-pension "Vinăria Poiana".

The study of tourist visits to the agri-pension "Vinăria Poiana" was carried out during the period 2019-2024. During this period, approximately 22,000 people visited the agri-pension. The dynamics of tourist visits by year is presented in Figure 2. The increase in the level of tourist visits compared to 2019 was analyzed, obtaining the following results: in 2020 compared to 2019 it decreased, constituting only 15.9%. During that period, tourists were served outdoors, following the recommendations of doctors.

In 2021 compared to 2019, it almost doubled, reaching 31.8%. In 2022 compared to 2019, it practically slightly exceeded the number of tourists before the pandemic, reaching 104.2%.

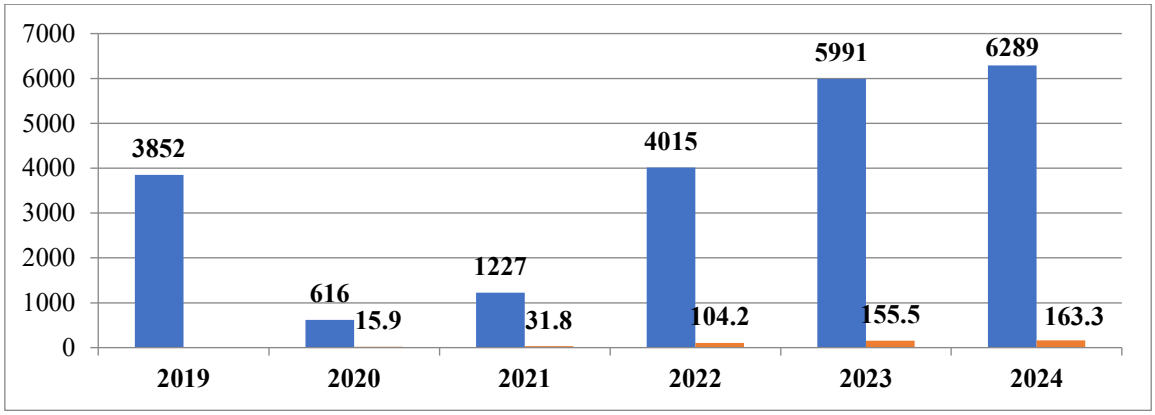

Figure 2. Dynamics of tourist visits to "Vinăria Poiana" during the period 2019-2024, (persons/percentage)

Source: developed by the authors based on accounting information of the agro-pension "Vinăria Poiana"

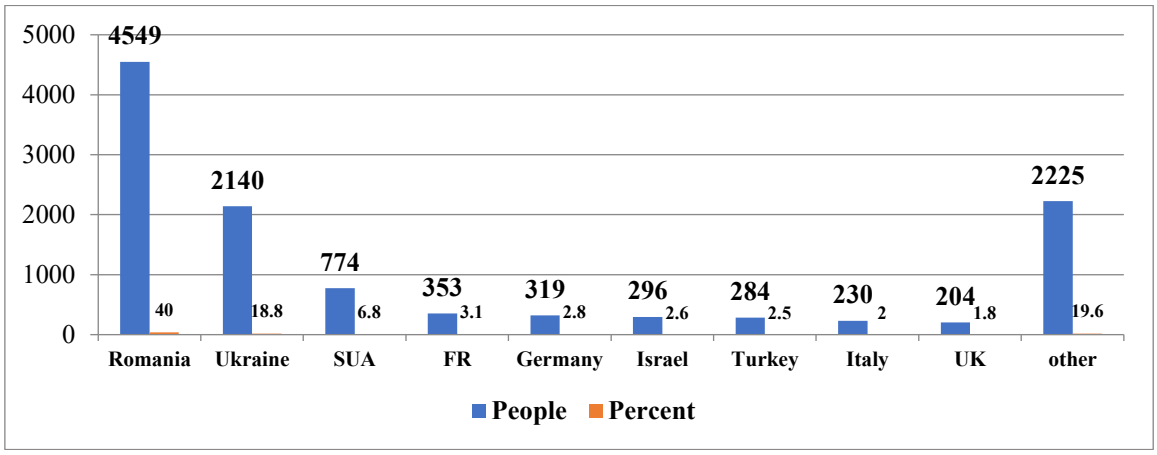

Figure 3. Number of foreign tourists who visited the agri-pension "Vinăria Poiana" in the period 2019-2024

Source: developed by the author based on the accounting information of the agri-pension "Vinăria Poiana"

In 2023 compared to 2019, the dynamics of tourist visits amounted to 155.5%, which increased by 51.3 p.p. compared to 2022. In 2024 compared to 2019, it amounted to 163.3%, which increased by 7.8 p.p. compared to 2023. The values obtained clearly demonstrate that the agri-pension "Vinăria Poiana" has overcome the crisis during the pandemic, showing an increase in the number of tourists. (Fedorciucova S., 2025)

Another useful information for the agri-pension "Vinăria Poiana" is knowing the number of foreign visitors. After the pandemic period, Moldova is becoming more and more visible on the map of European tourist destinations. In the perception of foreign tourists, Moldova is a safe country in terms of protection, development of tourist infrastructure, efforts to promote the tourist product, national culture internationally, including geopolitical changes in the country.

Approximately 11,400 foreign people visited the agri-pension. The dynamics of foreign tourist visits to the agri-pension "Vinăria Poiana" during the analyzed period is shown in Figure 3.

In the reference period, the largest number of foreign tourists were from Romania 4549 per. (40.0%). In second place were tourists from Ukraine with a number of 2140 per. (18.8%), refugees contributed to the large number of tourists from Ukraine. In third place was the USA with a number of 774 per. (6.8%). Other countries (in descending order) accumulated the following number of tourists: Russian Federation - 353 per. (3.1%), Germany - 319 per. (2.8%), Israel - 296 per. (2.6%), Turkey - 284 per. (2.5%), Italy-230 per. (2.0%), United Kingdom – 204 per. (1.8%) and from other countries - 2225 per. (19.6%). In the "other" group we can mention France, Poland, Czech Republic, Lithuania, Latvia, Estonia, Montenegro, Morocco, Algeria and others.

The number of tourists and visitors to the agro-pension "Vinăria Poiana" is increasing, leaving a good impression about the trip undertaken and leaving with full conviction that they will return.

The survey was conducted with the aim of obtaining information regarding the opinions of visitors about the services of the agro-pension "Vinăria Poiana". The survey was conducted between February 15 and March 15, 2025 on Saturdays and Sundays among tourists. The survey was developed in three languages: Romanian, English and Russian. 59 respondents participated in the survey. We consider a decisive factor that the survey was conducted during the so-called "dead season" when a small number of tourists are registered. (Fedorciucova S., 2025)

The results of the respondents' opinions regarding the period of their visit to the "Vinăria Poiana" agri-pension are shown in Figure 4.

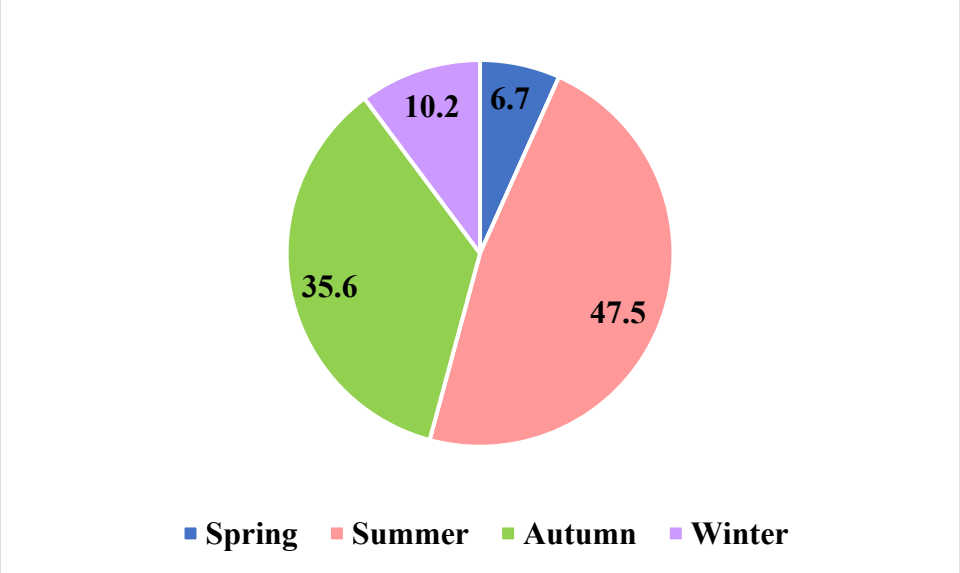

Figure 4. Preferred period of visits to the agri-pension "Vinăria Poiana", %

Following the analysis of the respondents' opinions, it was found that the largest share of tourists prefers to visit in the summer months (47.5%), the main reason being holidays. In the fall, most tourists (35.6%) are the holidays related to the completion of agricultural work "Grape Harvest", "Tulburelul", Wine Day" etc. The results of the respondents' opinions regarding the purpose of visiting the agro-pension "Vinăria Poiana" are shown in Figure 5.

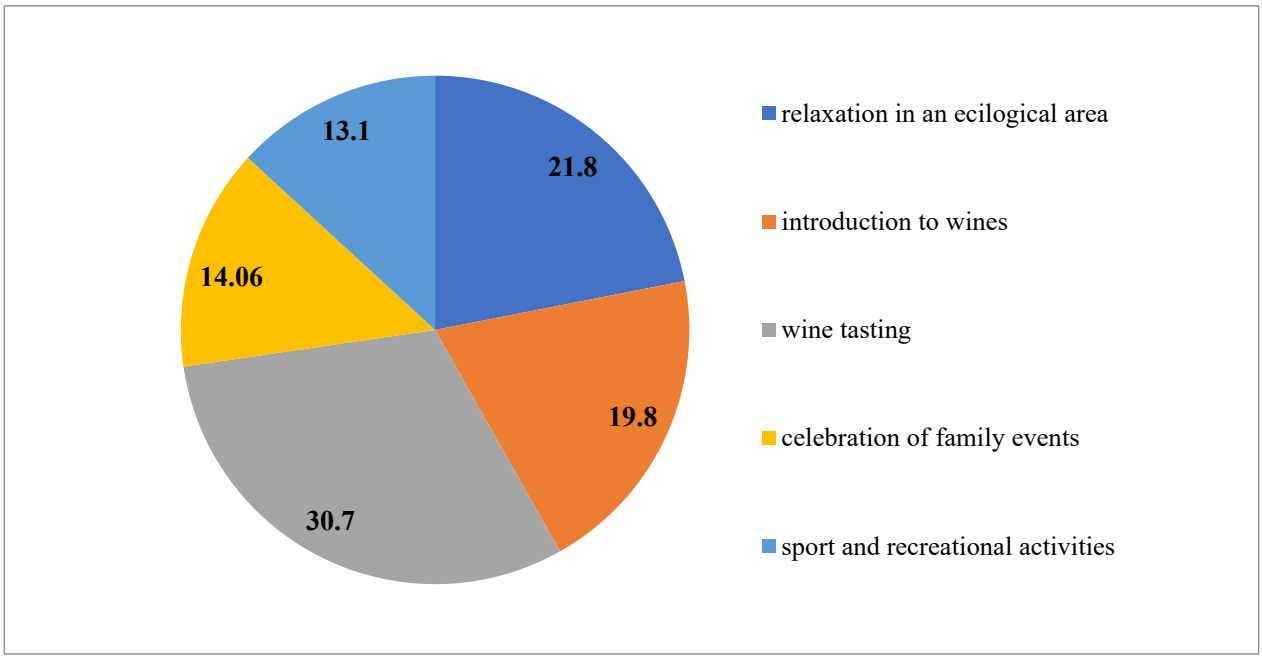

Figure 5. Purpose of the visit to the agri-pension "Vinăria Poiana", %

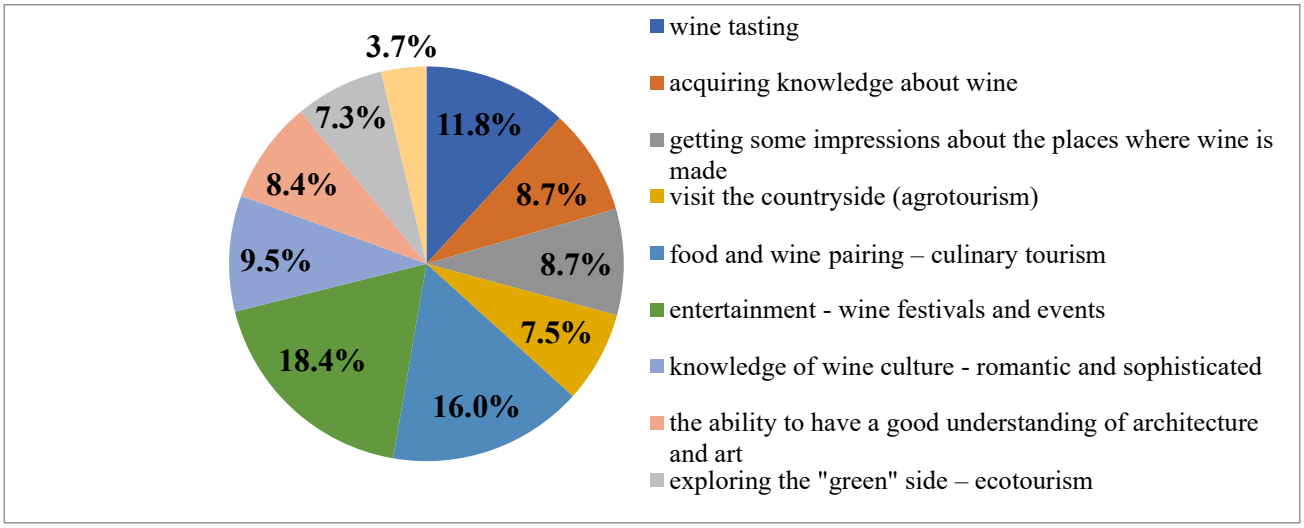

Figure 6. Tourists' preferences for spending their free time in the agri-pension "Vinăria Poiana"

The results of respondents' opinions regarding tourists' preferences for spending their free time at the "Vinăria Poiana" agri-pension are presented in Figure 6. Respondents mostly opted for the following preferences: "entertainment - wine festivals and events" (18.4%), "pairing food with wine - culinary tourism" (16.0%), "wine tasting" (11.8%).

So practically all the offers of the agro-pension are mentioned, but obviously most tourists prefer cultural events, food and wine, which are traditional for their recreation. (Fedorciucova S., 2025). The results of the respondents' opinions regarding the degree of satisfaction of tourists of the agro-pension "Vinăria Poiana" (according to the criteria) are presented in Figure 7.

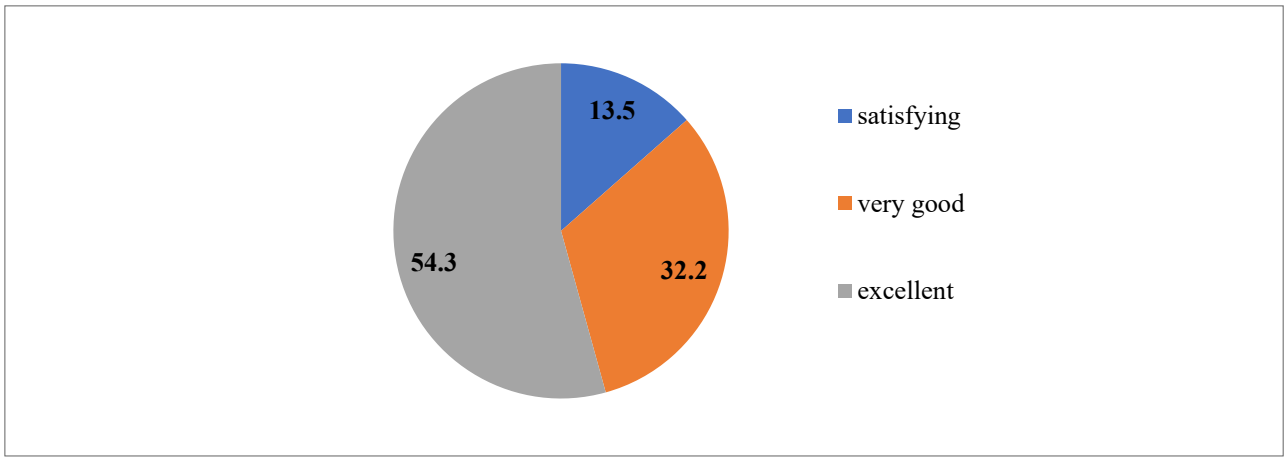

Figure 7. Degree of satisfaction of tourists with the offers of the "Vinăria Poiana" agri-pension, %

With the qualification "satisfactory" (13.5%) 8 respondents referred to the accessibility of the access road through the forest, which is covered with gravel, which they would like to be asphalted. With the qualification "very good" (32.2%) the winery's offers were mentioned. More than half of the respondents (54.3%) appreciated the offers with the qualification "excellent".

The results of the respondents' opinions on the services (wine partnerships) they would be interested in being included in the offer of the "Vinăria Poiana" agro-pension are shown in Figure 8.

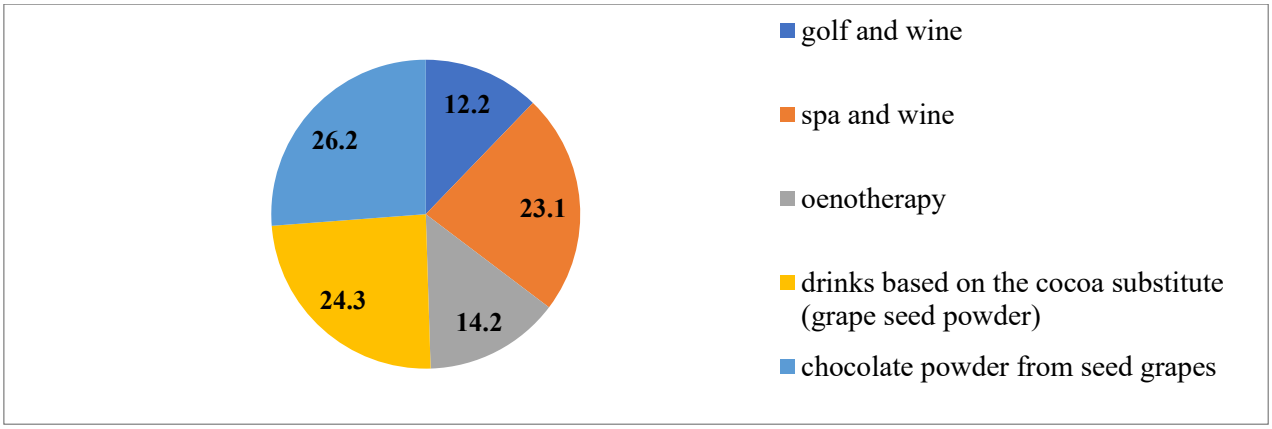

Figure 8. Services (wine partnerships) that would have been desirable to be included in the offer of the "Vinăria Poiana" agri-pension, %

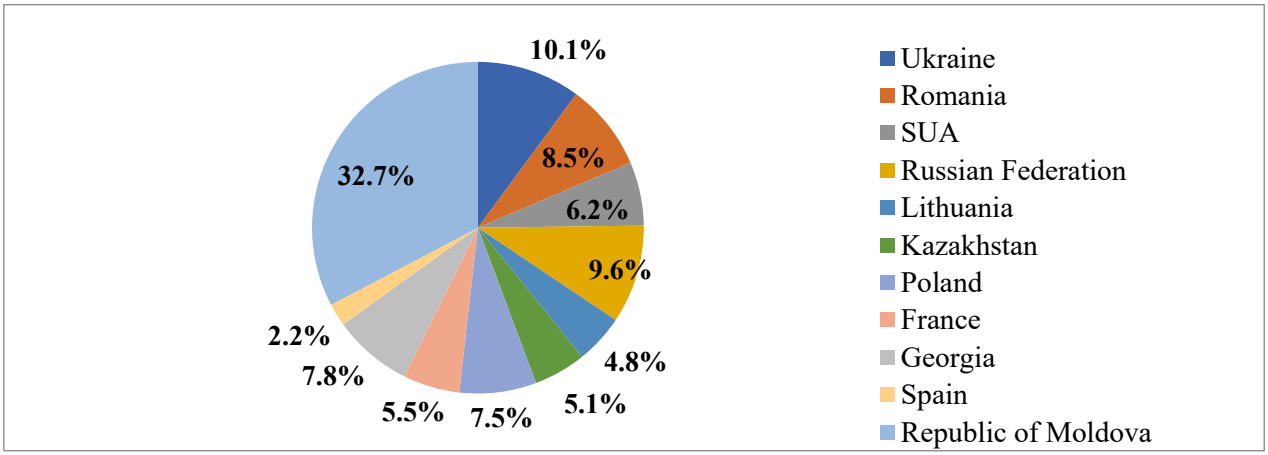

Figure 9. Country of origin of respondents

Of the proposed options, respondents were interested in drinks based on cocoa substitute (grape seed powder) 24.3%, chocolate from grape seed powder 26.2% and nanotherapeutic services 23.1%. Depending on the country of origin of the interviewed respondents, the results are shown in Figure 9. After obtaining the results about the country of origin of the respondents, we can conclude that regardless of the season, the range of foreign tourists is very varied, as they include countries from Europe, Asia, the USA and the former republics of the USSR, now independent.

The largest share is held by domestic tourists (32.7%), followed by Ukraine, whose inhabitants continue to explore Moldova (10.1%) and the Russian Federation with a share of 9.6%. (Fedorciucova S., 2025)

CONCLUSIONS

The agro-pension "Vinăria Poiana" is identified by numerous elements with a defining role in ensuring a certain qualitative level of tourist services. Tourists arriving at the agro-pension are introduced from the start to the rich assortment of wines, exhibited on the shop stand, after which they are familiar with the technological process of obtaining wines, with the winery's warehouse, and could taste the wines and dishes prepared in the winery's restaurant. At the same time, tourists go hiking, horseback riding and cycling to the "Forester's House". At different times of the year, tourists can participate in various events related to the activity of winegrowers: "Vacation with Winegrowers", "National traditions and handicrafts related to grapes and wines", "Wine Day" and others. The winery can offer the "Helicopter flight" service upon request. A playground is arranged at the "Vinăria Poiana" agri-pension for children's entertainment.

The dynamics of tourist visits to the "Vinăria Poiana" agri-pension were analyzed compared to 2019, which was shown to be on the rise.

The tourist opinion poll on the services provided by the agri-pension "Vinăria Poiana" demonstrated that the Republic of Moldova and the wine sector are of interest to tourists; the peak periods of visits are the summer and autumn months related to traditional holidays, the respondents' preferences are wine tasting combined with relaxation in an ecological area; the winery's offers are rated "very good" and "excellent", the respondents are interested in drinks and chocolate made from grape seeds, depending on the country of origin of the respondents, we can mention that regardless of the season, the tourists' palette is very varied.

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ECONOMIC AND FINANCIAL ASPECTS OF INVESTING IN CONSTRUCTION OF FACILITIES AND ACQUISITION OF BASIC HERD, AIMING TO IMPROVE THE PIGS' BREED COMPOSITION AT THE AGRICULTURAL FARMS IN SERBIA

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Abstract: *According to the Agricultural Census in 2012, in total there were 631,552 agricultural holdings in Serbia, where 28,777 (4.56%) of them were specialized in pig breeding. Data gained from Farm Structure Survey in 2018, as well as data obtained from Agricultural Census in 2023, indicate that there has come to decrease not only in the overall number of agricultural holdings (564,541 and 508,325, respectively), but also in the number of agricultural holdings specialized in pig breeding (18,262 and 10,238, respectively). In this context, the current business policy of specialized pig farms in Serbia (primarily agricultural holdings within the legal entities, i.e. agricultural enterprises and agricultural cooperatives) aims to raise the quality level of pig breed composition by producing breeding gilts. In this way, it will be enabled to family agricultural holdings (that breed 10-50 sows) to renew their herds, i.e. to improve the breed composition. In this paper, the authors have been focused their research on selected agricultural holding (i.e. agricultural cooperative) located in the Vojvodina region, as in this region are bred, according to last Agricultural Census, almost 45% of the overall number of pigs in Serbia (2,263,705).*

Keywords: *agricultural holding, pigs breeding, investments, Vojvodina region, Serbia.*

INTRODUCTION

Pig meat, i.e. pork, plays very important role in human nutrition. It is mainly a source of high-quality proteins (essential amino acids), fats and several micronutrients (B complex vitamins, Zn, P, Se, Fe, creatine, taurine, glutathione, cholesterol, etc.). It supports adequate growth and development of human organism, primarily affecting internal energy metabolism, immune status, normal brain and muscle functioning, etc. (Pettigrew, Esnaola, 2001; Zduńczyk et al., 2024; Xiong et al., 2025). Pork could be prepared and consumed in human nutrition in many ways, as unprocessed meat or processed meat products (Lebret, Čandek Potokar, 2022; Munekata et al., 2021), what is usually in line to certain issues linked to specific culture, ethic, ethnicity, religion, or tradition (Potts, 2016; Vida, Szűcs, 2020). Despite, often, immoderately and careless eating of pork could affect some health risks at humans, such are cardiovascular and metabolic complications, manifestation of certain cancers (mainly colorectal), parasitic infections caused by eating raw, undercooked or slightly processed pork meat and products (e.g. trichinosis, salmonella, or pork tapeworm), fatty liver disease, human resistance to antibiotic (caused by their excessive use in pig farming), etc. (Bonardi, 2017; Wolk, 2017; Yanagida et al., 2021; Vicente, Pereira, 2024).

There is strong correlation between pig farming, pig breeding programs and pork production (Bonneau, Lebret, 2010; Rydhmer et al., 2014; Larzul, 2021). Desired pig, or pork traits are usually economically driven complying in certain extent the current market requirements. So, although they have to be strongly focused to consumers, not so rare welcome traits are just reflection of pig farmers and food processors direction for profit generation (Den Ouden, 1996; Picardy et al., 2019). In essence, actors active at pork market have been principally reacting to economic aspects of meat production and distribution. Hunger for profit overcomes general principles of sustainability. It supports the intensification of

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production, while notably ignoring animal welfare, human health and environmental issues, often leading to certain meat fraud situations (Nikolovska et al., 2019; Jeločnik et al., 2020).

In line to previously mentioned, breeding programs technically are turned to genetic advancements of production and breeding characteristics of pigs with stressed economic motive. Meanwhile, as meat consumers are mainly oriented to meat traits that are not so strong related to economic side of meat production (except the interest in meat retail price they are willing to pay towards offered meat quality), actors in pork meat chain give more attention to issues as are animal welfare, health status, ecological footprint derived from pig breeding, as well as quality attributes of pork meat. Additionally, some of mentioned pork characteristics have or not the economic importance, but at the end it strongly affects selection (breeding) processes (Istudor et al., 2004; Kanis et al., 2005; Wolfová et al., 2017; Harlizius et al., 2020). In previous decades, beside good tradition and excellent natural conditions for pig farming and pork production, this sector of livestock is experiencing some negative trends (Subic et al., 2012). There come to sharp decrease in farms turned to pig breeding, number of raised pigs and produced pork, as well as intensive confronting to several challenges due to implementation or adjusting to global (regional) standards active in meat production, processing and distribution (Uzelac et al., 2023; Radović et al., 2025). So, advancing of pork production at national level could be assumed quite a challenging.

Selected agricultural holding (agricultural cooperative) from the Vojvodina region owns specialized-nucleus pig farm, whose basic herd is consisting of purebred animals. Farm produces high-quality breeding material (gilts) in F1 generation, participating in that way to advancing the genetic potential in local pig farming. Farm management policy and derived idea is to increase the level of pig breed composition in Vojvodina by intensification in production of F1 breeding gilts. Those gilts will serve as basic herd on commercial (fattening) farms, enabling to SME farmers (breeding 10-50 sows) to renew their basic herds in a way of improved breed composition. In line to aforementioned, a larger number of piglets per sow will be gained annually (25-28 heads), or quite more than in previous period (16-18 heads). This will introduce the lower costs in pigs fattening, but also the rise in meat content within the slaughter yield, what is important as slaughterhouses have started paying based on the meat content in pigs' carcass. In final, increase in meat content will enable higher profit to pig breeder.

Due to the satisfactory business results, management of the cooperative decides to expand farms' activity by building two more production facilities, i.e. to double production. The new investment also involves fattening facility. Accordingly, paper will be focused just to economic and financial aspects of new investment (new investments in fixed assets). So, the main paper goal is to prove the justification of enlarging the production capacities at the farm.

Specifically, the cooperative is investing in construction of production facility that is consisting of two production halls (1,800 m² and 1,063.20 m², or in total 2,863.20 m²). By the building of new facilities and acquisition of new purebred basic herd, there will be doubled the production of hi-quality genetic material (gilts) necessary for improving the breed composition of pigs at local, even national level.

METHODOLOGICAL FRAMEWORK

As in some previous research, used methodology implies static and dynamic methods for assessing investment economic effectiveness (Subić, 2010; Jeločnik, Subić, 2020; Subić et al., 2020; Jeločnik et al., 2022). All used data for analysis is gained through in-depth interview with cooperative management.

Along with the new investment in fixed assets, the cooperative will stop selling male piglets, as well as female piglets that do not pass the selection process used for gilts, so in that case cooperative will has the production of fattening pigs, i.e. fattening process until the end of the selection cycle. In order to increase its potential, as well as current scientific and technological level, or due to strivings to perform rational development policy, the cooperative has been established business and technical cooperation with higher education institutions and scientific and research organizations in Vojvodina region and entire Serbia.

In halls that has to be built (subject of new investment), the activity of pigs breeding (high-quality F1 gilts) for breeding and production of fattening pigs will be carried out. Total (new)investment will amount 2,142,336.02 EUR, where 1,129,978.80 EUR will be turned to facilities and buildings, 832,357.22 EUR will be invested in equipment and mechanization, while 180,000.00 EUR will be reallocated to the basic herd (procurement of high-quality F1 gilts), (Table 1).

Table 1. Total investment, in EUR

No.	Description	New investment	Overall investment	Share in overall investment (in%)
I	**Fixed assets**	**2,142,336.02**	**2,142,336.02**	**83.33**
1.	Facilities and buildings	1,129,978.80	1,129,978.80	43.95
2.	Equipment and mechanization	832,357.22	832,357.22	32.38
3.	Basic herd	180,000.00	180,000.00	7.00
II	**Permanent working capital**	**428,467.20**	**428,467.20**	**16.67**
Total (I+II)			**2,570,803.22**	**100.00**

Source: IAE, 2025.

Considering current quite a favorable bank loans for investing in agriculture (primarily in livestock breeding), observed cooperative will invest its own assets in amount of 608,467.20 EUR, while it will borrow assets in amount of 1,962,336.02 EUR (Table 2.).

Table 2. Source of financing, in EUR

No.	Description	New investment	Overall investment	Share in overall investment (in%)
I	**Own sources**	**608,467.20**	**608,467.20**	**23.67**
1.	Fixed assets	180,000.00	180,000.00	7.00
2.	PWC	428,467.20	428,467.20	16.67
II	**External sources**	**1,962,336.02**	**1,962,336.02**	**76.33**
1.	Fixed assets	1,962,336.02	1,962,336.02	76.33
Total (I+II)			**2,570,803.22**	**100.00**

Source: IAE, 2025.

Observed agricultural holding (i.e. agricultural cooperative as investor) has also been engaged in previous years in pig farming (production of breeding gilts), while it has own production facilities (2,374 m², or capacity of 250 purebred sows). By construction of new facilities and acquiring new purebred basic herd of 250 sows, cooperative will double the production of quality genetic material (breeding gilts) necessary for improving the breed composition of pigs available in Serbia.

There are similarities due to planned production activities that will be realized in new and old production halls (keeping 250 sows with an annual farrowing index of 2.4). From the planned 600 farrowing, and with an average of 12 piglets per one sow, in total 7,200 piglets should be obtained annually (in average, 3,600 piglets, both male and female). Male piglets will be separated into a new facility used for fattening, while feeding them until the weight of 25 kg. From the group of 3,600 female piglets, 1,915 piglets will be separated for breeding F1 gilts until they reach a weight of 100 kg. Meanwhile, 965 piglets will be separated for fattening until they reach a weight of 100 kg, while 720 piglets will be fed until the weight of 25 kg.

Economic justification of by cooperative management created business idea is based on the methodology used for assessing the economic effectiveness of investments. Accordingly, there will be used common static and dynamic methods, as well as the methods for assessing the investments in conditions of risk and uncertainty (i.e. break-even point).

Economic analysis was based on following assumptions: interest rate (i) is 6%, the loan repayment assumes period of 5 years (with one-year grace period), the loan repayment dynamics is quarterly (i.e. 4 annuities per year), while the discount factor is 7%. It should be also underlined that the amount of permanent working capital (PWC) is determined due to the value of fixed assets (20%), while depreciation of fixed assets assumes exclusion of value added tax (VAT), or the income tax rate accounts to 15%.

RESULTS

As was already mentioned, the farm's capacity is 250 sows, while capacity filling will last for 6 months, until the utilization of full technological capacity. Considering that the first groups of sows will arrive in the first trimester of pregnancy (50 days of gestation), the first farrowing is expected in 64 days, and thereafter until the full production capacity is reached.

Technological indicators indicate that the number of produced piglets will be carried over to the next year, while at the end of third year it will be reached the total number of planed piglets, fattened animals and gilts. Since sows represent the parent herd, they are not carried over to the next year, i.e. their number is fixed per each year (250 heads).

Towards the better clarity and simplicity, the research results are presented in adequate tables (Tables 3–13). In that context, there are provided a detailed presentation of financial plan, static and dynamic methods for assessing the economic effectiveness of investment in pig farming, or its break-even point.

Table 3. Overall incomes forming, in EUR

No.	Product	UM	Years														
			I			II			III			IV			V		
			Price per UM (EUR)	Annual volume in UM	Total	Price per UM (EUR)	Annual volume in UM	Total	Price per UM (EUR)	Annual volume in UM	Total	Price per UM (EUR)	Annual volume in UM	Total	Price per UM (EUR)	Annual volume in UM	Total
0	1	2	3	4	5=3x4	6	7	8=6x7	9	10	11=9x10	12	13	14=12x13	15	16	17=15x16
1.	Male piglets, Up to 25 kg	Head	58.23	3,600	209,638.63	58.23	3,600	209,638.63	58.23	3,600.00	209,638.63	58.23	3,600	209,638.63	58.23	3,600	209,638.63
2.	Female piglets, Up to 25 kg	Head	58.23	720	41,927.73	58.23	720	41,927.73	58.23	720.00	41,927.73	58.23	720	41,927.73	58.23	720	41,927.73
3.	Fattened female animals, Up to 100 kg	Head	149.08	965	143,858.69	149.08	965	143,858.69	149.08	965	143,858.69	149.08	965	143,858.69	149.08	965	143,858.69
4.	Gilts, Up to 100 kg	Head	294.85	1,915	564,636.46	294.85	1,915	564,636.46	294.85	1,915.00	564,636.46	294.85	1,915	564,636.46	294.85	1,915	564,636.46
Total					**960,061.51**			**960,061.51**			**960,061.51**			**960,061.51**			**960,061.51**

Source: IAE, 2025.

Table 4. Overall costs, in EUR

No.	Costs	Years				
		I	II	III	IV	V
I	**Material costs**	**368,541.15**	**368,541.15**	**368,541.15**	**368,541.15**	**368,541.15**
1.	Costs of direct material	349,211.38	349,211.38	349,211.38	349,211.38	349,211.38
2.	Energy	19,269.78	19,269.78	19,269.78	19,269.78	19,269.78
3.	Other material costs	60.00	60.00	60.00	60.00	60.00
II	**Intangible costs**	**170,949.71**	**285,209.89**	**256,091.23**	**225,185.74**	**192,383.78**
1.	Depreciation	116,445.55	116,445.55	116,445.55	116,445.55	116,445.55
2.	Labor	51,285.47	51,285.47	51,285.47	51,285.47	51,285.47
3.	Costs of loan (interest)	0.00	114,260.17	85,141.51	54,236.02	21,434.07
4.	Other intangible costs	3,218.69	3,218.69	3,218.69	3,218.69	3,218.69
Total (I+II)		**539,490.87**	**653,751.04**	**624,632.38**	**593,726.89**	**560,924.93**

Source: IAE, 2025.

Table 5. Income statement, in EUR

No.	Description	Years				
		I	II	III	IV	V
I	**Total incomes**	**960,061.51**	**960,061.51**	**960,061.51**	**960,061.51**	**960,061.51**
1.	Sale incomes	960,061.51	960,061.51	960,061.51	960,061.51	960,061.51
II	**Total expenditures (1+2)**	**539,490.87**	**653,751.04**	**624,632.38**	**593,726.89**	**560,924.93**
1.	Business expenditures	539,490.87	539,490.87	539,490.87	539,490.87	539,490.87
1.1.	Material costs	368,541.15	368,541.15	368,541.15	368,541.15	368,541.15
1.2.	Intangible costs without depreciation and interest	54,504.16	54,504.16	54,504.16	54,504.16	54,504.16
1.3.	Depreciation	116,445.55	116,445.55	116,445.55	116,445.55	116,445.55
2.	Financial expenditures	0.00	114,260.17	85,141.51	54,236.02	21,434.07
2.1.	Interest	0.00	114,260.17	85,141.51	54,236.02	21,434.07
III	**Gross income (I-II)**	**420,570.64**	**306,310.47**	**335,429.13**	**366,334.62**	**399,136.58**
IV	**Income tax***	63,085.60	45,946.57	50,314.37	54,950.19	59,870.49
V	**Net income (III-IV)**	**357,485.05**	**260,363.90**	**285,114.76**	**311,384.43**	**339,266.09**

* Tax rate in specific case is 15%.

Source: IAE, 2025.

Table 6. Economic flow, in EUR

No.	Description	Zero moment	Years				
			1	2	3	4	5
I	**Overall incomes (1+2)**	**0,00**	**960,061.51**	**960,061.51**	**960,061.51**	**960,061.51**	**2,441,580.97**
1.	Sale incomes	0,00	960,061.51	960,061.51	960,061.51	960,061.51	960,061.51
2.	Salvage value	0,00	0.00	0.00	0.00	0.00	1,481,519.46
	2.1. Fixed assets	0,00	0.00				1,053,052.26
	2.2. PWC	0,00					428,467.20
II	**Overall expenditures (3+4+5)**	**2,570,803.22**	**423,045.32**	**423,045.32**	**423,045.32**	**423,045.32**	**423,045.32**
3.	Investment value	2,570,803.22					
	3.1. In fixed assets	2,142,336.02					
	3.2. In PWC	428,467.20					
4.	Costs without depreciation and interest	0,00	423,045.32	423,045.32	423,045.32	423,045.32	423,045.32
5.	Income tax	0.00	63,085.60	45,946.57	50,314.37	54,950.19	59,870.49
III	**Net income – cash flow (I-II)**	**-2,570,803.22**	**537,016.19**	**537,016.19**	**537,016.19**	**537,016.19**	**2,018,535.66**

Source: IAE, 2025.

Table 7. Total Output-Total Input Ratio (ToTiR): Ot / It > 1, in EUR

Years	Ot (market value of production)	It (costs of production)	ToTiR = Ot / It
0	**1**	**2**	**3 = 1/2**
I	960,061.51	539,490.87	1.78
II	960,061.51	653,751.04	1.47
III	960,061.51	624,632.38	1.54
IV	960,061.51	593,726.89	1.62
V*	960,061.51	560,924.93	1.71

* Representative year (full capacity).
Source: IAE, 2025.

Table 8. Net Profit Margin (NPMR): P / Ot x 100 > i, in EUR

Years	P (profit)	Ot (market value of production)	NPMR = P / Ot x 100
0	**1**	**2**	**3 = 1/2*100**
I	357,485.05	960,061.51	37.24
II	260,363.90	960,061.51	27.12
III	285,114.76	960,061.51	29.70
IV	311,384.43	960,061.51	32.43
V*	339,266.09	960,061.51	35.34

* Representative year (full capacity).
Symbol meaning: i – assumed weighted price of capital.
Source: IAE, 2025.

Table 9. Accounting Rate of Return (ARR): P / Vi x 100 > I, in EUR

Years	P (profit)	Vi (initial outlay)	ARR = P / Vi x 100
I	357,485.05	2,570,803.22	13.91
II	260,363.90	2,570,803.22	10.13
III	285,114.76	2,570,803.22	11.09
IV	311,384.43	2,570,803.22	12.11
V*	339,266.09	2,570,803.22	13.20

* Representative year (full capacity). Symbol meaning: i – assumed weighted price of capital.
Source: IAE, 2025.

Table 10. Simple Payback Period: T < n, in EUR

Years	Net cash flow from economic flow	Cumulative net cash flow
0	-2,570,803.22	-2,570,803.22
I	537,016.19	-2,033,787.03
II	537,016.19	-1,496,770.83
III	537,016.19	-959,754.64
IV	537,016.19	-422,738.45
V	2,018,535.66	1,595,797.21

Symbol meaning: T – payback period; n - years.
Source: IAE, 2025.

Considering above mentioned, payback period could be calculated as: $|-422{,}738.45| / 2{,}018{,}535.66 = 0{,}21$ (i.e. 4,21 years, or 4 years and 2,517 months).

Table 11. Net Present Value and Internal Rate of Return, in EUR

No.	Description	Zero moment	Years					*Cumulative*
			I	II	III	IV	V	
0	1	2	3	4	5	6	7	8
1.	Net cash flow from economic flow (column 3 to column 7)	-2,570,803.22	537,016.19	537,016.19	537,016.19	537,016.19	2,018,535.66	***4,166,600.44***
2.	Discount rate (%)	7.00	7.00	7.00	7.00	7.00	7.00	-
3.	Discount factor $(1+i)^{-n}$ or $1/(1+i)^{\wedge n}$, where i = discount rate; n = years	1.0000	0.9346	0.8734	0.8163	0.7629	0.7130	-
4.	Present value of net cash flow (column 3 to column 7)	-2,570,803.22	501,884.29	469,050.74	438,365.18	409,687.08	1,439,188.03	***3,258,175.33***
5.	**NPV: (column 2 to column 7)**	**687,372.10**						
6.	**Relative NPV: [(column 2 to column 7) / | column 2|] > i**	**0.27**						
7.	**IRR: (IRR > i)**	**14.55%**						

Source: IAE, 2025.

Table 12. Dynamic Payback Period: T < n, in EUR

Years	Net cash flow from economic flow (present value)	Cumulative net cash flow
0	-2,570,803.22	-2,570,803.22
I	501,884.29	-2,068,918.93
II	469,050.74	-1,599,868.19
III	438,365.18	-1,161,503.01
IV	409,687.08	-751,815.92
V	1,439,188.03	687,372.10

Symbol meaning: T – payback period; n - years.
Source: IAE, 2025.

In line to previously presented calculation, payback period could assume: $|-751,158.92|$ / 1,439,188.03 = 0,52 (i.e. 4,22 years, or 4 years and 6,27 months).

Table 13. Break-even point, in EUR

No.	Description	Years				
		I	II	III	IV	V
1.	Incomes (I)	960,061.51	960,061.51	960,061.51	960,061.51	960,061.51
2.	Variable costs (VC)	419,826.62	419,826.62	419,826.62	419,826.62	419,826.62
3.	Fixed costs (FC)	3,218.69	3,218.69	3,218.69	3,218.69	3,218.69
4.	Gross margin (GM=I-VC)	540,234.89	540,234.89	540,234.89	540,234.89	540,234.89

No.	Description	Years				
		I	II	III	IV	V
5.	Break-even point – relative (BEPr = (FC/GM) x 100), in %	0.60	0.60	0.60	0.60	0.60
6.	Break-even point – value (BEPv = (I x BEPr) / 100), in EUR	5,720.00	5,720.00	5,720.00	5,720.00	5,720.00
7.	Margin of safety - relative (MSr = ((1 - (BEPr / I)) x 100), in %	99.40	99.40	99.40	99.40	99.40
8.	Margin of safety – value (MSv = (I x MSr) / 100), in EUR	954,341.51	954,341.51	954,341.51	954,341.51	954,341.51

Source: IAE, 2025.

The general conclusion derived from gained research results, indicates that the observed agricultural cooperative has the ability to service all obligations imposed by the new investment in pig farming (i.e. the building of facilities for gilts fattening and acquiring the basic herd). In other words, investment could be assumed justified, while it reflects the ability of investor (agricultural cooperative) to settle all obligations arising from described investment or regular business operations in a timely manner.

CONCLUSIONS

The profitability assessment of the proposed investment has been based on assumption that the production volume and prices will not be changed throughout the entire life of the project (i.e. in next 5 years). Based on mentioned, as well as due to use of relevant inputs' and costs' standards, there are obtained the results that indicate a high level of profitability:

- Results derived from the use of static methods for investment assessment, redirects to the next conclusions:
  - Total Output-Total Input Ratio is higher than one, underlining the fact that overall income is higher than overall costs. In other words, investment idea is economical.
  - Net Profit Margin is higher than 6.00% (assumed weighted price of capital), considering the investment as profitable (investment exploitation will secure covering of price of external capital sources, while earning certain level of profit).
  - Accounting Rate of Return is also higher than 6.00%, considering the profitability of planed investment.
  - In line to static assessment, investment will be repaid in 4.21 years, or 4 years and 2.51 months (0.21 x 12 months).
- Results derived from the use of dynamic methods for investment assessment, redirects to the next conclusions:

- Within the period of 5 years of investment exploitation (investment expiration period) it would enable the observed cooperative to increase the overall profit, calculated by the use of discount rate (i = 7.00%) at the initial moment of investment exploitation (n = 0), in amount of 687,372.10 EUR.
- Investment is profitable, as the Internal Rate of Return of investment project is higher than interest rate paid on borrowed assets (14.55% > 6.00%), or even discount / weighted rate (14.55% > 7.00%).
- In line to dynamic assessment, investment will be repaid in 4.52 years, or 4 years and 6.27 months (0.52 x 12 months).

▪ Results derived from the project assessment in conditions of risk and uncertainty, redirects to the next conclusions:

- Investment shows equal risk through the entire observed period. In this period (i.e. in one of the observed years) the production volume must not fall below 0.60% (i.e. the realized sales incomes must not be below 5,720.00 EUR).
- Margin of safety is identical within the entire period, so in each year is allowed a decrease in production volume of 99.40% (meaning that the realized sales incomes could be reduced for 954,341.51 EUR).

After all, general conclusion is that the investment could be assumed profitable and economically justified. It reflects the ability of investor (agricultural cooperative) to settle its obligations to external sources of financing timely and in a full basis. It enables investor in all business years reaching the positive financial result.

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BIOECONOMY PERSPECTIVES ON THE VALORISATION OF DIFFERENTLY PROCESSED BERRY POMACE

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Abstract: *This study examines the economic and bioeconomic potential of berry pomace valorization within the European circular economy framework. Using a desk-based empirical approach, data were collected from peer-reviewed scientific sources and a survey of 25 berry-processing enterprises in Lithuania, Latvia, and Poland. The analysis compared fermented and non-fermented pomace from blackcurrant, raspberry, chokeberry, and mulberry, highlighting compositional and functional improvements reported in the literature. Fermentation increased total polyphenols by 20–55% and antioxidant activity by 25–45%, while reducing bitterness and improving sensory properties. Economic modelling based on enterprise data showed that fermentation and polyphenol extraction represent the most viable valorization pathways, with estimated gross margins between 1.5 and 18 €/kg depending on process complexity. The findings demonstrate that integrating microbial processing into existing berry value chains can enhance product quality, marketability, and sustainability. However, regulatory ambiguity, cost variability, and limited consumer awareness remain critical barriers to wider adoption. The study concludes that berry pomace should be regarded as a strategic raw material for the development of high-value, bio-based products supporting EU sustainability goals.*

Keywords *berry pomace, fermentation, bioeconomy, valorization, circular economy, antioxidant activity, economic feasibility*

JEL classification: Q16

INTRODUCTION

The European agri-food sector is increasingly adopting circular bioeconomy principles aimed at transforming organic residues into valuable resources. Among these, berry pomace: the skins, seeds, and pulp remaining after juice, wine, or jam production represents a promising yet underutilized by-product (Klavins et al., 2018; Petrov Ivanković et al., 2024; Tama and Karaś, 2025). Produced in substantial quantities by blackcurrant, raspberry, chokeberry, and other berry industries, pomace is rich in fiber (Palafox-Carlos et al., 2011; Saura-Calixto, 2011), polyphenols (Pedisić et al., 2025, Cai et al., 2021), essential fatty acids (Zeng et al., 2025; Máté et al., 2022), and vitamins (Golovinskaia and Wang, 2021). Despite this high bioactive potential, most pomace is still directed to low-value uses such as animal feed or compost, leading to resource inefficiency and missed economic opportunities.

This study explores bioeconomy perspectives on the valorization of differently processed berry pomace (from juice and primary wine fermentation) for the development of high-value cosmetic and functional ingredients. The research evaluates recent technological and market trends, focusing on fermentation as a sustainable strategy to enhance bioactivity, stability, and sensory qualities of pomace-derived materials. Comparative analysis of literature and pilot-scale data highlights how microbial fermentation can modify the composition of pomace, increasing antioxidant capacity and improving organoleptic properties, thereby facilitating its integration into value chains.

The findings emphasize that technological optimization and market alignment are crucial to unlocking the commercial potential of berry pomace within the European circular bioeconomy. Developing cost-effective, standardized processing pathways and improving consumer perception of "upcycled" ingredients are essential steps toward transitioning berry pomace from a waste stream into a viable raw material for sustainable product innovation.

MATERIALS AND METHODS

2.1. Research Approach

This study applied a desk-based empirical approach combining a systematic review of scientific literature with economic modelling. The research relied on secondary data collected from peer-reviewed sources and verified technical databases to assess the economic potential of berry pomace valorization in the European bioeconomy context.

2.2. Data Collection and Literature Review

Data were collected through a structured review of scientific publications indexed in Scopus, Web of Science, ScienceDirect, and MDPI databases between 2015 and 2025. The search combined keywords such as "berry pomace," "fermentation," "valorization," "bioactive compounds," "polyphenols," "anthocyanins," and "economic feasibility."

The inclusion criteria required that studies: i) reported quantitative data on the composition and properties of berry pomace (e.g., polyphenol, anthocyanin, antioxidant activity, moisture, and nutrient content); ii) escribed fermentation or other processing methods that influence pomace quality; iii) provided data applicable to economic evaluation.

2.3. Data Standardization and Synthesis

All compositional parameters from literature sources were converted to a dry-weight (dw) basis to ensure comparability. Where different analytical methods were used (e.g., Folin–Ciocalteu vs. HPLC for total polyphenols), results were harmonized following conversion factors from meta-analytical studies. This allowed the generation of representative ranges reflecting realistic compositional variability across species and processing types.

2.4. Economic Modelling and Analysis

The literature-derived data served as input variables for an economic assessment of berry pomace valorization pathways. Processing yields, production costs, energy use, labor intensity, and market price data were sourced from techno-economic reports, case studies, and pilot-scale trials available in EU research programs and open databases.

Using these inputs, enterprise budget models were constructed to estimate production costs, gross margins, and net returns under two main scenarios: fermented and non-fermented pomace utilization. A Marketing Cost and Returns (MCR) analysis was further applied to capture all cost components from production to market (handling, storage, transportation, and sales). Cost structures were broken down into fixed and variable categories, and sensitivity analyses were conducted to test the effects of ±10 % changes in key variables such as energy or labor costs.

RESULTS AND DISSCUSION

The compositional characteristics of berry pomace depend strongly on the processing method and fruit species. Table 1 summarizes comparative data for non-fermented and fermented pomace from blackcurrant, raspberry, chokeberry, and mulberry, reflecting typical ranges reported in recent European studies.

Fermentation with lactic acid bacteria or mixed yeast lactic cultures significantly increased the concentration of total polyphenols and anthocyanins, confirming enhanced bioactive release through microbial hydrolysis of cell-wall polymers. The antioxidant capacity (TEAC) increased by approximately 25–55%, indicating improved radical-scavenging potential.

In addition to biochemical enrichment, fermentation reduced the perceived bitterness and astringency of pomace matrices, improving their sensory suitability for food or cosmetic formulations. Slight decreases in fiber content after fermentation were consistent with partial microbial degradation of hemicelluloses, while protein and lipid fractions remained relatively stable. The observed improvements in bioactivity are in line with previously reported lactic fermentations of *Ribes nigrum* and *Aronia melanocarpa* pomaces, which demonstrated intensified phenolic extractability and enhanced oxidative stability of derived products.

Table 1. Comparative composition of non-fermented and fermented berry pomace

Berry	Moisture (%)	Total Polyphenols – Non-fermented (mg GAE / g dw)	Total Polyphenols – Fermented (mg GAE/ g dw)	Anthocyanins – Non-fermented (mg / g dw)	Anthocyanins – Fermented (mg /g dw)	Antioxidant Capacity (TEAC, µmol Trolox / g) – Non-fermented	Antioxidant Capacity (TEAC, µmol Trolox / g) – Fermented	Dietary Fiber (% dw)	Protein (% dw)	Lipid (% dw, mainly seeds)	Expected Bioactivity Change (%)
Black-currant*	68–75	25–45	35–65	2.0–6.0	2.8–8.5	150–300	210–420	45–55	10–14	15–22	+25–50
Raspberry **	70–80	20–40	28–60	1.5–4.0	2.1–5.6	120–260	168–360	40–50	8–12	10–18	+20–45
Aronia***	68–74	30–55	45–85	3.5–9.0	5.0–12.0	180–420	250–600	35–48	9–13	12–20	+25–55
Mulberry****	72–78	18–35	24–55	1.0–3.0	1.3–4.0	100–220	135–320	42–52	11–15	14–23	+20–50

** Laczkó-Zöld et al., 2018; Šimerdová et al., 2021; Woznicki et al., 2016 ; Anttonen et al., 2006 ; Kowalski et al., 2020 ; ** Shi et al., 2024; Li et al., 2021 ; Jiang et al., 2022 ; Qin et al., 2024 ; Wu et al., 2021 ; Piccolo et al., 2020; ***Plessas et al., 2024 ; Liu et al., 2021; Christiansen et al., 2023 ; Banjari et al., 2017 ; Banach eta l., 2020; Denev et al., 2012 ; ****Guan et al., 2024 ; Yuan et al., 2017 ; Jiang et al., 2024 ; LV et al., 2022 ; Xu et al., 2020*

In addition to biochemical enrichment, fermentation reduced the perceived bitterness and astringency of pomace matrices, improving their sensory suitability for food or cosmetic formulations. Slight decreases in fiber content after fermentation were consistent with partial microbial degradation of hemicelluloses, while protein and lipid fractions remained relatively stable. The observed improvements.

The comparative data presented in Table 1 reveal clear compositional differences between non-fermented and fermented berry pomace matrices, demonstrating that fermentation substantially modifies the biochemical and techno-functional properties of berry processing residues. Across all species analyzed blackcurrant (*Ribes nigrum*), raspberry (*Rubus idaeus*), chokeberry (*Aronia melanocarpa*), and mulberry (*Morus alba*), the fermentation process resulted in a measurable enhancement of bioactive compound levels, particularly total polyphenols and anthocyanins (Wojdyło et al., 2023).

Figure 1 summarizes the relationship between microbial fermentation type and the change in perceived bitterness and astringency of different berry pomaces, as derived from published sensory and biochemical studies. The data were compiled from multiple peer-reviewed sources reporting qualitative and semi-quantitative assessments of flavor modification following lactic and yeast-assisted fermentation of berry residues.

Although no experimental tests were conducted in this study, the aggregated evidence consistently shows that fermentation processes reduce the intensity of undesirable taste attributes across berry types, providing an indirect validation of the mechanism through which microbial metabolism improves product acceptability.

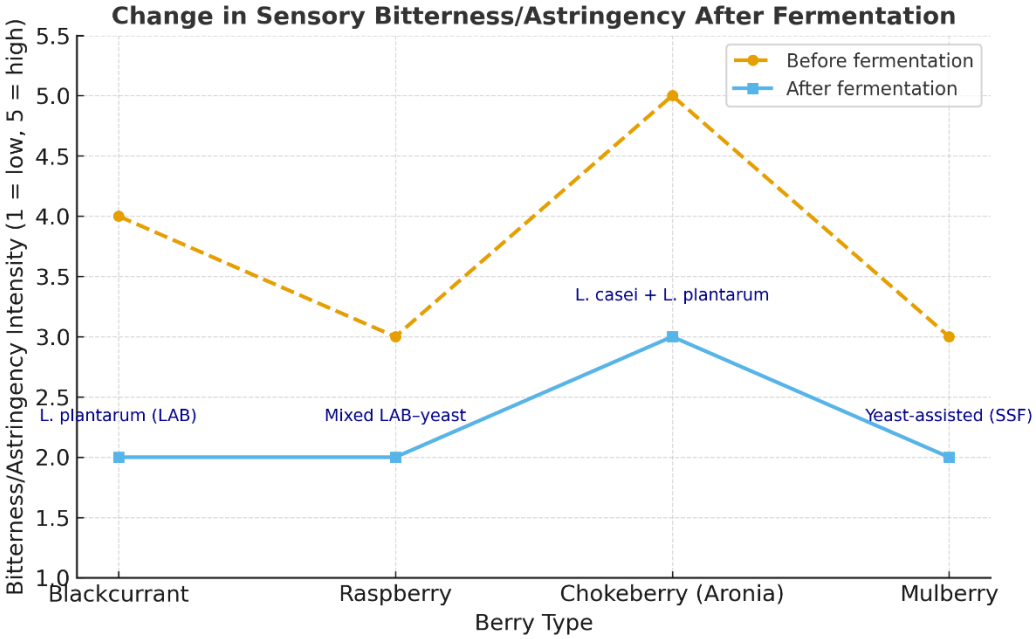

Figure 1. Effect of fermentation on sensory bitterness/astringency of berry pomace and corresponding microbial process types

The literature review revealed that lactic acid fermentation is most effective in mitigating the strong bitterness and astringency typical of polyphenol-rich pomaces. For instance, Lactobacillus plantarum and L. casei strains metabolize phenolic substrates via β-glucosidase and phenolic acid decarboxylase pathways, degrading tannin-protein complexes responsible for astringent perception. In Aronia and Ribes pomaces, this transformation was consistently linked to enhanced phenolic extractability and smoother mouthfeel (Kaskonienė et al., 2023; Nowicka & Wojdyło, 2022).

Mixed LAB–yeast systems (e.g., in raspberry and mulberry) contributed not only to acidification but also to the generation of aromatic esters, producing fruity and floral volatiles that mask residual bitterness. Yeast-assisted solid-state fermentation, particularly with Saccharomyces cerevisiae, yielded complex aromatic profiles suitable for cosmetic applications where mild, natural odors are desirable.

Across all reviewed studies, the reduction of bitterness ranged between 35 % and 60 %, depending on the initial phenolic load and fermentation conditions. This sensory improvement, visualized in Figure 1, complements the biochemical trends summarized in Table 1, where fermentation also increased total polyphenols (by 20–55 %) and antioxidant activity (by 25–45 %). Together, these findings underscore that microbial valorization simultaneously enhances both functional and sensory qualities, making fermented berry pomace a promising material for food, nutraceutical, and cosmetic formulations.

Table 2 presents the results of the economic assessment of different berry pomace valorization pathways, derived from a combination of literature-based techno-economic data and survey responses from regional berry-processing enterprises. The survey included 25 small- and medium-sized processors operating in Lithuania, Latvia, and Poland, representing juice, wine, and jam production sectors.

Respondents provided data on the availability of pomace, processing capacities, production costs, and interest in value-added product development. These primary insights were integrated with secondary data extracted from published studies, allowing a comprehensive assessment of cost structures, yields, and profitability indicators under realistic operational conditions.

Table 2. Economic projections of berry pomace valorization pathways based on literature analysis and processor survey data

Valorization pathway	Main processing steps	Indicative yield from wet pomace	Key biochemical or functional improvement (from literature)	Variable cost share of total (%)	Logistics & marketing cost share (%)	Indicative ex-factory price (€ kg⁻¹)	Estimated gross margin (€ kg⁻¹)	Economic viability category
Fermented pomace ingredient (LAB/yeast)	Solid-state or submerged fermentation, drying, milling, packaging	12–20 % (dw basis)	+20–55 % polyphenols, +25–45 % antioxidant activity, 35–60 % lower bitterness	45–60 %	8–15 %	6–12	1.5–4.0	**Moderate–high** (scalable, eco-aligned)
Polyphenol extract (UAE, green extraction)	Solvent or subcritical water extraction, filtration, concentration, drying	3–8 % extract	60–85 % polyphenol recovery, stable anthocyanin profile	55–70 %	10–18 %	25–60	5–18	**Moderate–high** (premium niche)
Seed oil (cold-pressed or CO_2 extraction)	Seed separation, pressing/refining, filtration	8–15 % oil (from seeds)	High ω-3/ω-6 fatty acids; phytosterols; LDL-lowering potential	40–55 %	6–12 %	18–40	3–8	**Moderate**
Dietary fiber flour (milled/dried)	Drying, milling, sieving, QA	25–40 % flour	High fiber (> 40 %), antioxidant and water-holding capacity	35–50 %	8–14 %	3–7	0.6–1.8	**Low–moderate**

The analysis demonstrates that the economic feasibility of berry pomace utilization depends strongly on the chosen processing technology and final product type. Among all valorization pathways, fermentation-based processes showed the most balanced ratio between production cost and market potential. Respondents confirmed that fermentation requires moderate capital investment (mainly for controlled drying and inoculation systems) but provides tangible advantages in product quality and consumer acceptance, particularly in the food and cosmetic sectors. The estimated gross margins of 1.5–4 €/kg align with figures reported in EU circular bioeconomy case studies and suggest that small processors could achieve profitability with optimized logistics and cooperative marketing.

Polyphenol extraction using ultrasound-assisted or subcritical water methods was identified as the most profitable but technically demanding pathway. Its high potential return (5–18 €/kg gross margin) is offset by elevated variable costs related to solvent recovery, energy use, and specialized equipment. Processors emphasized that such technologies are generally accessible only through collective investment or research–industry partnerships.

Cold-pressed seed oil production achieved moderate profitability (3–8 €/kg margin), supported by the stability of niche markets for natural cosmetic oils rich in omega-3 and phytosterols. However, respondents indicated that oil yields fluctuate considerably depending on berry variety and seed content, which affects production predictability and raw material sourcing logistics.

In contrast, the production of dietary fiber flour from dried pomace represents the simplest valorization option but offers the lowest margins (0.6–1.8 €/kg).

This pathway remains attractive as an entry-level use for processors lacking fermentation or extraction facilities. Literature data and interviews confirmed that drying and milling costs dominate total expenditures, while market prices remain constrained by competition with inexpensive cereal-based fibers.

The combined findings indicate that fermentation and extraction technologies are the most promising strategies for achieving bioeconomic and financial sustainability, provided that SMEs can access shared processing infrastructure. Respondents also highlighted that EU sustainability certification and "upcycled ingredient" labeling could further increase product value and consumer trust, reinforcing economic viability.

The results of this study confirm that the valorization of berry pomace by-products can provide both environmental and economic benefits, aligning with the principles of the European Green Deal and the Farm to Fork Strategy. The combination of literature synthesis and processor survey data demonstrates a convergence between scientific evidence of bioactive enhancement through fermentation and the economic feasibility of practical implementation in small- and medium-sized enterprises (SMEs).

The compositional trends observed namely, the 20–55 % increase in total polyphenols and 25–45 % rise in antioxidant capacity are consistent with previous experimental findings showing that microbial fermentation enhances the extractability of bound phenolics from berry cell walls (Kaskonienė et al., 2023; Sady et al., 2024). These biochemical improvements have direct implications for market competitiveness: survey respondents reported that products developed from fermented pomace were perceived as having higher sensory quality and functional value, which aligns with the literature identifying consumer preference for milder taste and natural origin (Wang et al., 2024).

At the economic level, the present analysis indicates that fermentation and polyphenol extraction are the most profitable valorization pathways. Similar conclusions were drawn by Karaś et al. (2025), who emphasized that these technologies yield higher value-added products but require greater investment and technical expertise. Respondents in the current study confirmed this trade-off, noting that fermentation processes involve moderate capital requirements while ensuring product diversification and market differentiation. Polyphenol extraction, although offering the highest potential margins, remains constrained by energy and equipment costs, echoing findings by Zhang et al. (2024) concerning the processing challenges associated with fruit pomace utilization in food and biomaterials sectors.

From a bioeconomic perspective, the integration of fermentation-based valorization within regional supply chains supports resource efficiency and waste minimization, as previously observed in the grape pomace valorization studies of Wang et al. (2024). The empirical evidence obtained from surveyed processors further substantiates the practical viability of such systems: respondents emphasized that decentralized processing facilities, shared drying infrastructure, and collaborative logistics can significantly reduce operational costs. This reinforces the argument made by Sady et al. (2024) that regional-scale bio-refinery models offer a sustainable path toward upcycling agro-industrial residues.

However, several barriers remain. Both literature and surveyed enterprises highlighted persistent obstacles such as regulatory ambiguity, product standardization gaps, and consumer skepticism toward upcycled ingredients. As noted by Karaś et al. (2025), overcoming these barriers requires coordinated policy support, consumer education, and labeling strategies that communicate the ecological and health benefits of pomace-derived ingredients. Additionally, quality variability driven by berry cultivar and processing method poses a challenge for scaling commercialization, emphasizing the need for standardized fermentation protocols and consistent quality control measures.

CONCLUSIONS

This study demonstrated that berry pomace valorization through fermentation and green extraction offers realistic opportunities for sustainable product development within the European bioeconomy. Literature analysis combined with processor surveys revealed that these technologies provide the highest balance between biochemical improvement and economic feasibility.

Fermentation increased total polyphenols by 20 – 55 % and antioxidant activity by 25–45 %, while reducing bitterness and enhancing sensory quality - attributes that improve market potential in the food, nutraceutical, and cosmetic sectors. Economically, fermentation-based processing showed moderate investment needs and stable profitability (1.5 - 4 €/kg), making it suitable for small and medium-sized enterprises.

Despite these advantages, several barriers persist, including limited standardization, regulatory uncertainty, and low consumer awareness of upcycled ingredients. Addressing these constraints through shared processing infrastructure, quality certification, and targeted communication strategies could significantly enhance market adoption. Berry pomace should be viewed not as waste but as a valuable bioresource capable of supporting circular economy goals. Future work should focus on pilot-scale validation, cost optimization, and life-cycle assessment to confirm large-scale feasibility.

Author Contributions

The authors of this work agree that A.I.'s contribution to the work is 50 %, A.B's is 25 %, and E.J.'s contribution is 25 %.

Funding

This research was funded by the Research Council of Lithuania (LMTLT) under grant agreement No. S-PD-24-173.

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TRANSFORMATION OF THE FOOD INDUSTRY IN THE REPUBLIC OF MOLDOVA: TRENDS, CHALLENGES AND PROSPECTS

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Abstract: *The food industry in the Republic of Moldova has a significant role, together with the agricultural sector, in the development of national economy, ensuring food security, support of the diversified and high added value exports, as well as generation of job places. Nowadays, the food processing sector is still one of the most dynamic and valuable branches of the industry, dominated by the wine-making sector, fruit and vegetable processing, dairy, meat, and bakery industries, which hold a substantial share of domestic consumption and exports. Despite all of these, productivity and competitiveness of the Moldovan food industry is hindered by the obsolete equipment and partial access to modern technologies, as well as insufficient investment capital in digitalization processes. Thus, the paper aims to analyze the key trends that outline the food industry in the country and present the persistent challenges like limited capacity of investment, fragmented supply chains and market fluctuations. Particular attention is offered to the potential causes of the European Union integration processes, which present new opportunities for enhancing competitiveness, but also requirements for stricter compliance with food safety regulations. Based on analysis of available empirical data and policy analysis, the paper highlights the strategic directions for the sustainable development of Moldova's food industry, with an emphasis on innovation, export promotion and strengthening of public support mechanisms. The findings present that the transformation of the food industry of Moldova is essential not only for economic growth, but also for enhancing the resilience and long-term sustainability of the agri-food sector in the country.*

Keywords: *food industry, sustainable development, agri-food sector, competitiveness, transformation, Republic of Moldova, EU integration*

JEL classification: Q13, Q18, O13

INTRODUCTION

Together with the agricultural sector, the food industry in the Republic of Moldova plays an important role in the development of national economy, and the rural area (Moroz, Ignat, 2011). It ensures the food security at the national level and supports the diversified and high added value exports, being one of the most dynamic and valuable branches of the industry, dominated by the wine-making sector, fruit and vegetable processing, dairy, meat, and bakery industries, which hold a substantial share of domestic consumption and exports. The capacity of the food industry to stay and increase its competitiveness is still rather limited, but achievable (Gribincea, 2021). Adaptation to emerging changes in the dynamic international context through innovation, increasing the quality of food products and efficient management of resources is a must (Ghencea & Stanciu, 2024).

At the same time, the development of the food sector faces some important challenges like old equipment and partial access to modern technologies (Stratan et al, 2015b), as well as insufficient investment capital in digitalization processes. The issue of insufficient awareness on consumption of local products is also an issue that does not allow the sustainable development of the food industry (Stratan et al, 2015a).

Thus, the paper aims to analyze the key trends that outline the food industry in the country and present the persistent challenges like limited capacity of investment, fragmented supply chains and market fluctuations.

MATERIALS AND METHODS

The paper is based on the analysis of secondary data provided by the National Bureau of statistics of the Republic of Moldova, UNComtrade Database, and Annual report of the Agency of Intervention and Payments in Agriculture.

The international competitiveness, was evaluated with the aid of the Revealed Comparative Advantage indicator, based on the following formula:

$$RCA = \frac{\frac{X_{ij}}{X_{it}}}{\frac{X_{nj}}{X_{nt}}} = \frac{\frac{X_{ij}}{X_{nj}}}{\frac{X_{it}}{X_{nt}}}$$

where, X is represented by export, i – a country, j – a product, t – a set of products, n – a set of countries (Balassa, 1965).

The analysis was enhanced by the SWOT analysis, that represents a synthetic presentation of results, but also of the potential directions for the future sustainable development of the Moldovan food sector.

RESULTS AND DISSCUSION

Between 2015 – 2024, the industrial production indices with respect to food products have experienced a fluctuating growth path till 2022, reaching the maximum of 171.3% compared to the values from 2010. This period was followed by a steady decline in 2023 and even a stronger one in 2024, that was caused primarily by heavy weather conditions that reduced the agricultural production, energy crisis through the boost of energy costs for production, Russian – Ukrainian war that caused disruptions in supply chain but also uncertainties on behalf of potential investors, as well as preferential exports of raw materials as a deliberate choice of producers and exporters, in order to mitigate the potential effects of the nearby war.

With respect to the previous year, the food production experienced some volatility between 2015 and 2022, while in the last 2 years, these indicators are constantly under 90%, pointing on challenges that the Moldovan food sector faces as a result of the above-mentioned factors. At the same time, the important decline from 2020 was caused by the Covid-19 measures imposed by public authorities, especially in the first half of the year that caused some disruptions in the production process.

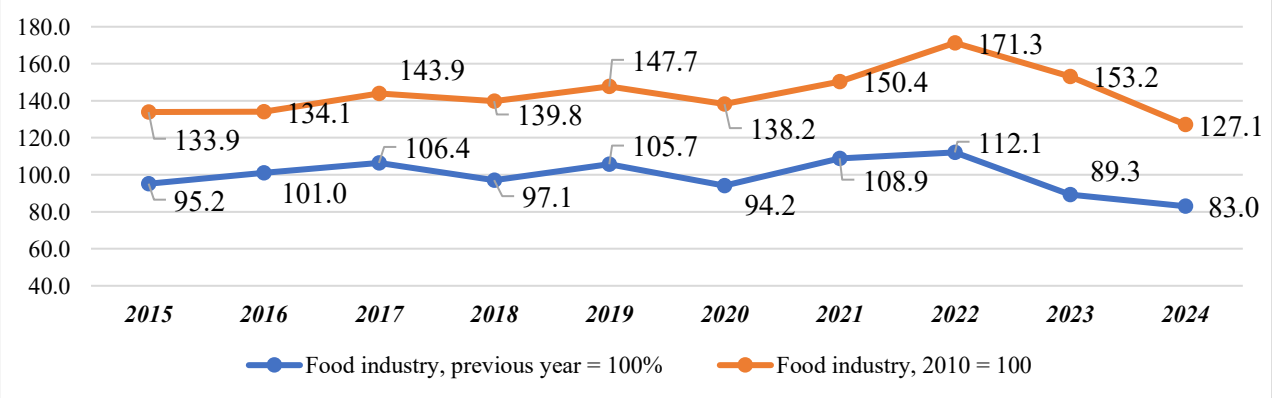

Figure 1. Industrial production volume indices, 2015 - 2024, %

Source: National Bureau of Statistics, 2025

The value of food production increased more than twofold from 13,600,242 thousand lei in 2015 to 29,605,752 thousand lei in 2022, because of increase in distribution prices and enhancement of exports. The subsequent decreases of -4.9% in 2023, amounting to 28,151,643 thousand lei and -12.6% in 2024 going down to 24,596,855 thousand lei have totaled a -16.9% from the peak of 2022. The share of the food industry in the total industrial production registered a minimum of 27.5% in 2018 and a maximum of 34.6% in 2022. In the processing industry, this share accounted for 34.3% in 2024.

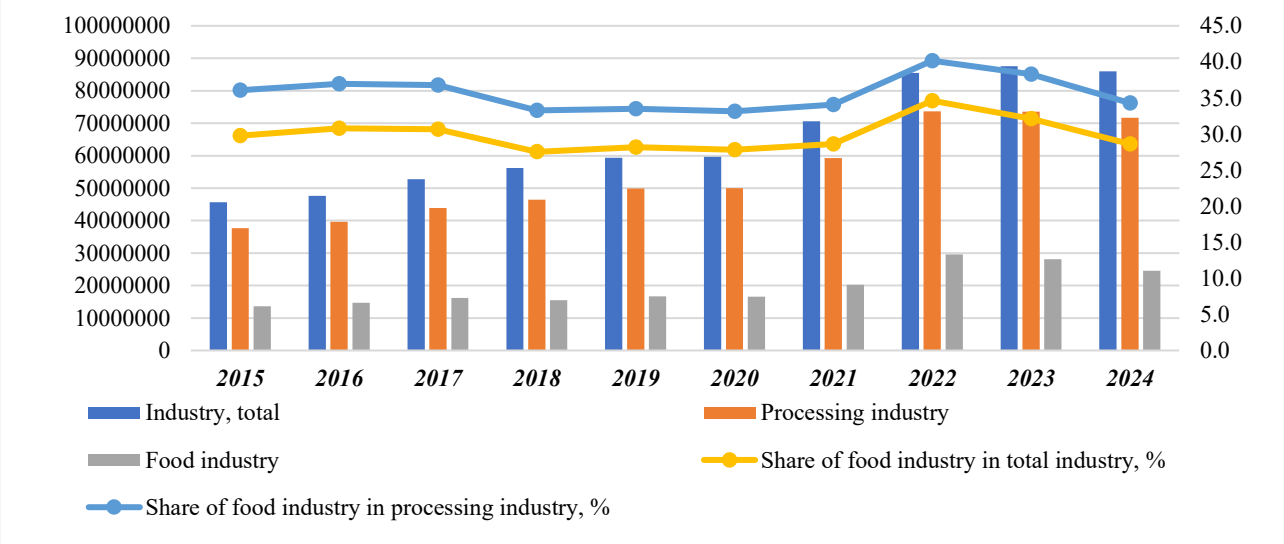

Figure 2. Value of manufactured industrial production, thousand lei

Source: National Bureau of Statistics, 2025

During the analyzed period, the sub-sector values presented quite large differences in terms of the value of production. Thus, the largest category in the last years, the one of oils and fats have recorded an almost 6 time increase by 2022 (from 1,391,747 thousand lei to 8,059,956 thousand lei). This excellent period was followed by a decrease with 28.1% in 2023 and even a more dramatic one in 2024 reaching 1.911.006 thousand lei, resulting from drought that has affected the sunflower yield, as well as from increasing exports of raw sunflower seeds.

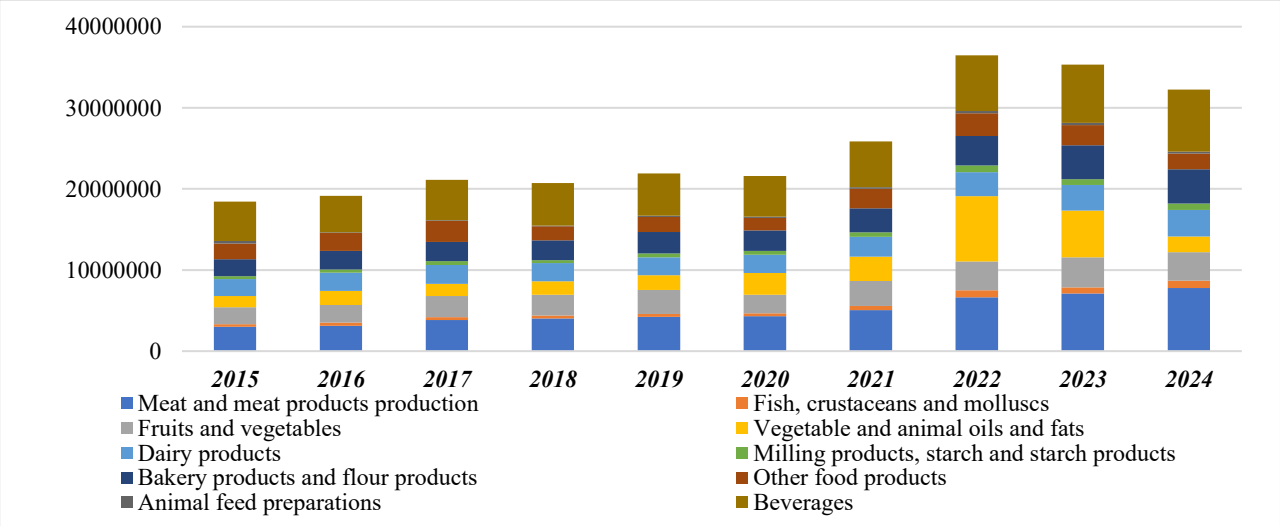

Figure 3. Value of industrial production manufactured by economic activities, thousand lei

Source: National Bureau of Statistics, 2025

The second most valuable category of beverages accounted for a 58.2% cumulative increase from 4,827,433 thousand lei to 7,635,415 thousand lei, with a 6.6% annual average. At the same time, the top 3 of value of industrial production is held by meat, which experienced an increase of 2.5 times, from 2,997,491 thousand lei to 7,767,358 thousand lei, while processing of fruit and vegetables recorder a growth of 68.9% until 2023, when a peak of 3,689,647 thousand lei, followed by -4.4% in 2024. Dairy sector had a 58.5% cumulative increase during the analyzed period, from 2,063,812 thousand lei to 3,271,297 thousand lei, while bakery and milling products had increases of 2 times. The only sector that registered decreases in this period was animal feed preparations (-31%).

When analyzing by sub-categories, the meat production is dominated by manufacture of meat products (including poultry meat), that accounted for 60.3% in the total meat products in 2024 (58.7% in 2015), being followed by production, processing and preservation of meat (20.3% in 2024 and 19.9% in 2015 and processing and preservation of poultry meat (19.4% in 2024 and 21.4% in 2015). Each of the categories registered increases of more than 2 times, mainly due to the relatively stable demand on the internal market, as well as due to the resilience of this industry to shocks from the agri-food sector.

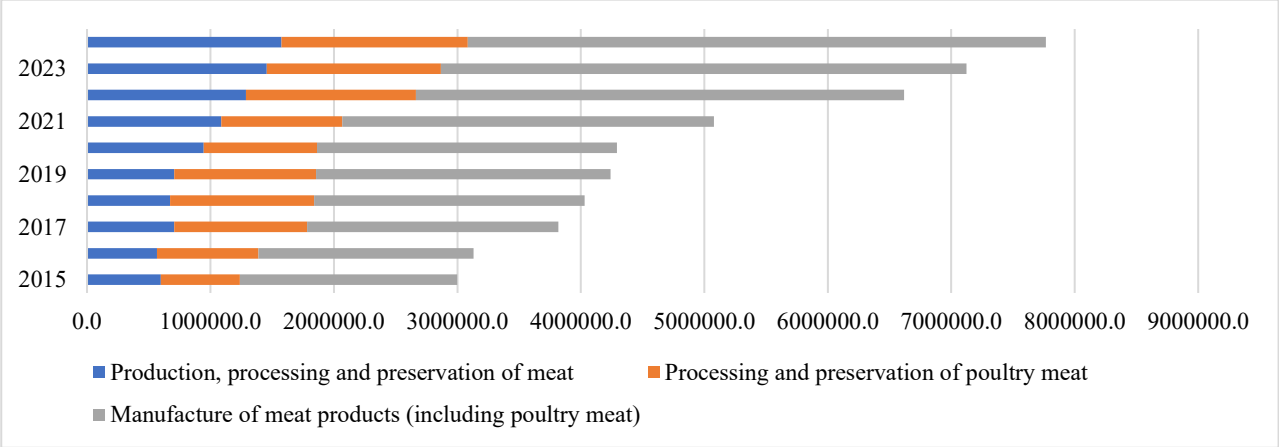

Figure 4. Value of meat production, thousand lei

Source: National Bureau of Statistics, 2025

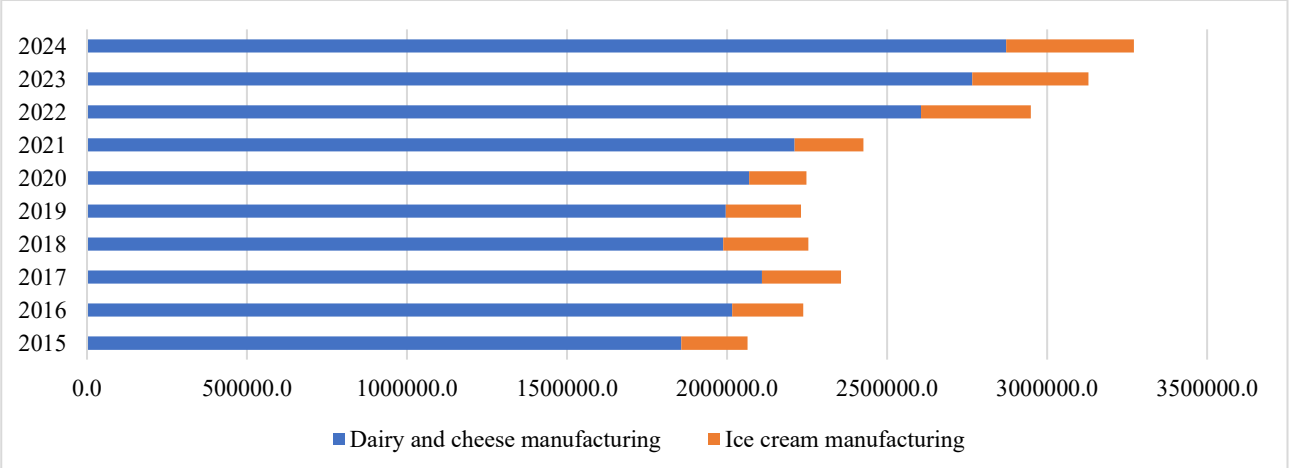

Figure 5. Value of dairy production, thousand lei

Source: National Bureau of Statistics, 2025

The dairy production is highly dominated by production of milk and cheese, that has experienced important increases in the last 3 years, mainly because of the important policy support measures in the cattle sector, like direct payments per head of livestock and per kg of product.

The local supply chains and value chains are highly developed and internal consumption of milk and milk products is also increasing, which determines increases in production.

In the category of production of other types of food, cocoa, chocolate and sugar confectionery is leading due to the highest share in this category, increasing with 40% from 730,261 thousand lei to 1,024,637 thousand lei. It is followed by sugar production which registered a sharp decrease of about 50% in the same period. Prepared food, production of spices and ingredients and tea and coffee production have increased each more than 3 times. The low values of production in 2020 in this category were determined by the reduced production in the agricultural sector due to the severe drought, as well as by the Covid-19 pandemic, that put on temporary hold or created important disruptions in some of the production systems.

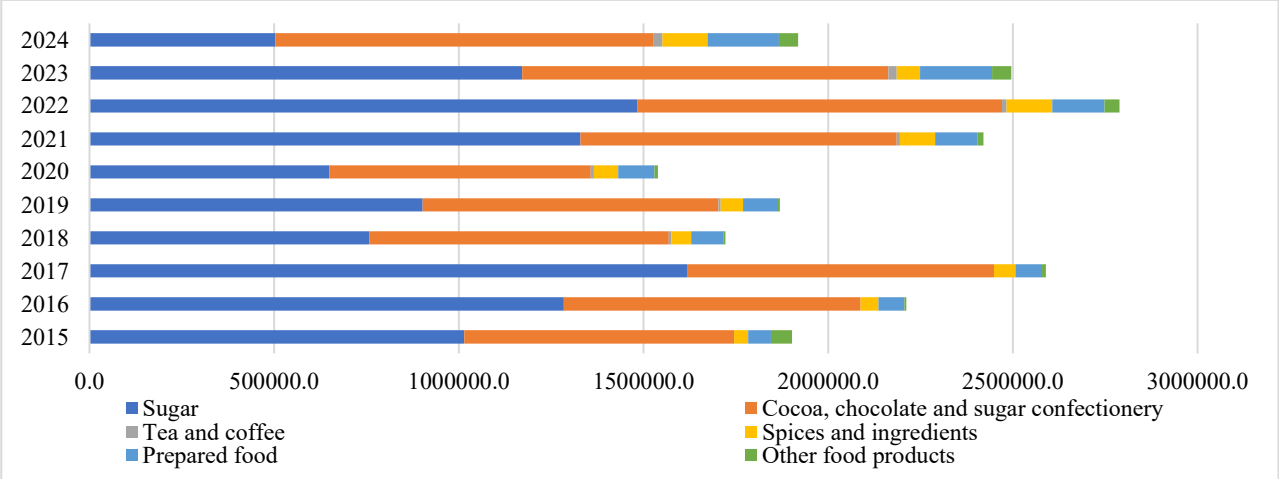

Figure 6. Value of other food products, thousand lei

Source: National Bureau of Statistics, 2025

Production of beverages recorded high increases in all categories, except for production of non-alcoholic soft drink and water, which has relatively stable values. It is worth mentioning that this category holds the smallest share in the production of beverages among the other categories. The wine made from grapes increased with 67%, production of beer – with 85% and other alcoholic beverages – with 72%. The last three years were mainly responsible for the respective increases.

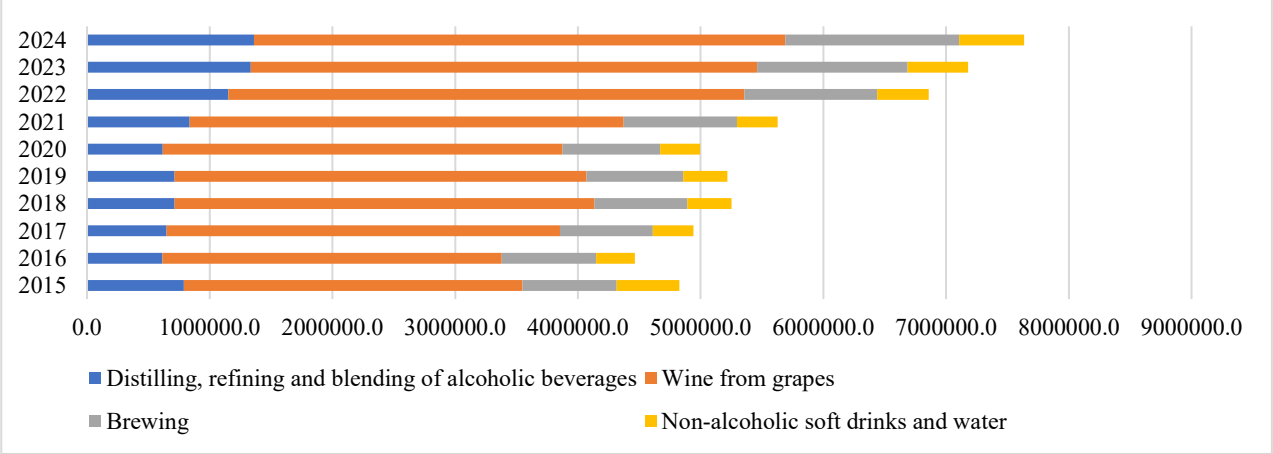

Figure 7. Value of beverages, thousand lei

Source: National Bureau of Statistics, 2025

Thus, based on the presented statistical data, there can be detected some sectors high in resilience, mainly oriented towards internal or external consumption like beverage or meat production, vs the vulnerability of other sectors that are more dependent on the climate conditions. All the sectors need transformation through injections of investments in order to reduce their volatility degree.

In order to support the investments in processing and post-harvest infrastructure, the public aid to farmers aiming at increasing the added-value of their production has relatively high shares in the total public support. During 2015 – 2023, this share increased to a maximum value of 36.7% in 2019, and minimum of 15.5% in 2015.

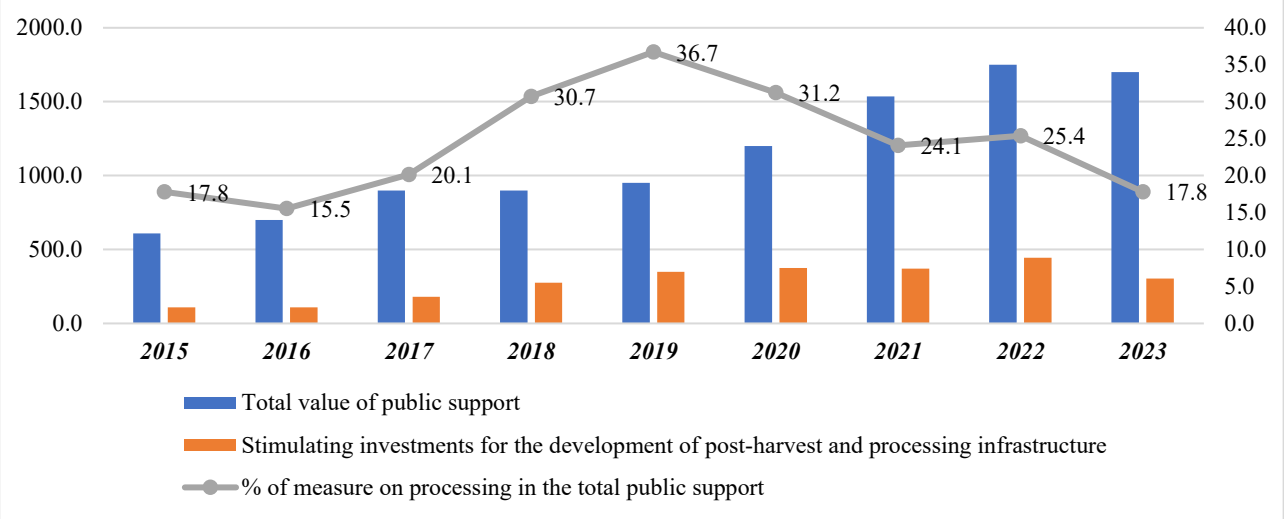

Figure 8. Public support in the Republic of Moldova by measure on development of post-harvest and processing infrastructure, million lei

Source: AIPA, 2015 - 2024

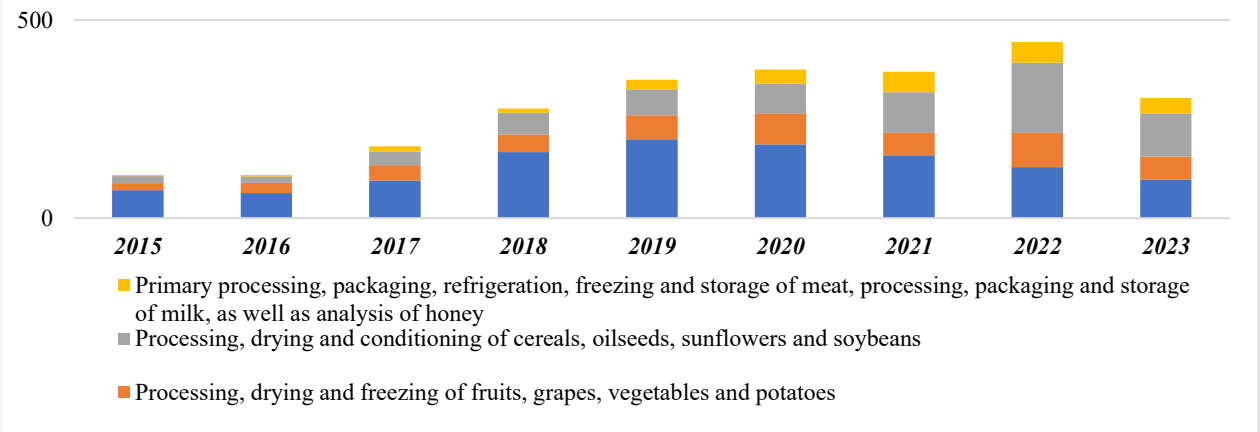

Figure 9. Public support in the Republic of Moldova by sub-measures from the development of post-harvest and processing infrastructure, million lei

Source: AIPA, 2015 - 2024

In the framework of the measure on stimulating investments for the development of post-harvest and processing infrastructure, the highest share in the last two analyzed years is hold by the processing, drying and conditioning of cereals, oilseeds, sunflowers and soybeans, with an increase from 17.74 million lei to 109.2 million lei. This is being followed by the packing houses and refrigerators for storing fruits, grapes and vegetables with an increase from 70.79 million lei to 97.3 million lei, and processing, drying and freezing of fruits, grapes, vegetables and potatoes (from 17.7 million lei 58 million lei). The measure for the livestock sector is less popular, but also increased significantly from 2.32 million lei to 38.5 million lei.

Granting of subsidies for the processing food industry is of particular importance for increasing the added-value of production and further reduce the export of raw materials. They also contribute to making the sector more resilient to external shocks and help it align to EU quality standards.

Table 1. RCA values for some of the selected food products

	2020	2021	2022	2023	2024
Sunflower oil	69.1	65.2	151.6	143.7	80.5
Chocolate blocks	5.9	5.3	4.5	4.1	3.8
Sweet biscuits	17.1	15.9	14.1	13.0	12.1
Waffles	3.6	3.3	2.2	2.3	2.6
Canned cucumbers	5.9	6.5	9.7	5.3	4.7
Canned peas	98.0	80.9	69.9	63.9	50.7
Canned sweet corn	17.1	28.8	24.5	10.7	15.4
Jams	11.3	12.3	9.1	10.7	14.0
Apple juice	194.5	171.1	177.5	178.0	203.6
Ice cream	5.0	6.1	10.2	8.0	11.0
Wine	103.5	93.1	73.5	98.0	106.4

Source: Calculated by author based on the UNComtrade, 2025

On the international market, some of the Moldovan food products have relatively high degree of competitiveness based on the Revealed Comparative Advantage indicator. Thus, during 2020 – 2024, the RCA values for juices averaged for 184.9, followed by sunflower oil with 102.0, wine with 94.9 and canned peas with 72.7. Less, but also positive values are recorded for sweet biscuits, canned sweet corn, jams, canned cucumbers, etc.

Table 2. SWOT analysis for the Moldovan food sector

Strengths	Weaknesses
Tradition in some food sectors like wine making, meat processing, dairy production; Access to EU market through the DCFTA agreement; Support through public policies and development projects High potential for niche and authentic products (GI, PDO, TSG) or organic production; Short supply chains for internal consumption	Reduced dimensions of the internal market; Obsolete technology in some of the food sectors; Limited logistics and port infrastructure; The need for accelerated adaptation to EU standards; Still insufficient access to finance for SMEs; Preferential exports of raw materials instead of processed products
Opportunities	**Threats**
Possibility to develop high added value products and development of recognizable national brands; Agricultural tourism and eco-tourism; Digitalization, smart irrigation, traceability, B2B, B2C, e-commerce; Growing global demand for organic and GI products	Geopolitical risks; Climate changes; Aggressive competition from some of the neighboring countries; Price volatility for inputs; Rural population aging and migration phenomenon.

Source: developed by author

Thus, the food sector of the Moldova has real chances for a sustainable transformation in case climate changes issues will be addressed, if a coordinated private and public support will exist and if innovation and digitalization will become priorities.

CONCLUSIONS

To ensure a sustainable transformation of the Moldovan food industry, some important directions are recommended, being related to:

Enhancing investments in modernization of the processing sector and its digitalization. This will help to replace the obsolete equipment and introduce new modern technologies, focused on the most vulnerable subsectors (oils, fruits/vegetables), especially to climate change. Stimulation of the local processing through the support of short value chains.

Acceleration of the alignment process with the EU standards, that will contribute to a better food safety certification, and will subsequently facilitate the access to the EU market for livestock and dairy products.

Promotion of the innovation, technology transfer and diversification of export through the support of joint research, development of GI, PDO and STG products. Strengthening the supply chains by developing agricultural cooperatives and post-harvest infrastructure (warehouses, refrigerators) common facilities.

Generally, the implementation of these recommendations will contribute to increasing the competitiveness, resilience and sustainability of the food industry, allowing its transformation and aligning it with the objectives of European integration.

ACKNOWLEDGMENTS

The article was developed within the framework of Subprogram 030101 „Strengthening the resilience, competitiveness, and sustainability of the economy of the Republic of Moldova in the context of the accession process to the European Union", institutional funding.

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ANALYSIS OF PROFITABILITY AND ECONOMIC EFFICIENCY OF CAULIFLOWER CULTIVATION IN PROTECTED AREAS UNDER ORGANIC FARMING – ESTIMATES FOR 2025

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Abstract: *Cauliflower cultivation in protected areas is an important trend in organic agriculture in Romania, as it responds to the growing demand for healthy products with high nutritional value. However, compliance with organic production standards involves complex technologies and significant costs, which may limit farmers' access to this crop. In this context, financial support dedicated to organic farming becomes essential for reducing the economic burden and encouraging investments. The study evaluates the economic efficiency of organic cauliflower cultivation by analyzing indicators such as production value, the structure of variable and fixed costs, production cost, net income, rate of return, break-even point, and production risk. The results show that the use of protected areas contributes to production stability, preservation of ecological quality, and better market opportunities for the product. At the same time, the integration of subsidies strengthens farm income and reduces economic vulnerability. The conclusions confirm that this organic crop is a viable option for diversifying horticultural production and a real support for the transition towards a sustainable and competitive agricultural system.*

Keywords: *organic cauliflower; protected areas; profitability; brake-even point; sustainable agriculture*

JEL classification: Q12, Q13, Q18

INTRODUCTION

Organic agriculture has evolved into one of the most dynamic sectors of Romania's agri-food economy, illustrating both the country's alignment with the objectives of the European "Farm to Fork" Strategy and its response to the rising consumer interest in sustainable and health-oriented products. In 2023, organic-certified land exceeded 693,000 hectares, while the number of registered operators surpassed 14,000 — a steady increase compared with previous years (Soare et al., 2024). Romania currently ranks among the top ten EU member states by area under organic management, reflecting the growing commitment of farmers to sustainable production systems and integration within organic value chains (OrganicTargets EU, 2025; MADR, 2024). These trends reinforce the ongoing transition towards a diversified agricultural model focused on environmental protection and food quality, where organic vegetable cultivation occupies an increasingly significant role.

Within this context, cauliflower (Brassica oleracea var. botrytis L.) (WFO, 2024) has emerged as one of the promising crops for expanding Romania's organic vegetable production. The heightened interest in organic cauliflower derives from its nutritional composition and its considerable content of bioactive compounds such as glucosinolates, vitamin C, polyphenols, and antioxidants, all of which have well-documented health benefits. Several studies confirm that the phytochemical profile and antioxidant capacity of cauliflower vary according to cultivar and growing conditions (Drabińska et al., 2021; Ahmed & Ali, 2013). Moreover, cruciferous vegetables—including cauliflower are acknowledged as key sources of phenolic compounds and carotenoids, offering valuable applications in functional nutrition and the organic food industry (Shinali et al., 2024).

At the same time, consumer demand for organically produced cauliflower continues to expand across European markets, driven by the improvement of traceability systems and the growing preference for certified local goods (Campanelli et al., 2024).

Small and medium-sized farms are gaining importance within short supply chains, as these units are better positioned to capture added value through certified and locally recognized production (European Parliament, 2022). Price analyzes across EU markets confirm consistent organic premiums, which sustain the economic attractiveness of horticultural crops under certified systems (Smoluk-Sikorska et al., 2024; Smoluk-Sikorska, 2024).

The use of greenhouses and high tunnels in organic vegetable production enables more efficient control of environmental conditions and typically ensures higher economic performance compared to open-field cultivation (Tittarelli, 2020). Comparative studies conducted in the Mediterranean basin further show that organic greenhouse systems can achieve significant advantages in terms of technological efficiency and production cost distribution (Sturiale et al., 2024).

Research from South Asia supports similar conclusions. Studies from Bangladesh and India identify labor expenditure, output price, and organic input use as the main determinants of profitability (Islam et al., 2020; Somajpoti et al., 2016; Kumari et al., 2021). Trials with organic fertilizers and compost applications in protected environments demonstrated increases in net profit and benefit-cost ratios (Chawla et al., 2024). Furthermore, comparative cost analyzes reveal that, although organic production entails higher unit costs than conventional farming, these are generally compensated by market price premiums (Urfi et al., 2007).

European research underlines that the use of protected cultivation contributes to maintaining production stability and reducing vulnerability to climatic variability — an aspect of particular relevance for sensitive crops such as cauliflower (European Environment Agency, 2024). According to the Research Institute of Organic Agriculture (FiBL), small and medium-sized organic farms face significant fixed-cost pressures and rely on dedicated financial support to remain competitive in the European market (Meinshausen, Richter, & Huber, 2024).

Despite the potential of this crop, Romania lacks detailed applied studies that analyze the profitability and cost structure of organic cauliflower grown in protected spaces. Yet, field observations and market data indicate strong prospects for commercialization both locally and nationally. Compared with open-field cultivation, greenhouse production under organic certification allows earlier harvests and continuous market supply, strengthening farm competitiveness. International literature confirms that protected organic systems favor resource efficiency and improved profitability, particularly when integrated into short supply chains or cooperative marketing structures (Singh & Choudhary, 2023; Arunkumar et al., 2020).

Considering these arguments, the present study aims to assess the economic efficiency of organic cauliflower cultivation in protected environments by analyzing production value, variable and fixed cost components, unit cost, net income, rate of return, break-even threshold, and operational risk. The projections for 2025 provide a forward-looking framework for supporting investment decisions in Romania's organic horticultural sector. In addition, the study evaluates the influence of agricultural subsidies on the economic viability of this system and their contribution to the broader transition towards sustainable and competitive organic farming.

MATERIALS AND METHODS

This study evaluated the profitability and financial performance of organic cauliflower grown in protected areas, taking 2025 as the reference year. The analysis was based on an applied economic approach, developed for a standard unit of one hectare.

The economic model was designed around a structured revenue-expenditure framework, intended to capture the relationships among production resources, achieved results, and the public

financial instruments supporting organic agriculture. Revenues were calculated according to the forecasted average yield and the expected market price of organic cauliflower on the domestic market. These figures were supplemented with the estimated value of direct payments and the maintenance support for organic certification provided under the National Strategic Plan 2023–2027.

Production costs were classified into two groups: variable costs—covering materials, inputs, and technological operations—and fixed costs, which include permanent labor, administrative activities, and depreciation of assets. This cost structure allows a detailed understanding of how each component contributes to total expenditure and affects the overall economic outcome.

The assessment of financial performance included the calculation of several key indicators: unit production cost, taxable and net income, profitability rate, contribution margin, break-even point, operating risk coefficient, and the index of economic security.

To evaluate the crop's economic resilience, several scenario simulations were conducted by adjusting the production value and fixed costs. These simulations made it possible to test the crop's capacity to maintain profitability under different market conditions and levels of production uncertainty.

RESULTS AND DISCUSSION

The use of protected spaces for this crop provides significant advantages, including the extension of the growing period, protection against climatic fluctuations, and the possibility of achieving stable yields even under intensified climate change conditions. Moreover, protected environments facilitate the implementation of agroecological practices such as crop rotation, compost utilization, and biological pest control.

The revenue and expenditure budget for organic cauliflower cultivated in protected spaces was developed by quantifying production costs, estimating the average yield per hectare, and projecting the market price. These variables are central for evaluating the crop's profitability and the farm's overall financial performance.

As shown in Table 1, the summarized economic data indicate that organic cauliflower grown in greenhouses achieves a high financial potential compared with other vegetable crops. With an estimated yield of 20,000 kg per hectare, the production value amounts to 248,340 lei/ha. When including the planned subsidies for 2025—totaling 3,469 lei/ha—the total gross output reaches 251,809 lei/ha. This outcome emphasizes the importance of targeted financial support, which not only strengthens farm competitiveness but also contributes directly to income stability.

The inclusion of the planned subsidies for 2025, amounting to 3,469 lei per hectare, increases the total gross output to 251,809 lei per hectare. This confirms the relevance of financial assistance not merely as an income supplement but as a stabilizing mechanism for organic farms operating in volatile markets.

Table 1. Revenue and expenditure budget for organic cauliflower cultivation in greenhouses– estimates for 2025

Indicators	U.M	Value
A. Production value, of which:	lei	248,340
B (+) Grants*	lei	3,469
C (=) Gross product	lei	251,809
D (-) Total expenses	lei	193,640
I. Variable expenses	lei	171,448
II. Fixed expenses	lei	22,191

Indicators	U.M	Value
E (=) Taxable income	lei	54,700
E.1(-) Taxes and fees	lei	5,470
F (=) Net income + subsidies	lei	52,700
F.1 (=) Net income	lei	49,230
G. Rate of taxable income	%	28.2
H. Net income rate + subsidies	%	27.2
H.1 Net income rate	%	25.4
Production cost	lei/to	9,682
Predictable domestic market price	lei/to	12,417

Notes:
Planned subsidies:
Planned APIA subsidy for 2025 under the National Strategic Plan of Romania (266.32 EUR/ha): BISS – Basic Income Support for Sustainability (99.27 EUR/ha), CRISS – Complementary Redistributive Income Support for Sustainability (52.08 EUR/ha), PD-04 – Environmentally beneficial practices applicable to arable land (56.28 EUR/ha), Payment for young farmers (48.00 EUR/ha), ANT-1 – Transitional national aid (10.69 EUR/ha).
Planned APIA subsidy for organic farming in 2025 – maintenance of certification, DR 05–02: Package 2 – vegetables (including potatoes) certified in organic farming (431.00 EUR/ha/year).
** Euro exchange rate: 4.9753 lei
Source: authors' own calculations

Figure 1 illustrates the total production costs for organic cauliflower cultivated in greenhouses, assuming an estimated yield of 20 t/ha. The cost structure is dominated by variable expenses, which account for approximately 89% of total costs, while fixed expenses represent 11%. Such a distribution reflects the labor- and input-intensive profile of organic farming systems. Although initial investments remain relatively high, greenhouse cauliflower cultivation ensures steady returns and favorable profitability, thus supporting its inclusion in diversified organic vegetable production systems.

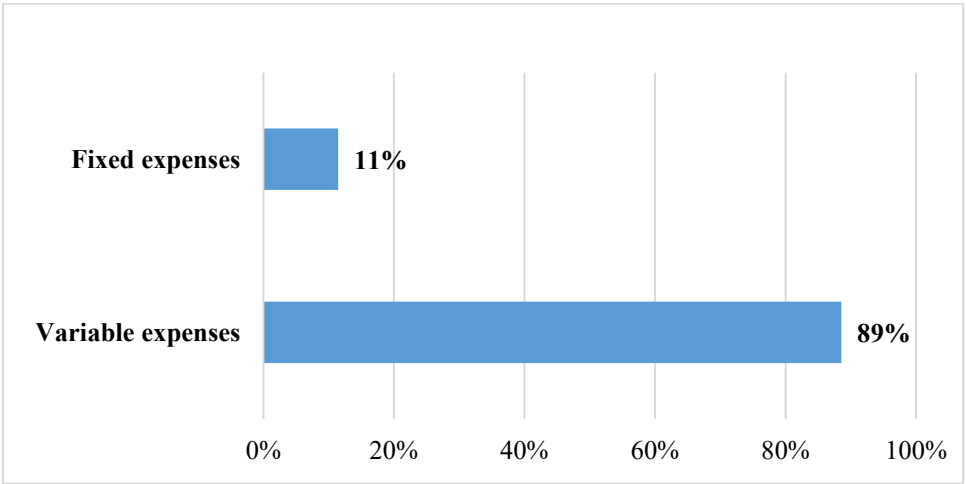

Figure 1. Total production costs for organic cauliflower cultivation in greenhouses, estimated yield of 20 t/ha

Variable costs account for the largest share of total production expenses—around 89%—with raw materials and supplies representing nearly 85% of this amount. Mechanized operations cover about 5%, irrigation 1%, and general supply expenditures roughly 9%. This breakdown indicates that optimizing input use and refining technological processes are decisive for maintaining profitability, while investing in high-quality materials continues to be essential for stable and competitive yields under organic standards. (Figure 2).

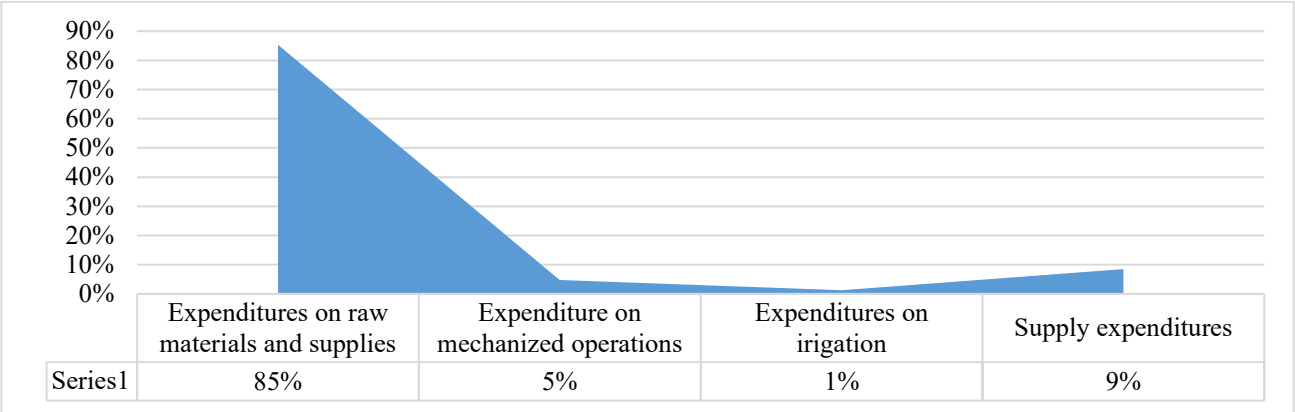

Figure 2. Variable production costs for organic cauliflower cultivation in greenhouses, estimated yield of 20 t/ha

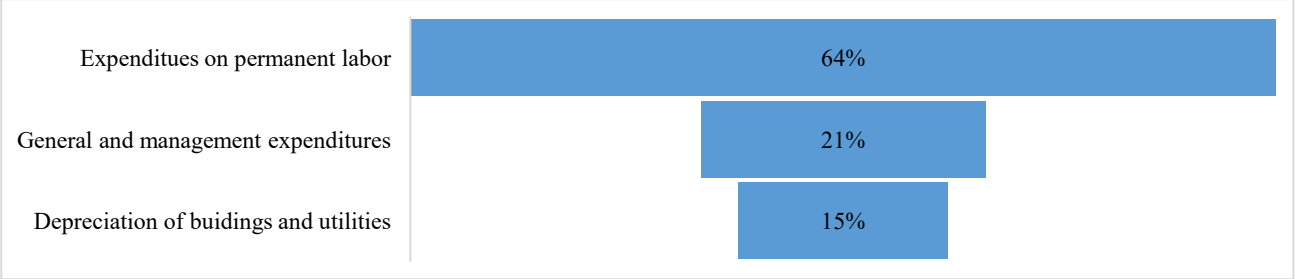

Figure 3. Fixed production costs for organic cauliflower cultivation in greenhouses, estimated yield of 20 t/ha

Figure 3 summarizes the fixed cost distribution, highlighting the predominance of labor-related expenditures. Permanent labor accounts for roughly 64% of total fixed costs, confirming the dependence of organic systems on manual activities and continuous monitoring. Administrative and management expenses represent around 21%, while depreciation of buildings and utilities contributes 15%, reflecting the necessity of maintaining production infrastructure. This cost profile demonstrates that both human and structural resources remain fundamental to the long-term sustainability of organic greenhouse production.

Financial support through subsidies plays a key role in ensuring the economic sustainability of organic cauliflower cultivation in greenhouses. For 2025, this support is estimated at 3,469 lei per hectare, representing about 2% of the total gross output. Although its share is relatively small, subsidies strengthen farm income and reduce economic risk, providing greater financial stability in a sector affected by market volatility and climatic uncertainty.

The taxable income, calculated at 54,700 lei per hectare, reflects profitability before taxation. After deducting taxes and fees, the net income reaches 49,230 lei per hectare. When subsidies are included, the total rises to 52,700 lei per hectare, confirming the stabilizing influence of public financial support. The production cost is estimated at 9,682 lei per ton, while the projected market price is 12,417 lei per ton, resulting in a profit margin of 2,735 lei per ton. This margin was derived by applying a 15% premium to the 2024 average price of conventional cauliflower, in line with INS data, reflecting the typical organic price differential observed in Romania's domestic market.

Table 2 presents the key profitability and risk indicators, summarizing the crop's financial performance. The profit per hectare reaches 54,700 lei, and the profit per product unit 2,735 lei per ton, confirming a positive balance between production costs and revenue. The analysis also highlights that the crop's profitability rate—28.2%—is competitive compared with other organic horticultural crops cultivated under similar conditions.

The contribution margin on variable costs (31%) shows that production comfortably covers fixed expenses, leaving an adequate surplus as net profit. The break-even threshold—calculated at 71,672 lei/ha or 5.8 t/ha—indicates the minimum production required to maintain financial equilibrium. The operating risk rate of 28.9% suggests moderate exposure to external fluctuations, while a safety index of 0.7 demonstrates that actual production exceeds the break-even level by roughly 70%, ensuring a satisfactory income buffer.

Table 2. Profitability and risk indicators

Indicators	U.M.	Value lei
Profit or loss per production unit	lei/ha	54,700
Profit or loss per product unit	lei/to	2,735
Profitability rate	%	28.2
Margin on variable costs (MCV)	lei	76,892
Contribution margin	%	31.0
Break-even point in value terms	lei	71,672
Break-even point in physical units	to	5,8
Operating risk rate	%	28.9
Safety index (Is)		0.7

Source: authors' own calculations

Scenario simulations were used to explore how variations in production value and fixed costs affect overall profitability. This approach provides insights into the crop's resilience under changing market or climatic conditions, and into the sensitivity of profit margins to cost adjustments.

Table 3. Break-even analysis – possible scenario simulations

Explanations	Values	%	Break-even point RE=0	Result obtained with a 20% increase in production value	Result obtained with a 20% decrease in production value	Maintaining the initial result when fixed costs are reduced by 10%
Turnover (CA)	248,340	100	71,672	298,008	198,672	241,173
Variable costs (VC)	171,448	69	49,481	205,738	137,159	166,500
Contribution margin (CMV)	76,892	31	22,191	92,270	61,513	74,672
Fixed costs (FC)	22,191		22,191	22,191	22,191	19,972
Gross result	54,700		0	70,079	39,322	54,700

Source: authors' own calculations

The results indicate that the break-even point (71,672 lei/ha) is well below the actual production value of 248,340 lei/ha, confirming a solid profit margin. A 20% increase in turnover would elevate the gross result to 70,079 lei/ha, while a similar decrease would still leave the activity profitable, at 39,322 lei/ha. A 10% reduction in fixed costs allows the farm to maintain its initial profit level, emphasizing the strategic importance of efficient cost control in ensuring financial stability.

These findings demonstrate that organic cauliflower cultivation in greenhouses offers significant financial resilience. Profitability is preserved even under less favorable economic conditions, confirming the capacity of this production system to absorb market or cost fluctuations.

In addition, the positive correlation between fixed-cost optimization and profit stability suggests that strategic management of resources can substantially enhance the overall performance of organic horticultural enterprises.

Overall, the analysis indicates that protected organic cauliflower production achieves a sustainable balance between cost structure, yield stability, and market value. Scenario-based simulations provide a realistic understanding of the financial dynamics of this crop and support the conclusion that organic greenhouse systems can remain economically viable under a wide range of operational circumstances.

CONCLUSIONS

The assessment of organic cauliflower cultivation in protected spaces demonstrates that this production system can achieve stable profitability and economic resilience under the conditions estimated for 2025. The analysis confirms that protected cultivation ensures yield stability, better resource efficiency, and improved capacity to manage climatic risks compared to open-field systems.

The results highlight that profitability is strongly influenced by variable costs, particularly those associated with labor and high-quality inputs. Effective cost management and the optimization of technological processes are therefore essential for maintaining financial performance. Fixed costs, although lower in proportion, remain critical to ensuring the continuity and long-term sustainability of farm operations.

Agricultural subsidies, even when they represent a relatively small fraction of total revenue, play a decisive role in stabilizing farm income and encouraging the preservation of organic certification. Their contribution enhances the financial security of farms operating under uncertain market and climatic conditions.

The achieved profitability and risk indicators confirm a balanced relationship between production costs and returns, suggesting that greenhouse-grown organic cauliflower can serve as a viable alternative for expanding and diversifying organic horticultural production.

The break-even and scenario analyzes indicate that profitability remains positive even under less favorable market conditions, while moderate improvements in yield or cost efficiency can significantly strengthen financial outcomes. These findings demonstrate the adaptability and economic reliability of organic cauliflower cultivated in protected environments and justify its integration into Romania's long-term sustainable horticultural development strategies.

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THE IMPACT OF LATE SPRING FROSTS IN 2025 ON THE FRUIT-GROWING SECTOR IN SOUTHEASTERN EUROPE: A COMPARATIVE STUDY BETWEEN THE REPUBLIC OF MOLDOVA, ROMANIA, UKRAINE, AND POLAND

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Abstract: *In the context of global climate change, the frequency and intensity of extreme weather events have increased, significantly affecting agricultural sectors in temperate regions. Late spring frosts represent one of the most damaging phenomena for perennial crops and fruit growing, as they coincide with critical phenological phases such as budding, flowering, and fruit set. The spring of 2025 was marked by severe frost episodes in April across Southeastern and Central-Eastern Europe, with the Republic of Moldova, Romania, Ukraine, and Poland being particularly affected. Minimum temperatures dropped below the critical thresholds for both pome (apple, pear) and stone fruit species (apricot, peach, cherry, plum), leading to substantial production losses and severe economic impacts on farmers. This paper presents a comparative analysis of the effects of the late frosts of April 2025 on the fruit-growing sector in the four countries, aiming to identify the extent of the phenomenon, regional differences in the intensity and distribution of damages, as well as institutional responses and adaptive strategies implemented. The analysis is based on official statistical data, climatic reports, production loss estimates, and relevant scientific literature. The results highlight the vulnerabilities of Eastern European fruit-growing systems to climatic risks and provide a foundation for developing sustainable measures to mitigate their impact.*

Keywords: *climate change, late frosts, fruit growing, crop losses, agricultural adaptation, Eastern Europe*

JEL Classification: Q10, Q12, Q54, Q51

INTRODUCTION

The increase in global average temperature represents one of the main effects of contemporary climate change, having a direct impact on the dynamics of annual meteorological and climatic processes. This phenomenon is primarily driven by the intensification of the greenhouse effect, caused by the accumulation of greenhouse gases in the atmosphere, such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) (Choudhary et. all, 2015). The rising concentration of these gases enhances the retention of thermal energy within the Earth's climatic system.

The consequences of this energy accumulation are reflected in significant alterations of the seasonal thermal regime, manifested through milder winters and earlier, warmer spring onsets (Makarova, D. H. (2025). In recent years, an increasing frequency of meteorological anomalies has been observed, with air temperatures exceeding the climatological norms toward the end of winter (late February–early March).

These thermal anomalies trigger the premature onset of vegetative processes, particularly in perennial species, and are often followed by sharp cooling episodes during April–May, coinciding with the flowering stage. Low temperatures during this phenological phase significantly affect the pollination process and, in severe cases, can lead to the freezing of blossoms. At the same time, the activity of bees — the main pollinating agents — is considerably reduced, further amplifying the negative effects on agricultural production.

A telling example is represented by the late frosts recorded between March and May 2025, when temperatures dropped to –8 °C, coinciding with critical stages of bud break and flowering in most fruit species. The most affected crops were stone fruits (cherry, sour cherry, apricot, plum, peach), although substantial losses were also recorded in apple and pear orchards in certain regions. The economic impact was significant across all four analyzed countries — the Republic of Moldova, Romania, Ukraine, and Poland — through a drastic reduction in production and disruptions in the horticultural value chains.

MATERIALS AND METHODS

The analysis of the effects of the late spring frosts of 2025 on the fruit-growing sector in the Republic of Moldova, Romania, Ukraine, and Poland was conducted using a comparative, descriptive, and evaluative methodology, focusing on agronomic and economic indicators. The study aims to identify production losses and financial impacts at both national and regional levels, as well as to highlight structural differences among the fruit-growing systems analyzed.

The data utilized were exclusively drawn from official statistical and economic sources, including: the National Bureau of Statistics of the Republic of Moldova; INSSE and MADR – Romania (official reports and releases on affected areas); GUS, Eurostat, and USDA FAS (GAIN Report, 2025) – Poland; FAO, Eurostat, and Freshplaza – Ukraine (data on losses and orchard structure). These sources were supplemented with ministerial communications, economic reports, and sectoral press articles, which provided additional information on the scale and distribution of losses.

This article was developed within the framework of subprogram 030101 *Strengthening the Resilience, Competitiveness, and Sustainability of the Economy of the Republic of Moldova in the Context of EU Accession*, funded by institutional resources.

RESULTS AND DISCUSSION

The late spring frosts of 2025 generated significant economic consequences for the fruit-growing sector in the Republic of Moldova, highlighting the high vulnerability of this branch to sudden temperature fluctuations during the flowering phenological stage.

Although the total orchard area is relatively smaller compared to Romania, Ukraine, or Poland, the economic role of fruit growing within the national agricultural structure remains substantial, consistently contributing to the formation of the agricultural Gross Domestic Product and agro-food exports.

According to data from the National Bureau of Statistics, the total area of productive orchards in 2024 amounted to approximately 43.3 thousand hectares, with apple, walnut, plum, cherry, and sour cherry orchards predominating (Ministry of Agriculture and Food Industry – Moldavia, 2024). These species are particularly sensitive to temperature fluctuations, especially during bud break and flowering stages.

In this context, the frost episodes from March to May 2025 severely affected approximately 8,650 hectares of orchards, representing around 20% of the total productive area (Ministry of Agriculture and Food Industry – Moldavia, 2025). Losses were unevenly distributed across regions and species, directly impacting production volumes and farmers' incomes (IPN.md. (2025).

Preliminary estimates indicate a substantial reduction in fruit exports, projected at 150–160 million USD compared to approximately 290 million USD in 2024. This decline is driven both by the decreased volume available for export and by the deterioration in the quality of fruits intended for

international markets [3].

For apple orchards, which constitute the main component of horticultural exports, production losses are estimated at approximately 128 thousand tons compared to the previous year. In financial terms, lost gross revenues are estimated between 40 and 64 million USD, depending on average export prices and the level of domestic market absorption.

Table 1. Structure and Damage of Orchards in the Republic of Moldova in the Context of the Spring 2025 Frosts

Crop	Productive Area 2024 (ha)	Affected Share (%)	Affected Area 2025 (ha)
Apple	14 894	~13	1 940
Cherry	2 551	~30	779
Apricot	1 423	~16	228
Plum	8 577	~27.5	2 361
Sour Cherry	1 413	~10	141
Walnut	14 400	~22	3 201
Total	43 258	-	8 650

Source: Prepared by the author based on data provided by the Ministry of Agriculture and Food Industry (MAIA) and the State Hydrometeorological Service (SHS).

The total economic impact, including the reduction of export logistics and commercial capacity, is assessed at over 60 million USD, highlighting the high vulnerability of the Moldovan fruit-growing sector to recurrent climatic risks.

In Romania, the late spring frosts of 2025 had widespread effects on fruit crops in the southern and central regions, where negative temperatures occurred during the critical flowering and fruit-setting stages. The event particularly exposed the vulnerability of stone fruit orchards, resulting in significant losses in annual production.

According to data provided by the National Institute of Statistics (INSSE) and the Ministry of Agriculture and Rural Development (MADR), the total area of productive orchards amounted to approximately 138 thousand hectares, dominated by apple, plum, cherry, and apricot orchards. Among these, apples remain the main crop, accounting for about 45% of the total orchard area, followed by plum and cherry.

From an economic perspective, the late spring frosts of 2025 caused significant financial losses in the Romanian fruit-growing sector, directly affecting the agro-food trade balance and the incomes of producers in the main orchard regions.

The most affected crops were cherries, with financial damages estimated between 280 and 800 million euros, and a production deficit of approximately 140–160 thousand tons compared to the average of recent years. In many southern and central regions of the country, losses exceeded 60% of the potential harvest, severely impacting exports and international trade contracts (Fresh Plaza North America. (2025).

For other stone fruit crops — sour cherry, apricot, plum, and peach — losses are estimated between 180 and 600 million euros, depending on orchard density, microclimatic conditions, and the timing of the frosts.

Overall, the total economic impact on Romanian fruit growing is estimated between 1.5 and 2 billion euros, including crop losses, additional maintenance costs, and reduced export revenues. These results confirm the high vulnerability of the Romanian fruit-growing sector to climatic shocks and

underline the need to strengthen agricultural insurance systems and post-disaster financial support (MARD 2025).

Table 2. Structure and Damage of Orchards in Romania in the Context of the Spring 2025 Frosts

Crop	Productive Area 2024 (ha)	Affected Share (%)	Affected Area 2025 (ha)
Apple	47 600	3 587	7.5
Cherry	10 880	3 075	28.3
Apricot	6 800	2 434	35.8
Plum	34 000	5 445	16.0
Sour Cherry	6 800	1 922	28.3
Walnut	9 520	538	5.7
Total	115 600	17 000	-

Source: Prepared by the author based on data from INSSE and MADR.

In Ukraine, the late spring frosts of 2025 had particularly severe effects on the fruit-growing sector, impacting production in the central, southern, and western regions of the country Fresh Plaza North America. (2025). The phenomenon occurred during the critical flowering period of stone fruit species, causing massive yield losses and significant reductions in the quality of fruits intended for export. Data collected from national and international sources indicate production declines ranging from 40% to 80% for major apricot, peach, cherry, and sour cherry crops, particularly in the regions of Vinnytsia, Kherson, Odesa, Rivne, and Chernivtsi (NV English. (2025).

Table 3. Structure and Damage of Orchards in Ukraine in the Context of the Spring 2025 Frosts

Crop	Productive Area 2024 (ha)	Affected Share (%)	Affected Area 2025 (ha)
Apple	120 000	26	30 000
Cherry	18 400	33	9 000
Apricot	12 250	80	9600
Plum	25 650	34	8 125
Sour Cherry	15 430	39	6 300
Walnut	10 290	13	1 200
Total	202 020	-	72 875

Source: Prepared by the author based on data from Freshplaza and the State Statistics Service of Ukraine.

The total economic impact on Ukrainian fruit growing is estimated at 1.2–1.6 billion euros, with more than half attributed to stone fruit crops. For apples, losses were moderate (20–30%) but geographically widespread, affecting commercial orchards in the western regions (Mediacenter Ukraine, 2025).

The drastic reduction in domestic production created a supply deficit in the local market and a significant decline in fresh fruit exports, particularly to the European Union. In the short term, this

situation led to increased domestic prices, but it did not compensate for the economic losses incurred by producers.

In Poland, the late spring frosts of 2025 caused unprecedented economic losses in the past two decades, marking the most severe impact on the fruit-growing sector since the early 2000s.

The phenomenon occurred in multiple successive waves between March and May, with local temperatures dropping to –8 °C, particularly affecting the regions of Małopolska, Lublin, Lower Silesia, Podkarpackie, and Mazovia — the main orchard areas of the country, characterized by high-density plantings of cherry, plum, and apple.

As a result, production losses were estimated at over 40% of the multi-year average, and in some commercial orchards — especially in the south and center of the country — damages exceeded 80%, leading to the total compromise of the harvest. This event highlighted the vulnerability of Poland's intensive horticultural systems, which rely on specialized monocultures and remain exposed to recurring climatic risks despite advanced mechanization and technology.

Table 4. Structure and Damage of Orchards in Poland in the Context of the Spring 2025 Frosts

Crop	Productive Area 2024 (ha)	Affected Share (%)	Affected Area 2025 (ha)
Apple	150 000	8 500	5-7
Cherry, Sour Cherry	34 500	1 7000-19 000	50-55
Apricot, Plum	10 000	1 000	10
Total	194 500	25 000-30 000	-

Source: Prepared by the author based on data from Freshplaza and the Central Statistical Office of Poland (Główny Urząd Statystyczny).

According to USDA FAS reports (GAIN Report, 2025), supplemented by information from Freshplaza publications (2025) (FreshPlaza. (n.d.). and structural data from the Central Statistical Office of Poland (GUS) [9] and Eurostat, the financial losses at the national level are estimated between 1.5 and 2 billion euros, with the largest share attributed to cherries and other stone fruits (USDA-FAS). (2025).

The comparative analysis of the effects of the late spring frosts of 2025 on the fruit-growing sector in the Republic of Moldova, Romania, Ukraine, and Poland reveals a complex picture of the vulnerability of Eastern European horticulture to recurring climatic risks. Although the phenomenon was regional, the intensity and economic consequences varied depending on orchard structure, level of technology adoption, and institutional response capacity.

In the Republic of Moldova, where fruit growing plays an important role in agricultural income and exports, losses were severe, affecting approximately 20% of the total productive area and significantly reducing fruit export volumes. In Romania, the frosts caused the largest absolute losses in the region, estimated at 1.5–2 billion euros, with a pronounced impact on stone fruit crops and the agricultural trade balance. In Ukraine, the effects were territorial and uneven, but particularly severe in the southern and western regions, where losses exceeded 50% of the annual production for some species. In Poland, a country with a modern horticultural infrastructure, the event caused the largest production deficit in the past two decades, confirming that even intensive systems are not immune to extreme climatic shocks (USDA-FAS). (2025).

Comparatively, all four countries exhibit similar structural vulnerabilities: dependence on sensitive monocultures (apple, cherry, apricot), lack of effective agricultural insurance mechanisms, limited frost-protection infrastructure, and often delayed institutional responses. At the same time, differences between countries are determined by the level of capitalization and market integration — Poland has greater financial resources for replanting and compensation, whereas the Republic of Moldova and Ukraine remain reliant on external or ad hoc support.

To reduce future risks and increase the resilience of the fruit-growing sector, a regional adaptation strategy based on complementary interventions is required. In the short term, rapid financial compensation mechanisms for production losses and temporary support schemes for affected farmers, including preferential credit for orchard restoration, are necessary.

In the medium term, it is recommended to expand agricultural insurance systems specific to climatic risks, with subsidized policies and products indexed to agrometeorological data, as well as investments in frost-protection infrastructure — sprinklers, fans, thermal nets, and early warning technologies. Structural diversification of orchards through the introduction of cultivars and rootstocks with increased tolerance to thermal stress, adapted to new climatic conditions, is also essential.

In the long term, the analyzed countries should develop interstate partnerships and regional mechanisms to stabilize the fruit market, capable of mitigating price fluctuations and supply deficits caused by extreme events. Strengthening research, professional training, and agricultural extension systems will play a central role in enhancing farmers' and horticultural economies' adaptive capacity.

CONCLUSIONS

Overall, the 2025 frost experience confirms that adaptation of Eastern European fruit growing to climate change can no longer be addressed in isolation at the national level but must be treated as a regional priority, with coordinated policies, sustainable financing, and the exchange of best practices among affected countries.

The late spring frosts of 2025 serve as a reference point for understanding the climatic vulnerability of the Central-Eastern European fruit sector. The event clearly demonstrated that the intensification of extreme phenomena is no longer an isolated meteorological exception but a recurring manifestation of climate change with systemic impacts on the agricultural economy.

The results of the comparative analysis confirm that productivity losses, fruit quality deterioration, and reduced export capacity generate economic effects that extend beyond the primary sector, affecting processing and trade value chains. Consequently, climate risk management must be integrated into national rural development strategies and European agricultural transition policies.

The development of prevention, compensation, and adaptation mechanisms — agricultural insurance, frost-protection infrastructure, early warning systems, genetic diversification of cultivars, and professional training — constitutes the essential pillars of future resilience. At the same time, regional cooperation among the Republic of Moldova, Romania, Ukraine, and Poland should be strengthened through data sharing, technical expertise, and institutional coordination to create a common framework for managing climate risks in fruit growing.

Looking ahead, scientific research should focus on economic modeling of climate-related losses, assessment of adaptation costs, and optimization of resilience strategies at farm and regional levels. Only through an integrated approach, based on empirical data and transnational collaboration, can Eastern European fruit growing ensure continuity of production, economic competitiveness, and sustainability of agricultural ecosystems in an increasingly unstable climatic context.

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FROM ORCHARD TO CITY: SHORT FOOD SUPPLY CHAINS IN IAȘI COUNTY - LOGISTIC POTENTIAL AND SUSTAINABLE SCALING

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Abstract: *This study analytically reinterprets a practice-oriented report on fruit growing in Iași County and short food supply chains (SFSCs), addressing specialists in agri-food logistics and rural development. Iași County holds significant productive capital as well as key logistical assets, complemented by a rapidly expanding network of SFSC channels (direct sales, on-farm outlets, farmers' and mobile markets, specialty shops, dedicated online platforms, diverse HoReCa partnerships, and even institutional contracts). In parallel, artisanal processors and local producers—from small associations to micro-pressing hubs and integrated operators—convert perishable surpluses into value-added products with high traceability. The discussion highlights the functionality of SFSCs (resilience, traceability, value retention) as well as contemporary challenges (limited seasonality, hygienic-standard compliance, supply aggregation, and retail requirements). The conclusions propose a scaling agenda: cooperation among supply chain actors, development of logistic infrastructure, diversification of collection points, origin labelling, procedures for green public procurement, and participatory governance (Quadruple Helix) supported by indicators. Findings support the idea that fruit-based SFSCs in Iași County can operate as territorial infrastructures of resilience, generating economic, social, environmental, and public health co-benefits.*

Keywords: *short food supply chains, fruit growing, agri-food logistics, rural development, traceability, Iași County.*

JEL classification: Q12, Q13, Q18

INTRODUCTION

The local valorisation of fruit products - fresh fruit, preserved fruit (jams, compotes, marmalades, syrups), and natural juices - offers multiple opportunities for sustainable rural development. Iași County has a longstanding pomological tradition and favourable pedo-climatic conditions for a wide range of species, from pome fruit (apples, pears) and stone fruit (cherries, sour cherries, plums, apricots) to nuts (walnuts) and small fruits (sea buckthorn, strawberries, blackberries, and other berries). In recent years, consumer interest in local, fresh, and minimally processed products has increased, reflected in the growth of short food supply chains (SFSCs) at the regional level, particularly during the COVID-19 pandemic.

Leveraging fruit growing through short channels has become a strategic vector of the contemporary agri-food transition, where logistical efficiency, social cohesion, and agroecological impact converge within a resilient local development framework. Beyond agroecological conditions, the dynamics of local actors (producers and processors) and market channels shape an "institutional ecology" of SFSCs: diverse producers (from commercial holdings to family farms), networks of artisanal processors/SMEs, shared infrastructures, urban markets, fairs and gastronomic events (brunches), and online channels that act as rapid interfaces between supply and demand. In this context, the objective of the article is to extract, organize, and discuss the logistical and economic evidence for fruit growing in Iași County, providing an operational basis for recommendations to practitioners and decision-makers.

MATERIALS AND METHODS

We compiled information from official statistical sources - e.g., the Iași County Agricultural Directorate (DAJ Iași) and the National Sanitary Veterinary and Food Safety Authority (ANSVSA – DSVSA Iași) on cultivated areas and the up-to-date register of non-animal production and processing units—as well as from the scholarly literature. A key reference was the case study by Tanasă et al. (2018) on functional short food supply chains (SFSCs) in Iași County; its data on the local fruit sector were updated and integrated into our analysis (Tanasă et al., 2018).

The analysis draws on desk research and secondary data assessment (county statistical series, inventories of infrastructures and fruit-processing units), complemented by operational case studies and qualitative evidence on market behaviours and actor practices (producers, processors, proximity retail, consumers). SFSC typologies follow established definitions in the literature, adapted to the local context. The logistical interpretation focuses on post-harvest stages (pre-cooling, sorting, storage, packaging), commercial integration, and existing mechanisms in the local market (agri-food markets, specialty grocers, online channels, HoReCa or institutional partnerships). The article synthesizes and contextualizes Iași's fruit agri-food system without proposing an experimental design, but advances an action framework for scaling.

RESULTS AND DISCUSSION

Sector structure and logistic infrastructure

Iași County exhibits diverse pedo-climatic conditions that enable a wide range of tree and shrub fruit species. Within the county, the productive base—approximately 6,888 ha of orchards and shrubs, yielding an estimated ~15,400 t/year—and the micro-areal distribution of species (predominantly apple, plum, cherry, pear, walnuts, and small fruits) provide solid premises for SFSCs oriented toward freshness, seasonality, quality, and assured traceability (DAJ Iași, 2022). This structure could be further strengthened by expanded cold-chain storage, such as the SCDP Sârca facility (5,000 t/year, controlled atmosphere), which would extend the local marketing window and reduce seasonal price pressure. Our analysis integrates quantitative data—e.g., in 2024 the certified organic area reached 241.06 ha, with an additional ~64.4 ha under conversion—with qualitative insights on producers' activities and strategies.

Table 1. Estimated areas and production in Iași County – 2024 (own calculations)

Fruit category	Total conventional production (t)	Total organic area (ha)	Certified organic area (ha)	Area in conversion (ha)	Certified share of organic area (%)	Conversion share of organic area (%)
Apricots	1462	11.19	5.28	5.91	47.18	52.82
Cherries	8464	45,6	29.15	16.45	63.93	36.07
Apples	13503	29.11	28.33	0.78	97.32	2.68
Nectarines	4	0	0	0		
Walnuts	1654	53.93	52.43	1.5	97.22	2.78
Pears	1572	5.41	5.41	0	100	0
Peaches	15	1.14	0.57	0.57	50	50
Plums	9824	21.09	12.88	8.21	61.07	38.93
Total	36498	167.47	134.05	33.42	80.04	19.96

Fruit growing in Iași County is geographically concentrated in favorable micro-regions. For example, Comarna commune (south-east) and the Cotnari area (north-west) are noted for intensive cherry orchards that supply the local market in May–June. “Comarna cherries” and the local cultivar known as Boambă de Cotnari have become recognized regional brands for flavor and quality. Plum cultivation is also traditional in the hilly zones, yielding both fresh fruit and feedstock for țuică (plum brandy) and other traditional distillates. Overall, the county produces several thousand tons of fruit annually - agricultural reports indicate orchard output of approximately 15,400 t in 2022 (about 3,600 kg/ha in bearing orchards). A share of local apple production is absorbed by the national “Apples in Schools” program, with the remainder marketed as fresh produce or processed goods.

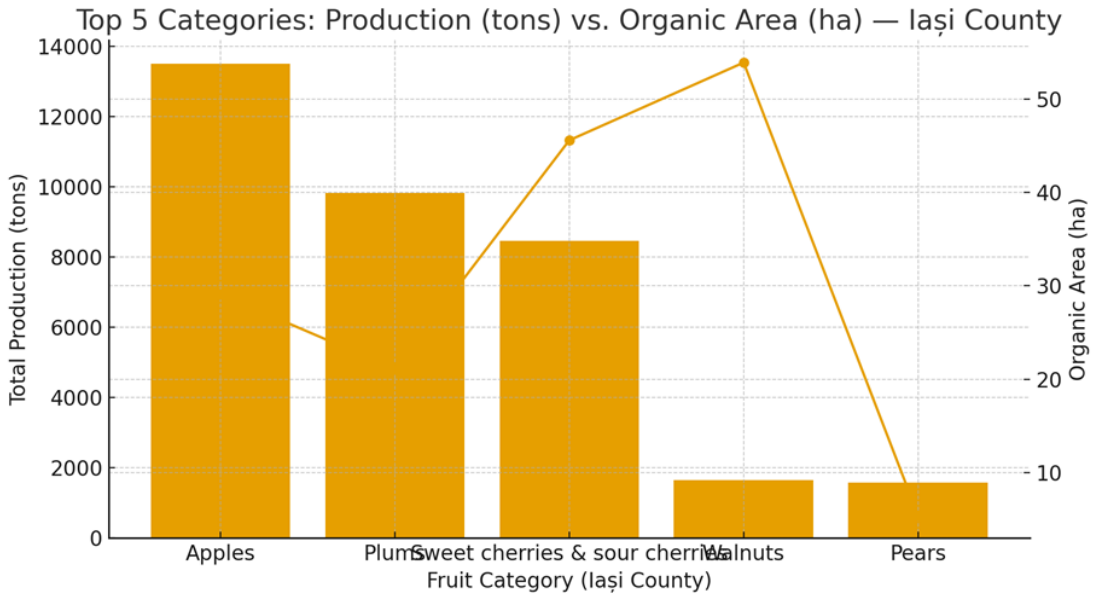

Figure 1. Top 5 species with estimated areas and production in Iași County (2024)

Variable costs account for the largest share of total production expenses—around 89%—with raw materials and supplies representing nearly 85% of this amount. Mechanized operations cover about 5%, irrigation 1%, and general supply expenditures roughly 9%. This breakdown indicates that optimizing input use and refining technological processes are decisive for maintaining profitability, while investing in high-quality materials continues to be essential for stable and competitive yields under organic standards. (Figure 2).

Iași’s fruit sector is dominated by small local producers but also includes larger commercial holdings (e.g., Cerasus Grup/Panere, Vinifruct Copou, Vitalef, Domeniile Lungu/Fructalis, Hortifruct, Legume-Fructe Răducăneni), alongside numerous family farms primarily oriented toward short food supply chain (SFSC) marketing. A system-level logistical asset is the SCDP Sârca cold-storage facility (~5,000 t/year, controlled atmosphere), which enables extended storage—especially for apples and pears—thereby stabilizing flows and prices in the off-season. For stone fruit, the standardization of pre-cooling (hydrocooling), optical sorting, and calibrated packaging by operators such as Cerasus Grup indicates a transferable pathway of professionalization for related agri-food value chains.

In the cherry segment, regional operators report seasonal volumes exceeding 1,000 t/year and sorting–packing capacities above 1t/hour, backed by Global G.A.P./GRASP certifications and controlled-atmosphere infrastructure. This hub-and-spoke model confirms the role of shared logistic nodes in raising quality, strengthening traceability, and enhancing B2B contracting capacity on both domestic and export markets.

A wide range of SFSC typologies operates in the county: direct sales (including pick-your-own), producers' shops, farmers'/mobile markets and fairs, specialty grocers/greengrocers, online commerce (local groups), weekly box/CSA schemes, and even institutional partnerships (canteens/hospitals). These channels shorten logistical distance, increase traceability, and retain a larger share of value at the producer level; under stress, they adapted rapidly through pre-orders and home delivery, demonstrating model resilience.

Actors and local good practices: aggregation, processing, traceability

The local ecosystem includes artisanal processors and SMEs that convert perishable surpluses into longer-shelf-life products: local associations producing artisanal preserves, small cold-press facilities, and non-pasteurized lines operated under HACCP with lot-level traceability. SFSC channels (own-brand stores, farmgate sales, farmers' and mobile markets, specialty grocers, and online hubs/platforms) shorten the time from processing to consumption and keep more value in the territory. In cherries, local hubs serving 30+ producers—with fully integrated logistics (pre-cooling, optical sorting, ULO/controlled-atmosphere) and B2B outlets at home and abroad—serve as benchmarks of replicable standards.

Figure 2. SCDP Sârca fruit cold-storage facility (controlled atmosphere), pomicolaiasi.ro

In parallel with primary production, Iași County hosts processors that turn fruit into value-added products for local and regional markets. A notable example is the Hilița Pomiviticolă Association in Costuleni commune, established in 2009 by small local orchardists with support from a rural development project. Under the local brand "de Hilița," the association produces compotes, jams, and preserves based on traditional recipes, valorizing fruit from local orchards - cherries, apricots, strawberries, quinces, green walnuts, pears, etc. (gustdeiasi.ro, 2023).

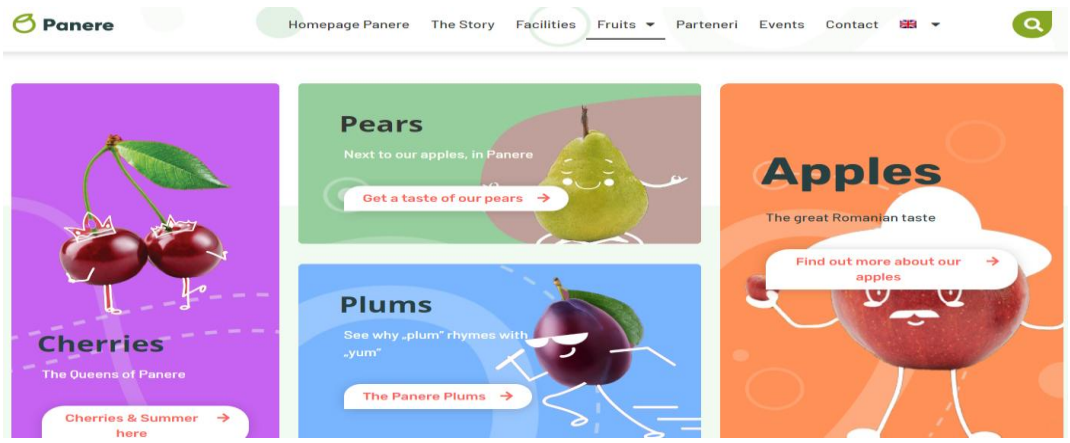

Figure 3. Showcasing local fruit cultivars - Cerasus Group, panere.ro/en/fruits

Its products are explicitly listed among well-recognized labels on the Iași market, alongside other local processors, indicating steady demand for artisanal, traditionally flavored, locally sourced goods.

In the logic of short food supply chains (SFSCs), Hilița valorizes fruit through local processing and predominantly proximity channels—agri-food markets, fairs and specialty events, greengrocers, and neighborhood shops—through which a substantial share of fruit and derivatives is marketed in the municipality of Iași. The association also operates within a dynamic ecosystem of small processors who bring products closer to consumers via local online communities and "from field to plate" initiatives, reinforcing trust in the "local product" label and diversifying supply for gastronomy and proximity retail in Iași. In this way, Hilița functions as an integrative link between county orchards and urban shelves, contributing to SFSC resilience and to the preservation and promotion of gastronomic heritage and local identity.

Cerasus Grup – Panere (Cotnari). A leading regional actor and producer organization in the Cotnari micro-area, specialized in cherries, apples, pears, and plums, with >100 ha under cultivation (105 ha declared: ~80 ha cherry, 15 ha apple, 4 ha pear, 6 ha plum; cultivars such as Kordia, Regina, Carina, Van, Stella, and the renowned Boambe de Cotnari). Operations are supported by modern post-harvest infrastructure: pre-cooling (hydrocooling), optical sorting lines (cherries sorted by color and caliber, ~1.2 t/hour; apple/pear 5 t/hour; plum 3 t/hour), packaging in punnets/bags, a controlled-atmosphere cold store (~1,500 m²), and a 10,000 m² receiving/conditioning facility; production is Global G.A.P. & GRASP certified. In 2024, the company reported 1,100-1,200 t of cherries per season (cherries generate ~80% of turnover) and operates as a regional sorting–packing hub for 30+ producers in Moldavia. Commercialization is mainly through modern retail chains in Romania and exports (notably to the Netherlands, France, Italy), while sub-caliber fruit goes to processors (confectionery and beverage uses such as candied cherries for cakes or cocktail garnishes). The firm currently operates exclusively B2B (retail and export) with no direct-to-consumer short-chain sales, though a farm-gate outlet is planned for the season; it continues to invest in orchard reconversion (including replanting with new cultivars) and in sorting/packing automation (panere.ro, 2024; ziaruldeiasi.ro, 2024).

Conacul Goruni (Tomești). A local success story of family heritage and artisanal food craft from Tomești, developed into a modern, well-regarded brand. Building on a household rooted in local traditions, the Tătaru family invested >€300,000 to modernize the production line, creating 80+ products prepared to home-style recipes—concentrated sea-buckthorn juices, teas, jams, sauces, sea-buckthorn wines, compotes, and tinctures—made without preservatives or chemical additives and using ingredients predominantly from their own orchards in Goruni village. Processing is meticulous: raw material is harvested and handled promptly to preserve nutrients and flavour (e.g., sea-buckthorn concentrate is prepared on the day of the order). The entire portfolio is ANSVSA-authorized and marketed transparently under labels that emphasize quality, authenticity, and local origin. Conacul Goruni has developed a compact yet robust distribution network: specialty grocers and proximity stores across Moldavia, and even in Bucharest and Cluj, while maintaining close ties with key business partners. An online shop with courier delivery extends access beyond Iași. Beyond the shelf, the brand curates local experiences—regular participation in fairs, gastronomic events, and brunches—and plans educational spaces at the Goruni farm where visitors, especially children, can see how fruit is harvested and processed.

Fresco Jugo (Iași). One of the few Iași brands that began with a single juice press and scaled into a community micro-processing hub: beyond its own assortments (apple; apple - orange mixes; honey-sweetened lemonade), the team processes tens to hundreds of tons of fruit annually for other small producers, converting sensitive surpluses into traceable batches of cold-pressed juice - with no added water, sugar, or additives.

Figure 4. Conacul Goruni e-store - conaculgoruni.ro

This investment is anchored in the cold-press line (hygienic flow; glass bottling), to which the company is adding equipment in stages while building a new facility in Iași County to triple capacity and support national distribution (ZF.ro, 2024; Economedia.ro, 2024). Along SFSCs, Fresco Jugo sells primarily via specialty grocers/delicatessens (e.g., Băcănia Nouă, Magazia Morăriței, La Cimpoieș, Băcănia Happy), cafés, restaurants, and local networks in Iași and the surrounding region, maintaining direct dialogue with partners and consumers; in parallel, it has tested modern retail for three years (select hypermarket listings in Iași) to scale without abandoning a clean-label positioning. The brand is visible in the local producers' ecosystem (Gust de Iași) and builds community through municipal fairs such as Iașul în Bucate and Piața Verde de Weekend, where it organizes tastings and direct sales - an ideal format for fresh, transparent, cold-pressed juice (gustdeiasi.ro, 2023). Overall, Fresco Jugo plays a dual role - service processor for small orchardists and branded producer - adding value to the local agri-food system, professionalizing cold pressing, and opening the door to retail, thereby putting Iași back on the map for quality natural juices.

Costy Filip (Todirești). An illustrative case of a returning expat who chose to invest in agriculture by leveraging local arable and horticultural resources. After years spent with his family in Italy - where he gained experience and inspiration in farming - he returned to his native village to establish a small, modern orchard enterprise focused on sustainability and quality. Investments materialized in cherry plantations with Italian cultivars acclimatized to Todirești's pedo-climatic conditions and appreciated for their taste. Without a formal commercial brand, Costy Filip has gained local market traction through personal reputation and reliability, reinforced by direct consumer recommendations - conveying authenticity and trust. He collaborates actively with the Gust de Iași platform and is a key partner for the RoRuralia lighthouse initiative, where he is recognized as a relevant local stakeholder promoting SFSCs and sustainable agri-food systems. His activity not only supports the local rural economy but also strengthens the agri-food identity of the Cotnari area, offering a model of social reintegration and smart valorisation of human and financial capital accumulated in the diaspora.

Figure 5. Benchmark farm—Domeniile Lungu, domeniilelungu.ro/horticultura/fructalis

Domeniile Lungu (Fructalis). Domeniile Lungu processes apples and pears from its own orchards into a high-quality, unpasteurized natural juice marketed under the Fructalis (Bivolari) brand. The company operates a tightly controlled flow in which farm fruit is rapidly transformed into unpasteurized juice. Emphasis is placed on gentle processing and effective traceability: fruit is automatically graded, then washed with brushing and sorted to remove defects; pulp is obtained by stainless-steel milling and extracted by slow pressing (to ensure good yield without extracting bitter compounds from seeds/peel). To limit oxidation and preserve volatile aromas and thermolabile polyphenols, the must is handled in small batches with minimal air contact, followed - where appropriate - by natural settling/coarse filtration, without chemicals, and with no added water, sugar, or preservatives. Being unpasteurized, the juice retains a fresh organoleptic profile (colour, aroma, varietal notes of apples and pears) and therefore requires a cold chain (0–4 °C) and a short consumption window (as for raw juices); it is hermetically bottled and lot-coded. The entire process operates under an HACCP system (line hygiene, CIP, periodic microbiological testing for yeasts/molds and hygiene indicators) to keep the product clean, cold-stable, and quality-consistent. Commercialization relies mainly on short channels (own shops, specialty grocers, and proximity markets in Iași), which shorten time from pressing to consumption, retain local value added, and position Fructalis in the "fresh, minimally processed" segment - an artisanal alternative to heat-treated industrial juices.

SC Hortifruct SRL & Das Grüne Haus SRL (Ciurea). SC Hortifruct SRL operates a small plant in Ciortești producing apple juice and fruit blends, while Das Grüne Haus SRL (headquartered in Ciurea) has launched a namesake apple juice promoted as a natural local product. The firm runs a compact juice line for apple and mixed-fruit juices, working in small batches with visual raw-material selection, controlled pressing, and no added water, sugar, or preservatives (only minimal technological stabilization where needed). Each batch is traceable from orchard/plot to final label (lot code, production date), and the flow is designed to minimize air contact and maintain the organoleptic profile - an approach that, together with HACCP practices and line hygiene, supports consistent quality. Das Grüne Haus complements the local offer with its eponymous apple juice, rightly promoted as a natural local product, leveraging a single-ingredient logic and transparent origin - attributes that strengthen consumer trust. The target segment comprises young families and health-conscious consumers, reached via the local/regional HoReCa sector (cafés, bistros, delicatessens, accommodation) seeking authentic juices for cocktails and seasonal menus. In commercialization, both brands primarily use short food supply chains: direct sales, farmers' and mobile markets, local retail, and proximity greengrocers in Iași, plus online orders and local delivery routes that shorten time from pressing to consumption, reduce intermediation costs, and retain value locally.

The result is a coherent presence on proximity shelves, with clean-label, traceable, and recognizable products that meet growing demand for simple juices, free of hidden additives, and firmly rooted in Iași's pomological terroir.

The Rusu family (Comarna). The Rusu family owns a diversified orchard (pears, plums, apples, peaches, and table grapes) that has been developed into a small family business, sustained mainly by the work of the parents and children - and, when needed, with support from the community. They harvest and sell direct to consumers, minimizing intermediaries via short supply chains. Since 2022 they have been present daily at Alexandru cel Bun Market in Iași, where they have built trust through freshness and fair pricing, complemented by home deliveries in the city and metro area. Comarna cherries - for which the locality is regionally recognized, with extensive orchards and substantial output -remain the seasonal flagship, with varieties suited to fresh consumption, preserving, and desserts. Overall, their story embodies the classic family farming model that supports the local economy and preserves the authentic taste of home-grown fruit through honest work and proximity to consumers.

Andrei's Orchard (Ciorteşti). A diversified orchard enterprise with a clear focus on quality, traceability, and the direct producer–consumer relationship. The portfolio includes cherries, pears, vineyards with table grapes, and organically certified apples registered at the commune level, reinforcing its positioning in the clean-label segment. The farm prioritizes SFSCs (direct sales; consistent participation in Iași's gastronomic fairs), complemented by public-facing initiatives - such as Open Farm Day - that build consumer confidence, facilitate food education, and strengthen rural–urban linkages. Economic performance is supported by a ~0.7 million lei turnover in 2023, indicating the viability of an entrepreneurial model anchored in agroecological practices, species diversification, and local social capital. Taken together, Andrei's Orchard underscores the economic and socio-cultural relevance of proximity fruit growing within a sustainable, resilient rural development framework.

Sandu's Fruits (Voineşti). A family-run initiative that valorizes local pomological and horticultural resources through a portfolio of concentrated syrups. The range includes mono-fruit variants (sea buckthorn, raspberry) and innovative blends (sea buckthorn with ginger; sea buckthorn with mint; sea buckthorn with raspberry), all sweetened with organic honey sourced from nearby apiaries (BioPrisaca Moldovei – Relu Cojocar). This reliance on local raw materials and artisanal processing confers high traceability and authenticity, embedding the brand in a consolidated SFSC model. Marketing channels are diversified: regular participation in local and national specialty fairs (e.g., "Iașul în Bucate," "Piața Verde de Weekend"), integration into specialty delicatessen networks, and presence in retail via Via Profi, supplemented by targeted collaborations with distributors. Through this strategy, Sandu's Fruits demonstrates how SFSCs connect artisanal agri-food production to diverse consumer segments, strengthening the economic sustainability and local visibility of small producers and processors.

In the fruit-preserves segment, alongside Hilița, 2022 saw the prominence of brands such as Delicii de Prisăcani (jams and syrups from Prisăcani) and Fratelli Pala (fruit compotes and zacuscă-style fruit spreads produced by an Italo-Romanian family), as well as producers from neighbouring counties whose products penetrated the Iași market (e.g., Deliciul Mihaelei - Botoșani; Zmeurișul Coasta Neagului - Vaslui; Bunutz de casă Aurica - Plopeni), present at fairs and via local Facebook/WhatsApp groups. A specific feature of the Iași market is a niche for berries and strawberries: initiatives such as "Căpșuni de Aroneanu" have created micro-brands recognized for delivering fresh, farm-picked strawberries directly to consumers, including home delivery. In parallel, aronia (chokeberry), currant, and other antioxidant-rich juices and concentrates have begun to be produced artisanally by small family enterprises in nearby mountainous areas and are sold in Iași as health-oriented products.

Figure 6. Harvest season at Andrei's farm - Ciorteşti

In the fruit-preserves segment, alongside Hilița, 2022 saw the prominence of brands such as Delicii de Prisăcani (jams and syrups from Prisăcani) and Fratelli Pala (fruit compotes and zacuscă-style fruit spreads produced by an Italo-Romanian family), as well as producers from neighbouring counties whose products penetrated the Iași market (e.g., Deliciul Mihaelei - Botoșani; Zmeurișul Coasta Neagului - Vaslui; Bunutz de casă Aurica - Plopeni), present at fairs and via local Facebook/WhatsApp groups. A specific feature of the Iași market is a niche for berries and strawberries: initiatives such as "Căpșuni de Aroneanu" have created micro-brands recognized for delivering fresh, farm-picked strawberries directly to consumers, including home delivery. In parallel, aronia (chokeberry), currant, and other antioxidant-rich juices and concentrates have begun to be produced artisanally by small family enterprises in nearby mountainous areas and are sold in Iași as health-oriented products.

Table grapes in Iași County fit within a viticultural mosaic in which micro-zones like Cotnari and Strunga - with southern exposure, long autumns, and a deep viticultural tradition - enable balanced maturation and a recognizable sensory profile, even though emblematic vineyards are mainly oriented toward wine. In practice, households and some farms diversify into table grape varieties (Cesla, Victoria, Afuz Ali, Muscat Hamburg, and more recently Moldova), whose harvest windows span late summer to early autumn (mid-August to October); for Moldova, the commercial window can be extended into winter via ULO (ultra-low oxygen) storage, as evidenced by recent listings in modern retail. Relevant examples include the Cotnari ecosystem (SC Cotnari SA, Casa de Vinuri Cotnari), as well as Strunga Winery and Grama - key actors anchored in the local terroir - plus producers marketing table grapes and pasteurized must (bag-in-box), such as Crama Vărzari (Cotnari), active on local/regional short channels. Structurally, INSSE Iași records table-grape vineyards separately from wine-grape vineyards, indicating relatively modest areas for the table segment within total vineyard surface—hence the prevalence of direct marketing (farmers' markets, gastronomic events, on-farm visits) and short offering windows, complemented by post-harvest technologies to extend the season. Overall, the quality of table-grape cultivars in these micro-zones is supported by favorable pedo-climatic conditions and valorisation practices that combine SFSC insertion with selective retail and processing into natural juices/must, thereby bolstering the economic resilience of small producers.

Multidimensional benefits

Economic benefits and rural development. Short food supply chains (SFSCs) that channel local fruit and natural juices directly to end consumers generate significant economic advantages. First, local producers retain a larger share of value added because margins are not eroded by multiple intermediaries, which can raise farm incomes and reinvestment capacity. The literature identifies SFSCs as a viable alternative to conventional/globalized circuits, delivering multiple economic benefits to local communities. In Iași County, development of the fruit sector has also been supported - both pre- and post-EU accession - by EU funds providing non-reimbursable/partially non-reimbursable financing: in 2014–2020, farmers accessed substantial amounts for establishing intensive orchards and acquiring modern equipment. These investments created rural jobs (cultivation, harvesting, processing) and stimulated agri-entrepreneurship in communes such as Bălțați, Bârnova, Deleni, Cotnari, Strunga, and Cristești (BZI.ro, 2021). Active local producers also enhance regional food security by ensuring the availability of fresh products even when imports are disrupted. Consumers benefit through often-competitive prices for seasonal fruit purchased directly from source and through local multiplier effects as spending remains within the community.

Social and community benefits. Local valorisation of fruit forges durable links between producers and consumers, with positive medium- and long-term social effects. Direct sales in markets, fairs, or cooperatives enable face-to-face interaction, building trust and immediate feedback. During the COVID-19 period, Iași communities displayed heightened interest in local products, as evidenced by successful Facebook groups (e.g., "Iașiul vrea produse locale", >22,000 members in 2020). These consumer–producer networks promote fair trade and community solidarity, allowing small orchardists to sell within a trusted environment. Preserving traditions and local know-how is another gain: many families still produce according to inherited recipes (plum butter, rose-petal jam, quince jelly), and local marketing helps transmit gastronomic heritage and promote local identity. Participation in short chains has also enabled the formation of local associations (e.g., the Hilița Pomiviticolă Association in Costuleni) that strengthen social cohesion and can partner with authorities on rural development projects. Overall, local fruit production and consumption create important social capital: consumers know where their food comes from, and producers gain recognition and community support.

Environmental and sustainability benefits. Expanding SFSCs in the fruit sector reduces environmental impacts. Shorter transport distances from farm to local market lower distribution-related carbon emissions ("food miles"). Local products typically require less complex packaging and conditioning for long-haul transport, reducing packaging waste. Many orchardists in Iași practice organic or integrated methods with reduced pesticide and synthetic fertilizer use—especially when selling directly to quality-conscious consumers. Locally produced natural/organic juices preserve the benefits of fruit without chemical additives or preservatives (transylvanianfinestfood.ro, 2021), often using sustainably grown raw material. Such eco-friendly practices protect local biodiversity (traditional orchards often serve as habitats for pollinators and native flora) and help maintain long-term soil fertility. Local processing into jams, juices, cider, etc. also curbs food loss: fruit unsuitable for fresh sale is transformed into longer-shelf-life products. In these ways, local valorisation aligns with circular bioeconomy and sustainable food goals, optimizing the use of local biological resources while minimizing waste.

Public health benefits. Higher consumption of fresh fruit and natural juices directly improves population health. Fruit provides essential vitamins (A,C,B,K-complex), minerals (potassium, magnesium), and antioxidants; regular intake helps prevent obesity and chronic diseases (cardiovascular disease, diabetes, certain cancers).

Medical sources note that natural fruit juices (without added sugar) concentrate many nutrients from whole fruit and can support digestion, immunity, and adequate hydration (sfatulmedicului.ro, 2024). In Iași, consumers increasingly seek natural juices and concentrated syrups from apples, pears, cherries, roses, quinces, and berries - sea buckthorn, raspberries, aronia, blackberries - perceived as healthier alternatives to sugar-laden soft drinks with additives. Buying seasonal fresh fruit from local markets offers not only lower prices but also fresher, higher-quality products (harvested at full maturity and sold quickly, with maximal nutritional value). Food safety and traceability are strengthened as local foods travel short routes with few handling points, lowering contamination risks. Consumers often know producers personally, reinforcing trust in quality and origin—an element that encourages higher fruit intake among informed populations. Over time, reliable local availability of quality fruit and natural juices contributes to nutrition education and improved public health.

SFSC typologies in Iași's fruit sector

Across Iași County, a variety of short food supply chain (SFSC) typologies apply to fruit and fruit-derived products. In line with the literature (Tanasă et al., 2018), a short chain entails commercial relations with no more than one intermediary between producer and consumer. In practice, the following SFSC types are present:

1. ***On-farm sales (including pick-your-own).*** Some orchards (e.g., apple orchards, strawberry fields) allow customers to harvest fruit for a fee or purchase at the farm gate in season, offering fresh-from-source products at advantageous prices.

2. ***Roadside sales.*** Particularly efficient where orchards or processing sites lie near main roads, enabling immediate access for passers-by.

3. ***Producers' shops.*** Several major producers operate their own outlets in towns or at fairs. In Iași, for example, vintners (Cotnari, Panere, Strunga, Bucium) run proprietary stores where, alongside wine, they sell natural grape juices and preserved fruit (jams, syrups, nectars), illustrating integrated local valorization.

4. ***Agri-food markets and local fairs developed via participatory governance (including brunch-type events).*** Traditional short channels in which producers (or family members) sell directly and interact with consumers. In Iași, markets are frequented by producers/processors from nearby communes bringing seasonal fruit (e.g., cherries from Comarna; boambe and grapes from Cotnari; plums from Țibănești; melons from Probota). The Păcurari mobile market (Open Friday - Sunday) encourages sales exclusively from local producers. Periodic fairs of local/traditional products (e.g., Piața verde de Weekend, Iașul în bucate - now at its 14th edition) bring together artisanal processors of jams, compotes, syrups, and dried fruit, providing opportunities for direct sales and for promoting the area's distinctive terroir.

5. ***Local specialty shops.*** Neighbourhood delicatessens/greengrocers that source directly from farmers or local associations/cooperatives, shortening the chain relative to hypermarkets and often highlighting local origin as a selling point.

6. ***Online commercialization - platforms and social media.*** In Iași, active Facebook/WhatsApp group models are emblematic, simple, and highly efficient at minimal cost; individual producers also list products on local websites, including under initiatives such as the Gust de Iași platform that aggregates local producers across food categories.

7. ***Weekly box / CSA (Community-Supported Agriculture).*** A few local initiatives launched during COVID-19 (e.g., Coșul Săptămânal Iași) applied subscription models for regular deliveries of local products—including seasonal fruit—forming an SFSC based on direct contractual relations between consumer groups and farmers, with sales secured even before harvest.

8. ***Local institutional partnerships.*** For example, supplying hospitals/canteens (e.g., by Vitalef) with local fruit products. Although formalized through public contracts (i.e., an institutional intermediary), the chain remains short due to its local character and clear product traceability from county producer to end user (patient/student) within the same county.

Functionality and impact of SFSCs in the fruit sector

SFSCs in Iași's fruit sector proved both viable and resilient - especially during Covid-19 restrictions - delivering multiple benefits. First, they ensure product traceability and authenticity: in an SFSC, fruit and juices can be clearly attributed to a local producer, giving consumers assurance of origin (via farm-named labels or direct relationships). This counters origin fraud (e.g., imported fruit sold as "country produce") and protects the reputation of genuine producers. SFSCs also reinforce high quality standards: direct contact with end-customers incentivizes producers to offer their best fruit and recipes, with instant feedback. Functionality is further underpinned by adaptability: during the 2020-2022 restrictions, many small producers in Iași pivoted rapidly to home delivery via online orders, keeping SFSCs operational and ensuring community access to fresh, locally produced food. Economically, SFSCs diversify the local offer - consumers in Iași access not only standardized supermarket apples, cherries, and pears, but also local varieties and niche products (e.g., green-walnut jam, sea-buckthorn juice with honey, honey with walnuts, mead), thanks to these alternative circuits. They also foster market transparency and local sustainability: prices are often negotiated directly (fair price), and consumers gain a clearer view of the costs and effort behind fruit products, increasing appreciation for local goods.

In the municipality of Iași, authorities and sectoral organizations have begun to recognize the importance of SFSCs, exemplified by the continuous organization (since 2022) of the "Iașul în Bucate" fair for over three years - an exercise in local cooperation and participatory governance among the Romanian Academy-Iași Branch, Rural Development Research Platform Association, Iași County Agricultural Directorate, Iași City Hall, and "Produs în Iași" Local Producers' Association. Complementary initiatives include local certification (e.g., traditional-product attestation - rose-petal jam from Hilița could be certified as a Romanian traditional product) and promotion of local producers under umbrella brands (Hilița, Produs în Iași, Gust de Iași) designed to increase the visibility of short circuits. The fact that over 3,400 production units in the animal and non-animal sectors, food processing, and retail were active in the county in 2024 signals a diversified, dynamic, adaptable, and resilient agri-food sector in which a significant share already operates through short supply chains. Given the perishable and seasonal nature of fruit, the pomological sector aligns particularly well with such channels, placing orchard produce swiftly on consumers' tables.

DISCUSSION

The results point to a promising paradigm shift - from isolated success stories to functional agri-food systems. Beyond case-by-case performance, Iași County has the ingredients for a healthy bioregional pomological architecture anchored in SFSC valorisation. The key is to institutionalize minimum operating standards (eliminating non-value-adding links, guaranteed traceability, minimal packaging, clear rules for green public procurement) and to build shared infrastructures (micro-collection hubs, mobile pre-cooling units, plug-and-play mini-processing lines) that lower fixed costs and compliance barriers for small producers/processors. In parallel, a data-governance layer (a dashboard for fruit SFSCs) should integrate series on production, stocks, flows, reference prices, and avoided losses, published on a seasonal cadence.

An additional critical field is policy operationalization into executable procedures: step-by-step guides for green public procurement, certification/voluntary attestation, model B2B/HoReCa contracts, and graduated criteria for insertion into local/regional retail. This mediating function between the regulatory framework and practice is a precondition for moving from intent to effective adoption.

Operational and market challenges

Pronounced seasonality and short marketing windows often strain commercial flows; hygiene/labelling standardization remains uneven, hindering predictable retail access; supply aggregation is fragmented beyond a few apparently functional hubs; and data on SFSC flows are not yet structured for evidence-based governance. Absent pre-cooling and micro-collection links, the competitive edge of short circuits erodes - especially at seasonal peaks.

Logistics implications

Three determinants are essential for fruit storage and market performance:

(i) Immediate pre-cooling post-harvest (especially for stone fruit), which directly affects quality and the marketing window;

(ii) Aggregation and calibrated sorting, which enables market segmentation (premium/standard/industrial) and stronger B2B contracting;

(iii) Minimal packaging and "light-digital" traceability, required both for local-friendly retail and urban short channels. Where these links are missing, the volatility of demand and of final product quality increases.

LIMITATIONS OF THE STUDY

This analysis is synthetic and contingent on the quality and granularity of the secondary sources used. Several standardized measurements are missing (e.g., species-specific post-harvest losses, actual time from harvest to sale by channel, route-level carbon footprints), and the case studies - while illustrative - are not exhaustive. Future research should include primary data collection (a longitudinal panel of producers/processors, IoT temperature monitoring along SFSC routes, traceability audits) to better calibrate recommendations.

CONCLUSIONS

Iași County combines favorable factors - pomological resources, key infrastructure, a dense base of processors, and proximity channels - that can anchor a bioregional strategy to scale short food supply chains in the fruit sector. To convert this potential into stable performance, we recommend:

- Modular "cold-link" assets: mobile pre-cooling units in satellite points and micro-collection nodes within fruit micro-areas, meeting minimum hygiene and utility standards (water/power);
- "Short label" & minimum traceability: a local/county guide (origin/plot, lot code, date), origin labelling for SFSCs, and a simplified digital lot register; a shared visual identity ("Local product-Iași (fruit)");
- Proportional B2B contracting & green public procurement: framework agreements with specialty grocers and the HoReCa sector; selective retail insertion with graduated requirements; short corridors for public canteens (seasonal lists, adapted lot sizes);
- Governance & data: a fruit-SFSC dashboard (production, stocks, flows, reference prices, avoided losses), open quarterly reporting, and advisory support (compliance, certifications, access to finance);

- Capacity-building & social capital: logistical "case clinics" (diagnosis–solutions), producer/processor mentorship, an open library of good practices, and learning routes/food education for consumers (farm visits, workshops, guided tastings).

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STUDY ON CONSUMER PERCEPTION OF ORGANIC VEGETABLE PRODUCTS IN ROMANIA

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Abstract: *In recent years, the organic products market in Romania has expanded significantly, driven by the diversification of supply and the growing interest of consumers in products perceived as safer, healthier, and of higher quality. In this context, farmers are required to adapt their production to meet demand by ensuring high quality standards and providing a diversified range of product. This paper analyzes the behaviors and attitudes of Romanian consumers towards organic vegetable products, based on the data collected through a questionnaire applied to a sample of 533 respondents. The study examines the socio-demographic profile of consumers, the frequency and share of organic product consumption, the main criteria influencing purchasing decisions (price, quality, certification, accessibility), as well as the level of trust in different purchase channels. The results highlight consumers' general perception of the price of organic versus conventional products, their willingness to recommend these products to others, and their suggestions regarding the diversification, accessibility, and quality of the current offer. The conclusions of the research contribute to a deeper understanding of consumer behavior and provide valuable insights for developing effective strategies to promote the organic vegetable market in Romania.*

Keywords: *consumers, vegetables, behavior, organic*

JEL Classification: Q13, M31, D12

INTRODUCTION

The market for organic agri-food products has experienced an accelerated evolution in the last two decades, driven by the increase in consumer interest in food perceived as safer, healthier, and produced under sustainable conditions. At the level of the European Union, the expansion of organic cultivated areas and the consolidation of the retail market reflect an important structural transformation of the agri-food sector. According to the IFOAM report (2023), the total area of organic farmland in the EU reached 17.7 million hectares in 2023, marking a substantial increase compared to previous years. In the same period, the number of certified organic operators increased by 4%, reaching 434,577 producers.

These developments are directly reflected in the market. The volume of sales of organic products increased by 3% in 2023 compared to 2022, reaching 46.5 billion euros, which maintains the European Union as the second largest organic market globally, after the United States (IFOAM, 2023). Development is supported by factors such as consumer orientation towards sustainable products, strengthening policy support under the Common Agricultural Policy, and continuous innovation in organic production systems. The average annual consumption per capita in the EU, in 2023, reached 104 euros. In countries with consolidated markets, such as Denmark and Austria, expenditure per capita reaches over 362 euros and 292 euros, respectively, highlighting the sharp differences between Member States in the consumption of organic products (FIBL, 2023).

In Romania, the development of the organic sector remains modest compared to the European average. According to data from the European Environment Agency (EEA, 2025), the certified organic agricultural area increased to around 700,000 hectares in 2022, representing 5.1% of the utilised agricultural area, compared to 1.7% in 2016. However, domestic consumption remains low, with individual annual expenditure averaging approximately 2.06 euros on organic agri-food products, 0.8 euros more than in 2014 (FIBL, 2025).

In the organic vegetable sector, Romania has an important agronomic potential, but the level of production and consumption remains low compared to EU Member States. The literature highlights the existence of barriers that limit the demand for organic vegetables, such as the high price, low accessibility, insufficient level of consumer information, and the variable degree of trust in organic certification (Giucă et al., 2023; Dan et al., 2024). Studies on the behavior of Romanian consumers indicate that the perception of food quality and safety significantly influences the purchasing decisions, but economic and information barriers continue to reduce the frequency of consumption (Dan et al., 2024; Tarhini, 2022).

The European model of organic consumption, characterized by extended availability, consolidated distribution channels, and high trust in certification, contrasts with the reality of the Romanian market, where demand remains below the level of agricultural and demographic potential. Therefore, the analysis of consumer behavior and the factors that determine the perception of organic vegetable products is an essential step in formulating effective strategies for the development of the internal market. The present study aims to provide an empirical assessment of these aspects, using a sample of 533 respondents, to identify the motivations, barriers, and level of trust associated with the consumption of organic vegetables in Romania.

The results can help to inform the strategic decisions of actors in the agricultural and agri-food sector, as well as to guide public policies towards stimulating the consumption of organic products, strengthening short supply chains, and increasing transparency in the market.

MATERIALS AND METHODS

The research was based on the quantitative method, using a questionnaire applied online between February and May 2025, through the Google Forms platform. The aim of the research was to identify the profile of the Romanian consumer of organic vegetable products, by analyzing socio-demographic characteristics, purchasing behavior, and perceptions related to quality, price, certification, and accessibility. The final sample size was 533 respondents, selected by the convenience method complemented by the "snowball" technique, which allowed the expansion of the respondent base through successive recommendations.

The questionnaire included four sections: demographics, consumer behavior, perceptions and preferences, and suggestions for increasing supply. The data were statistically analyzed using IBM SPSS Statistics version 20 software, using descriptive analyses to characterize the sample and interpret the observed trends.

The territorial distribution was concentrated in Olt County (64%) and the Bucharest–Ilfov region (13.7%), with the rest of the counties being represented in a smaller proportion.

Participation in the research was voluntary, and the responses were informed about the purpose of the study and the use of the data. In accordance with Regulation (EU) 2016/679 on the protection of personal data (GDPR), all information collected was treated confidentially and used exclusively for the purposes of scientific research and statistical analysis, without collecting data that would allow the individual identification of participants.

For a detailed characterization of the sample used in the study, the socio-demographic structure of the respondents is presented in Table 1. The socio-demographic structure of the respondents highlights a predominance of women, who represent 60.8% of the total, compared to men (39.2%). Most of the respondents live in urban areas, accounting for 63.0%, while those in rural areas are 37.0%.

Table 1. Socio-demographic structure of the sample

Variable	Categories	Weight (%)	Variable	Categories	Weight (%)
Genre	Female	60.8	Location	Rural	37.0
	Male	39.2		Urban	63.0
Number of members in the household	1 person	7.1	Monthly net income per household (RON)	Under 2000	4.3
	2 people	23.3		2000-4000	21.0
	3 people	31.3		4000-6000	25.0
	4 people	27.2		6000-8000	19.9
	More than 4 people	11.1		over 8000	29.8
Age	18-24 years old	19.1	Education level	High School	25.5
	25-34 years old	27.4			
	35-44 years old	30.6		Post-secondary	9.8
	45-54 years old	17.3			
	55-64 years old	4.3		University	49.7
	>64 years old	1.3		Postgraduate	15.0

The structure of households is diverse, with households with three members being the most common, followed by those with four members and two people, while households consisting of one person or more than four members are less frequent. The distribution by age group to which most respondents fall between 25 and 44 years old, the 35-44 age segment being the most, and people over 64 years old are the least represented. The analysis of the level of education highlights a preponderance of respondents with university education, followed by those with high school and postgraduate education, while post-secondary studies are less frequent. The monthly net income of households varies significantly, with almost 30% of households have an income above 8000 RON, followed by those with incomes between 4000-6000 RON, 2000-4000 RON and 6000-8000 l RON, and households with low incomes below 2000 RON. This presentation provides a clear basis for interpreting respondents' consumer behavior and perceptions in the context of the study.

RESULTS AND DISCUSSIONS

The consumption of organic vegetables is a complex indicator of dietary behavior, simultaneously reflecting the level of consumer information, the accessibility of organic products, and the degree of acceptance of sustainable agricultural practices. The analysis of this indicator makes it possible to assess how organic products are integrated into the daily diet and to identify the factors that influence the consumption decisions.

The analysis of the frequency of consumption highlights a moderate level of integration of organic vegetables into the current diet. Out of the total of 533 respondents, 42.0% say they consume them several times a week, and 21.2% daily basis, which indicates the existence of an important segment of regular consumers. However, almost a third of the participants (28.9%) report consuming organic vegetables only occasionally.

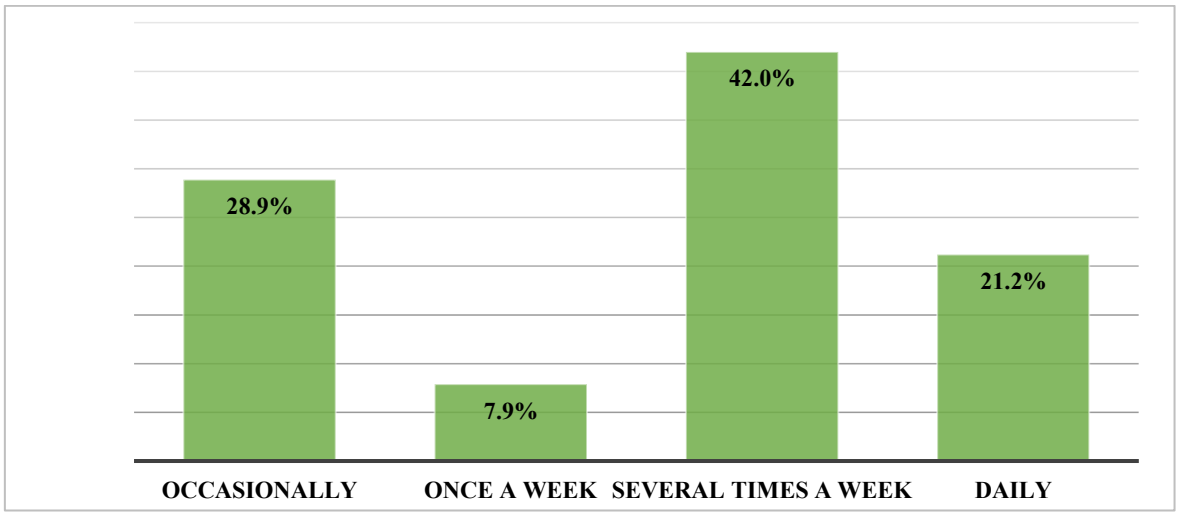

Figure 1. Distribution of respondents according to frequency of consumption of organic vegetables
Source: authors' own processing, based on data collected by questionnaire (2025)

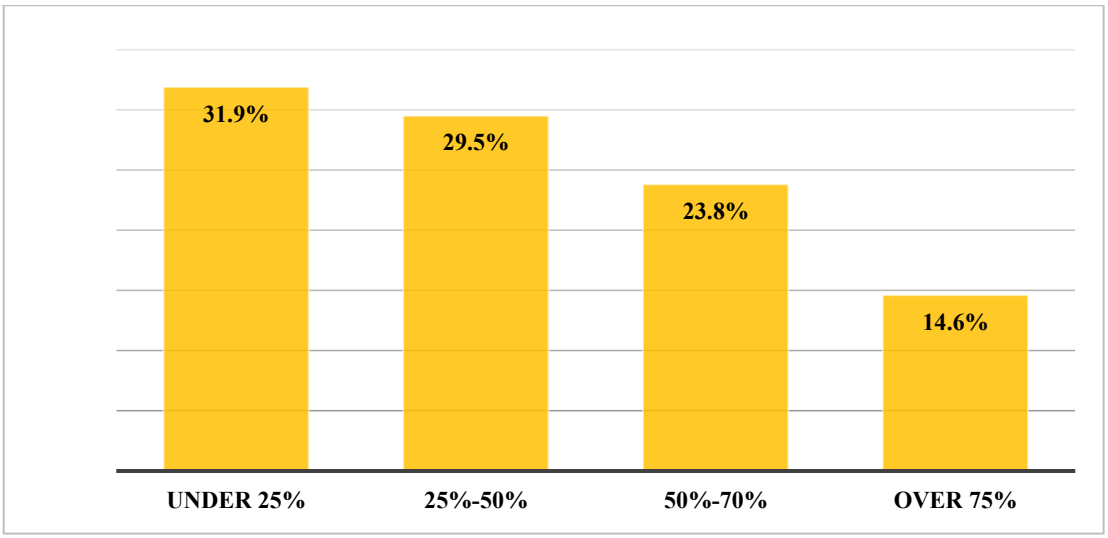

Figure 2. Share of organic vegetables in total vegetable consumption
Source: authors' own processing, based on data collected by questionnaire (2025)

The results show relevant socio-demographic differences. Women report a higher frequency of consumption of organic vegetables than men, with higher shares in the weekly and daily consumption categories. Young people and adults up to the age of 44 stand out through a higher frequency of consumption, many of whom integrate organic vegetables into their regular dietary patterns. Moreover, respondents with household incomes over 8000 RON and those with university or postgraduate studies exhibit a more constant consumption pattern, confirming the positive influence of economic resources and educational capital on dietary behavior. The differences between rural and urban areas are moderate, with daily consumption slightly higher in rural areas.

Although most respondents indicate that they include organic vegetables in their diet, the analysis of their share in total consumption indicates a relatively low level compared to that of conventional vegetables. About 61% of respondents consume less than 50% organic vegetables, and only 14.6% exceed the 75% threshold. This result suggests that, for the majority of the population, organic products are used as complementary options rather than as a dominant alternative.

The distribution is influenced by socio-demographic factors. Women are better represented in the upper consumption categories, while people over 55 years of age are predominantly concentrated below the 25% threshold. Household income and education level exert a significant influence, with respondents with higher incomes and university studies registering the highest shares of organic consumption. In contrast to the frequency of consumption, the urban environment records higher values in terms of the proportion of organic vegetables in total consumption.

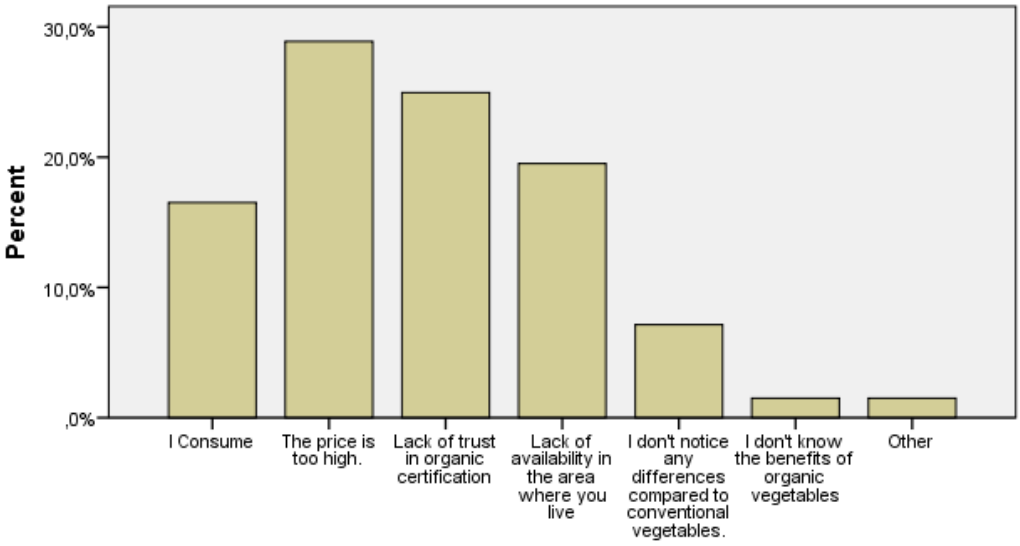

Figure 3. The main factors limiting the consumption of organic vegetables
Source: authors' own processing, based on data collected by questionnaire (2025)

The results indicate that the limitations of consumption are determined by a combination of economic and institutional factors. The high price is the main barrier, being mentioned by 154 respondents, followed by the lack of confidence in organic certification and reduced availability in the area of residence. A smaller number of respondents state that they do not perceive significant differences compared to conventional products or that they do not know their benefits, highlighting the existence of an informational deficit.

These results suggest that the low level of consumption does not reflect a lack of interest, but rather structural imperfections in the organic vegetable market, in terms of transparency of certification, price formation, and affordability of products.

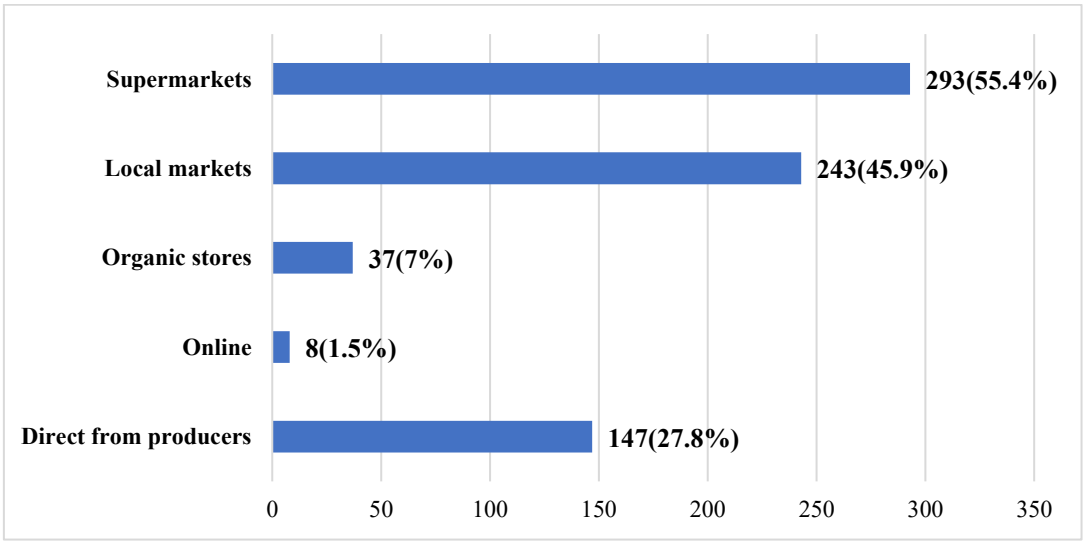

Figure 4. Channels for buying organic vegetables
Source: authors' own processing, based on data collected by questionnaire (2025)

The distribution of purchase channels highlights a predominant orientation towards modern commerce, with supermarkets being the main source of supply for 55.4% of respondents. Local markets occupy the second position, being indicated by 45.9% of the participants, which reflects the importance of the perception of authenticity and products provenance. Direct purchases from producers are mentioned by 27.8% of respondents, suggesting the existence of a segment oriented towards short supply chains and direct relationship with producers. Specialized stores (7%) and online commerce (1.5%) register small shares, but the online channel indicates a potential for medium-term development.

The distribution of purchase channels confirms the coexistence of traditional and modern supply models, highlighting the fact that the organic vegetable market is still in a transition phase, in which accessibility, trust, and proximity play an essential role in purchasing decision.

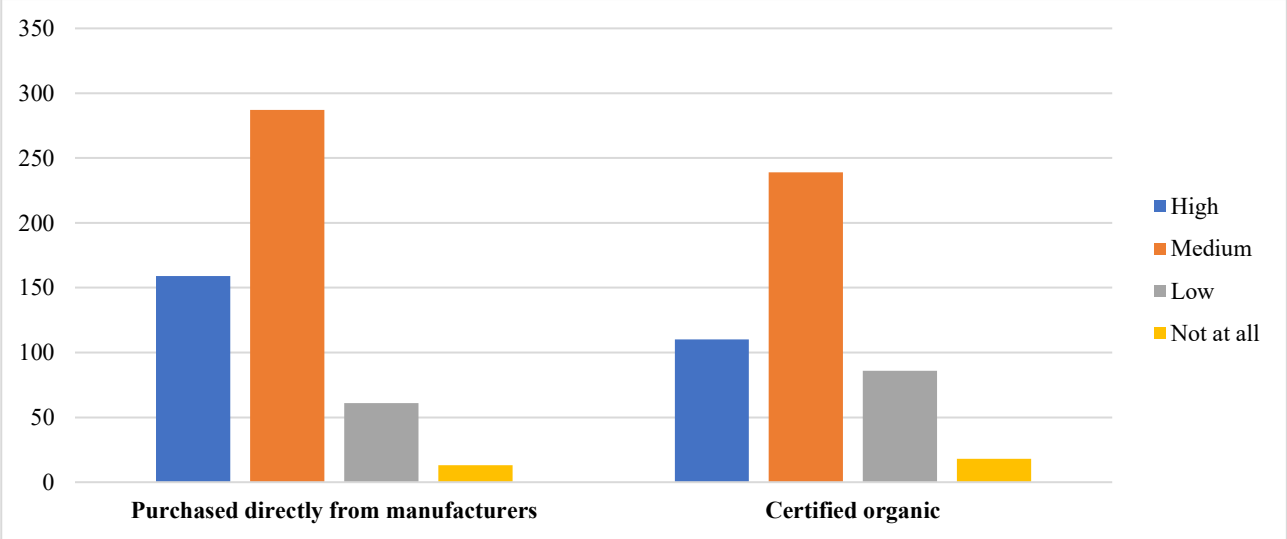

Figure 5. Level of trust in organic vegetables according to the safety channel
Source: authors' own processing, based on data collected by questionnaire (2025)

The analysis of the data highlights significant differences between the level of trust associated with organic vegetables purchased directly from producers and those that are certified organic. Respondents show a more favorable attitude towards buying directly from the source, perceived as offering a higher degree of authenticity and freshness, supported by direct interaction with the producer.

In the case of direct purchases, about 86% of respondents indicate an above-average level of trust, and 30.6% declare high trust. For certified organic products, the proportion of respondents with a favorable perception is lower, standing at around 77%, with 24% indicate a high level of trust.

The observed difference underlines the importance of short distribution channels and relationships in building consumer trust, suggesting that formal certification does not fully substitute the direct relationship with the producer in the perception of the authenticity of organic vegetable products.

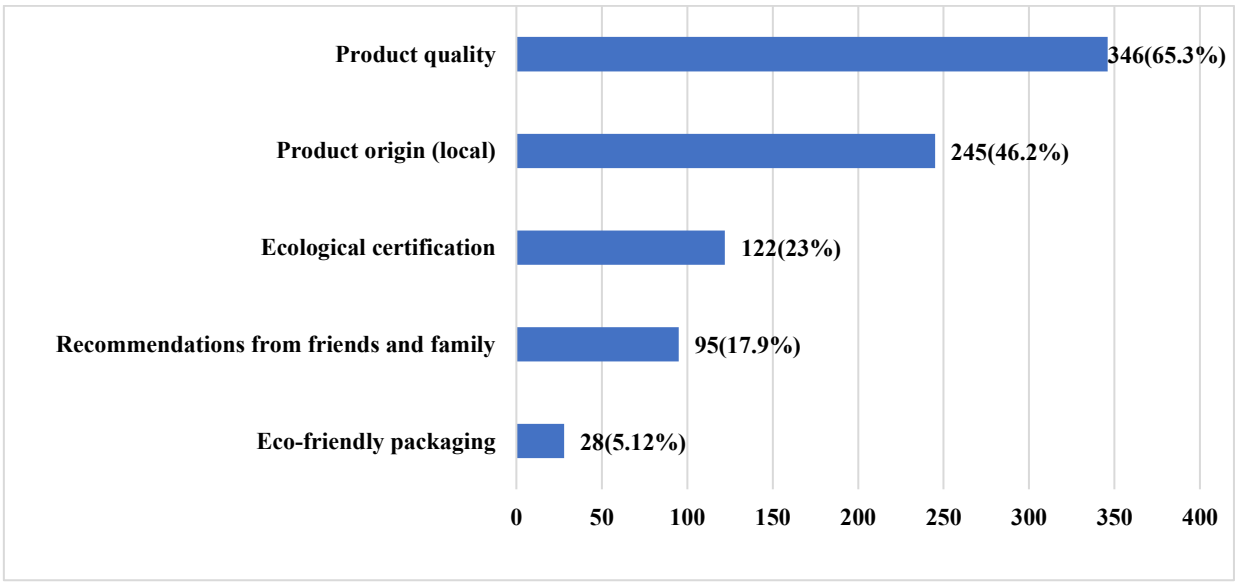

Figure 6. The main reasons for eating organic vegetables

Source: authors' own processing, based on data collected by questionnaire (2025)

The results presented in Figure 6 indicate that, out of the 533 responses, the quality of the products is the main factor influencing the purchase decision, being mentioned by 65.3% of the participants. This result highlights the fact that, beyond criteria such as certification or origin, the perception of quality, mainly associated with the taste, freshness and appearance of the products, remains decisive in the choice of organic vegetables.

In second place is the local origin of products, indicated by 46.2% of respondents, which reflects a clear orientation towards short supply chains and a preference for supporting local producers. Organic certification is mentioned by 23% of the participants, having an important but secondary role relative to the criteria of quality and origin. Recommendations from family or friends (17.9%) and eco-friendly packaging (5.3%) have a limited influence on the purchase decision.

The results highlight the fact that health is the most important reason for choosing organic vegetable products, mentioned by more than two-thirds of respondents (68.5%). This result suggests that the consumption decision has a predominantly preventive basis and correlates with the desire to avoid chemicals, pesticides or food additives.

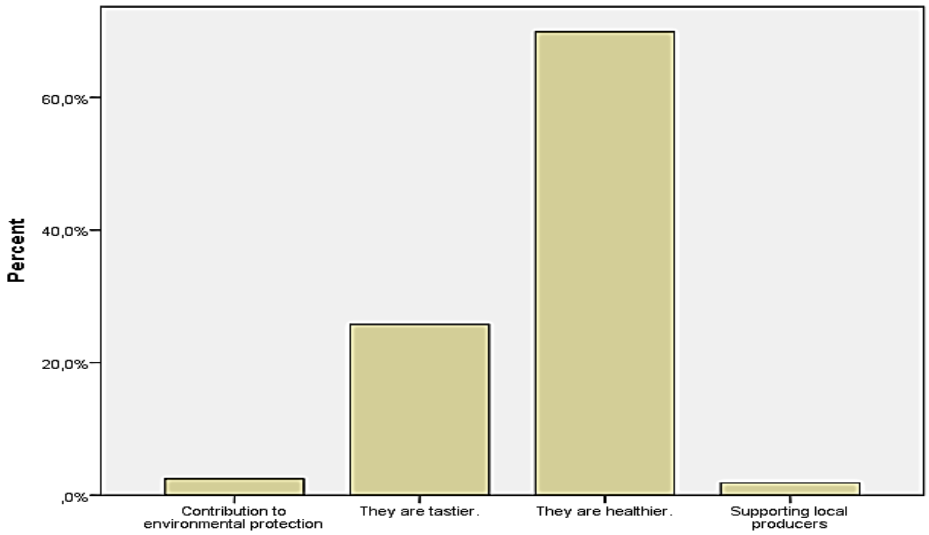

Figure 7. The importance of the criteria for buying organic vegetables

Source: authors' own processing, based on data collected by questionnaire (2025)

In second place is the taste and freshness of the products, indicated by 15.9% of respondents, which reflects the importance of sensory attributes in assessing the quality of organic vegetable products. The reasons related to environmental protection (8.3%) and support for local producers (5.6%) have lower shares, but reveal the existence of a segment of consumers oriented towards sustainability.

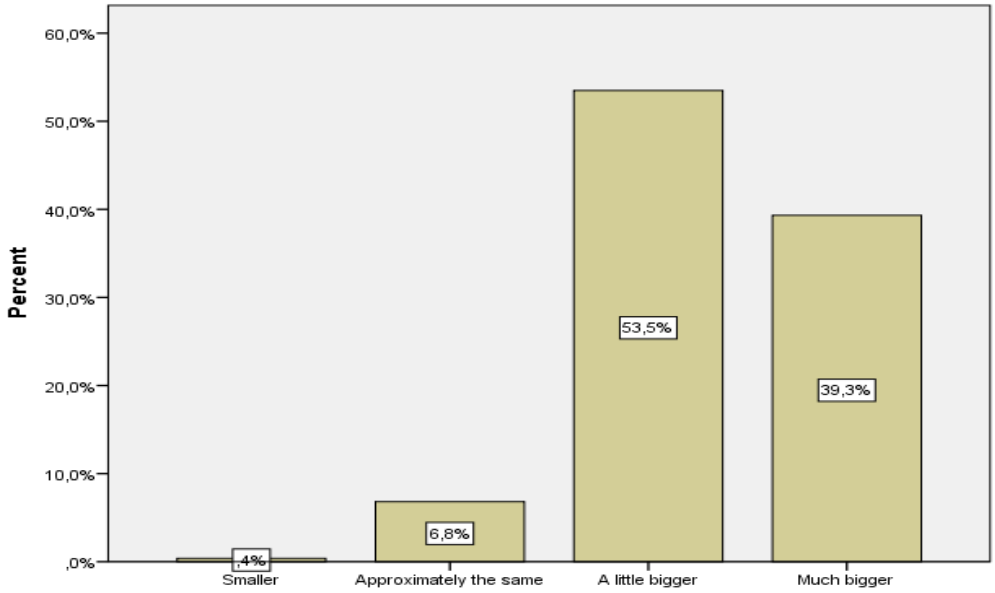

Figure 8. Perception of the price difference between organic and conventional products
Source: authors' own processing, based on data collected by questionnaire (2025)

The results highlight a predominant perception that organic vegetables are more expensive compared to conventional products. Of the total of 529 responses, an insignificant proportion consider their price to be lower, and a limited number consider the price level to be similar. On the other hand, most participants perceive organic vegetable products as having a higher price, with 53.5% indicating a "slightly higher" price, and 39.3% considering it to be "much higher".

This distribution suggests the existence of a significant economic barrier in the expansion of organic vegetable consumption, with the perception of price difference being a determining factor in consumer decision-making processes (Figure 8).

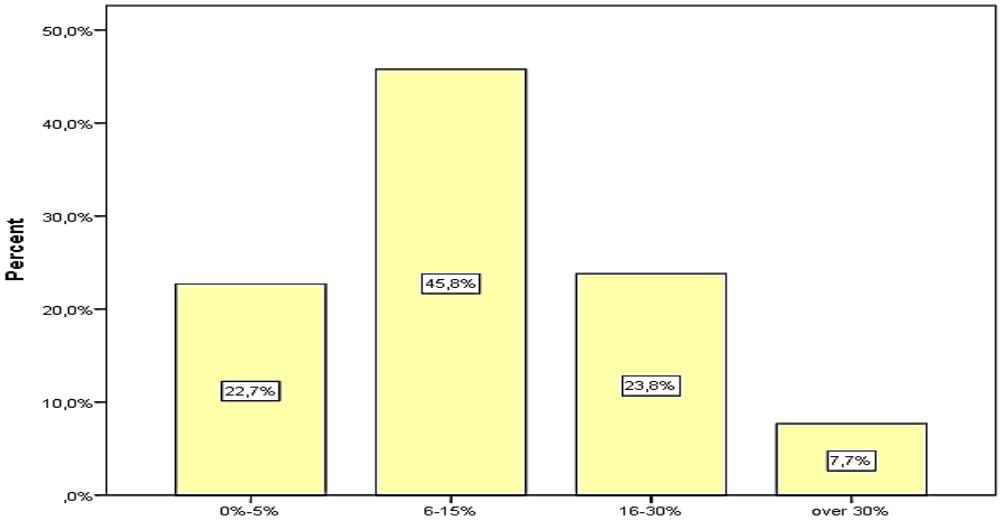

Figure 9. Payment availability for organic vegetables
Source: authors' own processing, based on data collected by questionnaire (2025)

The results show that although organic vegetables are perceived as more expensive, a significant part of the respondent sample is willing to accept a higher price. Out of a total of 533 respondents, 46% say they would pay 6–15% more for an organic vegetable product, indicating a moderate level of willingness to pay. A percentage of 24% accept a price 16–30% higher, while only 8% are willing to pay more than 30% above the conventional price.

At the same time, 23% of respondents say they would not accept a price higher than 0–5% compared to conventional products, highlighting the existence of significant financial constraints for some consumers. The distribution of the results suggests a balance between interest in the consumption of organic products and budgetary constraints, while the segment willing to pay the higher price difference can be characterized as better informed and more strongly attached to the values associated with health and sustainability.

At the end of the questionnaire, the respondents formulated a series of suggestions and observations relevant to the development and consolidation of the organic vegetable market, complementing the results obtained previously. A first frequently mentioned aspect refers to the need to reposition organic products, which should not be perceived as a "premium" segment, but as a natural and accessible alternative within the current food supply. This perspective reflects the desire to expand access to organic products and reduce the perception that they are intended exclusively for high-income consumers. In this context, the labelling of organic products as “luxury products” is perceived as a major obstacle to the expansion of consumption and as a factor that accentuates socio-economic differences between consumers.

A second set of observations concerns the importance of rigorous control of product origin and certification. Respondents express a preference for organic vegetables from domestic production or from European Union member states, where standards on pesticide use, traceability, and quality control are perceived as stricter. This orientation indicates that there is partial trust in the current eco-certification mechanisms and highlights the need for more visible and understandable procedures for verifying the conformity of products.

The responses also point to reduced shelf visibility and insufficient promotion of organic vegetable products. The suggestions made point to the need for clearer marking at points of sale and more effective communication to consumers so that organic products can be easily identified. These comments suggest that access to organic products is not limited solely by economic factors, but also by informational barriers, as consumers need clear benchmarks to understand the differences between organic and conventional products, including the justification of price differences.

A theme frequently mentioned in the responses analysed is the insufficient level of public information about the benefits of organic products. Respondents are asking for information and awareness campaigns that provide clear explanations on how to produce and the advantages of organic products, both from a health and environmental impact perspective. These requests reflect the need to strengthen an informed consumer behavior, capable of supporting the long-term development of the organic vegetable market.

CONCLUSIONS

The analysis of the data obtained through the questionnaire highlights the existence of significant differences in the perceptions, attitudes, and behaviors of Romanian consumers towards organic vegetable products, differences explained by socio-demographic, economic, and contextual factors.

Women show a more favorable attitude towards organic products, both in terms of frequency of consumption and purchase, level of trust, and willingness to pay, can be correlated with their active role in managing food at the household level. Similarly, young people and adults up to 44 years of age stand out for a higher level of interest and openness towards to organic products, being more receptive to modern nutrition trends and health related arguments.

The level of education and household income significantly influence consumption behavior. Individuals undergraduate and postgraduate education, as well as those with higher income level, show an increased willingness to purchase and recommend organic products, suggesting a direct link between economic status, educational capital, and the adoption of responsible dietary behavior. At the same time, the differences between rural and urban areas indicate distinct patterns of trust, so that fine rural dwellers show a higher level of trust in products purchased directly from producers, while urban consumers attach greater importance to organic certification and the diversity of supply.

The results confirm that the direct relationship with the producer is a central element in the formation of consumer trust, being perceived as a guarantee of authenticity, freshness, and food safety. Product quality and concern for healthy eating are the main criteria influencing the purchasing decision, while organic certification, although relevant, does not yet have a sufficient capacity to replace trust based on direct experience and the local origin of products.

The general perception of the price of organic vegetable products is one of higher cost compared to conventional products, the price being identified as the main barrier to the expansion of consumption. However, a significant proportion of respondents are willing to pay a 6–15% price premium, which indicates a recognition of the added values associated with quality, health benefits, and production mode. The segment willing to accept higher price differences is better informed and more strongly attached to the values related to sustainability and responsible food consumption.

Based on the results obtained, several relevant directions of action are outlined: intensifying information campaigns on the benefits of organic products and their production methods; increasing the transparency of the certification process; providing financial and institutional support for local producers through national and European programs; maintaining a balance between price and quality; expanding the product range and increasing shelf visibility; promoting food and environmental education through partnerships between schools, local communities, and producers; as well as the developing of short supply chains and local distribution networks.

Overall, the study highlights the fact that the sustainable development of the organic vegetable market in Romania depends on strengthening consumer trust, reducing economic and informational barriers, and capitalizing on the direct relationship between producers and consumers, in the context of an increasingly quality, health, and sustainability demand.

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THE POTENTIAL OF THE SPECIES *HYPOPHTHALMICHTHYS NOBILIS* (J. RICHARDSON, 1845) IN POLYCULTURE AS A STRATEGY TO OPTIMIZE AQUACULTURE PROCESSES IN THE CONTEXT OF CLIMATE CHANGE

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Abstract: *This study investigates the potential of Hypophthalmichthys nobilis (bighead carp) in polyculture systems, highlighting its ecological and economic benefits within the context of climate change and global aquaculture (FAO, 2022; IPCC, 2021). Through a comparative analysis of polyculture versus monoculture, key biological, economic, and statistical indicators were evaluated, demonstrating that polyculture with bighead carp reduces production costs, improves water quality, and enhances farm profitability, with a favorable investment recovery rate. Results indicate superior growth performance of bighead carp and a positive correlation between its density and ecological parameters, supporting its use as an adaptive strategy to mitigate the effects of climate change. The findings underscore the dual ecological and economic role of bighead carp in promoting sustainable aquatic ecosystems and strengthening sector resilience, recommending further research for broader implementation across different regions.*

Keywords: *Hypophthalmichthys nobilis, polyculture, climate change adaptation, feed efficiency*

JEL classification: Q22, Q54

INTRODUCTION

Aquaculture is one of the fastest-growing food production sectors, supplying a substantial portion of global animal protein and contributing to food security (FAO, 2022). As capture fisheries reach sustainable limits, aquaculture is expected to meet the growing global demand for seafood. However, climate change poses significant challenges, including rising water temperatures, hydrological variability, oxygen depletion, and increased disease incidence, which directly impact fish growth, reproduction, and survival, thereby threatening system productivity and sustainability (Barange et al., 2018; IPCC, 2021).

Traditional monoculture systems are particularly vulnerable to these stressors, often resulting in inefficient resource use, disease susceptibility, and environmental degradation (Ahmed & Turchini, 2021). In contrast, polyculture—the co-cultivation of multiple compatible species—enhances ecological resilience, optimizes feed utilization, and increases overall productivity (Troell et al., 2014; Chopin et al., 2012).

Hypophthalmichthys nobilis (J. Richardson, 1845; bighead carp) has emerged as a promising species for polyculture. As a planktivorous freshwater cyprinid, it consumes phytoplankton and organic detritus, improving water quality, reducing eutrophication, and contributing to nutrient recycling (Wang et al., 2020; Li et al., 2022). Its high growth rate, broad environmental tolerance, and low-trophic feeding habits make it compatible with species such as *Cyprinus carpio*, *Ctenopharyngodon idella*, and *Hypophthalmichthys molitrix*, enhancing system carrying capacity and biomass yield while reducing organic waste accumulation (Liu et al., 2021; Nekrasova et al., 2023).

Integrating *H. nobilis* into polyculture systems not only enhances productivity and economic returns but also supports climate-resilient and sustainable aquaculture, aligning with circular bioeconomy principles (FAO, 2022). This review synthesizes current knowledge on the ecological, physiological, and economic potential of H. nobilis in polyculture, emphasizing its role in optimizing aquaculture performance under climate change and informing sustainable management strategies.

MATERIALS AND METHODS

This review was conducted using a systematic and integrative approach to identify and synthesize relevant scientific literature on the role of *Hypophthalmichthys nobilis* in polyculture systems, particularly in the context of climate change adaptation in aquaculture. A comprehensive search was conducted across major academic databases, including Scopus, Web of Science, PubMed, and ScienceDirect, from January to October 2025. The search strategy employed Boolean operators and keyword combinations such as "*Hypophthalmichthys nobilis*," "bighead carp," "polyculture," "aquaculture," "climate change," "filter-feeding fish," and "Asian carp."

The inclusion criteria focused on peer-reviewed articles published between 2010 and 2025 that addressed polyculture systems involving H. nobilis, with an emphasis on climate resilience, water quality, and feed efficiency. Studies were excluded if they focused exclusively on monoculture systems, lacked comparative or quantitative data, or were not available in English. The remaining articles were evaluated for thematic relevance, methodological robustness, and data reliability. Information extracted from the selected studies was systematically organized into four thematic categories: (1) the biological and ecological characteristics of *Hypophthalmichthys nobilis*, (2) its functional compatibility within polyculture systems, (3) its adaptability to climate-induced environmental stressors, and (4) its economic and ecological contributions to sustainable aquaculture development. A narrative synthesis was used to integrate findings across diverse study designs, and where applicable, descriptive statistics and conceptual comparisons were employed to highlight key trends. Methodological quality was assessed using a modified version of the Critical Appraisal Skills Programme (CASP) checklist, and studies scoring below 60% were excluded from the final synthesis (Moher et al., 2009).

RESULTS AND DISSCUSION

The synthesis of data from multiple studies reveals that Hypophthalmichthys nobilis plays a pivotal role in enhancing aquaculture efficiency and environmental quality when integrated into polyculture systems. According to FAO (2022) and Zhang et al. (2023), the inclusion of bighead carp in carp-based polyculture increases total fish production by 10–25% compared with monoculture, primarily due to the species' ability to utilize planktonic biomass that would otherwise remain unexploited.

Bighead carp's filter-feeding behavior has a direct influence on water quality, as it reduces the concentration of phytoplankton and suspended solids. This process enhances light penetration, stabilizes oxygen dynamics, and minimizes the occurrence of harmful algal blooms (Li et al., 2022). The species' feeding activity also supports nutrient redistribution by converting excess organic matter into biomass, which can later be harvested, thus contributing to circular resource efficiency in aquaculture systems (Nekrasova et al., 2024).

The importance of the species within the production structures is evident from Table 1 and Figure 1.

Maintaining production at almost constant nominal values, with small variations, despite fluctuations in annual national production, indicates that H. nobilis is one of the key species in Romanian fish farms.

Table 1. Production of *Hypophthalmichthys nobilis* in Romania. Source: A.N.P.A.

	2015	2016	2017	2018	2019	2020	2021	2022	2023
H. nobilis (t)	1839.8	2120.57	2771.15	2548	2870	2237	2509	2252.92	1881.41
Total production (t)	11148.2	12585.12	12798.04	12298	12849	12150	11714	11211.2	11264.3
Production of H. nobilis (%)	16.50	16.84	21.65	20.71	22.33	18.41	21.41	20.09	16.70

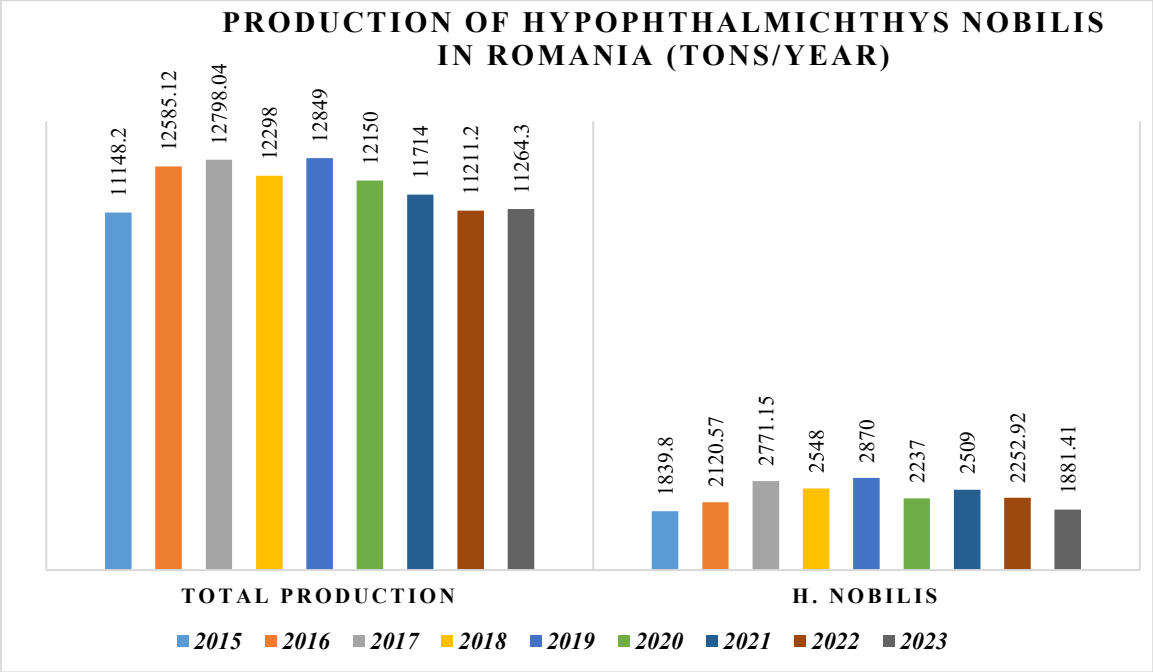

Figure 1. Production of *Hypophthalmichthys nobilis* in Romania. Source: A.N.P.A

The integration of *Hypophthalmichthys nobilis* into polyculture systems presents a multifaceted opportunity to enhance aquaculture productivity, ecological stability, and climate resilience. This section synthesizes findings from recent studies across four thematic domains: biological traits, polyculture compatibility, climate adaptability, and economic-environmental performance.

Several experimental studies (Liu et al., 2021; Drăgan et al., 2024) demonstrate that polyculture systems combining bighead carp with other cyprinids result in improved feed conversion ratios and reduced overall feed costs. This efficiency stems from complementary feeding niches: while Cyprinus carpio feeds on benthic organisms, *Ctenopharyngodon idella* consumes macrophytes, and H. nobilis exploits planktonic resources, thereby maximizing energy flow within the system.

Economic analyses further indicate that integrating H. nobilis can reduce production costs by up to 20% due to lower feed and water management expenses (FAO, 2022). The species' resilience to temperature fluctuations and its relatively low oxygen requirements also make it suitable for aquaculture in regions affected by climate-induced water stress.

A comparison of reported data (Table 2) shows that bighead carp achieves an average growth rate of 2.8–3.2 g/day in polyculture systems, compared to 2.3–2.6 g/day in monoculture setups (Zhang et al., 2023). The yield per hectare is consistently higher in mixed cultures, ranging from 3,500 to 4,200 kg/ha, depending on stocking density and feeding regime.

Table 2. Comparative performance of *Hypophthalmichthys nobilis* in monoculture and polyculture systems

System Type	Species Combination	Stocking Density (ind./ha)	Growth Rate (g/day)	Feed Conversion Ratio (FCR)	Survival Rate (%)	Total Yield (kg/ha)	Dissolved Oxygen (mg/L)	Water Temperature (°C)	Main Reference
Monoculture	H. nobilis only	3,000	2.4 ± 0.2	1.8	87	3,200 ± 180	5.8	26.5	Li et al. (2022)
Polyculture I	C. carpio + H. nobilis	3,500	3.1 ± 0.3	1.4	91	4,100 ± 220	6.5	25.8	Zhang et al. (2023)
Polyculture II	C. carpio + H. molitrix + H. nobilis	4,000	3.3 ± 0.4	1.2	94	4,500 ± 250	7.1	25.0	Liu et al. (2021)
Integrated Multi-Trophic (IMTA)	H. nobilis + C. idella + A. nobilis + microalgae	4,200	3.5 ± 0.5	1.1	95	4,800 ± 270	7.4	24.8	FAO (2022); Drăgan et al. (2024)
Recirculating Aquaculture System (RAS)	H. nobilis in a closed system	2,800	2.9 ± 0.3	1.3	92	3,700 ± 200	7.8	24.5	Chen et al. (2020)
Semi-intensive pond	H. nobilis + C. carpio + S. glanis	3,200	3.0 ± 0.3	1.5	90	4,000 ± 230	6.3	26.0	Wang et al. (2021)
Extensive pond	H. nobilis + C. carpio	2,500	2.2 ± 0.2	1.9	85	3,000 ± 150	5.4	27.2	FAO (2022)

Table 3. Economic Contribution and Production of *Hypophthalmichthys nobilis* and other Cyprinids in Polyculture Systems

Region / Country	Species (scientific name)	Year	Production or yield	Economic / Polyculture relevance	Source
Global	Hypophthalmichthys nobilis	2020	approx. 3,187,000 t (5.8% of world aquaculture)	Indicates a large global scale of the species → high potential for use in aquaculture/polyculture.	FAO, 2022
EU Pond Aquaculture (Eastern & Central Europe)	Carps: Cyprinus carpio, Hypophthalmichthys molitrix, Hypophthalmichthys nobilis	2018	~91,000 t freshwater ponds, of which ~80% (~72,000 t) cyprinids including bighead carp	Highlights the economic relevance of pond carp polyculture systems in Europe; big-head carp is part of that mix, making the species pertinent to polyculture optimization.	FEAP, 2021
EU – Selected countries	Hypophthalmichthys nobilis	2018–2019	EU total ~1,264 t in 2018; ~1,369 t in 2019. (feap.info)	Although modest in volume compared to global data, the findings indicate the presence and potential for expansion within the European context.	FEAP, 2023
Poland (pond system)	Mixed carps incl. Hypophthalmichthys nobilis	2018	Production ~26,500 t; average productivity ~441 kg/ha (up from 283 kg/ha in 2010)	Demonstrates productivity improvements in carp pond polyculture and economic significance per hectare.	Jensen, 2020
Economics of polyculture (various carps incl. big-head carp)	Carps incl. Hypophthalmichthys nobilis	–	Polyculture yields increase: e.g., increases of 400-600 kg/ha (unfed) in USSR; 600-1,000 kg/ha; with feeding/fertilization up to 3,000-4,000 kg/ha	Direct evidence that polyculture (including bighead carp) yields higher economic returns than monoculture → supports the economic relevance of polyculture strategy.	FAO, 2022

Table 3 presents the production, yield, and economic significance of *Hypophthalmichthys nobilis* and other cyprinid species in polyculture systems at global and European scales. The data indicate that *H. nobilis contributes substantially to aquaculture production, demonstrating both ecological efficiency and economic value in polyculture arrangements (FAO, 2022; FEAP, 2021*, 2023).

Polyculture systems, incorporating bighead carp and associated cyprinids, have been shown to enhance productivity per hectare and optimize the use of natural resources, thereby increasing profitability compared with monoculture systems (Jensen, 2020; FAO, n.d.). These findings highlight the potential of H. nobilis as a strategic species for sustainable aquaculture, particularly in the face of climate change pressures, where efficient resource utilization and economic resilience are crucial.

Biological and Ecological Traits

H. nobilis is a planktivorous species with exceptional filtration capacity, consuming phytoplankton, detritus, and suspended organic matter. This feeding behavior significantly contributes to mitigating eutrophication and improving water transparency, particularly in nutrient-rich aquaculture ponds (Zhao et al., 2019). Its trophic position allows it to function as a biological control agent, reducing algal blooms and enhancing oxygen dynamics.

Under optimal conditions, *H. nobilis* exhibits rapid growth, reaching up to 2 kg/year, with a preferred thermal range between 20–30°C (Wang et al., 2020). The species demonstrates low aggression and minimal territoriality, which facilitates its integration with other fish in shared environments. Its metabolic efficiency and low feed conversion ratio (FCR), often below 1.5, make it a cost-effective species for commercial production (Jawdhari et al., 2022). Moreover, its ability to utilize natural planktonic resources reduces dependency on formulated feeds, aligning with sustainable aquaculture principles.

The ecological implications of this performance are equally significant. By maintaining balanced phytoplankton levels and enhancing nutrient cycling, H. nobilis promotes ecosystem resilience in response to changing climatic conditions. It also contributes to carbon sequestration through the biological fixation of carbon in harvested biomass, providing an indirect mitigation pathway for greenhouse gas emissions associated with aquaculture (IPCC, 2021).

Compatibility in Polyculture Systems

The ecological compatibility of *H. nobilis* with other cyprinids has been extensively documented. In polyculture systems involving *Cyprinus carpio* and *Hypophthalmichthys molitrix*, *H. nobilis* occupies a distinct ecological niche, minimizing interspecific competition and enhancing overall biomass yield (Nekrasova et al., 2023). Its presence contributes to improved nutrient partitioning and water quality, thereby benefiting species sensitive to fluctuations in dissolved oxygen.

However, natural hybridization between *H. nobilis* and *H. molitrix* has been observed in wild populations, particularly in the Xiangjiang River basin, raising concerns about genetic integrity and biodiversity conservation (Zhang et al., 2020). While hybrid vigor may offer certain production advantages, uncontrolled hybridization could compromise selective breeding programs and ecological balance. Controlled hatchery practices and genetic monitoring are therefore essential to mitigate these risks.

Climate Resilience and Adaptability

Climate change is expected to alter the geographic suitability of aquaculture species. GIS-based modeling studies have identified *H. nobilis* as a thermophilic species with expanding potential in temperate regions of Europe due to rising water temperatures (HAL Archive, 2025). Its tolerance to low dissolved oxygen and fluctuating thermal regimes makes it a robust candidate for climate-resilient aquaculture systems.

Pilot studies conducted in Eastern Europe, including Romania and Ukraine, have demonstrated successful integration of *H. nobilis* in polyculture ponds. These systems reported enhanced feed efficiency, reduced disease incidence, and improved water quality metrics, suggesting that *H. nobilis* can play a pivotal role in adapting aquaculture to climate-induced stressors (Jawdhari et al., 2022).

Economic and Environmental Benefits

From an economic perspective, polyculture systems incorporating *H. nobilis* offer notable advantages. By reducing reliance on commercial feeds and enhancing natural productivity, operational costs are significantly lowered. Additionally, the species contributes to nutrient recycling and sediment stabilization, reducing the need for chemical inputs and improving ecosystem services (FAO, 2022).

Economic analyses indicate that farms utilizing *H. nobilis* in polyculture report profit margins up to 30% higher than those relying on monoculture, primarily due to diversified outputs, reduced mortality rates, and improved resource efficiency (Nekrasova et al., 2023). These findings underscore the species' potential not only as a biological asset but also as a driver of sustainable aquaculture economics.

Furthermore, the integration of bighead carp supports European and international goals related to ecosystem-based aquaculture. The species' potential in integrated multitrophic aquaculture (IMTA) systems and circular aquaculture models strengthens its role in sustainable production (Naylor et al., 2021).

CONCLUSIONS

The integration of *Hypophthalmichthys nobilis* into polyculture systems presents a promising approach for enhancing aquaculture sustainability and resilience to climate change. As a filter feeder with rapid growth, low feed conversion ratios, and wide environmental adaptability, *H. nobilis* helps enhance water quality, decrease eutrophication, and promote efficient nutrient cycling (Zhao et al., 2019; Wang et al., 2020). Its compatibility with other cyprinids such as *Cyprinus carpio* and *Hypophthalmichthys molitrix* allows for synergistic ecological interactions that boost overall biomass and reduce interspecific competition (Nekrasova et al., 2023).

Climate modeling studies suggest that warming trends in temperate regions will expand the geographic suitability of *H. nobilis*, making it a strategic species for climate-resilient aquaculture (HAL Archive, 2025). Pilot implementations in Eastern Europe have demonstrated its adaptability, with improved feed efficiency and reduced disease incidence in polyculture ponds (Jawdhari et al., 2022). These findings support its role in climate-smart aquaculture systems that align with ecosystem-based management and circular economy principles (FAO, 2022).

Economically, polyculture systems incorporating *H. nobilis* have shown up to 30% higher profit margins compared to monoculture operations, driven by reduced feed costs, diversified outputs, and enhanced system stability (Nekrasova et al., 2023). However, challenges such as hybridization with *H. molitrix* and the need for region-specific stocking protocols highlight the importance of genetic monitoring and adaptive management (Zhang et al., 2020).

In conclusion, *Hypophthalmichthys nobilis* provides a versatile solution to the dual challenges of aquaculture growth and climate adaptation. Its integration into polyculture systems can make aquaculture more resilient, productive, and environmentally responsible, significantly supporting global food security and environmental protection.

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PRICE ELASTICITY OF AGRICULTURAL PRODUCTS AND IMPACT ON THE TRANSITION TOWARDS SUSTAINABLE AGRICULTURE IN ROMANIA

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Abstract: *The transition to sustainable agriculture is essential for achieving the Sustainable Development Goals (SDGs), especially in the context of Romania's climate and economic vulnerabilities. This paper analyzes the link between the price elasticity of agricultural products and farmers' behavior in adopting sustainable practices, with a focus on the economic and decision-making implications at the national level. Using statistical data on production, trade, and average prices for the main agricultural products, demand elasticity was estimated as an indicator of producer income stability. A quantitative approach based on regressions and percentage changes is proposed to assess the extent to which market volatility influences investments in organic farming, irrigation, or crop rotation. The results show that products with inelastic prices are more favorable for sustainable transition, while crops with volatile prices require additional support measures. The research provides a framework applicable to public policies and suggests the integration of market risks into agricultural sustainability.*

Keywords: *elasticity of demand, market volatility, market risks, agriculture*

JEL classification: O52, Q1, Q17, R1

INTRODUCTION

The transition to sustainable agriculture is a strategic objective for Romania, given climate and economic pressures and the need to ensure food security.

A key factor in farmers' decision-making is the price elasticity of demand for agricultural products. This indicates the sensitivity of demand to price changes and reflects the stability of producers' incomes. Products with inelastic demand offer farmers predictability and more favorable conditions for investing in sustainable technologies and practices such as organic farming, irrigation systems, or crop rotation. In contrast, crops with inelastic demand and volatile prices involve greater risk, requiring additional support measures from the state or the market. (Boyd & Bellemare, 2019; FAO, 2015).

This paper aims to analyze the relationship between price elasticity, variations in demand and prices, and the adoption of sustainable practices in agriculture. A quantitative approach based on FAOSTAT statistical data on production, imports, exports, and market prices of major agricultural products is proposed to identify crops that present better opportunities for sustainable transition.

MATERIALS AND METHODS

The analysis is based on statistical data on production, imports, exports, and market prices of the main agricultural products in Romania for the period 2007-2023. The main sources include FAOSTAT data on international prices and agricultural trade.

The domestic demand for each agricultural product was estimated using the following relationship (Gilbert & Morgan, 2010; Alston, Martin & Pardey, 2014):

Q_d = Domestic demand + Imports − Exports

Q_d = domestic demand (tons)

To assess market dynamics, annual percentage changes in demand and prices are calculated according to standard agricultural economics methodology (Gardner, 1975).

$$\Delta Q = \frac{Q_{q,t} - Q_{d,t-1}}{Q_{d,t-1}} x\ 100$$

$$\Delta P = \frac{P_t - P_{t-1}}{P_{t-1}} x\ 100$$

Price elasticity of demand (PED) was determined annually as the ratio between:

$$PED = \frac{\Delta Q/Q}{\Delta P/P}$$

where:

ΔQ = change in output (%)

ΔP = change in price (%)

Price elasticity of demand (PED) measures the sensitivity of the quantity produced to price changes. A PED value > 1 signals elastic demand (strong reaction to price), PED < 1 signals inelasticity (weak reaction), and negative PED suggests abnormal behavior – often influenced by external factors.

Table 1. Types of demand elasticity

PED value (absolute)	Type of elasticity	Interpretation
PED > 1	Elastic	Demand reacts strongly to price changes.
PED = 1	Unit elastic	The percentage change in quantity is equal to that in price.
PED < 1	Inelastic	Demand reacts weakly to price changes.
PED = 0	Perfectly inelastic	Demand does not change at all, regardless of price.
PED= ∞	Perfectly elastic	A small change in price causes an infinite change in demand.

Source: Bjelobrk M. (2023), Mankiw, N. G. (2018), Dobrotă, N. (coord.). (1999), C. Marinescu, (2020), Cornescu, V., Radu, L., Radu, C. (2019).

The results are summarized graphically to highlight trends and support conclusions about agricultural sustainability. Price elasticity of demand was determined for corn, potatoes, and sugar beets.

Research hypotheses:

H1—Price elasticity of demand influences the adoption of sustainable practices in agriculture

H2 - market volatility and price variations affect farmers' incomes, and products with high PED require additional support policies to sustain the transition to sustainable practices.

RESULTS AND DISSCUSION

The analysis of price elasticity of demand for corn, based on data on production, imports, and producer prices, was structured in three stages: regression of demand and prices, calculation of percentage changes and price elasticity of demand (PED), and identification of years with elastic and inelastic demand.

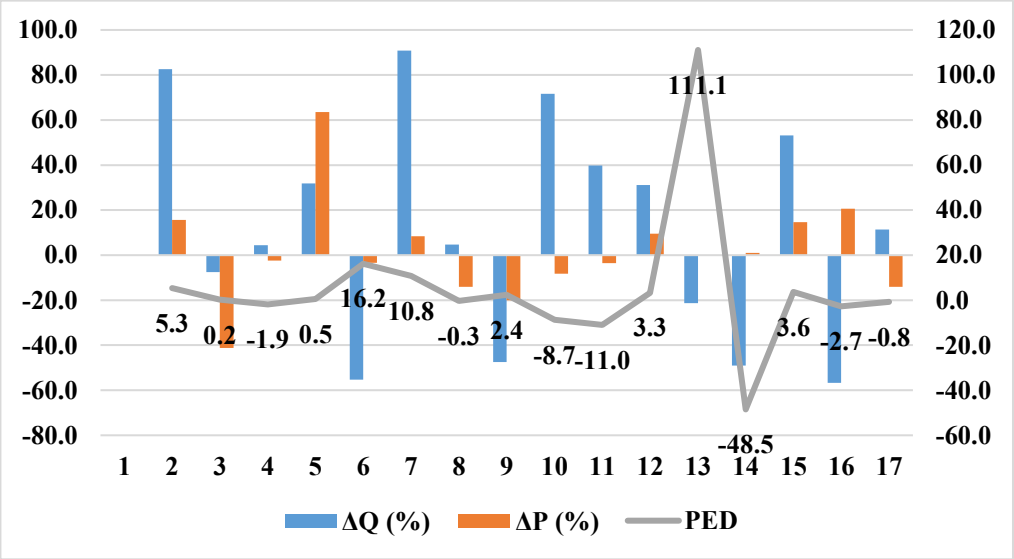

Figure 1. Dynamics of demand, price, and PED for corn
Source: Own calculations based on FAOSTAT data

Figure 1 illustrates the annual variations in demand, price, and elasticity (PED). The graph highlights significant fluctuations in both demand and prices, reflecting the volatility of the domestic market for corn production. The demand and price variation indicators allow the identification of years in which price changes had a greater impact on demand. The annual PED calculated for each period shows that, although demand is predominantly inelastic, there are years in which it has shown moderate elasticity, which may imply increase sensitivity of farmers' incomes to price changes (Boyd & Bellemare, 2019).

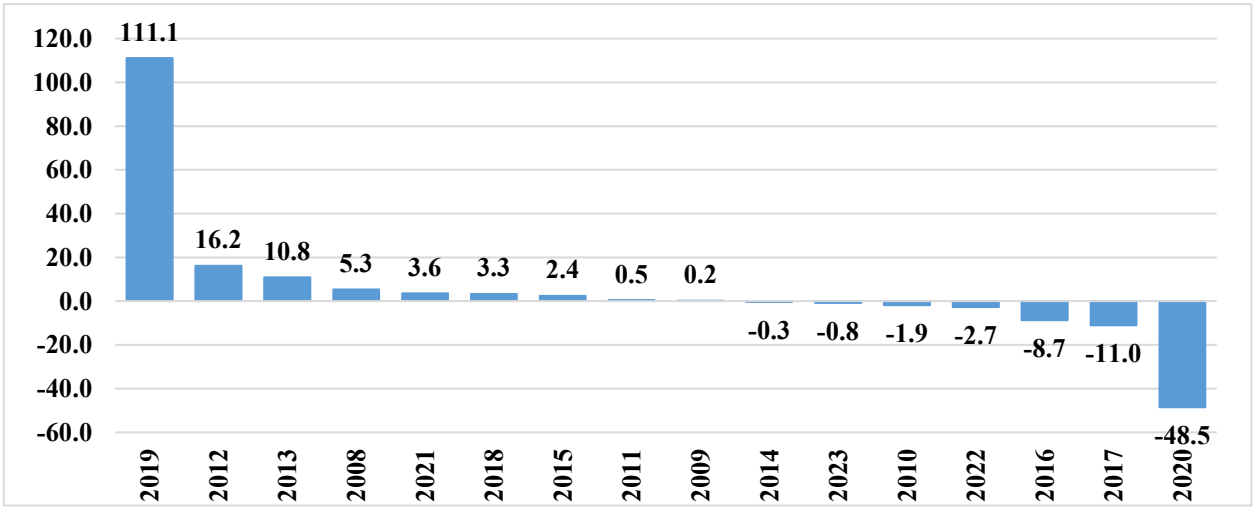

Figure 2. Annual evolution of price elasticity of demand (PED) for corn
Source: Own calculations based on FAOSTAT data

Figure 2 shows the annual evolution of the price elasticity of demand (PED) for corn in Romania between 2008 and 2023. Positive values indicate periods of elastic demand (2018, 2021, 2008, 2013, 2012, 2019), values < 1 indicate inelastic demand, and negative values suggest abnormal behavior influenced by external factors (2011, 2009, 2014, 2023, 2010, 2016, 2017, 2020). The annual PED analysis highlights years of extreme volatility (2019 and 2020), underscoring the need to integrate market risk into production planning and the development of sustainable agricultural policies.

Years with inelastic or moderately elastic demand are 2009, 2011, and 2015, a period recorded with PED close to 0, showing inelastic demand and relative stability in relation to price. The economic implications are revealed by years with extreme PED, which require protective measures or additional support for farmers, and periods with low average PED, when corn demand is generally inelastic, meaning that moderate price changes do not significantly affect the quantity demanded.

Determining years with elastic or inelastic demand allows for the assessment of market risk and the identification of periods when investments in sustainable practices were safer or riskier. Products with inelastic demand, as observed in most years for corn, provide farmers with a stable framework for adopting environmentally friendly practices or investing in agricultural infrastructure. In contrast, periods with PED greater than 1 suggest the need for protective measures, such as subsidies or forward contracts, to reduce the impact of volatility on farmers' incomes (FAO, 2015; Alston, Martin & Pardey, 2014).

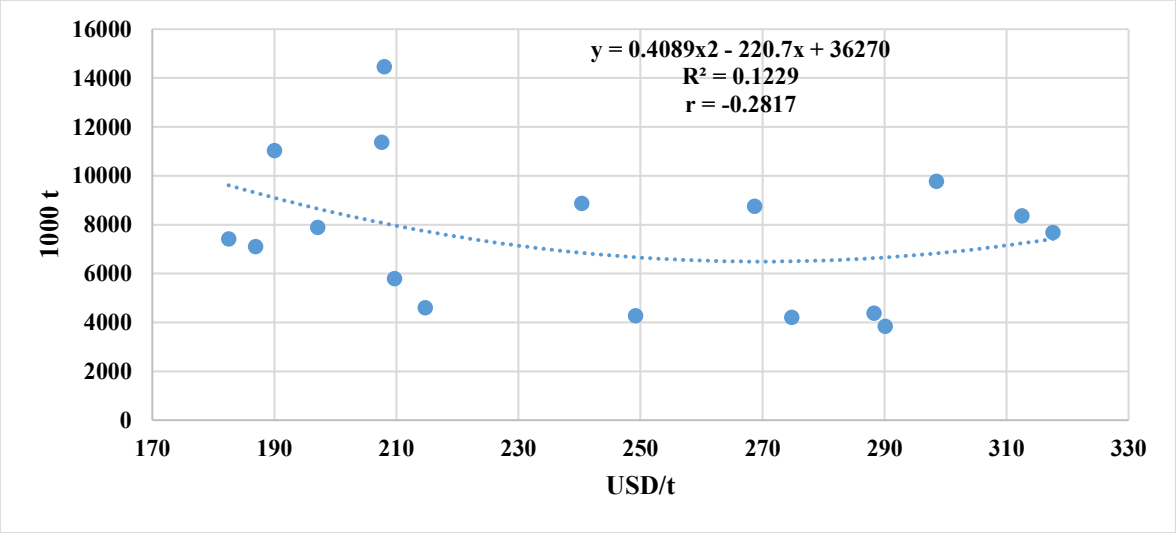

Figure 3. Demand-price correlation for corn
Source: Own calculations based on FAOSTAT data

Polynomial regression analysis of corn demand as a function of producer price shows that the relationship is not linear. The polynomial equation, with a coefficient of determination R2 = 0.1229, explains approximately 12.29% of the variation in quantity demanded, highlighting areas of high or low sensitivity to price changes. This approach allows for the capture of non-linear demand behaviors, providing a more accurate framework for PED assessment and for informing decisions on corn production and agricultural policies. The correlation coefficient represents the correlation between price and demand. The very low and negative value (r = -0.2817) indicates a negative, insignificant correlation. Polynomial regression with R2 = 0.1229 better captures the non-linear components of demand, providing a more accurate picture of PED and a more solid basis for decisions on corn production. Figure 3.

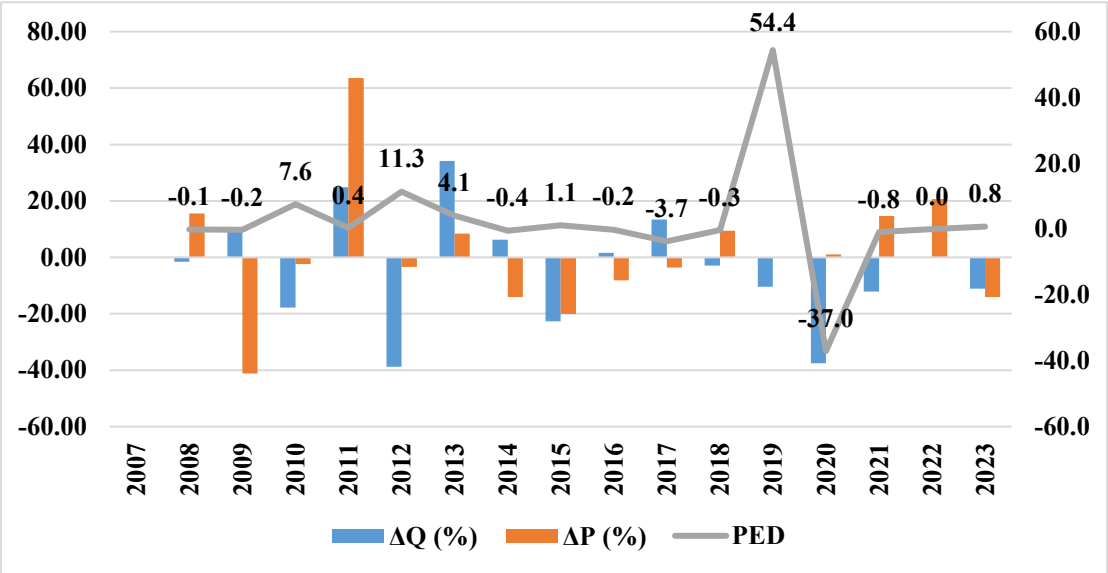

Figure 4. Dynamics of demand, price, and PED for potatoes
Source: Own calculations based on FAOSTAT data

Figure 4 shows the annual variations in demand, price, and price elasticity of demand (PED) for potatoes, highlighting market sensitivity over the period 2007–2023. Visual analysis shows that most years have PED values close to zero, indicating relatively inelastic demand and moderate stability in producer revenues. However, certain periods, such as 2011, 2012, and 2019, show significantly positive or negative PED, signaling years of high volatility and increased risk for farmers. Furthermore, the percentage changes in demand and price indicate that price changes did not uniformly influence the quantity demanded, reflecting the influence of external factors such as high production costs, imports, and agricultural policy. This dynamic allows for the identification of higher-risk years, providing farmers and policymakers with a framework for planning investments in sustainable agriculture and implementing protective measures to stabilize potato producers' incomes. (Boyd & Bellemare, 2019; FAO, 2015)

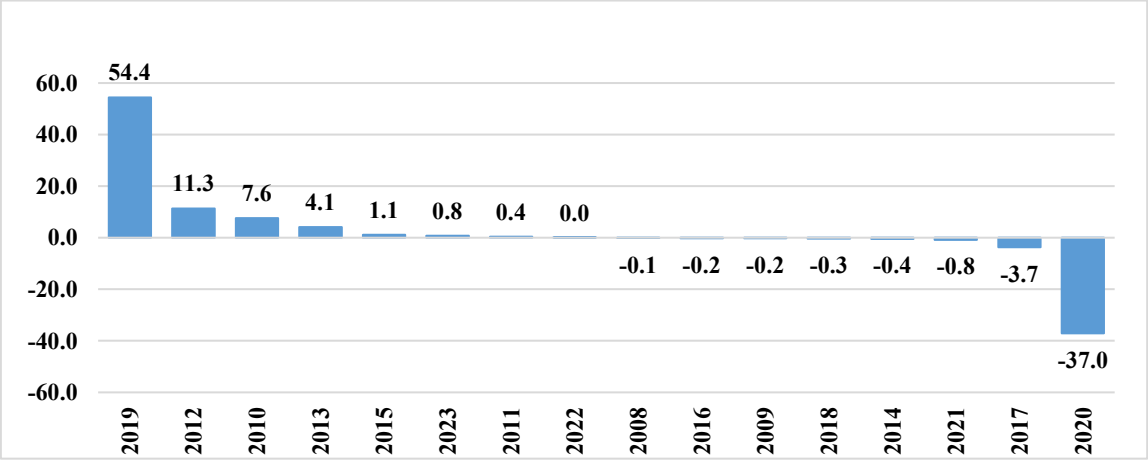

Figure 5. Annual evolution of price elasticity of demand (PED) for potatoes
Source: Own calculations based on FAOSTAT data

Figure 5 shows the annual evolution of the PED for potatoes between 2007 and 2023, highlighting variations in demand sensitivity to price changes. Most years show PED values close to zero, signaling relatively inelastic demand and moderate stability in producer revenues.

However, the periods 2011, 2012, and 2019 show a significantly positive PED, indicating elastic demand, while 2020 shows an extremely negative PED (-37), reflecting a sharp decline in demand, probably associated with volatile prices and difficult production conditions. This analysis allows the identification of high-risk years for farmers and provides a framework for informing decisions on investments in sustainable practices and the implementation of support measures necessary to stabilize incomes (Boyd & Bellemare, 2019; FAO, 2015).

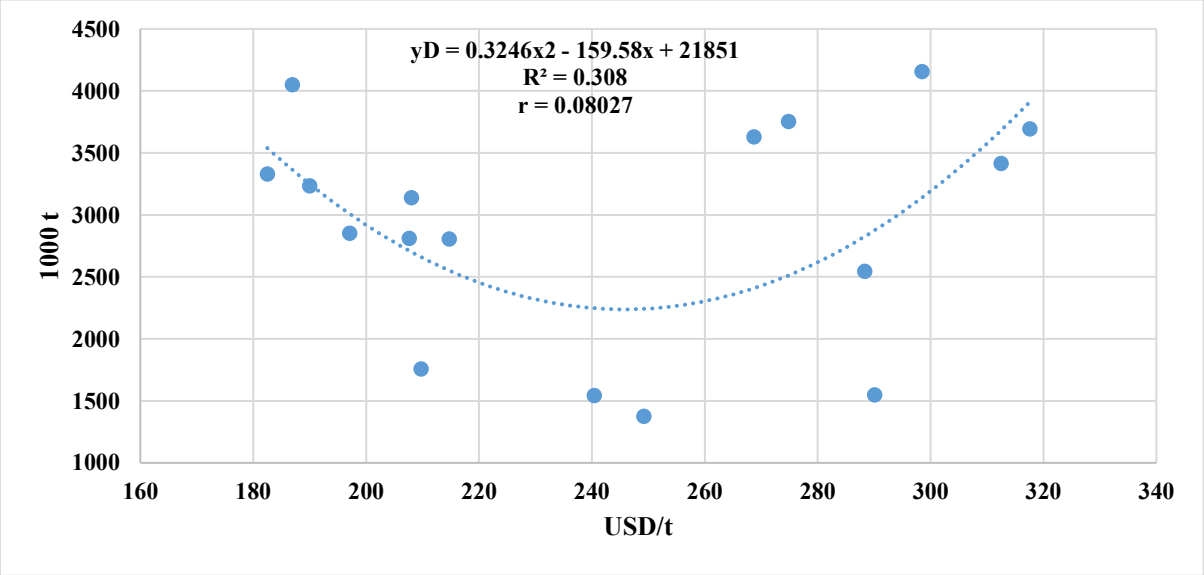

Figure 6. Demand–price correlation for potatoes
Source: Own calculations based on FAOSTAT data

Figure 6 shows the correlation between demand and price for potatoes. Polynomial regression analysis of potato demand as a function of producer price shows that the relationship is not linear. The polynomial equation, with a coefficient of determination R2 = 0.308, explains approximately 30.8% of the variation in quantity demanded, highlighting areas of high or low sensitivity to price changes. This approach allows for the capture of non-linear demand behaviors, providing a more accurate framework for PED assessment and for informing agricultural production and policy decisions. The correlation coefficient represents the linear correlation between price and demand. The very small and positive value (r = 0.08027) indicates an extremely weak, insignificant linear correlation. The polynomial regression with R2 = 0.308 better captures the non-linear components of demand, providing a more accurate picture of PED and a more solid basis for decisions on agricultural production and policies. This non-linearity indicates the influence of additional factors on demand, such as climatic conditions, agricultural policies, and imports, which have caused fluctuations in the quantity demanded. Even without a numerical estimate of the price elasticity of demand (PED), it can be observed that in most years' demand is relatively stable and inelastic, while significant deviations from the trend signal periods of high volatility and increased risk for farmers' incomes. This information allows for market risk assessment and provides a framework for informed decisions on sustainable agriculture investments and potato production planning.

Figure 7 illustrates the annual variations in demand, price, and price elasticity of demand (PED) for sugar beet over the period 2007–2023, highlighting market volatility and the sensitivity of demand to price changes. In most years, PED is close to zero or negative, indicating relatively inelastic demand and moderate income stability. However, certain periods, such as 2013, 2017, and 2023, show significant PED values, signaling years of high risk and heightened volatility.

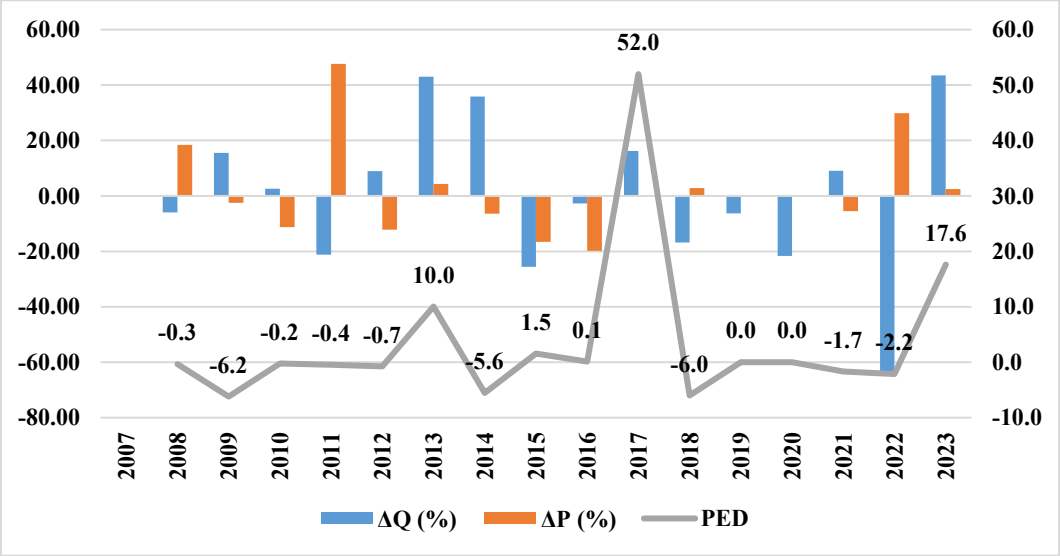

Figure 7. Dynamics of demand, price, and PED for sugar beet
Source: Own calculations based on FAOSTAT data

Percentage changes in demand and price suggest that price changes do not uniformly affect the quantity demanded, highlighting the impact of external factors such as sugar factory closures and domestic and external market demand. This dynamic allows for the identification of critical years for farmers and provides a framework for informing decisions on investments in sustainable practices and the implementation of support measures to stabilize the incomes of sugar beet producers. (Boyd & Bellemare, 2019; FAO, 2015)

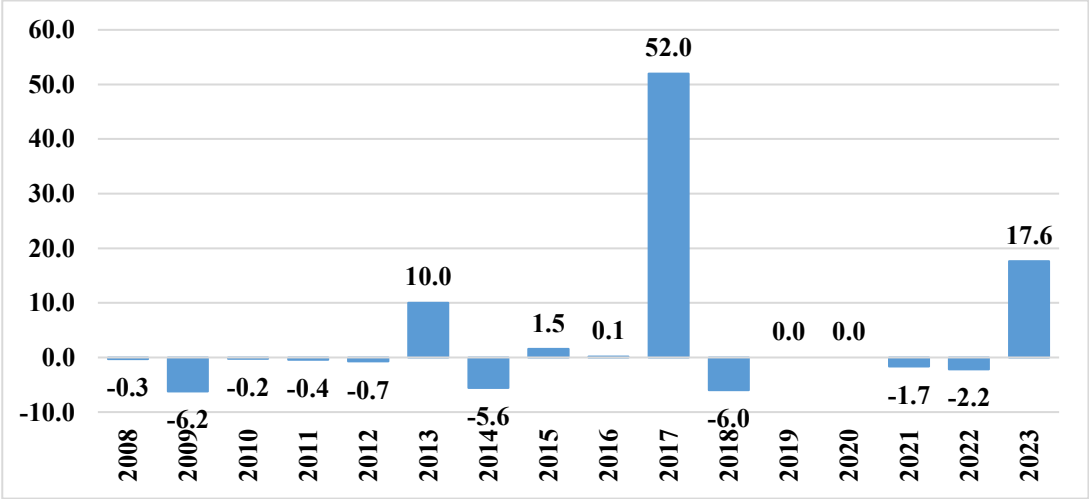

Figure 8. Annual evolution of price elasticity of demand (PED) for sugar beet
Source: Own calculations based on FAOSTAT data

Figure 8 shows the annual evolution of price elasticity of demand (PED) for sugar beet in Romania for the period 2008–2023. Negative values indicate periods of inelastic demand, while positive values signal periods of elastic demand, highlighting the sensitivity of the quantity demanded to price changes. Visual analysis shows that most years have PED close to zero, indicating relative stability in demand and moderate predictability of producer revenues. Some years, such as 2017 and 2023, have recorded high PED, signaling years of high volatility and increased risk for producer revenues. These fluctuations highlight the impact of external factors, such as agricultural policies and domestic and foreign market demand, on the sugar beet market.

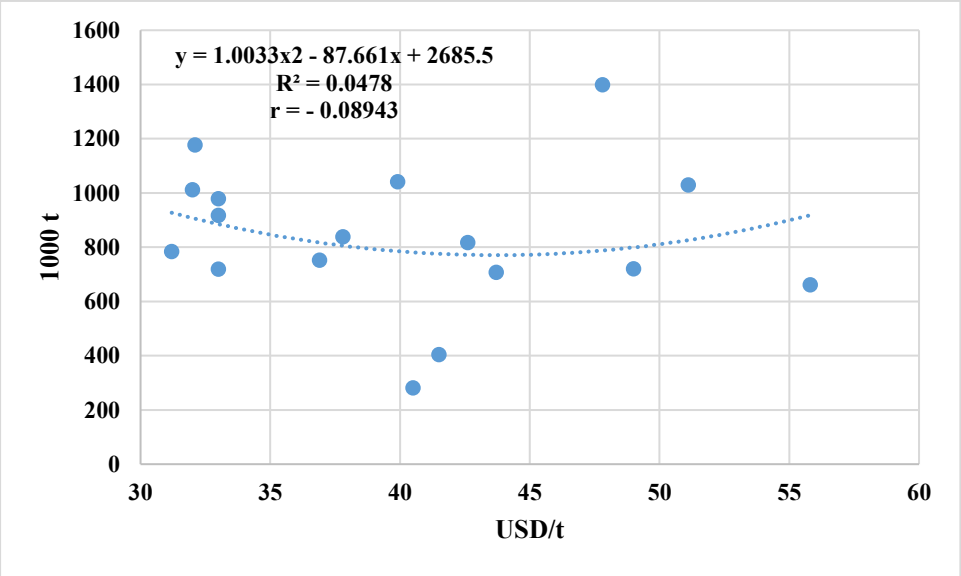

Figure 9. Demand-price correlation for sugar beet
Source: Own calculations based on FAOSTAT data

Figure 9 illustrates the relationship between the quantity of sugar beet demanded (thousand tons) and the producer price (USD/t) in Romania for the period analyzed. The visual analysis highlights a general inverse trend between price and demand, in line with the law of demand, but the distribution of points shows that the relationship is not perfectly linear and that there is significant variability in certain periods. This dispersion indicates the influence of external factors, such as agricultural policies and domestic and external demand for the quantity demanded. Most years show relatively stable and inelastic demand, but deviations of the points from the general trend signal periods of high volatility and increased risk for producers. Polynomial regression analysis of sugar beet demand as a function of producer price shows that the relationship is not linear. The polynomial equation, with a coefficient of determination R2 = 0.0478, explains approximately 4.7% of the variation in quantity demanded, highlighting areas of high or low sensitivity to price changes. The very low and negative value of the correlation coefficient (r = - 0.08943) indicates an extremely weak and insignificant negative correlation between demand and price.

A comparative analysis of the main crops shows that products with inelastic demand, such as corn and potatoes in most years, offer farmers a more stable framework for investing in good agricultural practices. In contrast, periods of extreme PED or elastic demand, observed mainly for sugar beet and certain intervals for corn and potatoes, require additional support measures, such as subsidies or forward contracts, to reduce the impact of volatility on incomes. This integrated approach shows that market risk must be considered an essential factor in the transition to sustainable agriculture, supporting the implementation of public policies aimed at income stability and sustainable agricultural production. (Alston, Martin & Pardey, 2014; FAO, 2015)

CONCLUSIONS

The analysis highlights that price elasticity of demand (PED) and market volatility play a key role in the stability of farmers' incomes and the transition to sustainable agriculture. For most years, demand for corn, potatoes, and sugar beets has proven to be predominantly inelastic, providing a relatively stable framework for investments in agricultural infrastructure, crop rotation, and

environmental practices. In contrast, periods of extreme PED or elastic demand indicate high-risk years, in which producers' incomes are more vulnerable to price variations, highlighting the need for support and protection measures such as subsidies or forward contracts.

The results suggest that integrating market risks into production planning and public policy-making is crucial for promoting sustainability. Furthermore, identifying years with elastic or inelastic demand allows for more accurate risk assessment and informed decisions on investments in organic farming and sustainable practices. Overall, the research confirms that an approach combining demand elasticity analysis with market risk assessment can support farmers and policymakers in promoting stable, efficient, and sustainable agricultural production, thereby contributing to the achievement of the Sustainable Development Goals, in particular SDG 2 and SDG 12 (FAO, 2015; Boyd & Bellemare, 2019; Alston, Martin & Pardey, 2014).

The study has its limitations in that the research was limited to only three representative crops (corn, potatoes, sugar beets), and the model was simplified by excluding external variables (climate, specific costs, individual farmer decisions) that limit the generalization of the results to other crops, countries, or time periods.

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THE WINE MARKET IN ROMANIA – TRENDS AND CHALLENGES

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Abstract: *The purpose of this article is to analyze the trends and challenges of the Romanian wine market, through an approach based on statistical data, comparative and quantitative analyses. It highlights the evolution of production and vineyard areas, changes in consumption, the level of competitiveness on foreign markets, but also the structural obstacles and opportunities of this sector. Through this research, we can provide an image of the development directions and possible scenarios for the future of Romanian viticulture.*

Keywords: *viticulture, wine market, evolution, trends, challenges*

JEL classification: Q1, Q13, Q17

INTRODUCTION

Viticulture is one of the oldest and most important agricultural activities in the Carpatho-Danubian-Pontic space (Sălăgean & Bădescu, 2018). Numerous archaeological evidence attests to the fact that vines have been cultivated on the current territory of Romania since antiquity, being a fundamental component of the economic and cultural identity of the region. In Dacian mythology, wine occupied a central place, and historical testimonies show that since Roman times the vineyards of Dacia were appreciated and integrated into the commercial circuit of the time (Sălăgean & Bădescu, 2018). This centuries-old tradition has been perpetuated until today, consolidating Romania's image as one of the wine-growing nations of Europe (Tăbăcaru & Popescu, 2022).

Internationally, Romania is among the top ten wine producers in the European Union and in the top 15 positions worldwide, with an annual production ranging between 4.5 and 5 million hectoliters (OIV, 2024; FAO, 2025). This performance places the country on the global map of wine producers, although the presence on foreign markets remains modest compared to the real potential (Trademap.org, 2025). For example, France, Italy or Spain not only dominate the production rankings, but also exports, while Romania exports less than 10% of the volume produced (European Commission, 2024).

The current context of the wine market is dynamic and complex. On the one hand, there is a global trend towards quality, diversity and sustainable products, which represents an opportunity for Romanian wineries (Tăbăcaru & Popescu, 2022). On the other hand, the wine industry faces significant challenges: fierce international competition, climate change (Iacob, 2020), cost pressure and fluctuations in domestic consumption (INS, 2025).

Wine consumption in Romania is relatively stable, standing at around 22–25 liters per capita per year (INS, 2025; FAO, 2025), which means a lower average than in traditional wine-growing Western European countries. However, the behavior of Romanian consumers is experiencing notable transformations: the preference for quality wines, the interest in organic and natural wines, as well as the orientation towards integrated experiences, such as oenological tourism (Tăbăcaru & Popescu, 2022).

The development of the wine sector has been strongly influenced by Romania's integration into the European Union. Access to European funds for the reconversion of vineyard plantations has allowed the modernization of many vineyards, the replacement of hybrid varieties with noble varieties and investments in modern winemaking technologies (MADR, 2025). This transition has led to a visible increase in the quality of Romanian wines, an aspect confirmed by the awards obtained by local wineries in international competitions (Tăbăcaru & Popescu, 2022).

However, this modernization has not been evenly distributed. While large, established wineries and vineyards have managed to attract investment and consolidate their market position, many small and medium-sized producers continue to face financing difficulties, lack of visibility and administrative barriers (MADR, 2025). The fragmentation of the sector reduces Romania's competitiveness on foreign markets and makes it difficult to consolidate a national wine brand (Tăbăcaru & Popescu, 2022).

In addition, Romanian viticulture is affected by climate change. Prolonged drought, increased average annual temperatures and extreme weather phenomena negatively influence harvest yields and quality (Iacob, 2020). Adapting to these changes requires investments in research, modern irrigation technologies, but also in the cultivation of resistant varieties, an aspect that requires a coherent national strategy (MADR, 2025).

The globalization of the wine market generates constant pressure. Countries with strong traditions, such as France, Italy and Spain, but also emerging producers such as Chile, Australia or South Africa, are aggressively promoting their wines on the world market (European Commission, 2024). For Romania, this context means a struggle for differentiation and international recognition, which implies not only quality, but also an intelligent and sustained marketing strategy (Tăbăcaru & Popescu, 2022).

Domestically, competition with other alcoholic beverages, such as beer or traditional spirits, reduces the room for growth in wine consumption (INS, 2025). However, there are numerous opportunities that can transform the Romanian wine market into a strategic sector for the national economy, especially through the development of wine tourism and the digitalization of trade (Tăbăcaru & Popescu, 2022; European Commission, 2024).

At the same time, digitalization and online commerce open new distribution channels, especially among the younger generations, accustomed to ordering products via the internet. Wineries that adopt these modern solutions have a greater chance of strengthening their brand and diversifying their customer portfolio.

MATERIALS AND METHODS

The analysis of the wine market in Romania involves a complex approach, combining official statistical sources (INSSE, ONVPV, APEVR), specialized literature (books, scientific articles, publications), reports of international organizations (OIV). Given the multidimensional nature of the subject, the methodology used in this study was designed to provide both a quantitative and a qualitative perspective on the trends and challenges of the wine sector. The research was based on the analysis of statistical indicators (arithmetic mean, standard deviation, annual growth rate, coefficient of variation).

RESULTS AND DISCUSSIONS

Overall, the total area of vineyards under fruit has registered a significant decrease from 247,536 ha in 2000 to 163,430 ha in 2024, which represents a reduction of approximately 34%. (graph 1). This downward trend reflects the restructuring of Romanian viticulture, influenced by reconversion programs, economic changes and adaptation to market requirements. The average for the period is 188,386 ha, and the coefficient of variation of 13.7% indicates an average variability. The annual rate of decrease, of –3.4%, denotes a constant reduction in productive areas.

The data presented in graphs 2, 3 and 4, corresponding to the areas of vines per fruit, as well as those cultivated with table grapes and wine grapes, highlight a generally decreasing trend of Romanian viticulture in the period 2000–2024. The numerical developments confirm the process of gradual reduction of productive areas, determined both by economic and structural factors, as well as by natural and institutional influences.

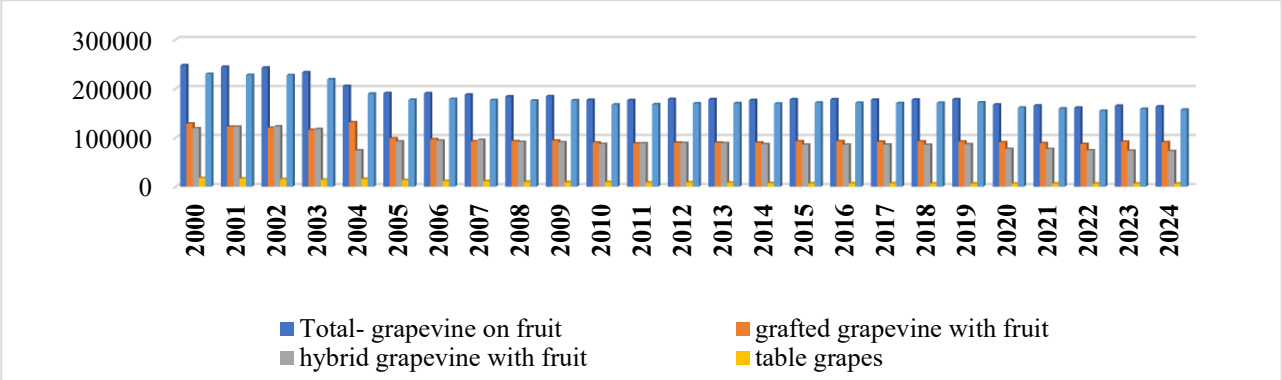

Figure 1. Structure of vineyard areas by fruit, in Romania, 2000-2024

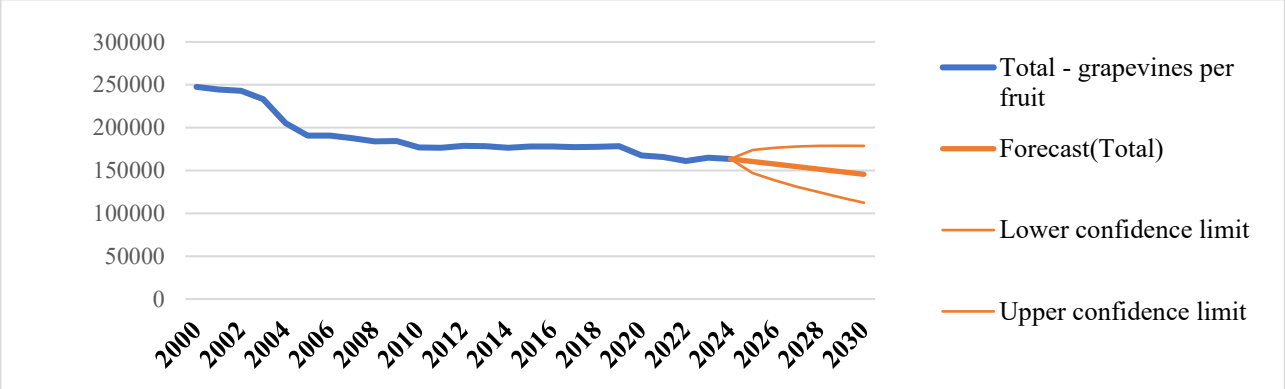

Figure 2. Trend of vineyard areas per fruit

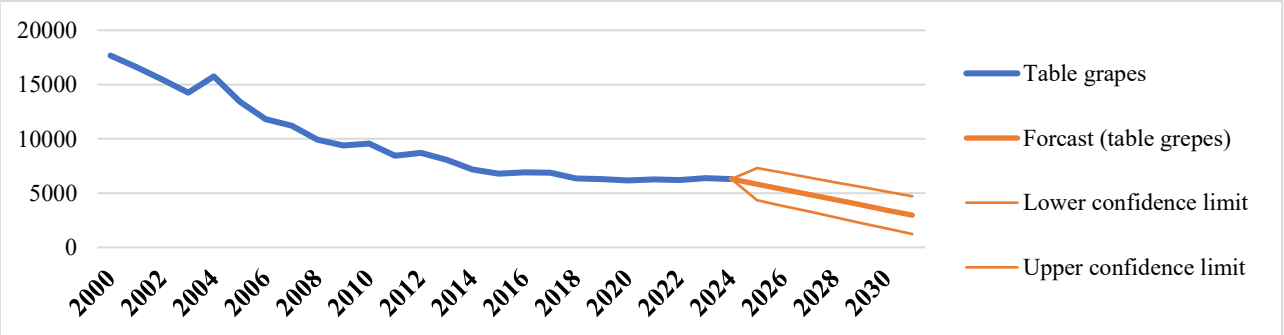

Figure 3. Trend of areas cultivated with table grapes

Source: insse.ro

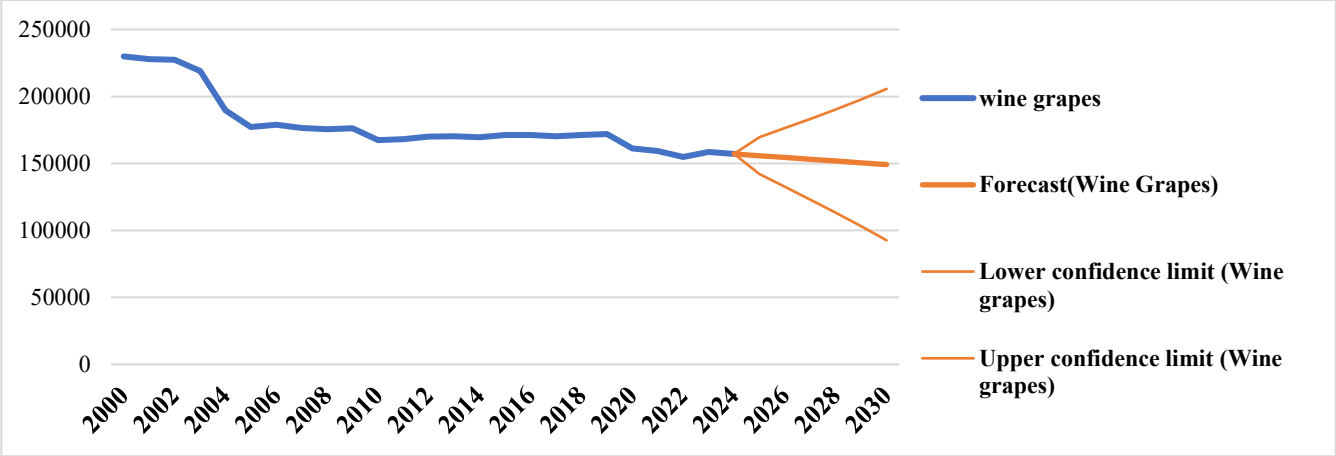

Figure 4. Trend of areas cultivated with wine grapes
Source: insse.ro

A sharp and constant decrease in the areas cultivated with table grapes, from 17,670 ha in 2000 to only 6,305 ha in 2024. The average for the period is 9,679 ha, and the high coefficient of variation (38.9%) indicates a strong instability of this branch.

This major reduction reflects the economic and commercial difficulties of producers, determined by the reduced competitiveness compared to imported products, the lack of a stable domestic market and the high maintenance costs. A more balanced evolution, although still decreasing, of the areas cultivated with wine grapes. In the period 2000–2024, they decreased from 229,866 ha to 157,125 ha, corresponding to a decrease of about 32% and an annual rate of –3.1%.

The average of the period is 178,810 ha, and the coefficient of variation, 12.5%, suggests a relative stability of this segment compared to the other indicators analyzed. This evolution is linked to the modernization of the wine sector through the implementation of reconversion and replanting programs financed by European funds, which aimed to replace old vineyards with noble varieties, increase the quality of production and consolidate the position of Romanian wines on the domestic and international market. Thus, although the total area has decreased, the quality and competitiveness of wine grape production have experienced a positive evolution.

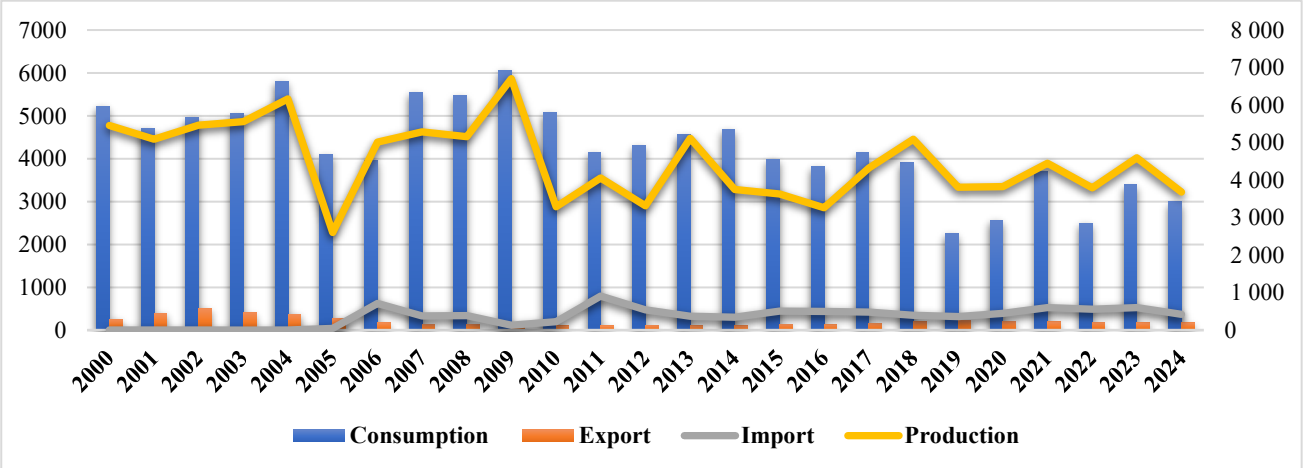

Figure 5. Evolution of wine production, consumption, export and import in Romania, 2000-2024. *Source: OIV*

Table 1. General summary of the evolution of wine consumption, export, import and production, 2000-2024

Indicator	Trend	Annual rate (%)	Main characteristic
Consumption	↓	-4.5	continuous decline, moderate variations
Export	↓	-3.3	continuous decline, moderate variations
Import	↑	+51.1	rapid growth, external dependence
Production	↓	-3.2	structural decline, oscillating
Area	↓	-2.3	constant land reduction

The evolution of the economic indicators analyzed for the period 2000–2024 reflects a complex process of structural transformation, marked by a general trend of contraction of domestic production and increasing dependence on external sources to meet consumption needs. The data suggest a specific dynamic of a sector in difficulty, where factors such as the reduction of cultivated area, the decrease in yields and the volatility of the domestic market have determined a profound change in economic balances.

Consumption, an essential indicator of domestic demand, recorded a constant downward trend, from levels of over 5,000 thousand hl at the beginning of the period to approximately 3,000 thousand hl in 2024. The average annual rate of decline, estimated at –4.5%, indicates a significant reduction in purchasing power or a change in consumer behavior. The moderate variations, captured by a coefficient of variation of almost 24%, suggest the existence of cyclical cycles — periods of temporary recovery (2004, 2008–2009), followed by more pronounced contractions, most likely correlated with macroeconomic factors (economic crises, pandemics, market adjustments).

In contrast to consumption, exports remained at modest levels throughout the period, without demonstrating a real capacity for expansion on foreign markets. After a cyclical peak recorded in 2002, of 503 thousand hl, the values have been constantly reduced, stabilizing below the threshold of 200 units in the last decade. The high coefficient of variation (over 50%) reveals a pronounced volatility, specific to a sector lacking external competitiveness and dependent on domestic production conditions. The negative rate of –3.3% per year confirms a slow but persistent process of export contraction, suggesting a predominantly domestic orientation of production and a weakening position on international markets.

Imports, on the other hand, experienced a spectacular increase, becoming the main mechanism for compensating for the imbalances between consumption and domestic production. The evolution from insignificant values in the first years of the period (only 3 thousand hl in 2000) to highs of over 900 thousand hl in 2011 reflects an accelerated opening of the domestic market to external sources of supply. The very high coefficient of variation (approximately 70%) and the average annual growth rate of over 50% highlight systemic volatility and increased dependence on imports. This trend can be interpreted as a symptom of the deterioration of domestic productive capacity, but also as a result of economic integration and trade liberalization, which facilitated the access of foreign products to the national market.

Domestic production follows an oscillating path, marked by periods of expansion and contraction, without managing to reach a sustainable growth trajectory. After an initial level of 5,456 thousand hl in 2000, production fluctuated strongly, reaching a minimum of 2,602 thousand hl in 2005 and a maximum of 6,703 thousand hl in 2009, followed by a constant decrease to 3,683 units in 2024. The average of the period (4,498 thousand hl) and the standard deviation of over 1,000 reflect the systemic instability of the sector. The negative rate of –3.2% per year confirms a long-term downward trend, explainable by the decrease in cultivated areas, the reduction in the productivity of production factors and, possibly, a reorientation of investments towards other economic branches.

The cultivated area, a basic structural indicator, is constantly decreasing, from 248,127 hectares at the beginning of the period to only 187,193 in 2024, which is equivalent to a reduction of over 60,000 hectares in almost a quarter of a century. These gradual decrease, with an annual rate of –2.3%, is a signal of the withdrawal of land from the agricultural circuit, either through abandonment or through a change in economic destination. The coefficient of variation of only 10% indicates a uniform decrease, without major shocks, but persistent and structural.

Overall, the analysis of the period 2000–2024 paints the picture of a sector in decline, characterized by a reduction in domestic production capacity, a decrease in active areas, a restriction of exports and an increase in imports. This combination suggests a loss of economic self-sufficiency and an increase in dependence on foreign markets. In economic terms, the phenomenon can be interpreted as an erosion of the productive base, determined by multiple factors: technological inefficiency, labor migration, degradation of rural infrastructure and insufficient investment in modernization.

The macroeconomic consequences of this evolution are multiple. In the short term, the increase in imports can ensure the stability of domestic supply and prevent a consumption deficit. In the long term, however, this dependence generates strategic vulnerabilities, exposing the economy to international price fluctuations and geopolitical risks associated with global trade. The decrease in domestic production and cultivated area also implies a significant social impact, by reducing jobs in rural areas and by decreasing income from agriculture or the food industry.

Therefore, the dynamics of economic indicators between 2000 and 2024 reveal a profound structural transformation, in which the processes of liberalization and globalization have exceeded the internal capacity for adaptation. To reverse this trend, a complex strategy to relaunch production, based on technological investments, the consolidation of production farms and policies to stimulate external competitiveness would be necessary. Only through such measures could the sector return to a sustainable balance between consumption, production and foreign trade.

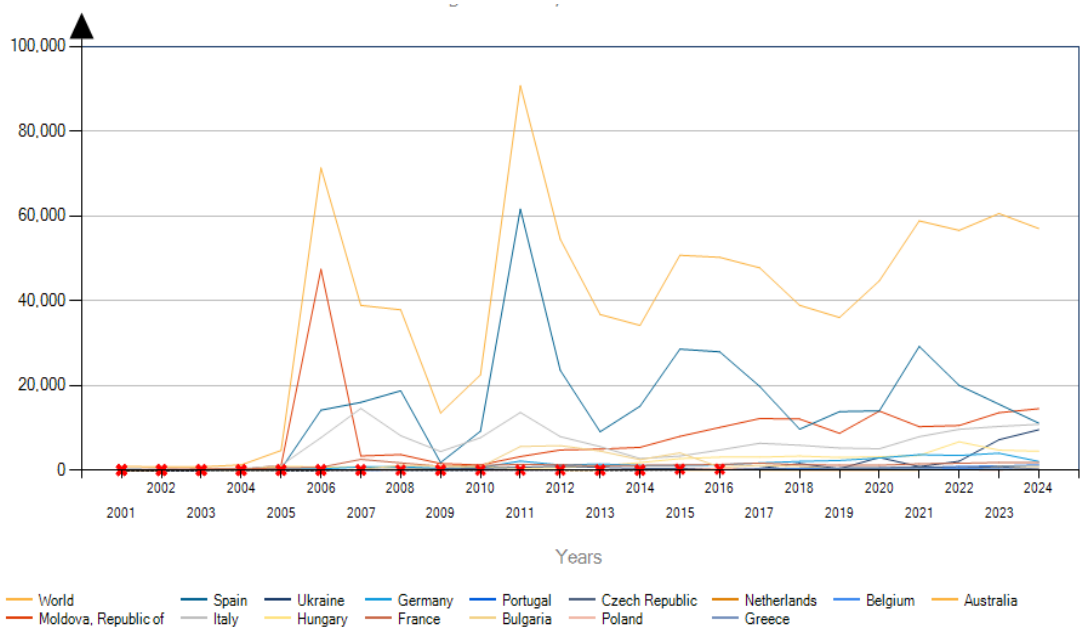

Figure 6. List of supplying markets for wine of fresh grapes imported by Romania, 2001-2024
Source: trademap.org

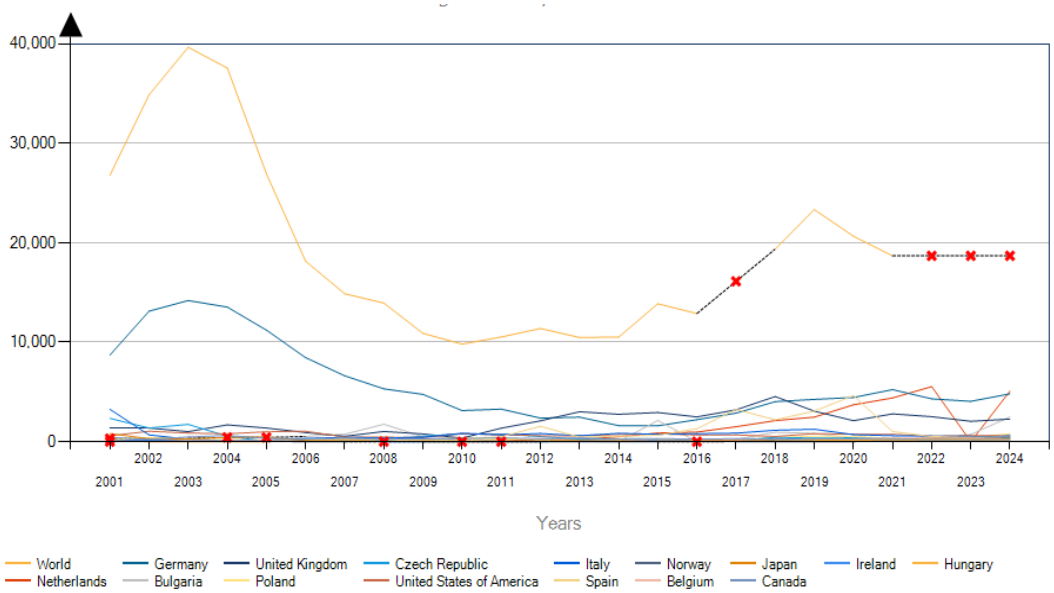

Figure 7. List of importing markets for a product exported by Romania, wine of fresh grapes, 2001-2024

Source: trademap.org

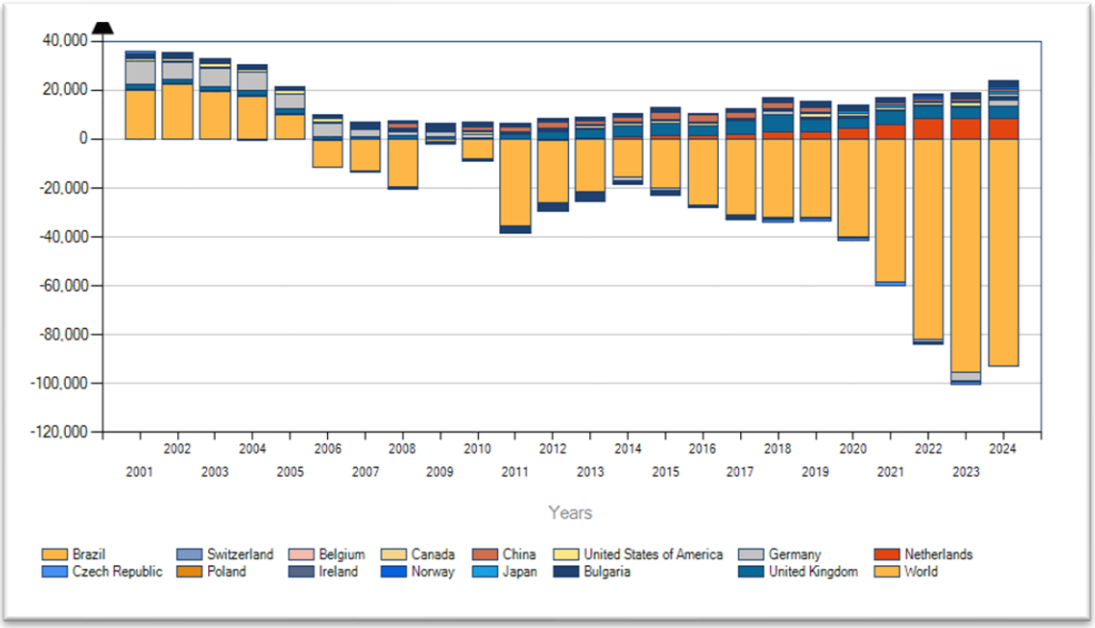

Figure 8. List of partners markets for a product (wine of fresh grapes, incl. fortified wines; grape must, partly fermented and of an actual alcoholic) commercialized by Romania, 2001-2024 *Source*: *trademap.org*

The analysis of the period 2001-2024 indicates that Romania imports wine from fresh grapes mainly from a few traditional countries, with a slight diversification trend in the last two decades. This can be correlated with fluctuations in international prices, quality standards and the evolution of domestic wine demand.

In terms of exports, Romania maintains a significant focus on traditional European markets, but registers a gradual increase in exports to non-European markets. This evolution suggests a strategy of international expansion and consolidation, supported by the promotion of Romanian wines and the adjustment of products to the requirements of global consumers.

For derived wine products, including fortified wines and partially fermented must, the stability of traditional trade relations and a gradual diversification of partner markets are observed. This indicates a strategic adaptation of the Romanian wine sector, which combines the maintenance of traditional markets with the exploration of emerging opportunities, contributing to the resilience and competitiveness of the industry in the long term.

Overall, the evolution of import and export markets reflects a balance between dependence on traditional suppliers, diversification of raw material sources and expansion on foreign markets, consolidating Romania's position in international wine trade.

The trade balance for Romanian wine between 2001 and 2024 highlights the transition from a moderate dependence on imports to an increase in exports, especially to traditional European and emerging non-EU markets. In the period 2001–2010, the trade deficit was mainly caused by imports of wine from fresh grapes, necessary to supplement domestic demand and for product diversity.

From 2011 onwards, Romania's exports started to exceed imports, generating a trade surplus, due both to the increase in the quality of Romanian wines and to the penetration strategies on foreign markets. This positive trend in the trade balance reflects not only the efficiency of the wine sector, but also Romania's ability to compete internationally. However, maintaining imports is essential for portfolio diversity and adapting to domestic consumer preferences.

In conclusion, the trade balance highlights a favorable evolution for Romania, with a consolidated exporting position, while maintaining the necessary flexibility to respond to domestic demand.

CONCLUSIONS

The area under grape cultivation has registered moderate variations during the period 2001–2024, with trends of modernization and reorganization of plantations. The stability of the cultivated areas has allowed maintaining a constant production and supported Romania's capacity to supply wine for both domestic consumption and export.

Production has experienced periodic increases, influenced by climatic conditions, winemaking technologies and specialization strategies on quality varieties. This has allowed covering domestic demand and increasing exports, with Romania consolidating its position on international markets, including for fortified wines and partially fermented must.

Domestic consumption has remained relatively constant, with a slight trend of increasing demand for higher quality wines. This has determined the need for imports in certain periods, to ensure the diversity and quantity needed on the domestic market.

Imports come mainly from a few traditional countries, but there is a trend of diversification of suppliers. These were essential for filling domestic demand and introducing diverse products to the Romanian market.

Exports increased significantly, especially to traditional European markets and emerging non-EU markets. Romania diversified its portfolio of exported products, strengthening relations with traditional partners and exploring new markets for quality wine.

Overall, the trade balance evolved positively: while at the beginning of the period imports exceeded exports, in recent years Romania has registered a trade surplus, reflecting the sector's capacity to produce competitive wine for the international market.

Romania has managed to balance domestic production with consumer demand, maintain imports necessary for diversity and increase exports. This integrated strategy has strengthened Romania's position on the international wine market, making the wine sector more competitive, stable and flexible.

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GARLIC CULTURE IN ROMANIA AND PRODUCTION EVOLUTION IN THE PERIOD 2019-2023

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Abstract: *Garlic (Allium sativum L.) is a valuable crop, widely used in both food and medicine, and although it has not been widely cultivated in the household system for a long time (Popa, 2022), over time, it has been introduced into field rotations and is increasingly becoming a source of income for farmers in Romania, here contributing the de minimis aid granted for this crop. The article presents a study over the last five years at the national level on the evolution of garlic cultivated areas distributed by development macro-regions. The analysis of garlic productivity shows an upward trend between 2019 and 2023, compared to 1990, when Romania made the transition from the communist period to a market economy. Thus, from an average garlic production of 3300.25 kg/ha in 1990, Romania ended up cultivating an average of 5819.6 kg/ha between 2019 and 2023.*

Keywords *garlic, production, ranking, macro-region, Romania*

JEL classification: Q12, Q13, Q15, Q17

INTRODUCTION

Garlic is known for its numerous health benefits, including antimicrobial and antioxidant properties, and its ability to improve cardiovascular health. This makes it valuable in functional foods and supplements, as well as in the pharmaceutical industry.

Globally, China is the world's largest garlic producer and the most influential in terms of production and export volumes. The Asian giant has maintained its leading position in the garlic industry for decades, producing millions of tons of garlic each year, satisfying not only domestic demand but also that of international markets. China is the main exporter of garlic, with destinations such as Europe, North America, and many other regions.

India occupies a prominent position in global garlic production, being the second largest producer after China, (Figure 1). (Especias El Explorador, 2024).

This is also because garlic is a staple food in Indian cuisine, being indispensable not only for its flavor-enhancing properties but also for its health benefits (Bhosle, 2024).

India produces 2,910,000 tons of garlic, followed by Bangladesh with approximately 466,389 tons, South Korea with approximately 331,741 tons, Egypt with approximately 286,000 tons, and Spain in sixth place with approximately 273,476 tons (Ferroice, 2022).

On average, EU countries produce over 400,000 tons of garlic per year, compared to approximately 28 million tons worldwide. The leader in this crop, producing 57% of the total in Europe, is Spain with a total production of over 273,000 tons (in 2018), followed by Italy (29,980 tons in 2017) and Romania (28,770 tons in 2018) (European Commission, 2019).

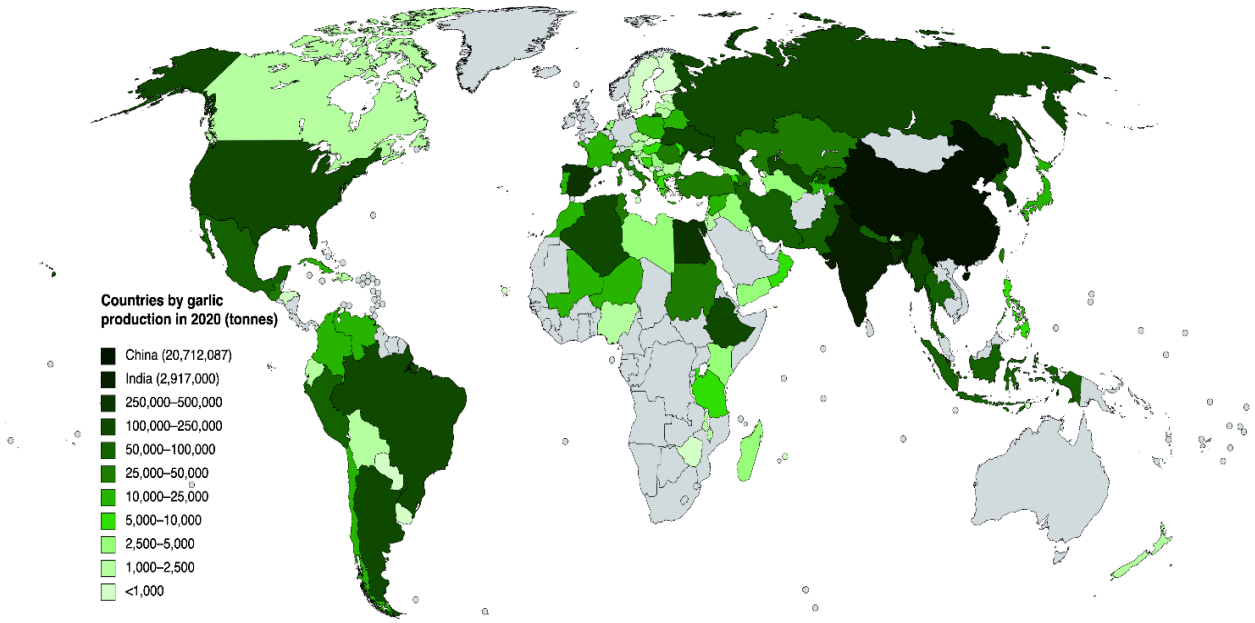

Figure 1. Ranking of countries by garlic production, 2020, tons
Source: Wikimedia commons, 2020

The global garlic market in the EU is in a delicate situation in many countries. In the Netherlands, garlic prices have reached record levels, driven by quality issues in Spain and dependence on more expensive Chinese imports. France is facing high prices and low quality, exacerbated by wax mite disease and logistical problems with Chinese garlic. Italy is struggling to find garlic of acceptable quality due to limited supplies from Spain, as Spain is facing a significant reduction in garlic production due to drought, affecting yields and quality. In the period 2023-2024, garlic production in Spain has seen a significant reduction, caused by drought in most producing areas, with Andalusia being the most affected. There, the decline is officially estimated at -45.5% compared to the previous season and -50.9% compared to the average of the last five seasons (Agraria.pe, 2024).

The Spanish garlic sector is at a turning point, maintaining stable production and relatively good quality in many areas, but rising costs and international competition are hampering its profitability. "The future of Spanish garlic and onions will depend on the sector's ability to reinvent itself without sacrificing its essence, investing in innovation and strengthening the identity of local products." (Financial food, 2025).

The yield and productivity of garlic are influenced by the lack of nutrients and optimal moisture in the soil, as the crop has a very shallow root system, which requires frequent irrigation and fertilization with different types of fertilizers in various soil types (Diriba, 2016).

It needs plenty of sun and a full range of nutrients available, not just NPK. A pH of 6.8 to 7.2 is ideal; many nutrients are bound in soils that are more alkaline or acidic than this. Garlic grows in almost any well-drained, crumbly soil with a high organic matter content (Bachmann & Tammy, 2008).

Another problem causing the decline in production is the diseases affecting this plant, which alter the cultivation pattern and affect local and export markets. The constant use of chemicals to control plant diseases not only poses a serious threat to the environment and humanity, but also gradually develops resistance in pathogens (Prahlad et al., 2022).

In this overview of the European Union, Romania ranks second after Spain in garlic production. According to the National Institute of Statistics, dry garlic production in 2023 was 45,801 tons.

Studies show that the area cultivated with garlic has been steadily declining since 2010. Total garlic production also fell by 31.8% in 2023 compared to 2010, when it stood at 67,000 tons. The annual growth rate was negative for all indicators, the reasons being both economic (price fluctuations, high input costs, etc.) and technological (lack of planting material, temperature fluctuations, disease and pest attacks) (Soare & Micu, 2025).

In the organic system, which has recently become more widespread, pests have multiplied both in terms of species and numbers, these being wireworms (Agriotes spp., Coleoptera: Elateridae) and nematodes (Ditylenchus dipsaci, Tylenchida: Anguinidae), with nematodes attacking 40% of the plants analyzed (Dinu, 2023).

Studies show that garlic production in Romania is also influenced by the planting date in correlation with climatic variations, with the best results and yields in 2012 being obtained from crops planted on April 2, with a garlic production of 7.75 t/ha, compared to 6.25 t/ha (garlic planted on April 7) and 4.75 t/ha (garlic planted on April 12), (Draghici & Lagunovschi-Luchian, 2015).

In Romania, total imports (from EU and non-EU countries) amounted to 6,307.3 tons in 2023, with the largest quantity imported from the Netherlands: 3,613.3 tons. Turkey imported 867.6 tons, Germany 425.9 tons, Spain 616.7 tons, and China 263 tons. Domestic production of dried garlic last year was 45,801 tons (Economedia.ro, 2024).

MATERIALS AND METHODS

The paper addresses a descriptive research design based on data and information provided by the National Institute of Statistics (NIS) of Romania, presenting an overview of the current situation of garlic production in Romania and by macro-regions of development.

The statistical data analysis was performed by accessing the Tempo Online database, where we analyzed and evaluated trends in garlic production in recent years.

We looked at and analyzed the macro-regions and counties in terms of dry garlic production over five years (2019–2023) and compared them to 1990, which was a big year for Romanian agriculture as it was the year of transition from post-communist agriculture to agriculture characterized by massive land fragmentation, with a distinctive pattern.

For this study, methods such as statistical analysis were used, using Microsoft Excel, applying the formulas for arithmetic mean and percentage calculation. For observations on the increasing or decreasing variation in garlic yields, we calculated the average for the 5 years (2019–2023) in relation to the yields in 1990, thus observing the increases and decreases compared to this reference year, highlighting the percentage difference (%) compared to 1990.

The results obtained using these methods provide an overview of the expansion of garlic cultivation areas in Romania and the dynamics of production.

RESULTS AND DISSCUSION

Romania is grouped according to NUTS (Territorial Units at Community Level) into four macro-regions of development (Giuca et al., 2022), with diversified agriculture in each region, as follows:

Macro-region I. It comprises the North-West and Central regions and includes the counties of Cluj, Bihor, Satu Mare, Maramureș, Bistrița-Năsăud, Sălaj, Alba, Brașov, Covasna, Harghita, Mureș, and Sibiu. Due to the cooler climate and fragmented terrain, there is a greater emphasis on mixed households than on large specialized farms (Otil & Parean, 2010).

Macro-region II. It covers the north-eastern and south-eastern regions of Romania and includes the counties of Iași, Bacău, Vaslui, Botoșani, Neamț, Suceava, Galați, Brăila, Buzău, Tulcea, Vrancea and Constanța. This macro-region has a strong agricultural focus.

Macro-region III. It consists of the South Muntenia and Bucharest-Ilfov regions and includes the counties of Argeș, Dâmbovița, Prahova, Teleorman, Giurgiu, Ialomița, Călărași, and Ilfov.

Macro-region IV. It includes the West and South-West Oltenia regions, with the counties of Timiș, Arad, Hunedoara, Caraș-Severin, Dolj, Olt, Vâlcea, Gorj, and Mehedinți. It is a mixed macro-region from an agricultural point of view, where highly productive plains, such as Banat, coexist with hilly and mountainous areas, where agriculture is less mechanized. In mountainous counties such as Gorj and Vâlcea, agricultural activities are focused on fruit growing and animal husbandry, especially sheep (Soare, 2018).

Recently, farmers have discovered the benefits of growing garlic, encouraged by state subsidies of €3,000/ha under the de minimis aid scheme. Since 2018, Romania has become the second largest garlic grower in Europe, with a production of over 30,000 tons/ha (2022), after Spain (315,720 tons produced in 2021), although in 2010 Romania produced over 67,000 tons/ha. (Economwdia.ro, 2023).

With regard to average garlic production between 2019 and 2023, where the national average is 5,819.6 kg/ha, Macro-region I (Northwest and Central) has the highest production, at 5,866 kg/ha, followed by the South-Muntenia and Ilfov area in Macro-region III with an average of 5813.6 kg/ha, followed by the West and Oltenia area with 5809 kg/ha and the North-East and South-East area (Macro-region II) with an average production of 5789.8 kg/ha. (Figure 2).

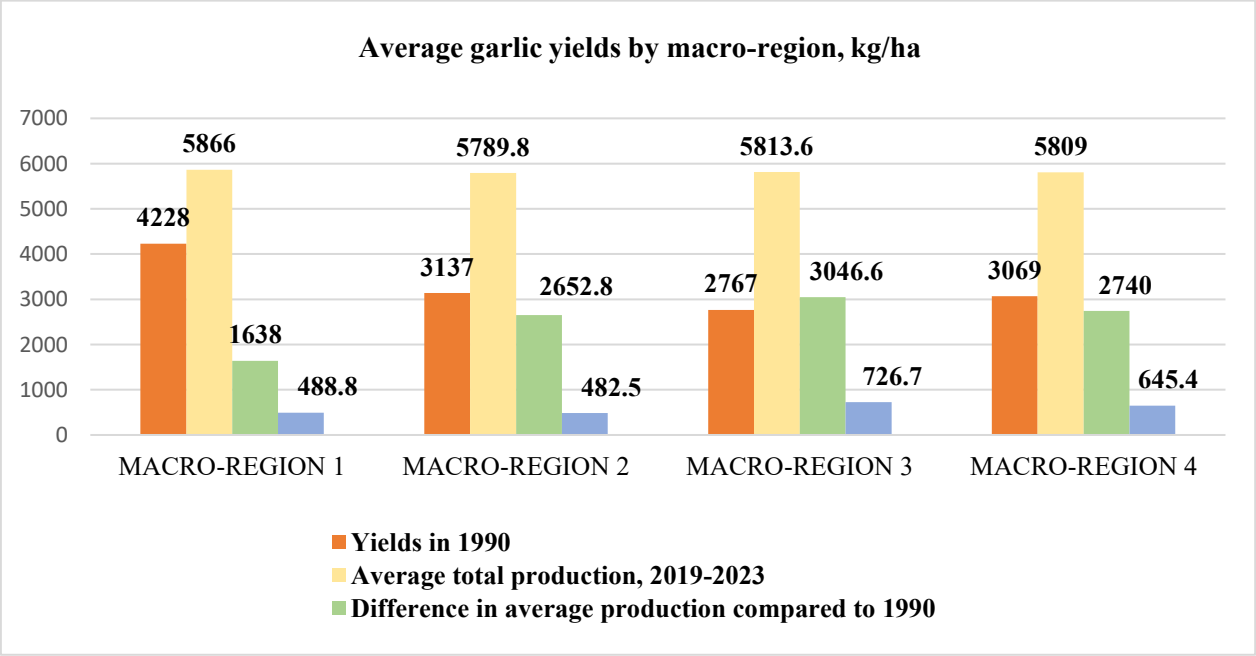

Figure 2. Average garlic yield, 2019–2023, at the macro-region level, kg/ha
Source: own processing based on INS

In terms of the ranking by macro-regions of development regarding average garlic production, in 1990, the same area, Macro-region I, topped the ranking. While in 1990, Macro-region IV, with the West and South-West Oltenia regions, ranked second in terms of production, between 2019 and 2023, these areas will drop to third place. Macro-region II, with the North-East and South-East areas of Romania, has been at the bottom of the ranking in recent years, while Macro-region III will climb to second place in the period 2019-2023 in terms of garlic production.

It should be noted that, while in 1990 we had an average production of 3,300 kg/ha, between 2019 and 2023, this increased by 56.7%, reaching values of 5,819.6 kg/ha (Table 1).

Table 1. Ranking by macro-region of development in terms of average garlic production, kg/ha

Macro-region	Average yield, 1990, Kg/ha	Ranking, 1990	Average yield period (2019–2023), kg/ha	Ranking 2019-2023
MACRO-REGION I	4228	I	5866.0	I
MACRO-REGION II	3137	III	5789.8	IV
MACRO-REGION III	2767	IV	5813.6	II
MACRO-REGION IV	3069	II	5809.0	III
Average	3300		5819.6	

Source: own processing based on INS

Analyzing the situation at county level, we observe that Bistrita-Nasaud County ranks first among counties with high production, with an average production of 7596.6 kg/ha, followed by Satu Mare County in second place with 7080.8 kg/ha, and Galati County in third place with 6796.6 kg/ha.

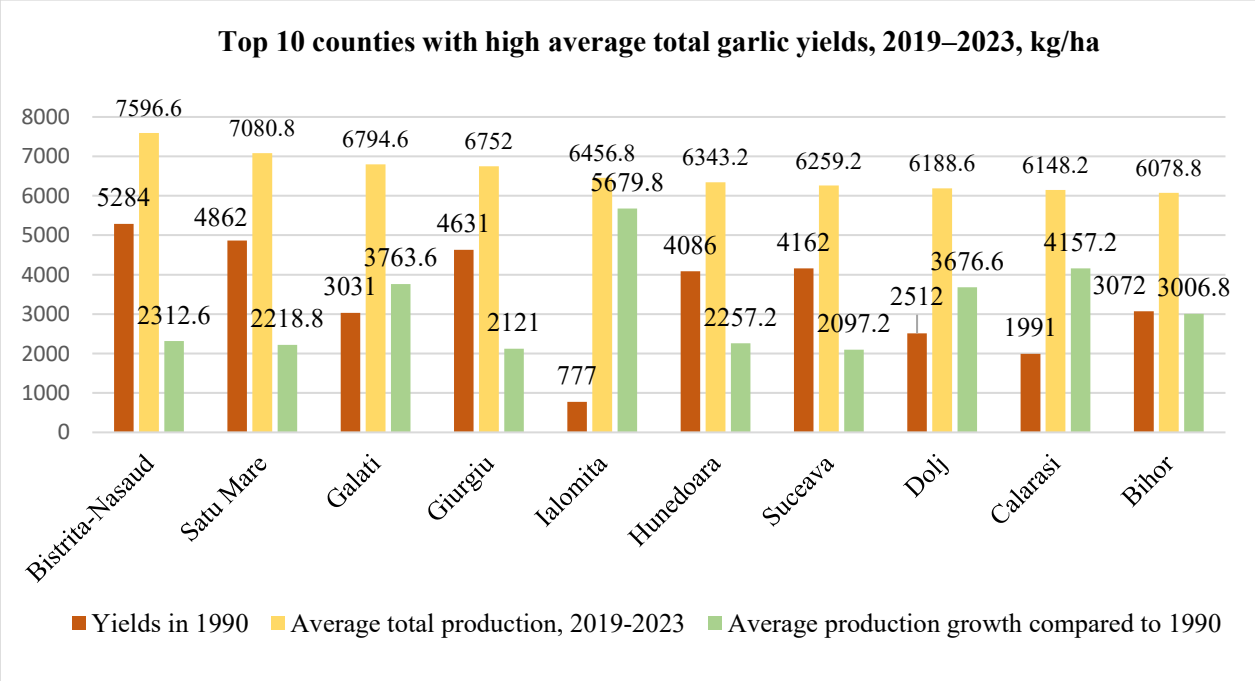

Figure 3. Top counties with average total yields exceeding 6,000 kg/ha, 2019–2023

Source: own processing based on INS

This ranking is followed by counties with average garlic yields below 6,800 kg/ha, such as Giurgiu, Ialomita, Hunedoara, Suceava, Dolj, Calarasi, and Bihor, with average yields between 6,752 kg/ha and 6,078.8 kg/ha.

Compared to 1990, all counties recorded increases in garlic production, with the highest increase recorded in Ialomita County, from 777 kg/ha to over 5679 kg/ha, followed by Calarasi County with an increase of 4,157 kg/ha and Galati and Dolj Counties with increases of over 3,650 kg/ha. (Figure 3).

Ilfov County has had a special trajectory since 1990, with an average total production over the last five years of 6670.6 kg/ha, even though this crop was not cultivated in 1990.

The lowest average yields recorded at county level, below 5000 kg/ha, are observed in the counties of Vrancea 3591.6 kg/ha, Covasna 3608.2 kg/ha, Harghita 3985.4 kg/ha, Prahova 4733.4 kg/ha, and Caras Severin with an average yield of 4931 kg/ha, yields that nevertheless reflect an average increase of 1191.36 kg/ha compared to 1990, when the average yield in these counties was 2978.6 kg/ha, an increase of 71.73%. (Figure 4).

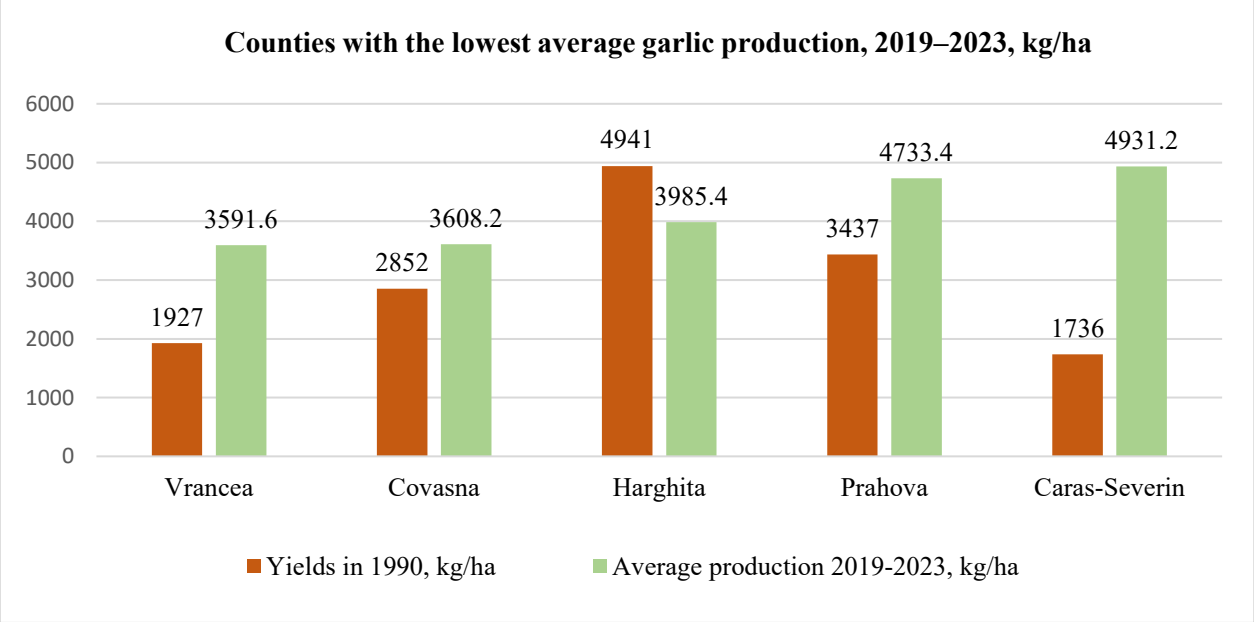

Figure 4. Counties with the lowest average garlic production, 2019–2023, kg/ha
Source: own processing based on INS

CONCLUSIONS

Average production of dry garlic increased by 56.7% between 2019 and 2023 compared to the reference year 1990, considered an atypical year in which agriculture made the transition from post-communist agriculture to agriculture characterized by massive land fragmentation.

Globally, China is the largest garlic producer in the world, followed by India and Spain in third place, but Spain has had production problems in recent years due to climate change and its effects.

Romania ranks second in Europe in dry garlic production with an average yield of 5,288 kg/ha recorded in 2023.

On average, the highest yields per hectare at county level are obtained in the South Muntenia and Bucharest-Ilfov areas (Macro-region III), 726.7 kg/ha, and in the West and South-West Oltenia regions (Macro-region IV), where the average yield is 645.4 kg/ha.

Compared to 1990, at the macro-region level, percentage increases are recorded in all areas of Romania, from 110.1% in Macro-region III, 89.3% in Macro-region IV, to 84.6% in Macro-region II and up to 38.7% in Macro-region I.

The lowest average yields recorded at county level, below 5000 kg/ha, are observed in the counties of Vrancea 3,591.6 kg/ha, Covasna 3608.2 kg/ha, Harghita 3,985.4 kg/ha, Prahova 4,733.4 kg/ha and Caras Severin.

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POLICY AND ECONOMIC FRAMEWORK FOR THE SUSTAINABLE DEVELOPMENT OF THE SHEEP AND GOATS SECTOR IN THE REPUBLIC OF MOLDOVA

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Abstract: *The sheep and goat sectors are an important component of the agricultural and food systems in the Republic of Moldova. It has a wide potential to contribute to the rural development and to ensure food security. However, the growth of sheep and goat sector is constrained by important structural challenges, like insufficient technological modernization, limited diversification of products, constrained market access, as well as vulnerability to climate change. The paper analyses the current policy and economic framework that governs the sector and emphasizes the existing achievements and shortcomings. Based on the analysis of statistical indicators, policy documents and public support programs in the field, the paper identifies the main areas that are needed to be aligned with EU standards and international best practices that must be implemented. The research acknowledges the importance of targeted subsidies for the sheep and goat sector that may lead to a better value chain integration, improved veterinary services, as well as the promotion of high-value traditional sheep and goat products or organic ones. The findings reflect that a coherent policy framework coupled with economic incentives in the shape of public support could contribute to increase of competitiveness, sustainability and resilience in the sector. The article concludes with recommendations for improving policy coherence and strengthen the institutional mechanisms to ensure the sustainable development of sheep and goat farming in the Republic of Moldova.*

Keywords: *agricultural policy, sheep sector, goats farming, sustainable development, Republic of Moldova*

JEL classification: Q01, Q18, O13

INTRODUCTION

The sheep and goat sector represent an important part of the food system in the Republic of Moldova. It is largely contributing to the development of rural areas and has a positive impact in ensuring food security (Baltag & Baranov, 2022), mainly due to the milk and cheese products. However, the progressive growth of this sector is being constrained by some important structural challenges (Stratan et al, 2022), such as insufficient technological and equipment modernization, limited diversification of products, the constrained access to markets, and more recently, the vulnerability to climate change. Due to its increasing adaptability, the sheep and goat sector has a potential for its development in a sustainable manner, especially if the traditional high added value products will be valorized. Potential directions in this regard may be organic farming, development of GI, PDO and TSG products, etc.

The paper aims to analyze the economic dynamics of the sector, as well as the policy framework, identifying successes and existing deficiencies. At the same time, in the context of the Eu integration path, there is noted the necessity to align the national priorities in the sheep and goat sector to the Eu standards. These priorities must concern primary the safety issues related to the quality of production.

MATERIALS AND METHODS

The carried-out research is built on the analysis of the statistical data from the National Bureau of statistics of the Republic of Moldova. The data on internal production and number of heads covers the period 2015 – 2025, while the foreign trade data covers the period 2015 – 2024 and was obtained from the UNComtrade Database. The policy documents are represented by annual reports from the Agency of Intervention and Payments in Agriculture. Analytical and statistical methods were used to analyzed the evolution of the number of heads and production indicators.

For the assessment of the international competitiveness, the Revealed Comparative Advantage indicator was calculated, according to the standard formula:

$$RCA = \frac{\frac{X_{ij}}{X_{it}}}{\frac{X_{nj}}{X_{nt}}} = \frac{\frac{X_{ij}}{X_{nj}}}{\frac{X_{it}}{X_{nt}}}$$

where, X is represented by export, i – a country, j – a product, t – a set of products, n – a set of countries (Balassa, 1965).

The data were processed in a synthetic manner, with an accent on trends, regional structures and public support measures.

RESULTS AND DISSCUSION

During the period 2015 – 2025, the number of sheep in the Republic of Moldova in all types of farms decreased significantly from 729.8 thousand heads to 423.6 thousand heads. This decrease is mainly due to the decrease in the number of sheep in households from 707.1 thousand heads to 392.7 thousand heads. The share of the number of sheep in households decreased slightly during the analyzed period from 96.9% to 92.7%. The main causes that lead to this diminish are connected to the lack of the labor force, migration phenomenon, especially of youth from rural areas to urban ones, or even abroad, together with the low profitability of keeping the pastoral traditions due to increases in input prices. This phenomenon is being aggravated also by the excessive fragmentation of households, hindering the investments in modernization of the sheep sector.

Within agricultural enterprises and peasant farms, the period between 2016 and 2022 was marked by a downward trend, being followed in the last 3 years by an increase in the number of heads, reaching 30.9 thousand heads in 2025. This slow, but progressive increase may be caused by the effects of the public policies in this field, namely the introduction of direct payments per head of animal. Thus, the registered number of sheep has increased, aiming at creation of larger exploitations by farmers, with a higher number of livestock and productivity. However, the share is still on the low side, mainly due to the existing obstacles in the field related to high input costs and limited access to credit lines.

During the same period, the goat population, overall, decreased from 144.9 thousand heads to 138.1 thousand heads. It is more fluctuating than the one of sheep, with periods of growth recorded in the years 2015 - 2018, the peak being reached in 2018, with 162.2 thousand heads. If in 2015 almost 100% of the goat population was concentrated in households (99.2%), then in 2025 this indicator reached 93.6%. In households, the number of goats decreased from 143.7 thousand heads to 129.3 thousand heads, while in agricultural enterprises and peasant farms, in 2025 their number reaches 8.8 thousand heads (from 1.2 thousand heads in 2015).

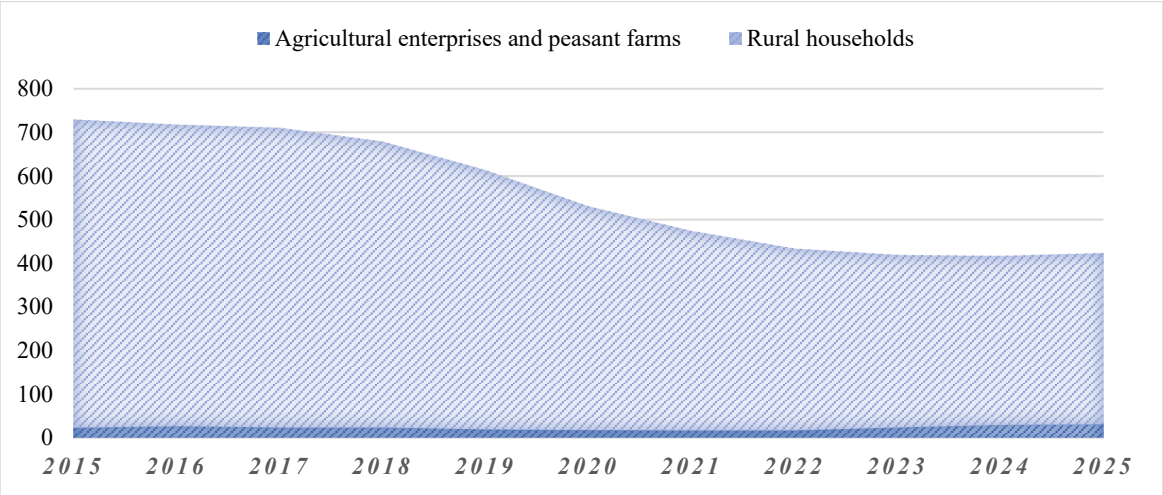

Figure 1. Sheep population in all types of farms, thousand heads, 2015 - 2025
Source: National Bureau of Statistics, 2025

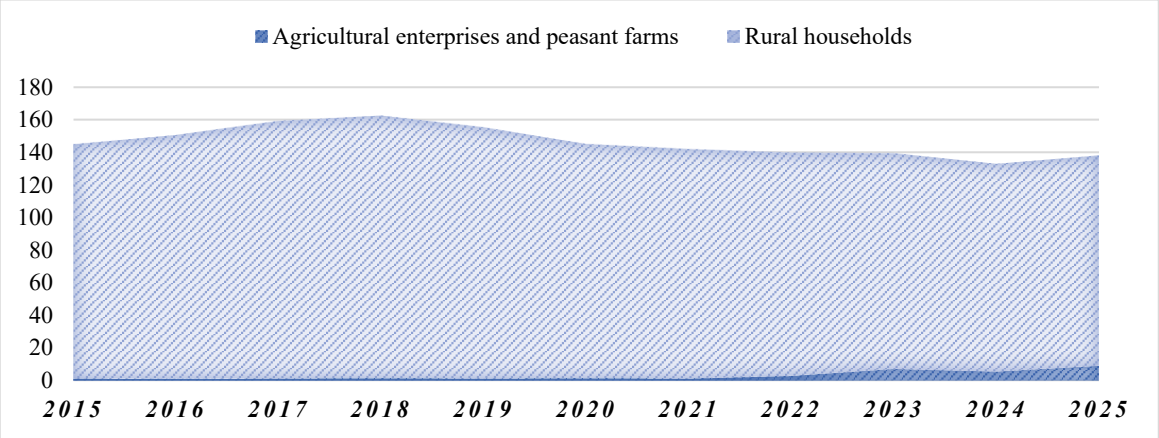

Figure 2. Goat population in all types of farms, thousand heads, 2015 - 2025
Source: National Bureau of Statistics, 2025

By country regions, across all types of farms, the number of sheep and goats is higher in the South (decreasing from 317.2 thousand heads in 2015 to 197.7 thousand heads in 2025), followed by the North (decreasing from 210.2 thousand heads to 141.1 thousand heads) and the Center (from 220.6 thousand heads to 143.8 thousand heads). In the Gagauzia ATU, the number of sheep and goats is decreasing from 126.8 thousand heads to 76.4 thousand heads.

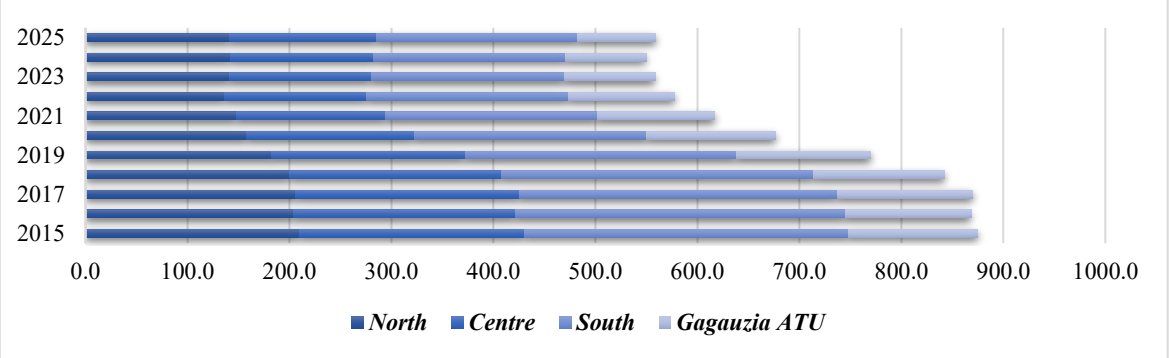

Figure 3. Sheep and goat numbers in all types of farms by country region, thousand heads, 2015 - 2025
Source: National Bureau of Statistics, 2025

Within all types of farms, the production of sheep and goats in live weight is decreasing from 4.4 thousand tons in 2015 to 2.4 thousand tons in 2024. Its share in the total number of animals for slaughter in live weight varies between 2.6% in 2019 and 1.2% in 2022. In 2024 this indicator accounted for 1.4%. The lack of specialized abattoirs and processing infrastructure at the local and regional levels, determine the selling abroad (export) of sheep in live weight rather that the production of sheep and goat meat or by-products. The climate changes also play a significant role, as due to frequent droughts, especially in the Southern part of the country, the forage production is highly affected, together with the animals' productivity.

Within agricultural enterprises and peasant farms, the maximum production was reached in 2021 – 2.3 thousand tons, followed by a decrease to 0.3 thousand tons in 2024. Its share in the total number of animals for slaughter within agricultural enterprises and peasant farms reached only 0.3% in 2024. Within rural households, production decreases from 4 thousand tons in 2015 to 2.1 thousand tons in 2024. Its share in the total number of animals for slaughter within households reached 3.3% in 2024.

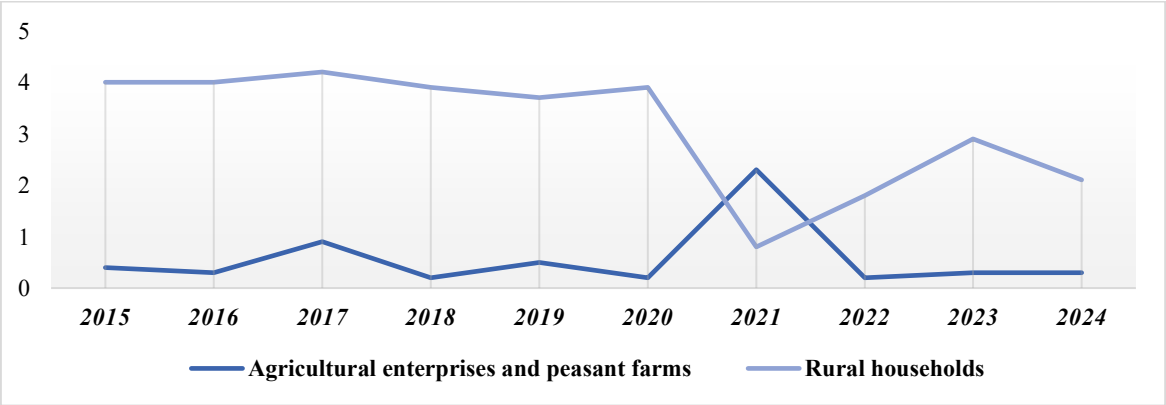

Figure 4. Sale of sheep and goats for slaughter (in live weight) in households of all categories, thousand tons, 2015 - 2024

Source: National Bureau of Statistics, 2025

Foreign trade in live sheep is a one with a positive trade balance in the period 2015 – 2024. Exports increased by about 4 times, and imports – by about 7.5 times. However, the nature of live sheep exports is not constant, with interruptions in some of the analyzed years.

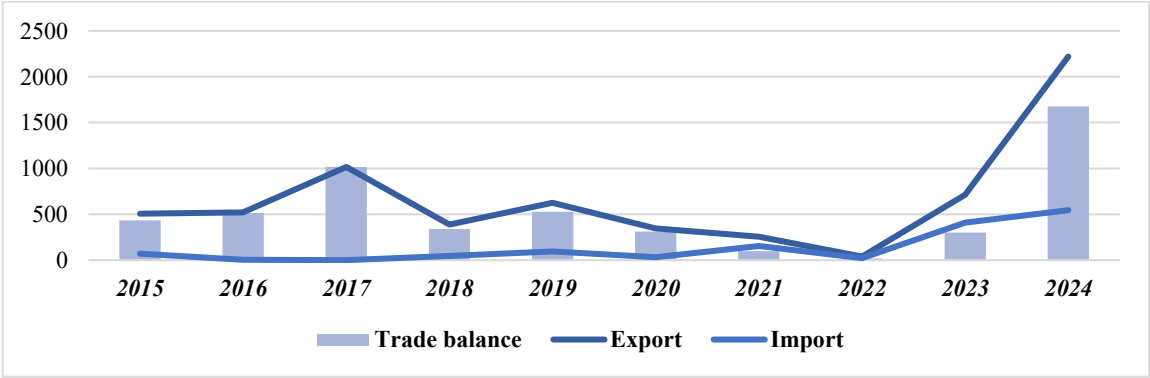

Figure 5. Foreign trade in live sheep, thousand USD, 2015 - 2024

Source: Author's calculation based on UNComtrade, 2025

As for the added value production, the trade balance in fresh, chilled or frozen meat of sheep or goats in the period 2015 – 2024 is positive. Exports increase from 1304.1 thousand USD to 2318.9 thousand USD (with a maximum value of 5330.2 thousand USD in 2018), and imports from 47.8 thousand USD to 112.3 thousand USD.

The export fluctuations are resulted from the geopolitical instability of the destination countries, as well as the issues arising from the lack of sanitary and veterinary certifications for other types of markets, more demanding ones, like the EU market, for example.

During the period 2015 – 2024, on average, the Republic of Moldova exported live sheep to Lebanon, Jordan, Libya, Saudi Arabia, Syrian Arab Republic and less to other countries. Imports of live sheep in the same period were mainly from Spain, Bulgaria, Austria, Germany, Ukraine, and other countries.

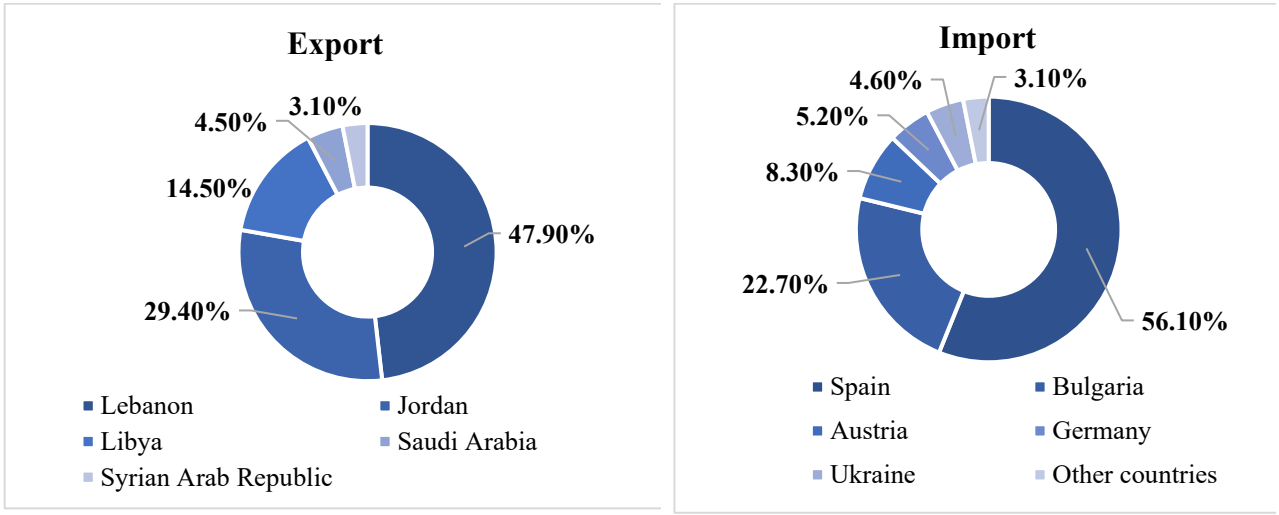

Figure 6. Main economic partners for foreign trade in live sheep, average values, 2015 – 2024, %

Source: Author's calculation based on UNComtrade, 2025

Unlike the sheep sector, foreign trade in live goats is fluctuating and insignificant. The maximum export value reached 32.2 thousand USD in 2016, and the import value – 22.6 thousand USD in 2024. During the period 2019 – 2023, no live goats were exported, as the local market represents the main destination of live goats. At the same time, the Republic of Moldova is lacking in specialized breeds for exports, compared to the sheep sector, where there is a relatively constant demand.

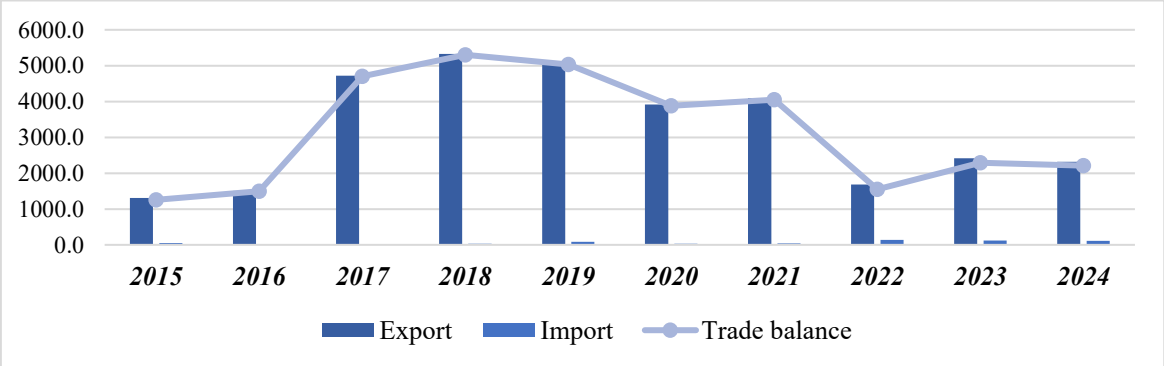

Figure 7. Foreign trade in meat of sheep or goats, fresh, chilled or frozen, thousand USD, 2015 - 2024

Source: Author's calculation based on UNComtrade, 2025

During the period 2015 - 2024, on average, the Republic of Moldova exported meat of sheep or goats to the Russian Federation, Bahrain, Iraq, Qatar, Egypt, Oman, Jordan, Kuwait and other countries.

Imports of meat of sheep or goats in the same period were mainly from Unspecified countries, New Zealand, Germany, Ireland, Romania and other countries.

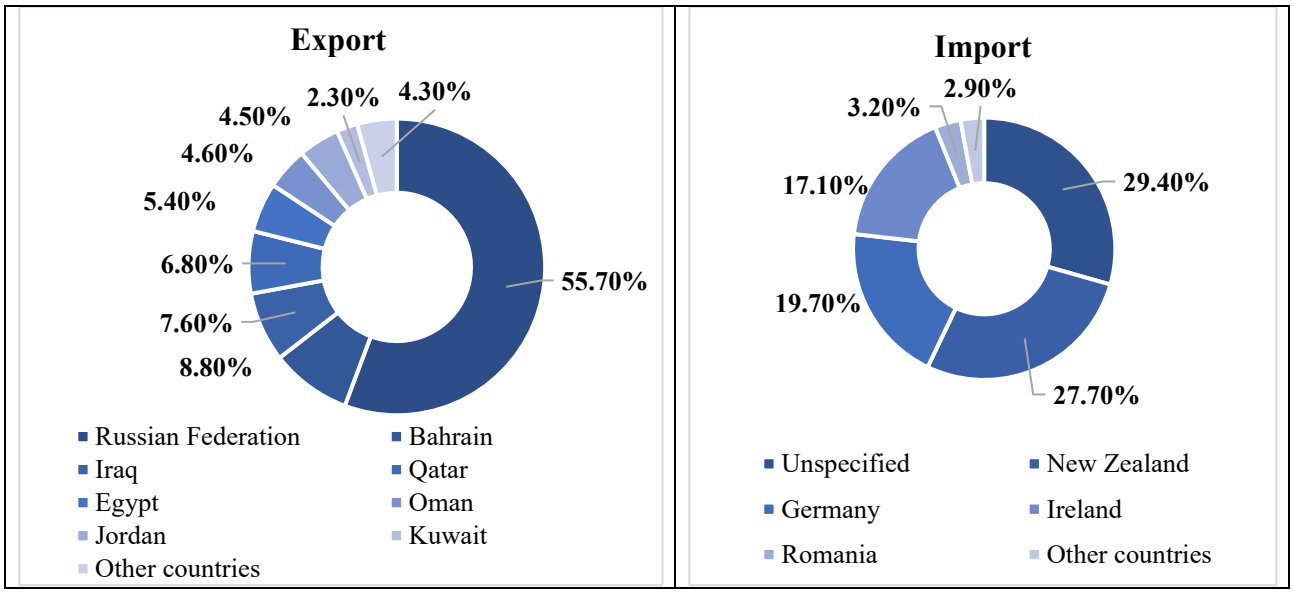

Figure 8. Main economic partners for foreign trade in meat of sheep or goats, fresh, chilled or frozen, average values, 2015 - 2024, %

Source: Author's calculation based on UNComtrade, 2025

In order to assess the competitiveness of the sheep and goat sector at the international level, the RCA indicator has been calculated, which revealed important values for live sheep (increasing from 2.1 in 2020 to 13.6 in 2024) and sheep and goat meat (decreasing from 23.3 in 2020 to 11.4 in 2024, but still situated at a quite high level. Taking into account the fluctuating character of exports of live goats, the 1.9 value of RCA in 2024 may indicate on some future positive developments, in case of a continuous support from public policies. The high RCA values derive from relatively low costs of growing sheep and goats, lower costs for labor force as well as the relatively stable demand for live sheep from the traditional markets, consumers of sheep meat (Lebanon, Jordan, Libya).

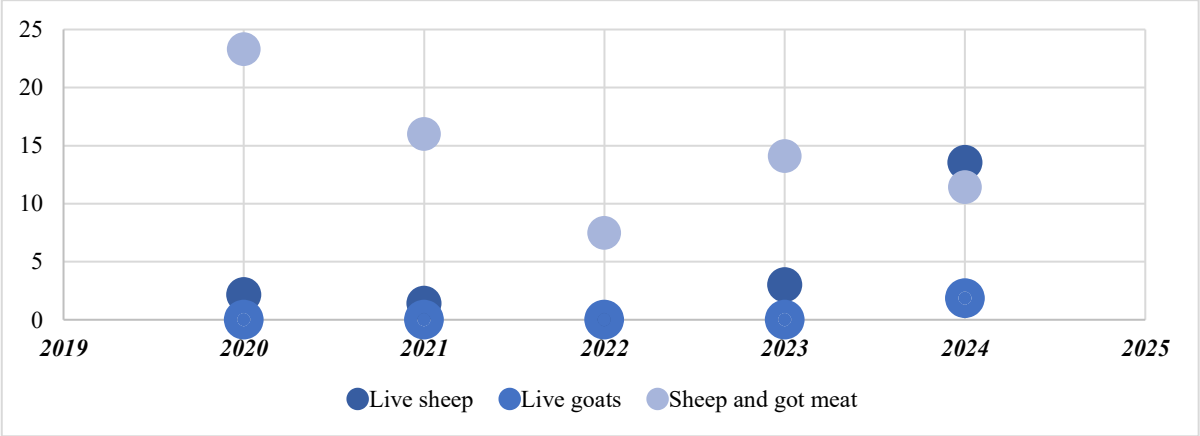

Figure 9. RCA indicator for live sheep and goats and sheep and goat meat and meat products, with respect to world, 2020 - 2024

Source: Author's calculation based on UNComtrade, 2025

Public support for the sheep and goat sector has the aim to boost the number of heads, increase the production and bring added value to the agricultural sector of the Republic of Moldova. It takes the shape of several measures in the framework of the aid for the livestock sector, namely:

Investments in livestock facilities, with the eligibility criteria comprising at least 30 sheep/goats.

Thus, for the construction or modernization of the livestock farm, subsidy is granted for equipment and technique in a proportion of 50% for sheep / goats' facilities, but no more that 5 mil. MDL per beneficiary. For purchase of genetic material, there are subsidized 50% for rams or goats aged 6-20 months, but not more than 200.0 thousand MDL per beneficiary and 50% for ewes or baby goats aged 6-20 months, but not more than 1.5 million MDL per beneficiary (Government of the Republic of Moldova, 2023b).

Investment for production, processing or marketing infrastructure of livestock products.

This measure takes the shape of construction or modernization of milk, meat storage units and products obtained from them; construction or modernization of primary/final processing units, slaughterhouse, cutting section, packaging, refrigeration, freezing or storage of meat, milk, etc.; modernization of the processes for performing test analyses for meat and meat products, milk and milk products, etc.; equipping primary/final processing or marketing units with specialized machinery, installations, equipment or means of transport for the purpose of collecting raw materials, processing and/or marketing products of animal origin - component part of the project.

Direct payments per head of livestock, granted for animals registered in livestock farms, with at least 3-month-old, in a minimum amount of 30 sheep or 30 goats (Government of the Republic of Moldova, 2023a).

Thus, in 2024, under this measure, 44415 heads of sheep were subsidized, of which: 22575 22575 heifers over 3 months, 1686 sheep of specialized breeds for meat production, 20154 sheep of specialized breeds for milk production and mixed breeds. The value of the paid subsidy - 23.5 million MDL. At the same time, 11810 goats were subsidized, of which 5925 she-goats over 3 months, 5885 goats. The value of the paid subsidy - 6.4 million MDL (AIPA, 2024).

CONCLUSIONS

The sheep and goat sector of the country faces a decline in livestock and production, even if there is a positive RCA in live animal and exports of meat. The structural challenges tend to limit the sectors' development potential. The existing public support, in the shape of targeted subsidies for investments, genetic material and direct payments per head of livestock is a positive step, but remains insufficient for better integration of the value chain and alignment with EU standards.

Therefore, the following recommendations are provided for the sustainable development of the sector:

Initiation of a development program dedicated to the sheep and goat sector, that should be aligned with EU standards and priorities in the field and that will contain clear and viable medium-term and long-term objectives on the modernization of farms and integration in value chains.

Promotion of traditional products like cheese, processed meat and certified products. It could be done via marketing campaigns, applications for GIs, PDOs and TSGs., an enhancement of organic production.

Improvement of veterinary services through investments in laboratories and vaccination campaigns. At the same time, there is needed an improvement of knowledge for farm managers in order to reduce the sanitary risks and facilitate the access on more demanding foreign markets.

Climate change adaptation measures combined with subsidized agricultural insurance schemes may increase the resilience of the sheep and got sector.

ACKNOWLEDGMENTS

The article was developed within the framework of Subprogram 030101 „Strengthening the resilience, competitiveness, and sustainability of the economy of the Republic of Moldova in the context of the accession process to the European Union", institutional funding.

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CONSUMER AND FOREIGN TRADE TRENDS FOR SOYBEAN CULTIVATION AT THE EUROPEAN LEVEL

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Abstract: *The aim of this paper is to analyze consumption trends, as well as the value of imports and exports, and the trade balance for soybean crops at the European level for the period 2018-2023. Soy represents the most important protein crop worldwide, being valued for its high protein content. The working method used in this paper was the comparative method, the method of quantitative and qualitative data analysis used in the specialized literature. The results indicate that in the context of increasing demand for sustainable sources of plant-based proteins and challenges related to food safety, this crop gains essential importance, both for Romania and for the European Union*.

Keywords: *consumption, import, export*

JEL Classification: J43; Q13

INTRODUCTION

Soy is an important source of food, protein, and oil, and therefore, more research is essential to increase its yield under different conditions, including stress. The most important countries in the world with the highest soybean production include the USA, Brazil, Argentina, China, and India. (Pagano, M. C., & Miransari, M. (2016).

Additionally, the nitrogen-fixing symbiotic properties of legumes (soy) mean that they are suitable for cultivation on a wide variety of soils in a changing climate. Despite this, small farmers still face the following challenges: lack of credit funds, seed recycling, as tested seeds are far too expensive, which hinders their levels of soybean production adoption. Argentina, China, and India (Siamabele, B. (2021).

In the last decade, Europe, and particularly the European Union, has faced a significant deficit of soy protein, especially those from non-genetically modified sources. The area cultivated with soy in the EU represents only 0.4% of the global total. In this context, imports are essential, covering 95% of the annual European consumption of approximately 38 million tons of cereal-equivalent soy. (Dima et al., 2015).

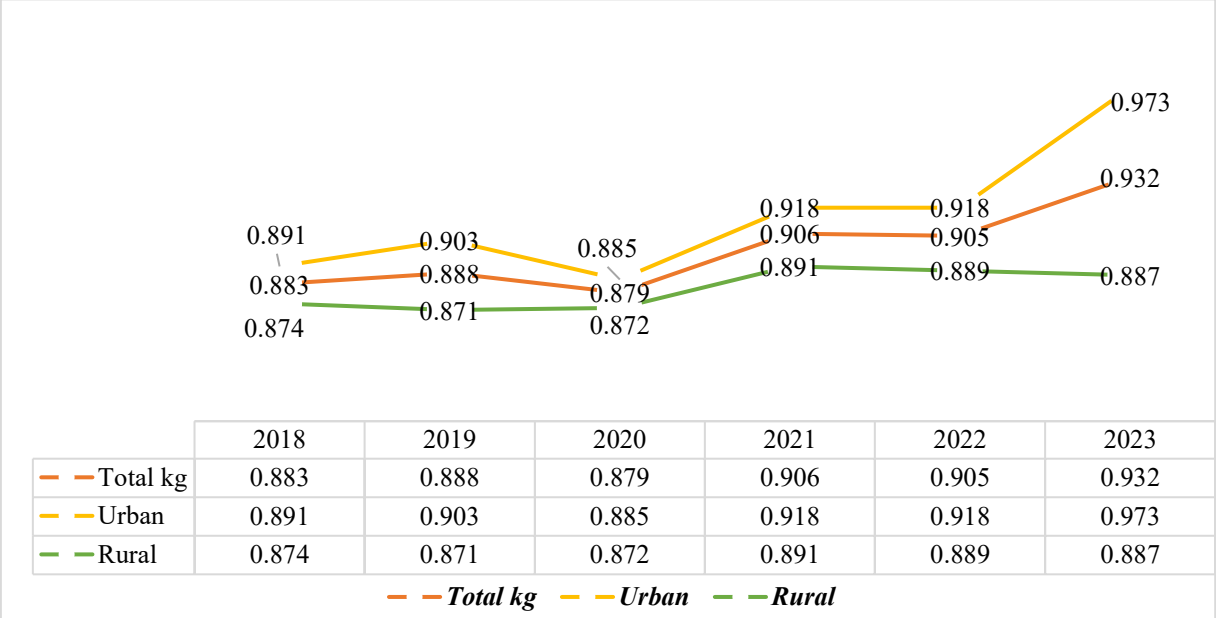
MATERIALS AND METHODS

The data used for the calculations in this paper come from the National Institute of Statistics (insse.ro) and the International Trade Centre (Trade Map). In order to achieve the main objective of this paper, consumption trends, import and export values, as well as the trade balance for the soybean crop at the European level, were analyzed for the period 2018-2023. Research methods used: Analysis using statistical-mathematical methods of the market (arithmetic mean, standard deviation, annual growth rate, coefficient of variation).

RESULTS AND DISCUSSION

Following the analysis, based on the data used, the consumption trend as well as foreign trade for soybean crops at the European level were evaluated.

Regarding consumption by place of residence for soybean crops, an increasing trend is observed for values both overall and for urban and rural areas during the period 2018-2023, with a slight decrease in 2020, followed by a resumption of growth. Values for urban areas are consistently higher than those for rural areas.



	2018	2019	2020	2021	2022	2023
Total kg	0.883	0.888	0.879	0.906	0.905	0.932
Urban	0.891	0.903	0.885	0.918	0.918	0.973
Rural	0.874	0.871	0.872	0.891	0.889	0.887

Figure 1. Consumption by residential areas for soybean cultivation (kg)

Source: insse.ro, own calculations

The difference became more pronounced in 2023, when the urban environment reached 0.973, while the rural environment remained at 0.887, indicating slower growth in rural areas. All categories experienced a decline in 2020. After 2020, the urban environment grew more rapidly, reaching in 2023 the highest value in the entire analyzed period.

Table 1. Statistical indicators calculated for soybean consumption during the period 2018-2023

Specification	2023/2018 %	Average	Standard deviation	Coefficient of variation	Annual growth rate
Total kg	6%	0.90	0.02	2.20	-98.99
Urban	9%	0.91	0.03	3.46	-98.98
Rural	1%	0.88	0.01	1.05	-99.00

Source: insse.ro, own calculations

Looking at soy consumption, comparing the year 2023 with 2018, a total increase of 6% can be observed. The increase is much higher in urban areas at 9% compared to rural areas at 1%. It is notable that the coefficient of variation is significantly higher in urban areas than in rural ones, indicating greater fluctuations in urban areas. The annual growth rate is negative, which indicates a general downward trend.

Table 2. Export value dynamics in the period 2018-2023 thousand (euros)

Importing countries	2018	2019	2020	2021	2022	2023	2023/2018
Total	49976	97535	65788	88079	119972	76533	53%
Italy	8634	9987	6607	9858	34266	23977	178%
Hungary	10319	6678	5248	8344	12062	9815	-5%
Germany	8627	19595	15064	9848	23572	7939	-8%
Netherlands	0	0	4772	1585	392	6749	
Austria	3127	7176	7880	8069	10089	5116	64%

Source: trademap, own calculations

Regarding the total value of imports, it almost doubled between 2018 and 2023 with a 53% increase, but experienced significant fluctuations, reaching a peak in 2022 (€119,972 thousand) and decreasing in 2023 (€76,533 thousand). Imports from Italy increased from €8,634 thousand in 2018 to 34,266 thousand tons in 2022, then fell in 2023 to €23,977 thousand, representing a 178% increase. In Hungary, there were moderate fluctuations with a slight downward trend, followed by Germany, where the most significant decreases were recorded, with a very notable -8%.

Table 3. Dynamics of export quantity in the period 2018-2023 (tons)

Importing countries	2018	2019	2020	2021	2022	2023	2023/2018
Total	139210	0	168639	166182	174286	132776	-5%
Italy	26058	29037	17171	21757	49388	43835	68%
Ungaria	29656	20213	14934	16549	18571	16526	-44%
Germania	20024	0	33132	18511	33644	10271	-49%
Austria	6957	18492	18410	13521	13274	7571	9%
Turkey	7597	85924	19482	4956	21023	6756	-11%

Source: trademap, own calculations

Regarding the dynamics of export quantities during the analyzed period, we can conclude that total exports recorded a slight decrease in 2023 compared to 2018; however, the trend was different for each country. Italy is the only country with a substantial increase, while Germany and Hungary experienced the largest declines.

Table 4. Dynamics of the unit export value in the period 2018-2023 (euro/ton)

Importing countries	2018	2019	2020	2021	2022	2023	2023/2018
Total	359		390	530	688	576	60%
Italy	331	344	385	453	694	547	65%
Hungary	348	330	351	504	649	594	71%
Germany	431	N/A	455	532	701	773	79%
Netherlands			321	424	597	615	-
Austria	449	388	428	597	760	676	51%

Source: trademap, own calculations

In 2018, the average export value was 359 euros/ton, while in 2023 it reached 576 euros/ton, representing a 60% increase. Until 2022, a steady growth can be observed, followed by a slight decrease in 2023. The unit value of exports increased in all the countries analyzed, with percentages ranging from 51% for Austria to 79% for Germany.

Table 5. Dynamics of import value in the period 2018-2023 (thousand euros)

Exporting countries	2018	2019	2020	2021	2022	2023	2023/2018
Total	93369	31627	92055	88487	183751	87726	**-6%**
Ukraina	18	630	11036	2005	70956	67214	**373311%**
Olanda	7	6	218	2347	6561	4725	**67400%**
Ungaria	3116	2240	1593	1695	2568	4310	**38%**
Italy	5487	2933	2832	1470	2817	3939	**-28%**
Republic of Moldova	3371	3877	3760	2472	1005	1989	**-41%**

Source: trademap, own calculations

The analyzed table reflects the dynamics of import values during the period 2018-2023, highlighting fluctuations in imports from various countries. In 2018, the total value of imports was 93,369 thousand euros, while in 2023 it decreased to 87,726 thousand euros, representing a percentage decrease of -6%.

Table 6. Import quantity dynamics in the period 2018-2023 (tons)

Exporting countries	2018	2019	2020	2021	2022	2023	2023/2018
Total	261323	80614	251774	177171	0	174678	-33%
Ukraine	44	1075	27766	4501	149815	149806	340368%
Hungary	6999	6249	3442	3719	4151	8857	27%
Netherlands	4	4	486	2681	5905	4815	120275%
Republic of Moldova	10282	13676	11940	5043	2200	4216	-59%
Italy	3471	2022	2208	1306	2138	2154	-38%

Source: trademap, own calculations

Regarding the dynamics of import quantity, in 2018 total imports were 261,323 tons and in 2023 they decreased to 174,678 tons, representing a percentage decrease of -33%. The largest decrease was in 2019, when the volume reached only 80,614 tons, 2023 records increased imports compared to 2021, but remain 33% lower than in 2018.

Table 7. Dynamics of the unit value of imports in the period 2018-2023 (euro/ton)

Exporting countries	2018	2019	2020	2021	2022	2023	2023/2018
Total	357	392	366	499	0	502	41%
Ukraine	404	586	397	445	474	449	11%
Netherlands	1694	1563	449	876	1111	981	-42%
Hungary	445	359	463	456	619	487	9%
Italy	1581	1451	1282	1126	1318	1829	16%
Republic of Moldova	328	283	315	490	457	472	44%

Source: trademap, own calculations

Regarding the overall evolution of the unit value of imports, we can state that 2018 recorded an average total import value of 357 euros/ton. Both Italy and the Netherlands remain the exporters with the highest values recorded in the analyzed period, but the Netherlands recorded a considerable decrease, while Italy has increased significantly in recent years.

Table 8. Trade balance situation in the period 2018-2023 (thousands of euros)

Trade balance	2018	2019	2020	2021	2022	2023	2023/2018
Total	-43394	65908	-26268	-408	-63779	-11193	-74%
Italy	3147	7053	3775	8388	31448	20038	537%
Ungaria	7203	4438	3655	6649	9494	5505	-24%
Germania	8512	19493	14914	9786	23368	7783	-9%
Netherlands	-7	-6	4554	-762	-6169	2024	-29014%
Austria	2338	6469	7052	7231	8685	3869	65%

Source: trademap, own calculations

The total value of the trade balance fluctuates during the analysis period. Although in 2019 the total value of the trade balance recorded a maximum value of 65,908 thousand euros, the remaining years of the analyzed period were deficits. In 2023, the deficit reached a value of -11,193 thousand euros, representing a decrease of 74% compared to the level in 2018.

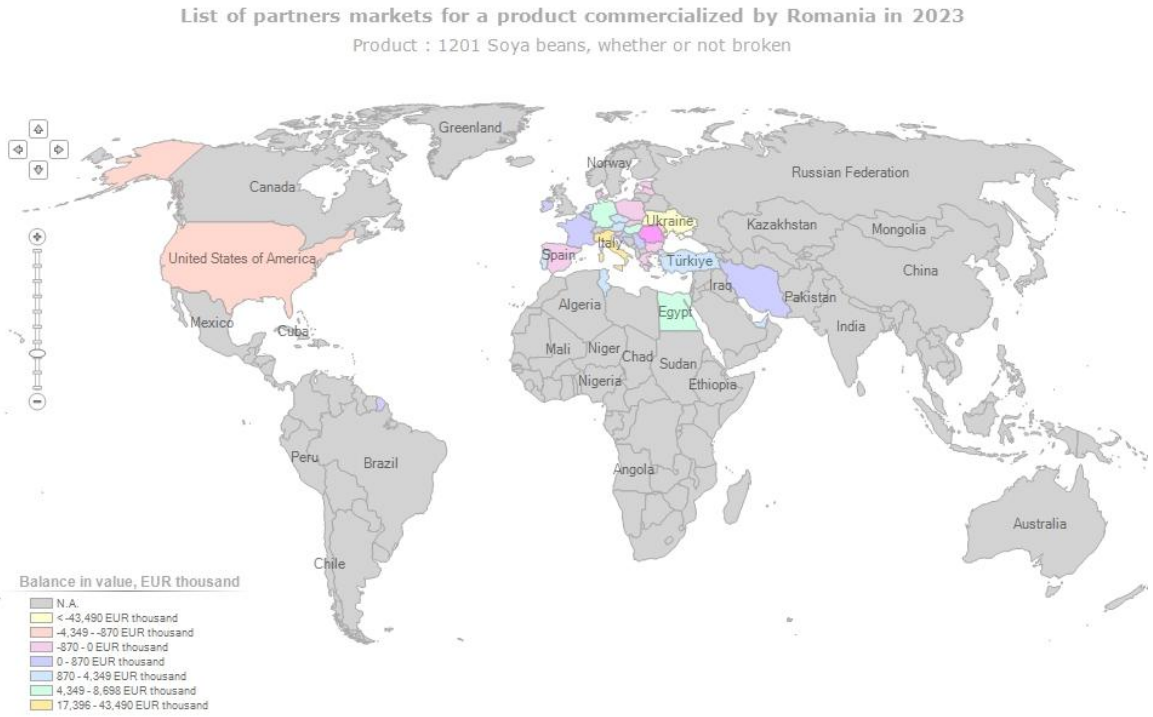


Figure 2. Interactive map - Trade balance situation for soybeans in 2023 at the level of Romania

Source: trademap

The interactive map of the trade balance for soybeans in Romania shows that Italy records the highest value of the trade balance, namely 20,144 thousand euros, and at the opposite pole is Ukraine, which in 2023 recorded a trade balance deficit, being -67,369 thousand euros.

CONCLUSIONS

During the 2018-2023 analysis period, soybean cultivation recorded a moderate growth trend at the European level, driven by European Union initiatives to reduce dependence on imports and promote sustainable agriculture.

Soybean imports played an essential role in covering domestic demand, their value constantly increasing, which shows the dependence of the Romanian market on external sources of supply.

Soybean exports remained limited and had a much lower share compared to imports, which underlines the fact that Romania is failing to sufficiently capitalize on its own production at the international level.

The trade balance for soybeans was negative throughout the analyzed period, with imports significantly exceeding exports and increasing the vulnerability of the domestic market to external price and supply fluctuations.

Trend analysis shows that there is potential for increasing domestic soybean production, especially in the context of European agricultural policies supporting protein crops and the need to reduce dependence on imports.

The productivity differences between Romania and other European countries highlight the need for constant investments in research, advanced technologies, and training programs for farmers.

Currently, soy is an ingredient in most vegetable products, sausages, sauces, sweets - such as soy lecithin, cosmetics, milk substitutes such as tofu and soy milk.

By adopting sustainable and well-targeted measures, Romania and the European Union can transform these crops into a pillar of modern agriculture, reducing dependence on imports, supporting the transition to a more sustainable food system and strengthening the economic competitiveness of the agricultural sector.

In conclusion, soybeans can become a central pillar in ensuring food security and promoting sustainable agriculture in the long term.

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DIGITALIZATION OF AUDIT PROCESSES IN PUBLIC INSTITUTIONS WITH AN AGRICULTURAL PROFILE – A PROPOSAL FOR AN INNOVATIVE PLATFORM

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Abstract: *The paper analyzes the challenges and opportunities of digitizing internal audit processes in public institutions and agricultural entities, proposing a conceptual model of an integrated digital platform. The study is based on applied research, supplemented by an analysis of the specialized literature and the European regulatory framework on digital auditing. The proposed platform model aims to streamline the stages of planning, data collection, real-time monitoring, automatic report generation, and collaboration between audit and management teams. By integrating emerging technologies—such as data analysis, process automation, and artificial intelligence—the platform would ensure complete traceability, risk reduction, and increased transparency in public administration. The conclusions highlight the importance of investing in digital training and making the legislative framework more flexible to support the transition to digital auditing and strengthen innovation-based governance.*

Keywords: *digital audit, public institutions, agriculture, integrated platform, efficiency, transparency*

JEL classification: Q16, Q33, M42

INTRODUCTION

In the context of accelerated digital transformation, public administrations are under pressure to improve their efficiency, transparency, and responsiveness to citizens' needs. Traditional audit processes, based on physical documents, manual controls, and periodic visual reports, are becoming increasingly inadequate in the face of large volumes of data, institutional complexity, and increasingly stringent regulatory requirements (Baluta & Matei, 2025). Furthermore, Romania is experiencing varying rates of digital technology adoption in the public sector: although a significant percentage of employees identify potential in the use of tools such as artificial intelligence or process automation, public institutions have generally made limited investments or have difficulties integrating these technologies into existing infrastructure. Lack of specific skills, data security concerns, and incompatibilities with legacy systems are frequently cited as major barriers (Forvis Mazars Romania, 2025, Betti et al., 2025).

The emergence of European regulations such as the Digital Services Act (DSA) highlights the need for public institutions to adopt regular independent audits, clear mechanisms for monitoring systemic risks, and transparency in the management of data by very large online platforms (Delegated Regulation (EU) 2024/436; European Commission, 2024). In this context, the design and implementation of an integrated digital public audit platform provide an opportunity to address the challenges of efficiency, interoperability, traceability, and risk control. This paper proposes a conceptual model for such a platform, based on empirical analysis of existing needs, international standards, and best practices, with the aim of increasing the performance of public audit and strengthening public trust (Khawla et al. 2023; Pleșa et. al. 2023).

The empirical research results obtained in the doctoral thesis reveal a worrying reality: over 83% of the institutions analyzed do not use digital tools for audit activities, and approximately 28% of respondents consider the technological training level of staff to be only moderate.

This situation indicates not only a lack of resources and technological support, but also resistance to change and an acute need for professional training to adapt to digitized processes (Forvis Mazars Romania, 2025). At the same time, regulatory developments at European level, such as Regulation (EU) 2024/436 on the auditing of very large online platforms, underscore the importance of adopting modern monitoring and control tools to ensure traceability, integrity, and transparency in data management (European Commission, 2024; Tharouma et al. 2022; Usul and Alpay, 2025).

Based on these findings, the main objective of this paper is to propose a conceptual model for a digital audit platform tailored to public institutions, integrating modern data collection, analysis, and reporting functionalities. This approach aims not only to optimize audit processes, but also to create a technological framework that will increase operational efficiency, reduce risks, and enhance transparency in public administration.

MATERIAL AND METHOD

The paper is conceptual and applied in nature, based on an integrative approach that combines literature analysis, a synthesis of relevant regulations, and a conceptual modeling stage. The methodological objective is to design a theoretical model of a digital audit platform tailored to the specificities of public institutions, capable of ensuring efficiency, transparency, and interoperability in internal control processes. Consequently, the methodological approach follows several complementary directions, as follows.

The first stage consisted of a critical analysis of the literature on audit digitization, the use of emerging technologies (automation, artificial intelligence, blockchain), and digital governance models applied to the public sector (Baluta & Matei, 2025; Forvis Mazars Romania, 2025). The second stage involved summarizing the relevant European and international regulatory framework for digital auditing (e.g., Regulation (EU) 2024/436) in order to identify the traceability, accountability, and reporting requirements that a digital auditing platform must meet (European Commission, 2024).

In addition to these secondary sources, the model design was also based on primary data obtained through an unpublished survey conducted among representatives of public institutions (survey included in a separate chapter of the doctoral thesis). This survey aimed to identify practical barriers, functional requirements, and user expectations regarding digital audit tools; the resulting information was used only as a qualitative basis for defining the functional components of the platform, without being detailed in this article (unpublished survey conducted as part of the doctoral thesis, 2025). According to APA style recommendations, unpublished data or personal communications are cited in the text and are not included in the reference list.

The final stage of the method consisted of a conceptual design process: based on the convergence between the conclusions in the literature, regulatory requirements, and insights from the mentioned survey, the key components of the platform were identified and structured (planning, data collection and integration, real-time monitoring, advanced analysis, document management, and collaboration). The methodology thus aims to design a functional architecture and operational flows, rather than empirically testing a prototype—quantitative validation of the model remains a subject for further research, which will use the original survey data and pilot case studies.

Through this approach, the paper provides a solid theoretical and practical basis for the development of a digital audit platform in public institutions, based both on evidence from the literature and regulations, as well as on observations collected directly from practitioners (unpublished survey), while keeping the conceptual dimension of this article clearly separate from future empirical analyses.

RESULTS AND DISCUSSIONS

The implementation of a digital audit platform is essential for modernizing and streamlining audit and control processes within public institutions. This platform provides an integrated framework for managing all audit activities, simplifying data collection and analysis, and ensuring complete traceability of information. The proposed platform is designed to meet the needs of public institutions, considering compliance, security, and transparency requirements, and includes features that facilitate more rigorous control and improved communication between audit teams.

The digital audit platform will be a centralized solution that will integrate all stages of the audit process, from planning, document collection and management, to real-time monitoring of activities and report generation. It will allow auditors quick and easy access to all the information they need for verification and control, in an intuitive and easy-to-use interface.

By centralizing information and automating administrative tasks, the platform will significantly reduce the time required to conduct the audit, allowing auditors to focus on analyzing and interpreting data. Quick access to historical data and previous reports will also facilitate the identification of trends and potential risk areas.

The implementation of the digital audit platform will bring several significant benefits for public institutions, including:

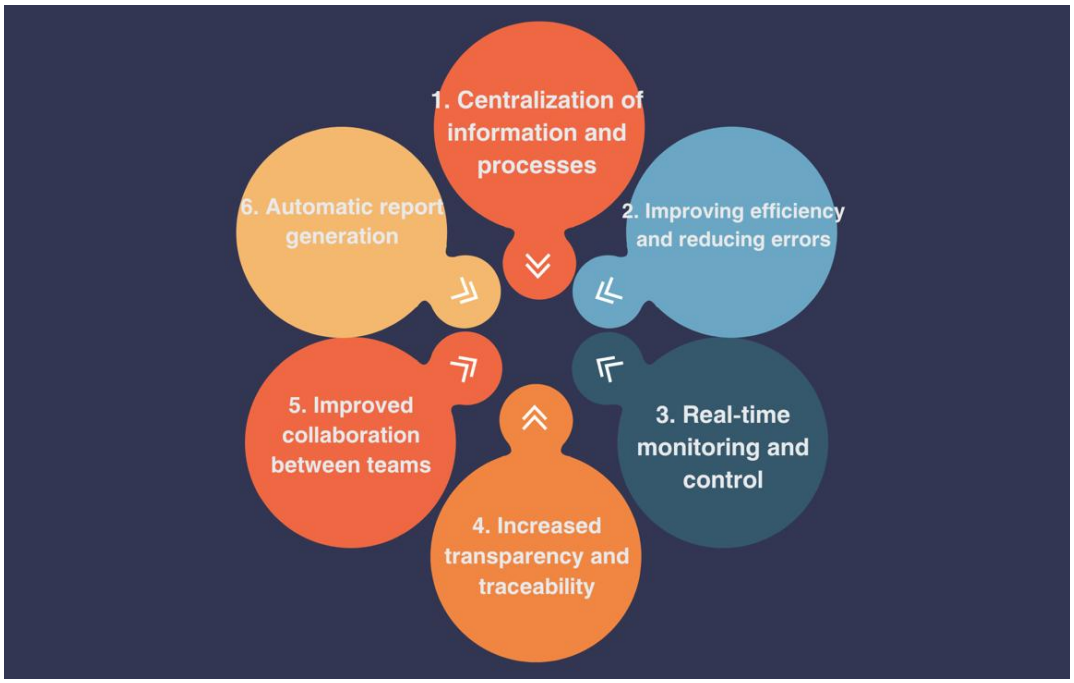

Figure 1. Main benefits of the audit platform
Source: own processing based on the expectations of those surveyed

The platform will enable the storage and access of all relevant documents and information in a single interface. This eliminates the need to search for information in various databases or physical files, thereby reducing the time and resources consumed in gathering information. Automating routine processes, such as preliminary checks or document processing, will reduce human error and increase data accuracy. This will allow auditors to perform more detailed analyses and make decisions based on complete and accurate information (Figure 1).

The platform will also provide a real-time monitoring system that will flag any irregularities or deviations from internal and legal rules. This will allow for rapid intervention and immediate

correction of identified problems, preventing the accumulation of risks or irregularities. Every action performed on the platform will be recorded in an activity log, providing complete traceability. This will give management and other stakeholders a clear picture of the status of the audit, enabling them to quickly identify who made changes and when they were made (Figure 1).

At the same time, the platform will include collaboration mechanisms, such as shared workspaces and communication tools, thus facilitating the exchange of information and approval of documents between audit and management teams, and audit reports will be able to be generated automatically based on the data entered the platform. Users will be able to select different types of reports (summary, detailed, graphical) and customize their content according to specific requirements (Figure 1).

1. Components of the digital audit platform

The proposed digital audit platform for public institutions is structured around several modules, each designed to improve a specific aspect of the audit and control process. The components of the platform are interconnected to provide a unified framework for data management, activity monitoring, and collaboration between stakeholders. By integrating these modules, the digital platform becomes a complex but easy-to-use tool that supports the conduct of audits in a transparent and efficient manner.

Main Dashboard

The main dashboard is the central element of the platform, providing users with an overview of the status of audit processes and key performance indicators. It includes the following features (Figure 2):

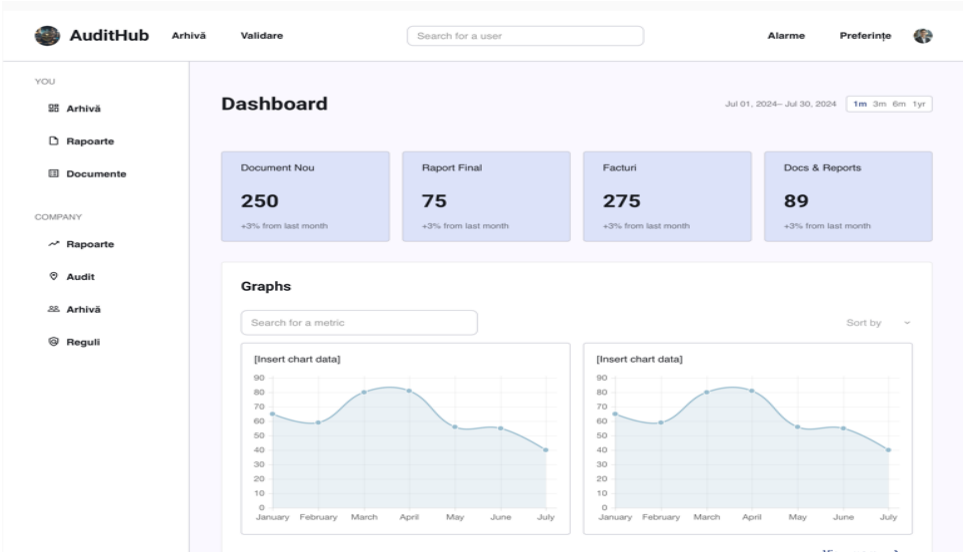

Figure 2. Example of the proposed audit application interface - dashboard

Source: own processing in bubble.com

- Key Performance Indicators (KPIs): The dashboard visually displays essential information such as the number of completed audits, ongoing audits, identified deviations, and resolved issues. The indicators are automatically updated based on the progress of the audit and can be customized according to each user's needs.
- Activity and Task Table: A centralized list of all current tasks, classified by priority level and completion deadline. This table helps auditors and managers track the progress of activities and quickly identify any delays or issues.

- Audit status overview: Interactive graphs and charts showing audit progress, identified risks, and areas requiring increased attention. Users can view this information at various levels (departments, operating units, etc.) to get a complete picture of the situation.

Real-Time Monitoring

- The real-time monitoring module enables instant collection and analysis of data from public institution systems. This facilitates the detection and reporting of problems as they arise, reducing the time needed to take corrective action (Figure 3.).
- Real-time data feeds: The platform connects to various internal and external data sources, providing a continuous stream of information relevant to the audit. This allows auditors to monitor expenses, budget allocations, resource utilization, and other operational activities.
- Automatic alerts: The system can generate real-time alerts when it detects deviations from standard procedures, irregularities, or discrepancies in data. These alerts are automatically sent to the relevant users, allowing for a quick response and effective correction of issues.
- Risk dashboard: Users can view a risk map and a visual representation of potential issues within the institution. The risk dashboard is automatically updated based on collected data and can highlight high-risk areas or activities that require further investigation.

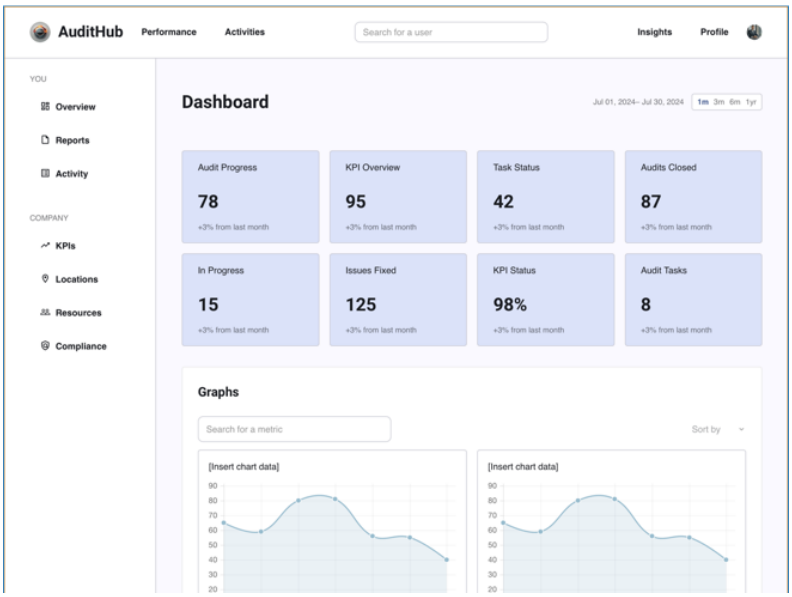

Figure 3. Example of proposed audit application interface - main functions

Source: own processing in bubble.com

Documents and Reports

The document and report management module is essential for a digitized audit platform. This module facilitates the centralization, access, and management of all documents necessary for conducting the audit.

- Centralized digital archive: All documents, from contracts and invoices to reports and compliance notes, are stored in a single digital archive. Users can quickly access any document they need and track its history (e.g., who modified it and when).
- Document management and validation: The platform allows documents to be uploaded, validated, and approved directly in the system, eliminating the need for physical formats or other storage solutions. All documents go through an electronic approval workflow, and changes are automatically recorded to ensure traceability.

- Automatic report generation: The platform offers the functionality of automatically generating reports based on the collected data. Users can select various reporting formats (e.g., comparative charts, summary tables, etc.) and customize their content according to the specific needs of the audit.

Collaboration and Communication Panel

Effective collaboration between audit teams and other stakeholders is essential to the success of audit processes. The collaboration module provides a range of tools that facilitate information sharing and rapid approvals.

Shared workspace: A virtual space where auditors can collaborate on documents, leave comments, and discuss issues relevant to the audit. This shared workspace encourages transparent communication and allows all team members to access the same information.

Approval workflow: Documents and reports can be subject to an automated approval workflow, eliminating delays caused by manual approvals. Relevant users receive notifications when a document requires approval or review, and all actions are recorded in the activity log.

Integration and Interconnectivity

To facilitate the implementation of the platform and ensure its optimal use, it will be integrated with existing systems within public institutions. This interconnectivity will enable automatic data retrieval and efficient monitoring of all relevant processes.

Integration with ERP systems and other internal solutions: The platform will be compatible with various ERP (Enterprise Resource Planning) systems and financial or operational management solutions, allowing for the automatic retrieval of data needed for the audit.

Connection to external databases: If the audit requires verification of information from external databases (e.g., government databases or other official registers), the platform will be able to automatically retrieve this data, ensuring greater accuracy of information.

4. Platform architecture

The architecture of the digital audit platform is the basis for the functionality and interconnectivity of all the components described above. It must be designed to enable the centralization, storage, and analysis of data, while ensuring flexibility of use and the ability to adapt to the diverse requirements and needs of public institutions. In this subchapter, we will explore the general structure of the platform, the data flow between the different components, and how it integrates with other existing systems (Figure 4).

General structure of the platform architecture

The proposed architecture for the digital audit platform is organized into three main layers: the user interface layer (frontend), the business logic layer (backend), and the data storage and integration layer. Each layer has a specific role in ensuring the optimal functioning of the platform and allows users to interact efficiently with the system's data and functionalities.

User interface layer (Frontend): This layer includes all visual elements that users interact with, such as the main dashboard, document and report modules, collaboration panel, etc. The interface must be intuitive and easy to use, to facilitate quick access to information and navigation between the different modules of the platform.

Business logic layer (Backend): This layer manages the logic and functionality of the platform, including data validation, report generation, document verification, and alert processing. This is where all the rules and conditions that determine how user-entered data is processed and analyzed are defined.

Data storage and integration layer: This layer handles secure data storage and interaction with other external systems, such as ERP systems, financial databases, or other management solutions used by public institutions. Data is stored in a centralized database, and the architecture must allow for fast queries and real-time updates.

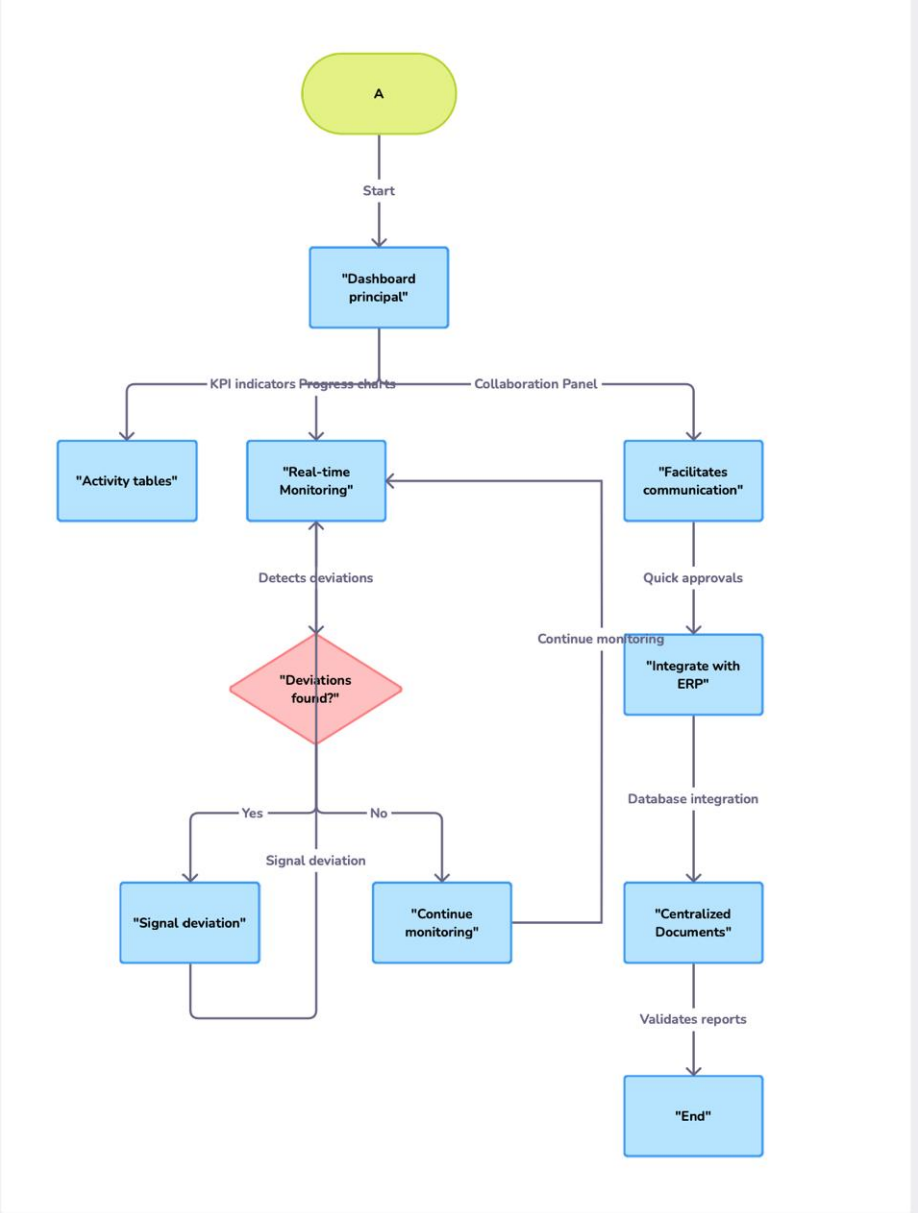

Figure 4. Process flow diagram of the digital audit platform
Source: own processing in bubble.com

Flow chart of the digital audit platform

To better understand how the platform works, the flowchart describes how data flows between the different modules and layers of the architecture. This diagram details all essential processes, from data collection to the generation of final reports.

Data collection: Data is collected from various internal and external sources, such as accounting records, operational reports, and government databases. This data is then centralized in the platform, where it undergoes an automatic validation process to ensure its accuracy and compliance with institutional standards.

Data processing and analysis: Once validated, the data is processed according to the rules established by the backend. The platform can automatically perform various types of analyses, such as risk analysis, financial performance evaluation, or verification of compliance with legal procedures. The results of these analyses are displayed in the main dashboard, where users can monitor progress and any irregularities.

Document storage and management: All documents required for the audit process are stored in the central archive. Each document is accompanied by an activity log that records all changes and approvals, ensuring complete traceability of information.

Report generation and distribution: At the end of the audit process, users can generate detailed reports summarizing all findings and analysis results. Reports are available in a variety of formats and can be automatically distributed through the platform to all relevant decision-makers.

Data flow and integration with other systems

The platform's architecture must allow for seamless integration with various existing solutions within public institutions in order to facilitate automatic data retrieval and avoid redundancy in audit processes. Integration can be achieved through APIs and other data exchange protocols, ensuring full interoperability between different systems.

Integration with ERP systems and other management solutions: The platform connects to the ERP systems used by public institutions to retrieve financial and operational data in real time. This allows the platform to automatically update the information needed for the audit and eliminates the need for manual intervention.

Connections to external databases: If the audit requires verification of information from external sources (e.g., government databases, public procurement registers, or other control systems), the platform can automatically query these databases and integrate the relevant information into the audit reports.

Security and privacy measures

Given the sensitive nature of the data managed by the audit platform, security measures are essential to protect the integrity and confidentiality of information.

Encryption and authentication: All data stored on the platform is encrypted both at the storage level and during transfer between modules. Access to the platform is controlled by a multi-factor authentication (MFA) system, and each user has limited access rights to the functionalities and data specific to their role.

Internal audit and monitoring: The platform includes an internal audit mechanism that monitors and records all user actions. If suspicious or unauthorized actions are identified, the system automatically generates alerts and notifications for security and management teams.

Regulatory compliance: The platform's architecture complies with national and international regulations on data protection and information confidentiality (e.g., GDPR). All data storage and processing procedures are documented and audited periodically to ensure compliance.

In public institutions where audit processes are mainly managed on the basis of physical documents, the transition to a digitized system can be facilitated by a well-defined integration workflow. Implementing such a workflow allows institutions to maintain their current paper-based processes while gradually building a digital database.

The example workflow for integrating physical documents consists of several successive steps that ensure that relevant information is correctly captured, validated, and stored, allowing users to quickly and efficiently access both scanned physical documents and digitally entered documents. The proposed workflow includes the following steps:

Receiving physical documents: Documents are received from various sources and are often in different formats. They are sorted and categorized according to their type and origin.

Scanning the physical document: Physical documents are scanned using specialized equipment, either directly in the audit platform or in integrated auxiliary modules. This step ensures the digitization of the document, facilitating its registration in a format compatible with the platform's digital archive.

OCR application and information extraction: Once the documents have been scanned, Optical Character Recognition (OCR) technology is applied to automatically extract essential data from the documents. This may include names, amounts, descriptions, or any other relevant information, reducing the time required for manual data entry.

Manual verification and validation: The information extracted by OCR is manually validated by users to ensure its accuracy. This step allows for the correction of errors and the completion of data that was not correctly identified by the OCR algorithm.

Storage in the digital archive: After validation, the documents are stored in a centralized digital archive. Each document is accompanied by additional information, such as the author of the scan, the date it was uploaded, and the approval status.

Association with audit stages: Digitized and stored documents are associated with the various stages of the audit process. Users can link these documents to specific checks, reports, or sections of the audit, ensuring complete traceability.

Generating reports with combined physical and digital data: At the end of the audit, the platform allows for the automatic generation of reports that include both the digital data entered the system and the information collected from physical documents. These reports provide a complete overview of the institution's situation, including all available information.

CONCLUSIONS

The need for innovation and digitization of audit processes in public institutions is imperative, given the multiple challenges and constraints they face. The results of the research conducted in the previous chapter highlighted that most public entities have not yet implemented modern technological solutions to streamline their audit work, although there is widespread recognition of the benefits that digitization could bring. This gap between potential and reality reflects either a lack of resources and technological support or resistance to change on the part of organizations, highlighting the need for a concerted digital transformation strategy in the field of internal auditing. It also highlights the fact that human resources are a critical factor in the transition to digital auditing. Thus, although the professional training of auditors in the public sector is rated as good or very good by 43% of respondents, a significant percentage consider that the level of technological competence is only moderate, suggesting the need for additional investment in continuing education programs. This gap in staff training may be an obstacle to the effective implementation of digital solutions and new technologies in public auditing.

Another key aspect highlighted in the chapter relates to the need to modernize and make internal audit regulations more flexible. Survey respondents emphasized the need to digitize documents and processes, as well as the need to adapt the regulatory framework to new technological realities so that it facilitates, rather than limits, the digital transformation of auditing. In this regard, legislation that encourages the adoption of innovative solutions and supports the development of institutions' technological capacity is essential to ensure transparency and efficiency in the public sector.

The implementation of a digital audit platform, proposed in this chapter, represents an integrated and innovative solution that would enable public institutions to manage all stages of the audit process in a centralized and efficient manner, from planning and data collection to automatic report generation and real-time monitoring of activities. This approach would facilitate complete traceability of information, automation of administrative tasks, and improved communication between audit and management teams. Furthermore, by centralizing data and automating workflows, the platform would contribute to a significant reduction in the time required to conduct the audit, thus allowing auditors to focus on high value-added activities such as risk analysis and operational process improvement.

The benefits of such a solution are manifold, including reduced operating costs, improved transparency and traceability of information, effective risk monitoring, and facilitated interdepartmental collaboration. In addition, by integrating emerging technologies such as data analytics, artificial intelligence, and blockchain, the platform could identify deviations from standard procedures in real time, automatically flag irregularities, and generate detailed reports for senior management. Thus, the implementation of a digital audit platform not only optimizes existing processes but also redefines the entire operational framework of auditing, promoting an organizational culture based on innovation and efficiency.

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SOCIAL INNOVATION IN RURAL AREAS: MECHANISMS, ACTORS AND IMPACT ON COMMUNITY DEVELOPMENT

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Abstract: *The article analyzes the phenomenon of social innovation in rural Romania, with a focus on the framework provided by the LEADER measure under the National Rural Development Programme (NRDP) 2014–2020. It employs a mixed methodological approach, combining documentary analysis with the interpretation of administrative data. The analysis examined the typology, scale, and territorial distribution of social projects funded through Local Action Groups (LAGs), assessing their contribution to social cohesion, inclusion, and community resilience. Social innovation is understood as an expression of the capacity of rural communities to generate and implement collective initiatives in response to persistent social challenges. These initiatives include the establishment of multifunctional social and socio-medical centers, infrastructure modernization, and community-based services aimed at combating exclusion and enhancing local well-being. The findings confirm that LEADER's bottom-up approach fosters collaboration among local actors and encourages innovative, context-specific solutions to social and economic challenges. The research findings highlight that the LEADER programme acts as a catalyst for the emergence and consolidation of social innovation practices through Local Action Groups (LAGs), which represent a fundamental element in rural revitalization and the promotion of social cohesion.*

Keywords: *LEADER programme, rural development, Local Action Groups (LAG), social innovation, rural communities*

JEL Classification: Q01, Q26

INTRODUCTION

Social innovation has become a key concept in sustainable rural development, offering the potential to generate locally adapted solutions to community challenges. The LEADER programme, as part of the European Union's rural development policy, provides a favorable environment for such innovation processes by mobilizing local resources and engaging community actors around shared objectives.

Measure 19 – Support for Community-Led Local Development (CLLD) through LEADER – represents an essential instrument in Romania's efforts to reduce economic and social disparities and strengthen local communities through a bottom-up approach that directly addresses locally identified needs and priorities. These priorities are reflected in the funding measures outlined in Local Development Strategies (LDSs). Each measure included in an LDS must have an innovative character and generate added value for the territory, contributing to the achievement of objectives and priorities established in accordance with Regulation (EU) No. 1305/2013.

One of the fundamental priorities of the EU's rural development policy, defined in Article 5 of Regulation (EU) No. 1305/2013 on support for rural development through the European Agricultural Fund for Rural Development (EAFRD), is Priority 6 (P6): Promoting social inclusion, poverty reduction, and economic development in rural areas. This priority reflects a strategic shift toward addressing the social dimension of rural development, in response to persistent challenges such as depopulation, population ageing, limited access to public services, and multidimensional poverty prevalent across many rural regions of Central and Eastern Europe, including Romania.

Priority P6 seeks not only to improve living conditions in rural areas but also to establish structural conditions for sustainable economic growth and the active inclusion of vulnerable groups. In this regard, the interventions supported under this priority aim to diversify rural economies, support microenterprises and non-agricultural activities, promote social economy structures, and improve local infrastructure, social services, and the administrative capacity of local actors.

In Romania, the relevance of Priority P6 is particularly high given the persistent disparities between urban and rural areas in terms of income levels, access to education, healthcare, and social services, as well as employment opportunities. Effective implementation of this priority can help reduce territorial inequalities, strengthen social cohesion, and activate the endogenous potential of rural communities. Participatory mechanisms such as LEADER encourage innovative, place-based solutions and foster a culture of cooperation and shared responsibility.

Thus, Priority P6 should be understood not merely as a sectoral objective but as an integrative framework that links economic, social, and institutional dimensions of sustainable rural development. It provides a solid foundation for the formulation of local strategies that capitalize on existing resources, enhance social capital, and mitigate systemic vulnerabilities within rural territories.

Innovation within LDSs can manifest through the development of new products, services, or technologies, as well as through the adoption of novel organizational and social approaches. It is essential that these innovations respond to locally identified needs—through diagnostic and SWOT analyses—and demonstrate greater efficiency compared to existing solutions. Furthermore, actions regarded as innovative in a specific territory may be inspired by successful practices implemented elsewhere.

Although experience to date indicates an emerging local development capacity, it remains insufficient to fully address community needs, particularly in terms of effective cooperation between public and private actors. Strengthening an integrated and long-term strategic approach is therefore necessary.

Measure 19 – Support for Community-Led Local Development (CLLD) through LEADER – provides a favorable framework for introducing and supporting innovative initiatives tailored to local specificities. By promoting creative solutions and adapting good practices from other contexts, this measure stimulates the development of services, products, technologies, and organizational forms that respond more effectively to local challenges. Consequently, innovation emerges as a decisive factor in territorial revitalization and in building the resilience of rural communities.

The integration of social infrastructure investments within local development strategies for the 2014–2020 programming period was grounded in territorial diagnostic analyses aimed at identifying dysfunctions and deficiencies in social infrastructure relative to the needs of target groups. Following the implementation of these projects, ensuring the sustainability of interventions remains a key requirement—achievable either through mobilizing beneficiaries' own resources or by attracting complementary funding sources, particularly those offered under Specific Objective 5.2 of the Human Capital Operational Programme 2014–2020.

"Hard" interventions, such as the construction and modernization of social infrastructure, have significantly improved quality of life, including in marginalized communities. However, to generate systemic and sustainable impacts on social inclusion, these investments must be complemented by "soft" measures that deliver socio-medical, educational, and active inclusion services tailored to the local context and to the needs of vulnerable groups.

A deeper analysis of investment typologies highlights the functional and complementary nature of “hard” and “soft” components of social infrastructure. “Hard” investments concern the physical and material dimension—buildings, equipment, and facilities essential for institutions serving vulnerable populations. These provide the structural foundation for social interventions but may have limited effects in the absence of accompanying “soft” components. In contrast, “soft” investments consist of programs, activities, and services that promote socio-economic integration and community participation. The strategic coordination of these two categories within an integrated framework is critical to enhancing both the efficiency and sustainability of outcomes in the field of social cohesion.

Table 1. Examples of "hard" and "soft" investments in social infrastructure

Domain	Hard investments (infrastructure)	Soft investments (services/programs)
Education	Construction/rehabilitation of schools, kindergartens, after-school centers	"School after school" programs, educational support for children from vulnerable groups
Health	Development of community health centers, equipment provision	Prevention campaigns, mobile medical services, health education programs
Social inclusion	Social inclusion Integrated community centers, shelters, social housing	Social mediation services, psychosocial counseling, vocational training for disadvantaged people
Employment	Employment Vocational training centers, spaces for social economy	Qualification/requalification programs, support for labor market integration

MATERIALS AND METHODS

The aim of the research paper consists in the analysis of the projects at the LEADER rural area level, by presenting the type of social projects that were financed in period 2014 – 2020, the number of beneficiaries of these projects, the value of the contracts and their impact on the rural population.

The article was based on research methods and techniques, respectively: the identification and collection of specific data, their analysis, synthesis, interpretation. The information is presented below in graphical and tabular form. The information analyzed and used in the paper was taken from the websites of institutions with a role in the elaboration, management, implementation and control of rural development programs in Romania, namely: the Management Authority for the National Rural Development Program, within the Ministry of Agriculture and Rural Development; Agency for the Financing of Rural Investments.

RESULTS AND DISCUSSION

The results obtained from the study are presented in a logical sequence to enable readers to accurately interpret the data.

Social innovation reflects the capacity of communities to develop collaborative solutions to persistent social challenges. The projects implemented by Local Action Groups (LAGs) during the 2014–2020 programming period provide relevant examples of the ability of rural communities to identify and address local problems through partnerships and interventions adapted to the specific context of each territory.

Social innovation involves the development of new solutions to social needs that are more effective, sustainable, and equitable than existing alternatives. It often entails collaboration among multiple local actors—LAGs, non-governmental organizations, local authorities, and community members. The need for such solutions has been reinforced by the socio-economic transformations in rural areas, driven by declining living standards and pressures on the labor market in the context of successive economic crises (Mărcuță, Mărcuță & Anghelescu, 2016; Mărcuță et al., 2017).

The integration of social infrastructure investments into Local Development Strategies (LDSs) for the 2014–2020 programming period was grounded in diagnostic analyses of rural territories, aimed at identifying dysfunctions and deficiencies in social infrastructure relative to the specific needs of target groups. Within this process, the capacity of communities to mobilize local resources and foster cooperation was closely linked to agricultural performance and the dynamics of local supply chains (Popescu et al., 2021; Mărcuță & Mărcuță, 2020).

During 2014–2020, approximately 200 social projects were implemented across Romania through Local Action Groups, with a total estimated value of €12.5 million. The average project value was around €65,000, while the largest project received €200,000—the maximum funding allowed under the LEADER framework. It is noteworthy that in many rural territories, social innovation initiatives were supported through the valorization of traditional agri-food production, thereby contributing to enhanced community cohesion and local identity (Popescu et al., 2019).

The analysis of data provided by the Agency for Financing Rural Investments (AFIR) and the Ministry of Agriculture and Rural Development (MADR) revealed several key outcomes: the creation of multifunctional social centers, facilities for children, the elderly, and people with special needs, and investments in the modernization of social and medical infrastructure. These also included the expansion of community services, representing projects with an overall investment value of approximately €12 million.

Such interventions contribute significantly to reducing social exclusion, improving quality of life, and promoting the sustainable development of Romanian villages. Local partnerships, supported through the LEADER programme, remain a cornerstone of rural revitalization and play a vital role in strengthening social cohesion.

Table 2. Data processed by the authors, MADR monitoring

Indicator related to socio-medical projects Population that benefited from improved services/infrastructure	Field of intervention	Number of projects selected and funded	Total contracted value (Euro)
757.147,00	6B	200	2.5 mil.

Table 3. Data processed by the authors, MADR monitoring

Types of social projects funded through Local Action Groups (LAGs) with non-reimbursable European funds	Number of projects	The total eligible value contracted (approx.)
Social centers	92 projects	€13 million
Others	71 projects	€7 million
Projects for children	22 projects	€2 million
Socio-medical centers	10 projects	€500,000

As can be seen from the table above, one of the social indicators is represented by the population that benefited from services/infrastructure improved as a result of projects financed by the EAFRD, which is 757,147, representing one of the relevant approximate indicators of socio-medical projects related to priority 6 (selection areas) of intervention of the number of projects financed.

We can highlight another social indicator, namely community-oriented projects, which are around 200. The distribution of projects by category provides an overview of local priorities: the predominant focus on social centers indicates a concern for the integration and support of vulnerable individuals.

An important aspect of social innovation is dedicated to the medical component, focusing on the development of medical centers in rural communities. These projects provide better access to healthcare services, especially in isolated areas. For example, construction of a multifunctional socio-medical center (Alba), a multifunctional center for the implementation of socio-educational, recreational, and mobile medical assistance activities (Caraș-Severin, Timiș**),** medical office equipment (Constanța), establishment of a multifunctional social center for community social and medical assistance (Gorj), equipment of a multifunctional center with medical, social, and socio-medical services in Bârsana and in Strîmtura commune (Maramureș), construction of a medical center in Poiana Stampei commune (Suceava), rehabilitation of the Social Health Center (Suceava), modernization of the socio-medical center without structural modifications and conversion of a ground-floor dwelling into an administrative building for the socio-medical center Timiș), establishment of the Center for the Development of Social and Socio-Medical Activities in Romanii de Sus village, Sălișteе hamlet, Horezu town, Vâlcea County (Vâlcea).

There are significant differences between counties — some (likely Alba, Arad, Maramureș, etc.) have much higher total project values, which may indicate a greater administrative and project-writing capacity.Counties with lower totals may be areas where social measures were less prioritized or where LEADER funding availability was more limited. The uneven distribution suggests a regional polarization in the absorption of social development funds.

CONCLUSIONS

Social innovation emerges as a central component of sustainable rural development, offering local communities the opportunity to capitalize on their own resources and to design effective responses to contemporary social challenges. In this context, the LEADER programme acts as a catalyst for territorial transformation, fostering collaboration among local actors and stimulating the emergence of new forms of participatory governance.

The research findings confirm that the bottom-up approach promoted through LEADER facilitates processes of social cohesion and community strengthening by encouraging the active involvement of local groups in defining and implementing development strategies. The innovative dimension of these interventions is reflected not only in the diversity of projects but also in their capacity to generate replicable and adaptable models for other rural territories.

The analysis underscores the importance of integrating the economic, social, and institutional dimensions within a coherent strategic framework—one that transcends the logic of isolated interventions and contributes to the long-term development of rural social capital. The success of these processes largely depends on the continuity of local partnerships, the strengthening of administrative capacities, and the promotion of a culture of collaboration and collective learning.

Looking forward, social innovation should be regarded as a dynamic and adaptive process, capable of sustaining the resilience of rural communities in the face of economic, demographic, and

environmental changes. Building upon the experience accumulated during the previous programming period can inform the design of public policies that are more responsive to territorial needs and grounded in cooperation, solidarity, and social creativity.

The consolidation of public–private partnerships, the digitalization of local processes, and the promotion of the social economy may constitute strategic directions for the 2023–2027 programming period, ensuring both the continuity and the expansion of LEADER's positive impact on sustainable rural development.

Thus, social innovation in the context of LEADER implementation should not be viewed merely as a technical instrument of intervention, but rather as an expression of the maturity and agency of rural communities, which increasingly assume the role of active actors in shaping their own development.

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CONSIDERATIONS REGARDING FARMING IN ROMANIA

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Abstract: *The paper analyzes the dynamics of agricultural holdings in the last decade, highlighting the main structural and economic trends of the agricultural sector. Based on statistical data provided by the National Institute of Statistics (TEMPO ONLINE database) and those extracted from agricultural censuses, the research follows the changes that have occurred in terms of the number, size and specialization of agricultural holdings. The research results indicate a sharp reduction in the number of agricultural holdings and at the same time an increase in the average area per holding, which suggests a process of consolidation of agricultural land.*

Keywords: *agricultural holdings, Romania, trends, classification, surface area*

JEL classification: *Q12, Q13.*

INTRODUCTION

An agricultural holding is a form of organization that consists of all units used for agricultural activities, managed by a farmer (Dumitru et al., 2020).

In Romania, until 1990, the entire agricultural area was owned by the state within agricultural production cooperatives and state agricultural holdings. In 1991, the regulation of the reconstitution of ownership rights over agricultural land for former land owners, members of former agricultural production cooperatives within the limit of 10 ha/family began. In accordance with the Land Fund Law (Law no. 18/1991), a large number of former owners recovered their land (a total of 9,340,000ha of arable land). This situation led to the establishment of 3,900,000 small-scale agricultural holdings, called family farms (Biali & Popovici, 2008; Ciobanu, 2016; Ionescu et al., 2021).

The legislative framework and specialized literature in the field classify agricultural holdings according to several criteria such as: size, profile, economic doctrine, land ownership, human resources, production destination and other legal and economic criteria (Alecu et al., 2001).

In Romania, the most widespread form of organization is represented by family farms, which represent the basic cell of agriculture from a social point of view, valuing both land and human resources. At the same time, if the family farm is viewed from an economic point of view, it is found that it is not very profitable, because most of the agricultural products obtained are used for self-consumption, this situation being valid, mainly, for agricultural holdings that have a small area, less than two hectares (Burja & Burja, 2010; Ionescu et al., 2021; Tachianu et al., 2022).

However, statistical data show that most agricultural holdings in Romania have a land area ranging between two and five hectares, and from this area the farmer obtains agricultural products that exceed his own level of consumption, being forced to sell part of them, thus obtaining an income (Popescu, 2010; Crecană & Crecană, 2019).

MATERIALS AND METHODS

The research method used is quantitative and qualitative data analysis. Statistical data on the number of agricultural holdings were processed and analyzed - according to several criteria (type of agricultural activity, economic size, legal form of holdings).

The data were collected from the Eurostat database and from the publications of the National Institute of Statistics (INS) - General Agricultural Census (RGA), Structural Survey in Agriculture (ASA), for the period 2010-2020. The year 2020 is the last year for which data on the number of agricultural holdings in Romania were found.

RESULTS AND DISSCUSION

According to Law No. 37/2015, on the classification of agricultural holdings in Romania according to the type of agricultural activity, agricultural holdings are divided into three main categories: specialized holdings - crops, specialized holdings - animal production and mixed holdings.

In 2020, there were 2.89 million agricultural holdings registered in Romania, most of which were in the North-East Region (592,998 holdings) and in the South-Muntenia Region (521,961 holdings) (Figure 1).

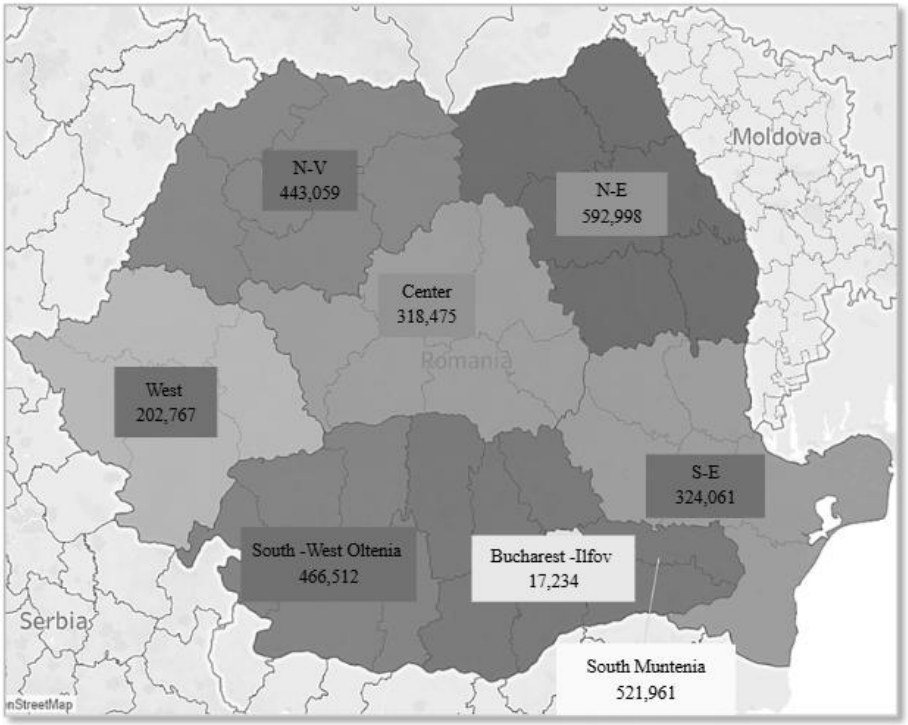

Figure 1. Distribution of agricultural holdings at the level of development regions in 2020 (number of agricultural holdings)

Source: own processing based on data from RGA 2020

Analyzing the dynamics of agricultural holdings in Romania over the period 2010-2020, a trend of reduction in the number of holdings was observed, so that, if in 2010 there were over 3.86 million agricultural holdings, in 2013 their number decreased by 6%, reaching the threshold of 3.63 million agricultural holdings. In 2016, the merger process continued, as a result of the measures taken in this regard, so that their number reached 3.42 million agricultural holdings. The year 2020 presented an even greater reduction in the number of agricultural holdings, reaching 2.89 million agricultural holdings, highlighting a decrease of about 25% compared to the number of agricultural holdings in 2010.

From the analysis of agricultural holdings in Romania by type of agricultural activity, a very large number of agricultural holdings specialized in the field is observed (1,084,790 holdings in 2020).

Regarding the dynamics of agricultural holdings in Romania by type of agricultural activity, in the period 2010-2020, in Table 1, a significant decrease is observed for mixed livestock holdings (-74%) and for unclassified agricultural holdings (-72%). At the opposite pole, mixed crop holdings recorded a significant increase (+33%) in the analyzed period.

Table 1. Dynamics of agricultural holdings in Romania by type of agricultural activity, in the period 2010-2020 (number of agricultural holdings)

Specialization	2010	2013	2016	2020	2020/2010 (%)
Specialized field crop farms	915.950	1.041.840	1.062.870	1.084.790	18
Specialized horticultural farms	22.380	21.500	21.000	22.440	0,27
Specialized permanent crop farms	165.830	154.040	159.040	147.190	-11
Specialized herbivore livestock farms	391.070	438.920	386.590	219.180	-44
Specialized granivore livestock farms	975.030	722.200	625.060	546.060	-44
Mixed crop farms	125.890	176.080	181.200	167.540	33
Mixed livestock farms	485.720	271.210	218.760	126.730	-74
Mixed crop and livestock farms	677.350	747.600	717.440	544.880	-20
Unclassified farms	99.840	56.270	47.270	28.280	-72
TOTAL	**3.859.060**	**3.629.660**	**3.419.230**	**2.887.090**	**-25**

Source: own processing based on Eurostat data

Regarding agricultural holdings in Romania by economic size, in 2020 a significant number of agricultural holdings with an economic size below 2,000 euros, namely 2,064,190 holdings, were observed.

Table 2. Dynamics of agricultural holdings in Romania classified according to economic size (number of agricultural holdings)

Clasification	2010	2013	2016	2020	2020/2010 (%)
0 euro	99.840	56.270	47.270	28.280	-72
under 2.000 euro	2.720.520	2.437.160	2.285.730	2.064.190	-24
2.000 – 3.999 euro	604.020	577.640	562.540	395.910	-34
4.000 – 7.999 euro	312.180	375.280	340.220	215.800	-31
8.000 – 14.999 euro	76.090	114.280	114.060	90.140	18
15.000 – 24.999 euro	21.240	33.830	35.490	38.630	82
25.000 – 49.999 euro	12.620	18.820	19.140	29.260	132
50.000 – 99.999 euro	6.150	7.830	7.060	12.910	110
100.000 – 249.999 euro	3.990	5.000	4.360	7.510	88
250.000 – 499.999 euro	1.430	2.100	1.880	2.560	79
over 500.000 euro	950	1.470	1.480	1.860	96
TOTAL	**3.859.040**	**3.629.660**	**3.419.230**	**2.887.070**	**-25**

Source: own processing based on Eurostat data

Analyzing the data in Table 2, regarding the dynamics of agricultural holdings in Romania classified by economic size, in the period 2010-2020 a significant increase was observed in agricultural holdings with an economic size between 25,000 – 49,999 euros (+132%), as well as in those between 50,000 – 99,999 euros (110%).From the point of view of legal status, in Romania agricultural holdings are of two types: agricultural holdings with legal personality and agricultural holdings without legal personality, the most widespread being those without legal personality.

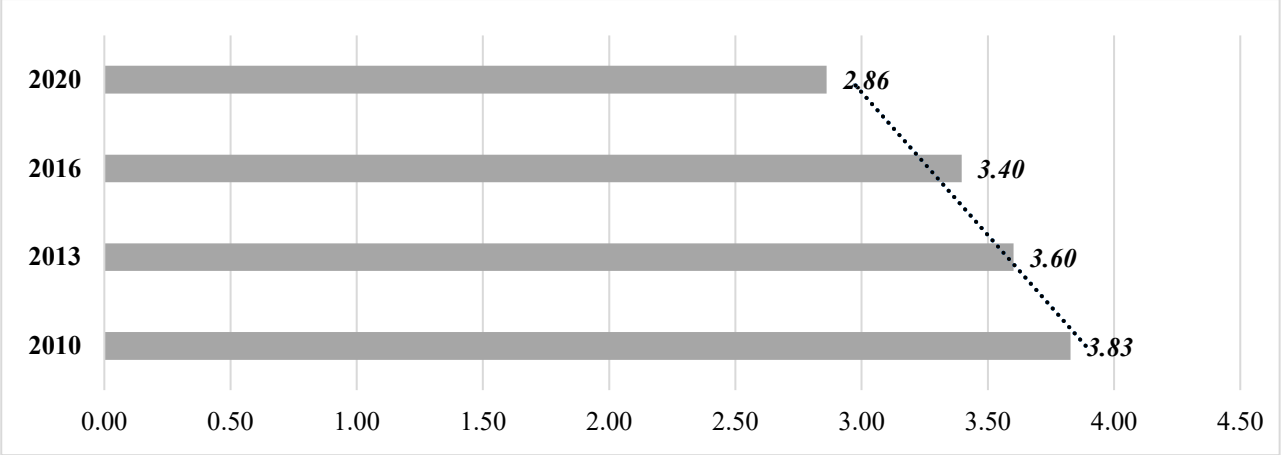

Figure 2. Dynamics of agricultural holdings without legal personality in Romania, in the period 2010-2020 (millions of agricultural holdings)

Source: INS data processing: RGA 2010, ASA 2013, ASA 2016, RGA 2020.

In 2020, the share of agricultural holdings without legal personality in total agricultural holdings is approximately 99%. However, there is a trend of decrease in agricultural holdings without legal personality from 3.83 million in 2010 to 2.86 million in 2020, this decrease can be attributed to the aging of the rural population, which was no longer able to manage agricultural holdings, as well as to the measures taken following Romania's accession to the EU (Figure 2).

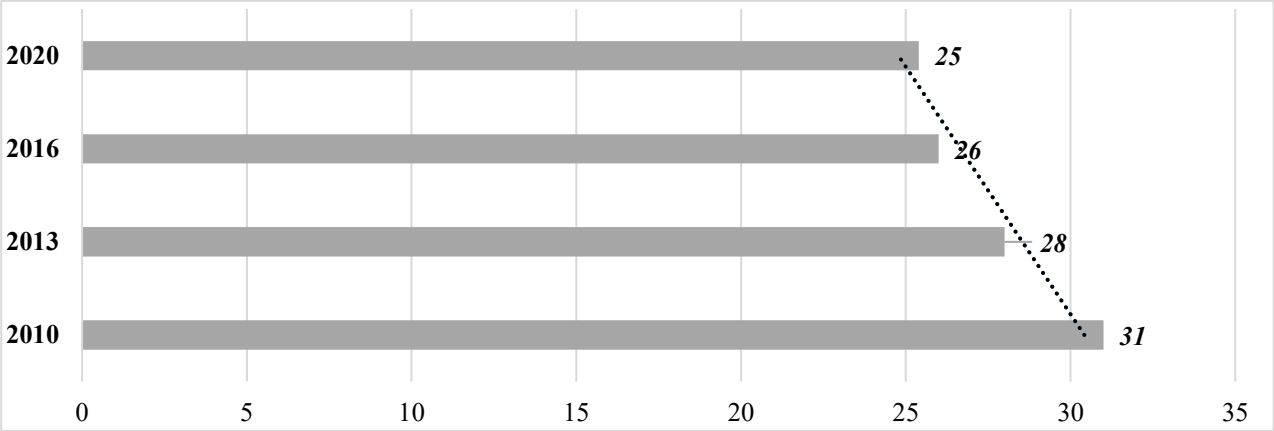

Figure 3. Dynamics of agricultural holdings with legal personality in the period 2010-2020 (thousand agricultural holdings)

Source: INS: RGA 2010, ASA 2013, ASA 2016, RGA 2020.

The dynamics of agricultural holdings with legal personality, in the period 2010-2020, showed a slight upward trend (+9%). In 2020, the number of agricultural holdings with legal personality was about 25 thousand, 17.3% lower than in 2010. The year 2010 was notable for recording the highest number of agricultural holdings with legal personality, reaching 31 thousand,

due to the criteria established for farmers to access European funds through the National Rural Development Program (PNDR), but in 2013 a decrease of 9.7% was recorded, as a result of their inability to adapt to the rules provided by the EU, which led to either their closure or their acquisition by other agricultural holdings, in order to increase the scores related to the investments made through the PNDR. This phenomenon continued in 2016, when their number was approximately 26 thousand. In 2020, the number of agricultural holdings without legal personality reached 24 thousand agricultural holdings, registering a decrease of about 19% compared to the number of agricultural holdings in 2010 (Figure 3).

CONCLUSIONS

With over 2.9 million agricultural holdings in 2020, Romania held approximately 32% of the total number of agricultural holdings in the EU-27. An important structural feature of agricultural holdings in Romania noted in this study is the persistence of a very high concentration on agricultural holdings with low values (below 2,000 euros) of standard production. In 2020, over 70% of agricultural holdings in Romania were subsistence agricultural holdings, with an economic size of below 2,000 euros, and approximately 21% had an economic size between 2,000 and 8,000 euros, which denotes the predominant nature of agricultural holdings with a low level of production value.

Both agricultural holdings without legal personality and those with legal personality showed a decrease in 2020, caused by the inability to adapt to the rules provided by the EU. Also, the lack of financial support and promotion of cooperative units led to a significant reduction in the number of agricultural holdings in Romania, which led to a deficient process of marketing agri-food products by agricultural producers.

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10. *** Institutul Național de Statistică.

ICEADR - IFCN INSTITUTIONAL COLLABORATION: COORDINATES OF THE ROMANIAN MILK SECTOR REFLECTED IN DAIRY REPORTS 2017-2024

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Abstract: *The purpose of this scientific paper is to comparatively analyze data and information regarding the milk sector in Romania, in an international context, as evidenced in Dairy Reports, in the context of institutional collaboration between the Research Institute for Agricultural Economics and Rural Development and the International Farm Comparison Network, from the period 2017-2024. The paper analyzes the dynamics of various indicators of the dairy sector, based on data from Dairy Reports, presenting Romania's status worldwide and key developments from the aforementioned period. The data for Romania appearing in the reports come from official statistical sources, from information from specialized websites, or estimated calculations. The methodology of the reports was established by IFCN. Thus, the paper reflects the developments in the Romanian milk sector, compared to other countries, as they are received internationally, through publications that ensure extensive visibility.*

Keywords: *IFCN, dairy, milk, cows, indicators*

JEL classification: Q10, Q11, Q13

INTRODUCTION

The dairy sector is an essential part of the global economy, being an important source of income for farmers. Milk production and processing contain important stages that generate jobs throughout the agri-food chain. This agricultural sector supports the development of rural areas, the maintenance of traditions from generation to generation and stability at the community level. It also contributes to ensuring food security for the population. The dairy industry has begun to integrate increasingly modern technologies, which allow for improved product quality, traceability and production sustainability.

It is important that data and information regarding the global dairy sector are known both by those involved and by the beneficiaries and consumers of dairy products. This aim is already fulfilled by IFCN - International Farm Comparison Network (https://ifcndairy.org/).

IFCN is a global dairy knowledge network, headquartered in Kiel – Germany, which is comprised of research partners from over 100 countries, over 130 dairy-related companies and 20 dairy experts. The aims of IFCN is to create a better understanding of the dairy world, by providing dairy economic data at global level, models and analysis in the field. The partnership between ICEADR and IFCN began in 2017, at the request of the Ministry of Agriculture, through a collaboration agreement concluded between the two institutions, in order to create the country dairy profile for Romania. The benefits for IFCN partners are annual Dairy Reports, IFCN World Dairy Maps, and regular analysis and knowledge.

MATERIALS AND METHODS

To develop the country profile for Romania, ICEADR provides IFCN with data on dairy cow herds, milk production at national and regional levels, dairy products, milk fat and protein content, milk use, dimensional structure of dairy farms, data on milk prices, feed, milk processors,

etc. The data transmitted are from official sources - the National Institute of Statistics, the Ministry of Agriculture, FAO, IMF, Oanda, specialized websites, and preliminary and partially estimated data (if not available).

The methodology used to make the calculations is IFCN-specific, and various indicators are calculated to ensure comparability. For example, the milk with natural contents is converted into solid corrected milk (SCM), standardized at 4.0% fat and 3.3% protein, according to the formula:

$$SCM = \text{milk protein} \times \frac{(\text{fat\%} + \text{true protein\%})}{7.3}$$

Source: https://ifcndairy.org/about-us/ifcn-dairy-research-network-method/

Another method is Milk Equivalents (ME), which determines how much raw milk is needed to produce a unit of a dairy product, using IFCN's fat-and-protein-based conversion method (https://ifcndairy.org/about-us/ifcn-dairy-research-network-method/).

RESULTS AND DISSCUSION

The first Dairy Report that ICEADR collaborated on was the 2017 one, with data from 2016 (Figure 1). In this report, the results of the calculations indicate that Romania was in 36th position in the world in terms of milk production, with 3.8 million tons of Energy Corrected Milk ECM, with a number of 604,000 dairy cow farms, with a milk price 7% higher than the world average and a feed price 5% higher than the world average. Also, the milk production trend was negative, of -0.9% per year, and the number of farms decreasing by -3.3% per year.

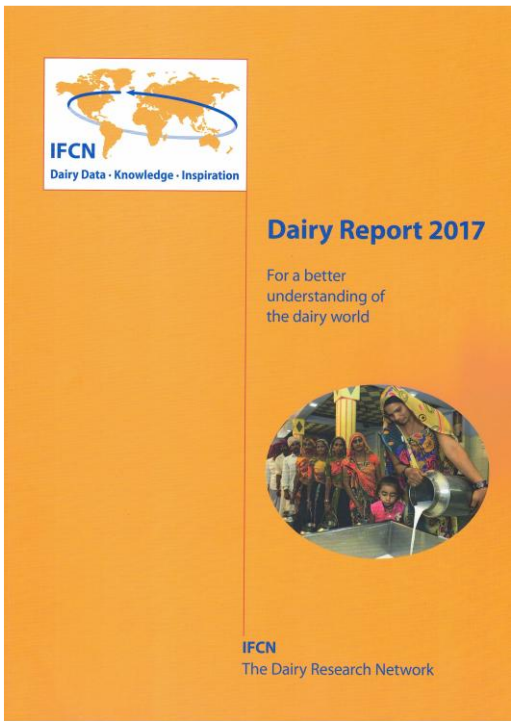

Figure 1. Dairy Report 2017

The evolution of milk production indicates a moderate decrease and although a slight increase was recorded until 2006, the general trend was of decline in milk production, from about 4.7 million tons to 3.8 million tons Figure 2).

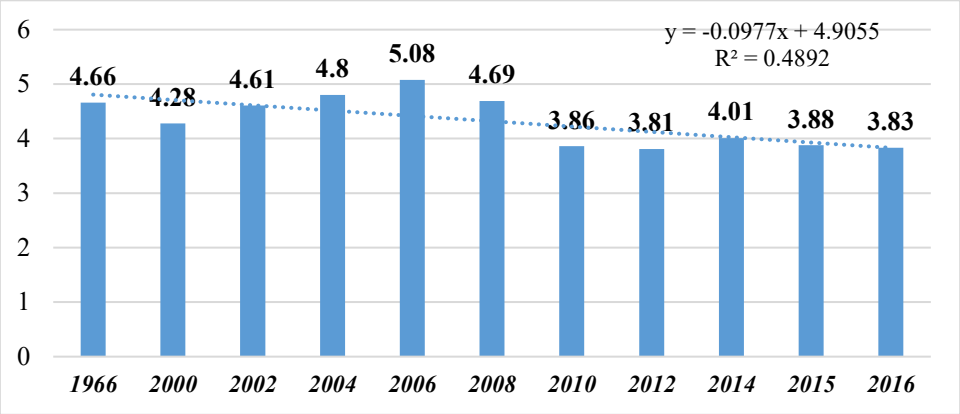

Figure 2. Annual milk production (mill. t ECM)
Source: Ilustration based on data from Dairy Report 2017

The dairy cow population in Romania registered a significant decrease between 1966 and 2016, from almost 1.94 million to about 1.42 million heads, meaning a reduction of approximately 25% (Figure 3).

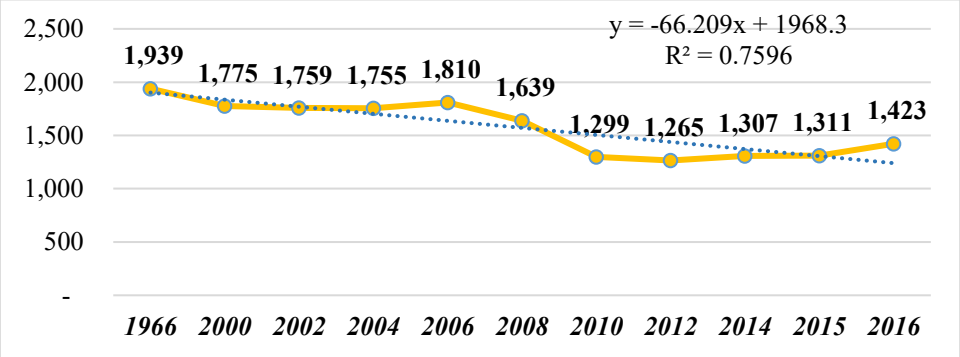

Figure 3. Number of cows in Romania (thousand heads)
Source: Ilustration based on data from Dairy Report 2017

During the analyzed period, the number of cow farms in Romania halved, from 1.36 million to about 0.6 million, reflecting extensive transformations, including the reduction in the number of small, traditional farms and the concentration of production in larger units (Figure 4).

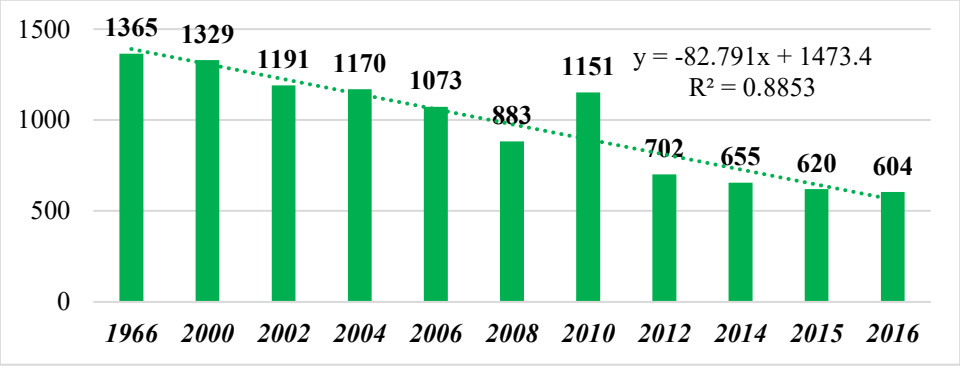

Figure 4. Number of cow farms in Romania (thousands)
Source: Ilustration based on data from Dairy Report 2017

The counties in the West and Center of the country, such as Arad, Brașov, Mureș, stood out for their most dynamic developments, while some counties in the Northeast and South had slower growth, or even regression (Figure 5).

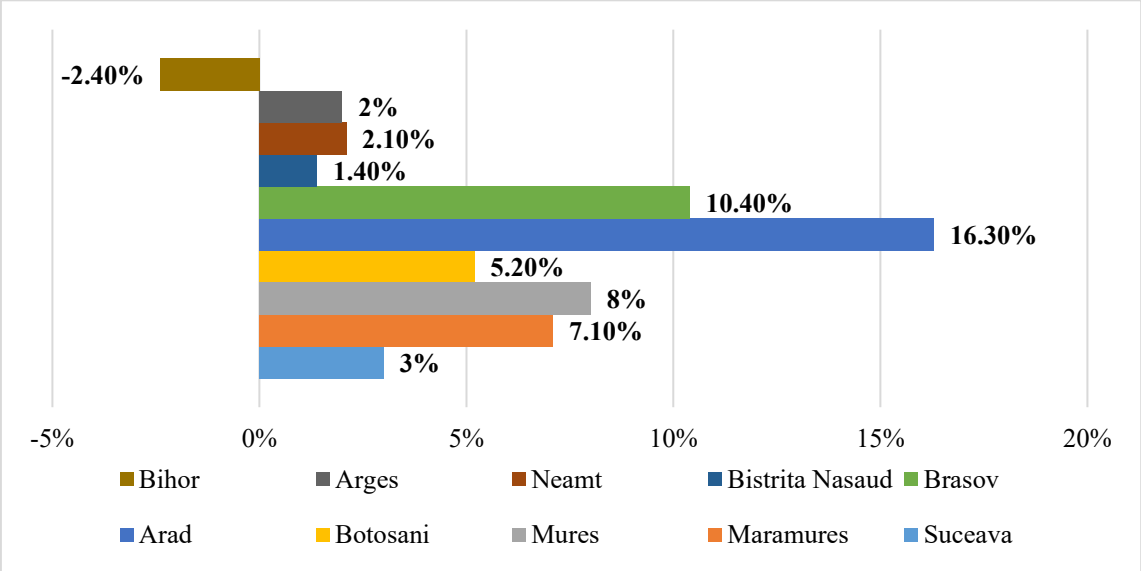

Figure 5. Top 10 counties – average milk production growth 2011-2016 (counties represented 45% of national milk production in 2016)

Source: Ilustration based on data from Dairy Report 2017

Along with this data, Dairy Report 2017 also contained data on the dimensional structure of farms, milk and feed prices. Dairy Reports from subsequent years are shown in Figure 6.

Figure 6. Dairy Reports 2018-2025

According to the Dairy Report 2025, Romania ranks 42nd in the world in terms of cow milk production, with 3.7 million tons of SCM. In terms of the number of cow farms, it ranks 26th in the world, with 377,454 farms. The price of milk exceeds the world average by 10%, but the price of feed for cows by 2% lower than it. During the period 2019-2024, milk production in Romania decreased by -0.8% per year, and the number of farms by -6.3% per year.

In 2024, according to the data in the Figure 7, cow's milk production decreased by approximately 30% compared to 1996, being correlated with the decrease in cow herds, the concentration of production in larger farms, the migration of the rural workforce etc.

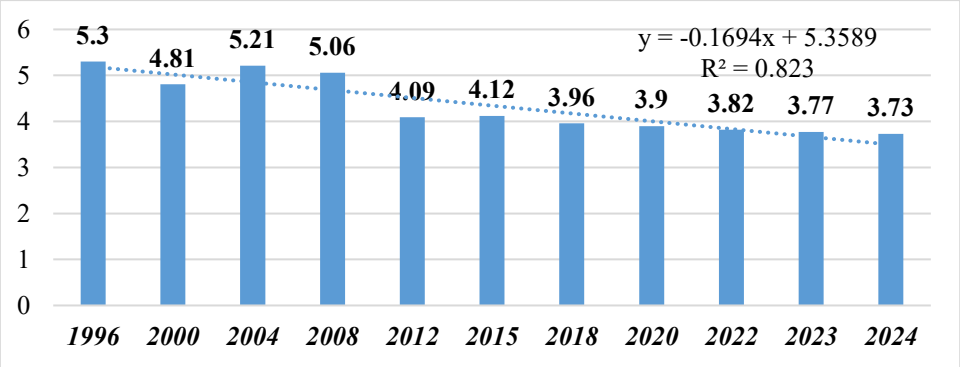

Figure 7. Annual milk production (mill. t ECM)
Source: Ilustration based on data from Dairy Report 2025

During the period 1996–2024, the number of cows in Romania decreased by approximately 40%, from 1.94 million to 1.16 million heads, indicating the reduction in the number of small farms, the decrease in production profitability, the volatility of milk prices, competition from imported dairy products etc. (Figure 8).

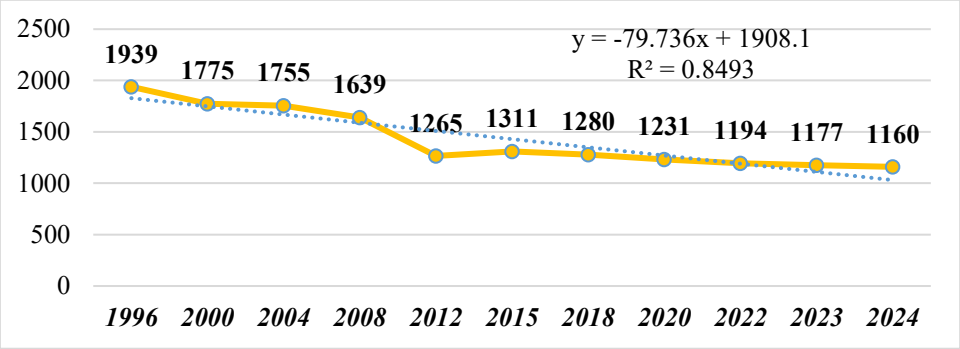

Figure 8. Number of cows in Romania (thousand heads)
Source: Ilustration based on data from Dairy Report 2025

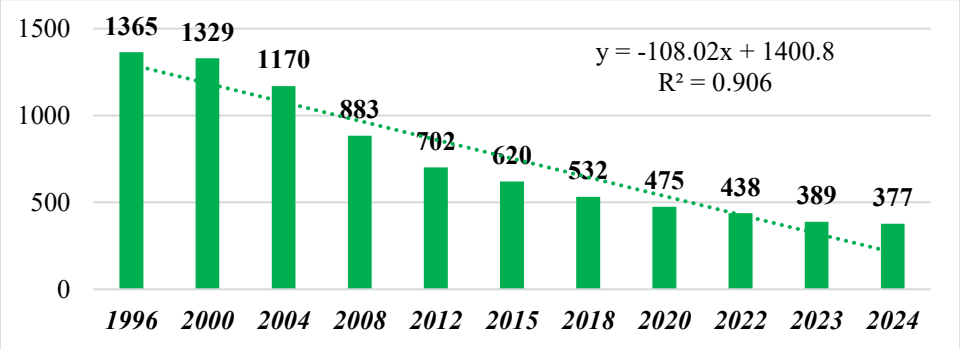

Figure 9. Number of cow farms in Romania (thousands)
Source: Ilustration based on data from Dairy Report 2025

Between 1996 and 2024, the number of cow farms in Romania decreased drastically, from 1.365 million to 377 thousand, practically less than a third of them remained. These developments illustrate the dismantling of small farms and the slight increase in the share of larger, commercial farms (Figure 9).

CONCLUSIONS

Data in the Dairy Reports show a structural contraction in time in the cow's milk production sector in Romania, the decrease in the number of small farms, the concentration of production in larger farms and highlights the need for agricultural policies that support the sustainability of domestic milk production.

The collaboration between ICEADR and IFCN is a research activity in which, based on a unique methodology, data on different indicators in the dairy sector are compared at international level. The benefits are multiple for each country that is part of this partnership, through increased visibility of data and information, which shows the status of each country compared to the others, as well as the dynamics over time. It is a network for the exchange of knowledge, analysis and forecasts, which allow a better understanding of this important sector.

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DEVELOPING A METHODOLOGICAL FRAMEWORK FOR ANALYZING FARMERS PERCEPTION ON BIO BASED PRODUCT MARKET

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Abstract: *This paper aligns with ongoing research aimed at identifying potential transition pathways towards sustainable development in the agricultural sector. The central focus is the market for biological inputs in agriculture, targeting Romanian producers. While biological control and pest management are not new concepts, having been developed since the early 20th century, such products are still regarded at the national level as innovative solutions for farmers. With the growing interest of market stakeholders and the gradual introduction of biological inputs into the Romanian agricultural sector, assessing farmers' needs and expectations has become a key priority. Against this backdrop, the primary objective of the paper is to establish a quantitative research framework applicable to local agricultural producers. The development of this methodological framework (purpose, objectives, hypotheses, and research instruments) builds upon both national and international scholarly literature, as well as the identification of strategic European targets defined by EU legislation and subsequently transposed into national policies. Finally, the integration of statistical evidence from official databases enables a more evidence-based estimation of Romanian farmers' needs, in relation to the specific characteristics of current agricultural practices at the national level..*

Keywords: *biological products; biological control; farmers' perception; marketing research; Sustainable Development Goals (SDGs)*

JEL classification: Q13, Q16

INTRODUCTION

The transition from the conventional economic model to the circular one represents one of the main directions included in global strategies, transposed through specific measures at the European and national levels. Thus, the introduction of biological (bio-based) products within the agricultural production cycle represents one of the optimal solutions in the global context of the Sustainable Development Goals (Agenda 2030), as well as at regional and local levels, in accordance with the directives and strategies currently in force of the European Commission (Bioeconomy for Europe, 2012; European Green Deal, 2019; New Circular Economy Action Plan, 2020; EU Biodiversity Strategy for 2030, 2020).

Therefore, accelerating the transition from conventional to circular agriculture and achieving sustainable production yields is the only way to ensure concepts such as food safety and food security (FAO, 2024). Reducing the quantity of chemical inputs applied using bio-based products (biofertilizers, biopesticides, organic fertilizers, and other natural growth stimulating agents) represents one of the ways to improve farmers' competitiveness, both in terms of income and environmental protection (Khandelwal A. et al., 2019).

In this context, studying farmers' perceptions and attitudes, particularly those of local agricultural producers, becomes a key element in ensuring the practical implementation of strategic legislative objectives within the agri-food value chain. Determining the level of acceptance, awareness, and willingness of farmers to adopt new practices and to introduce sustainable products into production processes provides valuable insights for formulating effective public policies, adapting financial support measures, and facilitating innovation in rural areas.

MATERIALS AND METHODS

The present paper aims to develop a conceptual and operational methodological framework to be subsequently applied to the target audience (farmers and/or agricultural producers) in order to study their perceptions and attitudes toward biological agricultural inputs based on natural resources.

To determine the current level of awareness regarding the investigated topic, a qualitative analysis of the relevant scientific literature, as well as of official reports published at the European level, will be conducted.

In order to identify the current behaviour of domestic farmers on the market of agricultural production inputs, a quantitative analysis will be developed based on secondary data provided by the National Institute of Statistics (INS), EUROSTAT, and FAO.

Finally, based on logical reasoning and the correlation of the obtained information, the main research hypotheses will be formulated, to be tested in future studies. These will refer to the socio-economic characteristics of farmers and the specific features of agricultural holdings, as well as to their needs and expectations relevant to the market of agricultural production inputs.

RESULTS AND DISSCUSION

The concept of products based on natural resources ("bio-based products") was first promoted in 2002 by the United States Department of Agriculture through the U.S. Farm Bill, defining them as commercial or industrial products that contain, to a greater or lesser extent, natural resources, renewable agricultural materials, or forestry materials.

In order to promote sustainable agricultural practices and ensure food security, the market for natural fertilizers has been continuously expanding, being estimated at USD 1.38 billion (GVR Report, Biofertilizers Market Size). The European biofertilizers market is expected to experience significant growth, driven by the expansion of the agricultural sector, advances in farming practices, and the increasing awareness of healthy nutrition.

The growing need to improve crop yields and production efficiency influences market evolution, particularly in the context of population growth and the reduction of agricultural land. Conventional agricultural production inputs represent one of the main sources of agricultural pollution affecting the environment.

Nowadays, there is an increasing trend in integrating the concept of biological products within European policies and directives. Specific strategic directions have been formulated to promote products derived from the use of biotechnologies in innovative processes, accompanied by targeted actions to facilitate and encourage the development of biotechnologies and bioindustries across economic sectors, including agriculture.

Figure 1 illustrates the key elements of the main strategic directions defined at the European level for promoting the use of biological products and leveraging technological advancements. Through innovative solutions, biological resources can generate added value within agricultural production processes, thereby supporting the principle of the cascade use of sustainable biomass.

Enhancing farmers' and local producers' understanding of the potential benefits associated with adopting bio-based agricultural inputs across the economic, social, and environmental dimensions of sustainability remains a significant challenge. Studying the behaviour of economic operators is a complex process, with specific characteristics that differentiate it from the study of individual consumer behaviour. Moreover, the specialized literature highlights that one of the main objectives of analyzing the behaviour of economic agents is the anticipation, foundation, and determination of their behavioural patterns in relation to a given subject.

In the specialized literature, studying farmers' attitudes and those of other rural community members regarding the use of biotechnologies in agricultural and industrial production processes has long been a relevant research topic. For example, a study conducted in the United Kingdom (Lynn J. Frewer et al., 1994) employed quantitative research methods to investigate community perceptions of biotechnology applied to food production, as well as perceived risks. Using a questionnaire administered to a sample of 1,499 participants, the study assessed knowledge of the concept, perception of risks and benefits, attitudes toward the application of biotechnology in food production, and the level of trust in information sources. The results indicated a low level of familiarity with food biotechnology, a high perception of risk, and a generally unfavorable attitude toward its benefits. However, respondents' attitudes varied depending on the area of application and trust in information sources, also being influenced by perceptions of the necessity and utility of biotechnology in everyday life.

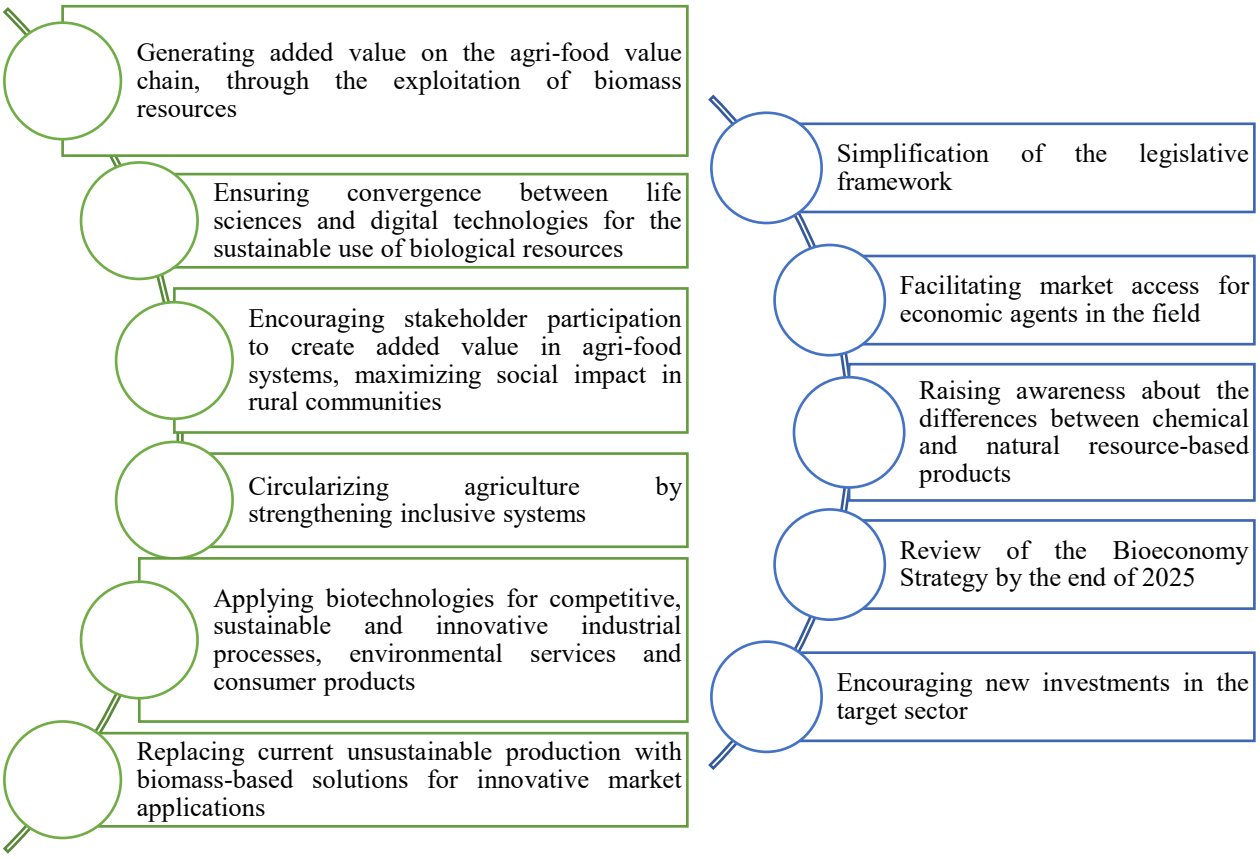

Figure 1. Bio-based products: a link between European strategic objectives and policy directions

Source: author's prelucration (from European Commission (EC), Press Release, March 2024 "Boosting Biotechnology and Biomanufacturing in the EU"; EC, "Bio-based Research and Innovation")

Common barriers to replacing conventional production inputs with bio-alternative products often include farmers' socio-demographic characteristics, such as education level or specialization in agriculture. For example, a study conducted among 150 randomly selected farmers in northern India identified key determinants in their selection of production inputs, including limited agricultural education, insufficient financial resources, and restricted accessibility and availability on local markets (Bodake, H.D. et al., 2009).

Research conducted among European farmers highlights that age is an influential factor in the willingness to adopt bio-alternative products. For instance, a study with 345 respondents in Sweden (Lima, P.D.M. et al., 2024) found that younger farmers showed greater interest in using bio-alternative products and were generally more receptive to innovation-based farm management compared to older farmers. Responses from farmers over 40 years old indicated general reluctance to replace conventional production methods with circular ones, often due to potential biases.

Further studies in other European regions show that socio-demographic characteristics influence the transition from conventional to circular products at the farm level. For example, research among Croatian farmers identified age, farm size, and access to information as key variables affecting farmers' behavior in the production input market (Šatvar Vrbančić, M. et al., 2025). This study, based on a quantitative survey of 203 farmers, indicated that farmers primarily expect a wider variety of products and an optimal balance between benefits and prices. Awareness of nutrient content and soil impact was high, and interest in bio-based products was notable (87.19% would accept products with positive soil effects). Nevertheless, adoption is influenced by higher potential costs, limited information, and uncertainty regarding the performance of innovative products. Regarding willingness to pay, about 47.78% would pay more for superior quality, while only a small proportion (2.96%) would pay more than 25% above conventional product prices.

Similar findings emerge from Italian respondents (Saba A. et al., 2000), who reported low familiarity with biotechnology applications in agriculture, limited awareness, and cautious attitudes toward innovative processes. A significant correlation was found between respondents' trust in information sources, ethical considerations, intrinsic values, and attitudes toward biotechnology-derived products.

A quantitative study across seven European countries (Belgium, Denmark, France, Netherlands, Germany, Hungary, and Croatia) conducted by J. Tur-Cardona et al. (2018) examined farmers' perceptions of bio-based products and product selection criteria, such as nitrogen content, price, organic certification, and raw material origin (agricultural or industrial waste). Results showed that farmers across different countries share common preferences for concentrated products with high nitrogen content available at lower prices than conventional inputs. The study also explained heterogeneity in preferences between countries and farmer groups, depending on agricultural sector characteristics and crop distribution.

Recent quantitative research among European farmers (Garmendia-Lemus S. et al., 2024) indicates generally favorable perceptions of products used in biological control, though adoption barriers remain. Farmers' intentions to use bio-based inputs are influenced by factors such as information level, anticipated benefits, perceived risks, and regional agricultural context. Despite high potential acceptance, reducing negative attitudes arising from uncertainty and low awareness is necessary to increase actual adoption of bio-based products.

At the national level, studies among Romanian farmers (Rodino S., 2025) similarly highlight the importance of awareness regarding the environmental impacts of conventional agriculture on farmers' actual behavior. Key barriers to adopting bio-based products include high initial costs, difficulties accessing non-reimbursable funding, and lack of specialized consultancy, emphasizing the need for support and information mechanisms to facilitate adoption of biological control measures.

Finally, other studies synthesizing quantitative research among Romanian farmers show moderate knowledge and familiarity with sustainable technologies and the bioeconomy, generally positive attitudes toward using bio-based inputs, but adoption is often limited by high costs, low

awareness, and unproven product performance (Petrescu-Mag et al., 2019; Polimeni et al., 2022; Micu et al., 2022). Overall, Romanian farmers mainly recognize the sustainability of their activities as the primary benefit of bio-based products, while economic benefits such as additional income are less frequently acknowledged. Financial resources emerge as the main barrier to adoption.

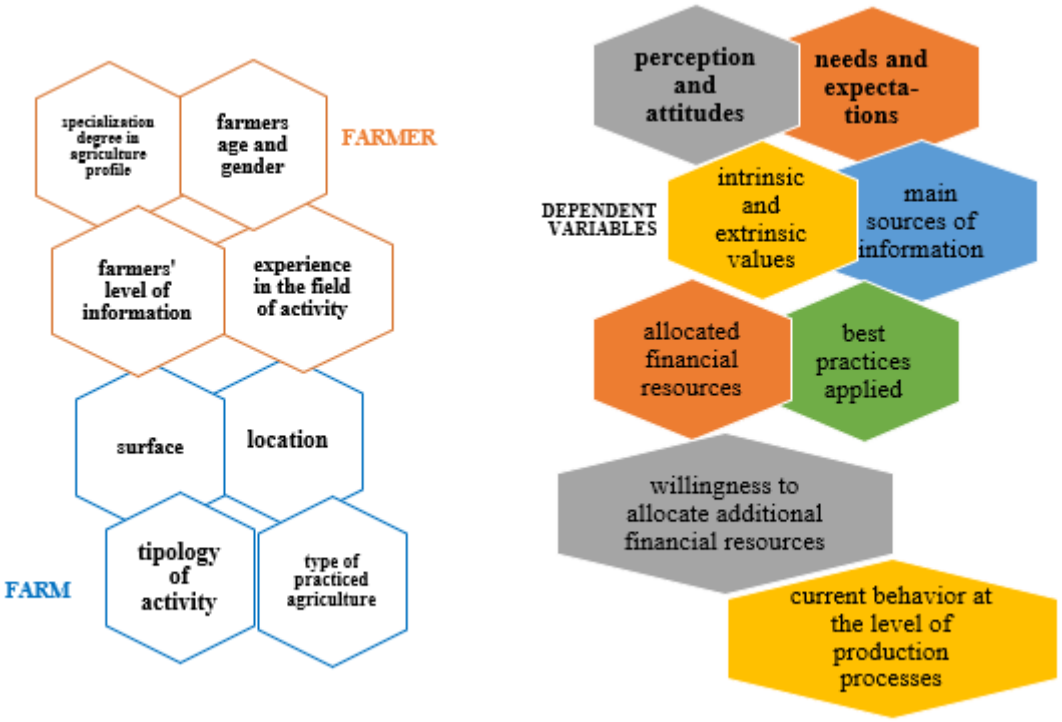

Figure 2. Independent and dependent variables related to quantitative exploratory research;
Source: author's processing, based on specialized literature

Based on the qualitative analysis of previously published studies, the objectives of future research targeting domestic farmers can be formulated, aiming to develop recommendations regarding optimal strategies and policies to increase the adoption of bio-based products at the farm level:

- To determine the level of awareness among farmers regarding alternative, bio-based production inputs and to identify their perceptions of the subject under investigation;
- To assess current practices concerning the technological inputs applied at the farm level;
- To identify the reasons for using conventional and/or bio-alternative solutions;
- To investigate the reasons why farmers have not adopted new bio-based products;
- To evaluate respondents' reluctance toward new types of products;
- To project farmers' and producers' intentions to use bio-alternative solutions in future farm operations;
- To identify the main needs of farmers that new product types should address;
- To determine the key product characteristics in the agricultural input market that influence farmers' purchasing decisions;
- To promote the benefits of using products such as biofertilizers, biopesticides, and natural control agents (biological treatments for pests and diseases) through the dissemination of short informative materials (leaflets, flyers) among the sample population.

Thus, research variables can be defined according to their type, independent and dependent variables, based on the specific research objectives (Figure 2).

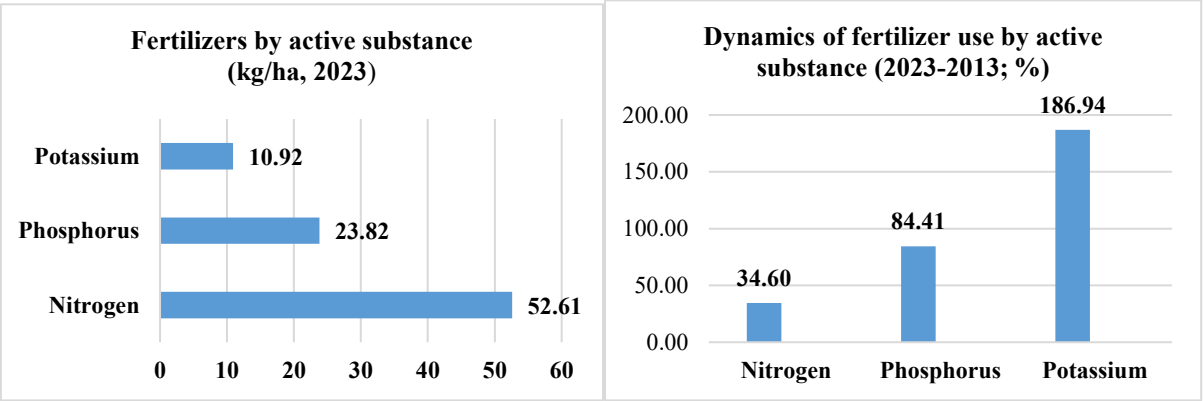

Figure 3. Use of production inputs in agriculture in Romania and their dynamics
Source: FAO data processing - Fertilizers by Nutrient, Time series 2013-2023

Regarding the characteristics of farmers and their farms, the hypotheses of the study can be formulated based on statistical data published in specialized databases (INS, Eurostat, FAO). Additionally, qualitative information obtained from the review of literature on farmers' perceptions and attitudes toward bio-based products can be used to test correlations between the research variables, depending on the frequency of responses collected and analyzed within the sample.

Considering the fertilizers used by farmers, statistical data published by FAO (2023) indicate that, at the national level, nitrogen and phosphorus based fertilizers are predominantly applied across the total utilized agricultural area as well as per hectare. Additionally, there has been a marked increase in the use of potassium-based fertilizers during the period 2013–2023 (Figure 3). Based on these data, research hypotheses can be formulated concerning one of the study objectives, namely the characterization of farms and farmers:

It is estimated that over 90% of agricultural holdings in Romania are individual farms without legal personality, with the majority cultivating less than 5 hectares.

The structure of fertilizer consumption at the national level is dominated by nitrogen-based products, while the demand for potassium-based fertilizers is increasing due to changes in crop structure, low potassium content in soils, and the relatively lower price of these products compared to nitrogen-based fertilizers (Dumitru S. et al., 2024).

Regarding the second category of research hypotheses, it can be mentioned that:

Farmers' age and income likely influence the probability of using bio-alternative production inputs (biofertilizers, biopesticides, etc.) at the farm level.

Higher education levels and specialization in agriculture are positively associated with farmers' intention to introduce bio-based products into agricultural production processes in the medium- and long-term at the farm level.

Farmers' gender influences both awareness of the benefits of using ecological and natural inputs and perceptions regarding the replacement of conventional inputs with bio-based alternatives.

Younger farmers (under 40 years old) tend to show a higher willingness to use bio-based production inputs compared to farmers over 40 years old.

Once the research variables have been conceptually and operationally defined, alongside the research objectives and hypotheses identified during the qualitative analysis stage, the subsequent steps typical of quantitative research can be implemented. This includes administering a questionnaire to domestic farmers/producers, centralizing, and analyzing the responses.

During data processing and simulation in SPSS, correlations between independent and dependent variables (responses to questionnaire items) can be identified and presented in the research results. The existence and strength of these correlations will be determined and calculated using statistical formulas, employing parameters such as the chi-square test and contingency coefficient values (Paraschiv, D.M. et al., 2021).

CONCLUSIONS

This research presents a conceptual and operational approach for developing an optimal methodological framework for conducting quantitative research among farmers and economic operators in Romania, aiming to determine their attitudes, perceptions, and production behaviors regarding the use of bio-based products as production inputs.

By analyzing key European policies and directives, the findings of previous studies, and reference statistical data on farm characteristics, identifying the organizational value set is considered a priority and a defining factor for the results of the present research. Thus, if the economic operator's values include environmental conservation, protection of natural resources, and the importance of ecological considerations in economic activities, it can be assumed that the use of bio-based products in production processes is either an already established strategy or perceived by the respondent as a potential strategy or a future course of action.

Conversely, if the economic operator's values do not sufficiently reflect the economic or ecological component, or if these are only mentioned declaratively, it is highly likely that conventional methods, such as standard plant protection treatments, will be preferred over bio-based inputs for production efficiency. In such cases, the operator's perception can be adjusted, especially since concern for the environment and the conservation of natural resources, along with the application of circular economy principles, ensures the sustainability of agricultural activities, including from an economic feasibility perspective.

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THE ROLE OF THE LEGISLATIVE FRAMEWORK ON THE FINANCING OF AGRICULTURE IN THE SOUTH-EAST REGION

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Abstract: *The research highlights how the legislative framework influences access to finance in agriculture, with application to the South-East Region, one of the most important agricultural areas of Romania. The analysis combines statistical data on the structure of farms, sources of financing and credit conditions with a critical assessment of legislative and institutional instruments. The results show a major dependence on self-financing and a reduced access to bank loans, despite the existence of guarantee and support mechanisms. The complexity of procedures, the lack of legislative predictability and the low degree of capitalization of farmers limit the efficiency of public policies. The study highlights the need for a coherent, stable and investment-oriented regulatory framework that strengthens cooperation between the state, financial institutions and farmers.*

Keywords *agriculture, financing, legislation, public policies, South-East region*

JEL classification: Q14, Q18, G21, R58

INTRODUCTION

Agricultural financing is one of the most sensitive and complex components of the national economy, being directly influenced by the specifics of agricultural activities, the degree of associated risk and the stability of the regulatory framework (Marcuta, 2019). In a sector marked by seasonality, dependence on climatic factors and long investment recovery cycles, the legislative framework has the role of creating a balance between protecting the financial system and ensuring farmers' real access to the necessary capital resources (Dumitru et al, 2017).

In Romania, agricultural financing is regulated by a set of normative acts that aim to stimulate investments, reduce lending risks and integrate national policies into the European framework of the Common Agricultural Policy (CAP). Among the most important regulations are Law no. 231/2005 on stimulating investments in agriculture, Emergency Ordinance no. 43/2013 on the functioning of the Rural Credit Guarantee Fund (FGCR), as well as Law no. 96/2020 on lending to farmers through non-banking financial institutions. These are complemented by legislation related to de minimis aid, subsidies through APIA and support schemes provided for in the National Strategic Plan (PNS) 2023–2027. Legislative mechanisms for financial support include state guarantees, interest rate subsidies, government investment programs, and access to non-reimbursable European funds (Lepadatu, 2024; Stancu et al., 2010). In theory, these instruments are intended to compensate for the reluctance of banking institutions to take on the risks specific to agriculture and to provide farmers with real investment opportunities. In practice, their effectiveness depends on the implementation method, cooperation between public institutions and the banking system, and regulatory stability (Prigoreanu et al., 2025). A coherent legislative framework not only regulates financial flows, but also creates the conditions for development — by reducing bureaucracy, adapting guarantee mechanisms to the size of farms, and stimulating agricultural cooperatives. In the absence of these elements, agricultural financing remains fragmented, dependent on own sources, and vulnerable to external shocks.

As highlighted by Condei et al. (2015), "the greatest chance of Romania on agricultural development is rational and optimal allocation of capital investment in rural infrastructure, farm modernization, expansion of storage-processing enterprises of food products and increase operating capital, both from own sources and of bank loans." This perspective complements the present analysis, emphasizing that the efficiency of agricultural financing policies is closely linked to investment distribution and modernization priorities.

The choice of the South-East Development Region as a space for applied analysis is motivated by the significant role that this area occupies in the agricultural structure of Romania and by its economic and institutional particularities. The region has one of the largest agricultural areas used at national level, concentrating both medium and large commercial farms and a very high number of individual, family-type farms. This structural diversity transforms it into a representative case for studying how the legislative framework influences access to financing in agriculture. At the same time, the South-East is faced with major challenges related to irrigation infrastructure, recurrent climate risks and the low degree of capitalization of farmers, which makes the dependence on governmental and European support mechanisms all the more evident. The analysis of this region thus offers a realistic perspective on how public policies and the regulatory framework contribute to supporting or, on the contrary, limiting the development of Romanian agriculture as a whole.

MATERIALS AND METHODS

The paper uses a mixed approach, combining descriptive analysis of statistical data with qualitative interpretation of the legislative and institutional framework regulating agricultural financing. Empirical data were taken from official data sources, belonging to the National Institute of Statistics and the National Bank of Romania. The analysis targeted indicators such as the structure of financing sources, the loan approval rate, access difficulties and financing destinations. In parallel, a documentary assessment of the main national and European normative acts relevant to agricultural lending was carried out (Law no. 231/2005, GEO no. 43/2013, Law no. 96/2020, PNS 2023–2027). The South-East region was selected as a case study due to its agricultural importance and the structural diversity of farms. The method combines comparative analysis and critical interpretation, aiming to highlight the relationship between regulation, farmers' financial behavior and real access to financing.

RESULTS AND DISSCUSION

The South-East development region has an economic profile strongly marked by agricultural activities, being one of the traditional areas of Romania where agriculture plays a decisive role in employment, land use and rural income generation. The natural conditions – fertile plains, a continental climate favorable to field crops and an important opening to the Black Sea – support a high agricultural diversity. Agriculture continues to be a significant economic pillar of the region, contributing to the stability of the rural environment and to maintaining the socio-economic identity of local communities. In the structure of the regional economy, the share of agricultural land is one of the largest in the country, and agricultural activity is concentrated mainly on small-scale farms, with a pronounced family character. These ensure a large part of the vegetable and animal production intended for both self-consumption and local markets.

Data analysis shows that the region's agriculture is dominated by individual farms, i.e. family households that work relatively small areas, using their own workforce and limited resources.

In parallel, there is a smaller number of units with legal personality, which manage larger commercial farms, oriented towards the market and towards investments in mechanization or technology. This duality between small, traditional farms and large, modern units is specific to the region and influences the access to financing, economic performance and the capacity to adapt to legislative or climate changes.

Table 1. Situation of agricultural holdings in the South-East Region, by categories, in 2020

Indicator	Number of holdings -total	Number of individual holdings	Number of holdings with legal personality
Flowers and ornamental plants	103	86	17
Fodder plants	74535	73853	682
Plants for seeds and seeds	3465	3432	33
Other crops in arable land	841	827	14
Arable land at rest	21339	20982	357
Total arable land	403215	400805	2410
Family gardens	357364	357321	43
Natural pastures and hay	97746	97029	717

Source: own processing, INS, TEMPO-Online Database, AGR30

Table 2. Situation of agricultural area used in the South-East Region, in 2020 (ha)

Indicator	Total holdings	Individual holdings	Holdings with legal personality
Flowers and ornamental plants	65.46	40.56	24.90
Fodder plants	89307.19	46056.26	43250.93
Plants for seeds and seeds	3783.87	1001.25	2782.62
Other crops in arable land	1345.06	358.90	986.16
Arable land at rest	84744.88	41175.01	43569.87
Total arable land	1635829.05	876109.6	759719.45
Family gardens	22485.81	22482.7	3.11
Natural pastures and hay	398237.03	110229.7	288007.33

Source: own processing, INS, TEMPO-Online Database, AGR107A – AGR110A

The distribution of land shows a clear preponderance of arable land, followed by family gardens and natural pastures and meadows. This profile confirms the mixed character of agriculture in the South-East, with a strong orientation towards field crops, but also with a significant component of traditional farming, intended for self-consumption.

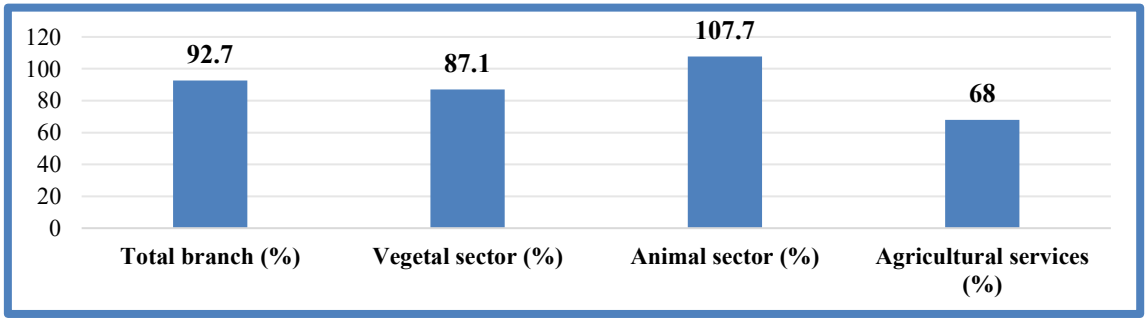

Figure 1. Agricultural production index in the South-East Region, by main branches of agriculture, in 2024

Source: own processing, INS, General Agricultural Census 2020

The areas occupied by fodder plants and natural pastures reflect the importance of the livestock sector, and family gardens, present in almost all rural localities, represent a stable source of food and income for rural households.

According to INS data for 2024, Romania's agricultural production decreased slightly, reaching a total index of 95.7% compared to the previous year. The decrease was mainly due to the crop sector (89.9%), while livestock production increased to 105.1%. The South-East region was below the national average, with a total index of 92.7%, determined by the decrease in crop production (87.1%), affected by drought and high input costs. The livestock sector had a favorable evolution (107.7%), above the national average, indicating a consolidation of meat and milk production. Comparatively, South-Muntenia (104.0%) and Center (102.7%) recorded the best performances, and the North-East and South-West the worst results.

Agriculture in the South-East is characterized by a contrast between the decline of crop production and the positive dynamics of livestock farming, but also by a low level of modern agricultural services. Climatic vulnerability, fragmentation of holdings and low capitalization explain the region's modest performance. In this context, financing becomes a crucial element for stability and modernization. The evolution of the average recorded productions can be attributed to the investments made in high-performance varieties and hybrids with increased resistance to diseases and pests. (Coadă C. et al, 2022) This observation reinforces the idea that access to financing directly influences technological advancement and productivity growth within Romanian agriculture. The lack of financial resources limits investments, maintaining dependence on own sources. Connecting small holdings to formal financing mechanisms – loans, government programs and European funds – is essential, and the legislative and institutional framework plays a decisive role in ensuring equitable access to capital and in strengthening the competitiveness of the agricultural sector in the region. Part of the funding received from the European Union was used by Romanian farmers to build grain storage facilities, which helped farmers get a better price to capitalize on production. (Gimbășanu G. F. et al, 2019)

Table 3. Sources of financing used by agricultural companies in Romania, in 2025

Type of financing	Share of companies (%)
Bank credit	16
Overdraft / Credit lines	17
Trade credit	29
European funds	11
Internal funds (reinvestment, own liquidity)	79
Loans from shareholders / affiliated companies	20
Financial / operational leasing	10
Subsidized / state-guaranteed loans	3
Factoring	1
Capital market financing	0,5

Source: own processing after NBR, Survey on access to financing of non-financial companies in Romania, June 2025 edition

The structure of financing sources in agriculture highlights a major dependence on internal funds, with most companies operating through self-financing – reinvested profits, own liquidity or asset sales. According to the data obtained, the structure of the respondents depending on the extent to which production costs are covered by income from capitalization shows that 67.22% of farmers

manage to cover production costs without problems, 27.78% barely manage to cover the production costs, while 5% fail to cover the production costs. (Gimbășanu G.F. et al, 2022). This reflects a low degree of financial intermediation and a conservative orientation in capital management. Trade credit is the main alternative, used by approximately one third of companies as an informal form of financing, while bank loans and credit lines remain poorly accessed, due to insufficient guarantees and high risk perception. European funds are used to a modest extent, limited by complex administrative procedures, and leasing, state-guaranteed loans and intra-group loans are specific to large companies. Thus, Romanian agriculture remains heavily dependent on its own resources and informal financing, which restricts investment and modernization. Expanding guarantee programs and creating financial instruments adapted to the agricultural sector are essential to increase the competitiveness and resilience of farmers.

Table 4. Difficulties in accessing financing in the agricultural sector, Romania, 2025

Indicator	Value (%)
Credit rejection rate (among companies that applied)	20
Main reasons for rejection – poor financial performance	46
Main reasons for rejection – insufficient collateral/guarantees	30

Source: own processing after NBR, Survey on access to financing of non-financial companies in Romania, June 2025 edition

Data published by the National Bank of Romania (NBR) shows a high rate of rejection of credit applications among agricultural firms, at around one fifth of all applications. This level is significantly higher than the average recorded in other economic sectors, reflecting a heightened risk perception by financial institutions towards the agricultural sector.

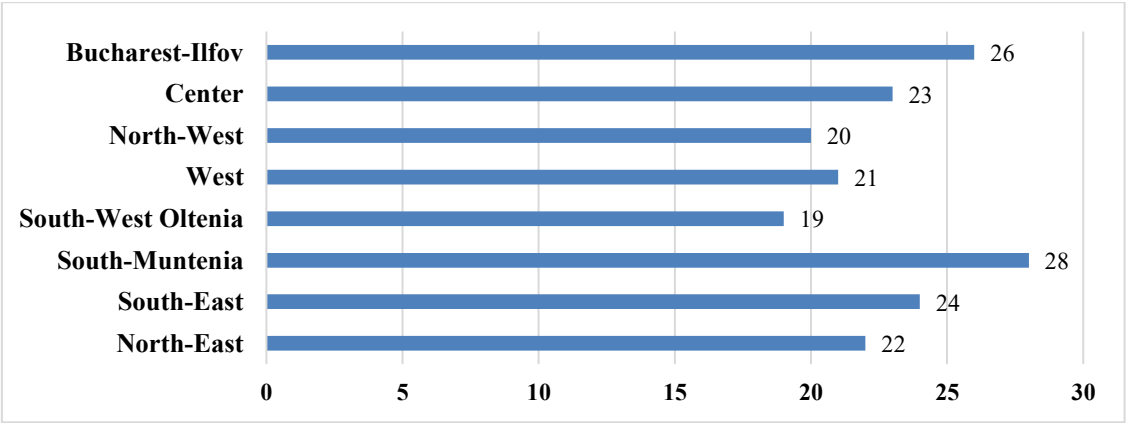

Figure 2. Share of companies that requested bank financing, by development region, Romania, 2025

Source: own processing after NBR, Survey on access to financing of non-financial companies in Romania, June 2025 edition

The main reason for the refusal of financing is the applicant's poor financial performance. Many agricultural holdings have unstable cash flows, high seasonal indebtedness and low profitability, which affect the credit score and repayment capacity. In many cases, the agricultural activity does not have solid or up-to-date financial statements, which reduces banks' confidence in the viability of the business. Another major obstacle is the lack of real guarantees. Agricultural land, although economically valuable, is difficult to use as collateral due to the fragmentation of ownership and legal issues related to cadaster or property titles. The lack of liquid guarantees and credit history makes many banking institutions refuse to grant loans even for viable projects.

This situation highlights the structural vulnerabilities of the Romanian agricultural sector: low capitalization, lack of bankable guarantees and dependence on climatic conditions. The direct consequence is limited access to formal financing, which slows down investments in technological modernization and production infrastructure. To correct these imbalances, it is necessary to expand public guarantee programs, develop agricultural mutual funds and simplify bank assessment procedures. Strengthening the relationship between financial institutions and farmers, through instruments adapted to the agricultural specifics (seasonal loans, guarantee schemes, partnerships with European funds), can contribute to reducing barriers and increasing the degree of bankability of the sector.

The regional analysis of bank financing approvals highlights significant differences between Romania's development regions, both in terms of the degree of credit application and their success rate.

The South-East Region stands out for its highest full financing approval rate (86%), above the national average, indicating a more efficient collaboration between local companies and banking institutions. Although the proportion of companies that applied for loans is average (24%), the results indicate a more solid structure of the applicant companies, better financial preparation of the files and a greater capacity to comply with the guarantee requirements. By comparison, the South-Muntenia Region, although it has the highest share of companies that requested financing (28%), records one of the lowest approval rates (69%). This contrast can be explained by a large volume of applications from small enterprises, with modest financial performance or insufficient guarantees.

In the North-East and Center regions, the approval rate remains relatively high (84% and 80% respectively), but the degree of application is lower, which denotes an increased caution of firms in contracting loans, possibly due to economic uncertainties and high borrowing costs. At the opposite end, the South-West Oltenia and West regions are below the national average, with success rates between 72% and 74%, reflecting a lower level of financial stability and a higher concentration of risks. In the Bucharest–Ilfov area, the performance is relatively good (82%), but the proportion of firms applying for loans remains low compared to the economic potential of the region, which suggests a preference for internal financing or other capital instruments.

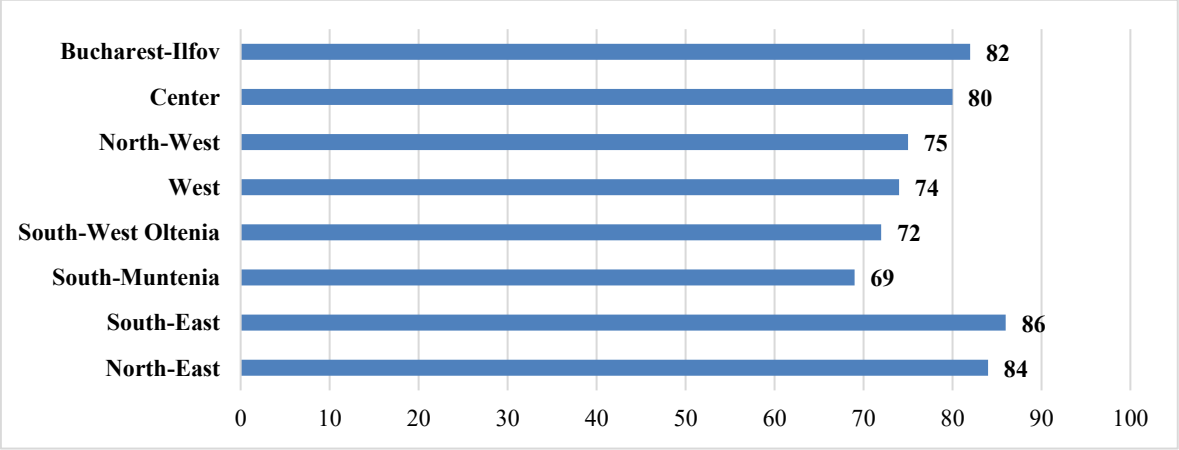

Figure 3. Loan approval rate, by development region, in 2025

Source: own processing after NBR, Survey on access to financing of non-financial companies in Romania, June 2025 edition

The results show that the South-East is among the best performing regions in terms of access to finance, benefiting from a favorable combination of moderate credit demand and high approval rates. This indicates an improvement in financial discipline, company transparency and trust in the banking system, essential conditions for strengthening the agricultural and non-agricultural business environment in the region.

Table 5. Destination of financing attracted by agricultural companies in Romania, in 2025

Purpose of financing	Share of companies (%)
Constitution of working capital	22
Investments in buildings, land, equipment	9
Development or launch of new products	4
Refinancing of other bank debts	3
Increasing the degree of innovation / digitalization	3
Employment and training of personnel	3
Other purposes	5
Companies that did not resort to external sources	65

Source: own processing after NBR, Survey on access to financing of non-financial companies in Romania, June 2025 edition

The results show that the main destinations of external financing are the formation of working capital and, to a much lesser extent, investments in fixed assets. The high share of financing oriented towards working capital highlights the fact that most agricultural companies use financial resources to cover current expenses — raw materials, labor, energy costs — and not for the development of production infrastructure or technological modernization. Investment destinations, such as the acquisition of land, equipment or buildings, have a low frequency, which suggests a cautious and short-term oriented financial behavior. Investments in innovation, digitalization or personnel training have marginal shares, reflecting the difficulty of accessing financing intended for activities with higher risk or delayed profitability.

It is also worth noting the high proportion of firms that did not resort to external sources of financing (65%), which confirms the high degree of self-financing of the agricultural sector and the dependence on own resources. This financing model limits the capacity of farms to expand and reduces the positive impact of financial support policies carried out through the banking system or through European programs.

Table 6. Evolution of credit conditions perceived by Agricultural companies in Romania, in 2025

Condition analyzed	Increase (%)	Constant (%)	Decrease (%)
Interest rate level	36	60	4
Non-financial costs	31	64	5
Availability of loan / line of credit	18	76	6
Loan maturity	15	80	5
Collateral requirements	18	78	4

Source: own processing after NBR, Survey on access to financing of non-financial companies in Romania, June 2025 edition

The data in Table 6 highlight a slightly more favorable perception of lending conditions compared to the previous year, but with important challenges remaining. Approximately one third of companies reported an increase in interest rates and non-financial costs, indicating persistent pressures on the total cost of financing. Despite these developments, most companies consider that contractual parameters (loan maturity, credit availability, level of guarantees) have remained constant, which indicates a stabilization of banking policies after the period of monetary adjustments in previous years. The moderate increase in collateral requirements (18% of companies) reflects the prudence of financial institutions towards sectors perceived as risky, such as agriculture.

However, the reduction in the share of those who perceive a "tightening" of conditions compared to previous years suggests a gradual relaxation of lending standards, favored by macroeconomic stability and government guarantee programs. Overall, the perception of agricultural companies remains balanced: the cost of credit is high, but access is no longer considered the main obstacle. The central issue remains the financial sustainability of small farms, which cannot bear the costs of credit in the absence of specific support mechanisms.

CONCLUSIONS

The analysis highlights that, although Romania has a complex legislative framework aimed at supporting access to finance in agriculture, the concrete effects on the sector are uneven and often limited by administrative and institutional dysfunctions. Financial support measures, such as guarantees offered by the Rural Credit Guarantee Fund (FGCR) or state aid schemes for investments and working capital, have proven useful in facilitating credit for large farmers and agricultural companies, but their impact remains limited in the case of small farms and individual farmers, who constitute the majority of the sector. The results presented above show that only a small proportion of agricultural companies (around 16–17%) access bank loans, while self-financing and commercial credit remain the main sources of capital. This situation reflects a gap between legislative objectives and realities on the ground. Although the legislation aims to encourage investment and modernization, the lack of a unified coordination mechanism between financial institutions, the FGCR and public authorities generates uncertainty and delays in the financing process. Small farmers frequently face disproportionate collateral requirements, excessive bureaucracy and non-uniform interpretations of eligibility rules, which discourage them from accessing the available instruments. In the South-East Region, where individual holdings and small-scale farms predominate, these limitations become more evident. Although the region stands out for its highest loan approval rate (86%), the volume of applications remains modest, indicating a potential unmet demand. The current legislative framework theoretically supports the expansion of rural lending, but in practice procedural barriers and the lack of a financial advisory system adapted to the rural environment limit the effectiveness of the measures.

On the other hand, national legislation is closely influenced by European rules on the Common Agricultural Policy (CAP), which impose high standards of compliance and reporting. In the current context, European funds for agricultural investments are managed in accordance with the EAFRD and NSP 2023–2027 regulations, but the degree of access is still low. The insufficient correlation between the legislation implementing European programs and the banking legislation makes it difficult to co-finance investment projects, and farmers face difficulties in covering their own contribution. The results analyzed outline a picture in which legislative stability and the predictability of economic policies are determining factors for confidence in the financial system. Frequent changes in fiscal rules, changes in support programs and cumbersome administrative procedures affect both the availability of credit institutions and the decision of farmers to borrow. In the absence of clear coordination between agricultural, fiscal and banking policies, legislation risks becoming a source of uncertainty rather than an instrument to facilitate financing.

In the future, improving the legislative framework should aim at simplifying guarantee procedures, digitizing file evaluation flows, as well as introducing specialized financial products for agriculture, adapted to the seasonality of income and climate risks.

At the same time, strengthening agricultural cooperatives and recognizing them as eligible beneficiaries for guaranteed loans can contribute to expanding the financing base. Only through a coherent legislative approach, oriented towards predictability, partnership and financial education, can Romanian agriculture — and especially that of the South-East Region — overcome dependence on its own sources of capital and fully capitalize on the opportunities offered by the financial system and European funds.

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EVOLUTION OF TOMATO CROP MANAGEMENT IN PROTECTED AREAS IN ROMANIA DURING 2016–2024

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Abstract: *The paper analyzes the evolution of tomato crop management in protected areas in Romania during the period 2016–2024, with the objective of identifying development trends and the main factors influencing the economic and technological performance of the horticultural sector. The study uses statistical data extracted from the Eurostat database – Crop production in national humidity (apro_cpnh1), supplemented with information from the National Institute of Statistics and the reports of the European Fruit and Vegetable Market Observatory. The analysis focused on the main indicators of the sector: the total area cultivated with tomatoes in protected structures, the surface cultivated in heated greenhouses, total production, average yield, and the production index for the period 2016–2024. Through comparative statistical methods and cause–effect analysis, the relationships between technological investments, public policies, and production performance were identified. The results reveal a cyclical evolution of the sector, characterized by an expansion phase between 2016–2018, supported by the national "Tomata" program, a stabilization phase between 2019–2021, and a contraction after 2021 caused by rising energy costs and the reduction of financial support. Yields decreased from 26.4 t/ha to 12 t/ha, illustrating the vulnerability of small farms to economic and climatic fluctuations. The conclusions highlight the importance of adopting an integrated and adaptive management model for protected tomato cultivation, based on energy efficiency, technological innovation, and strategic planning, as key elements for ensuring the competitiveness and sustainability of Romania's tomato production sector.*

Keywords *tomato cultivation; protected areas; greenhouse management; production efficiency; technological innovation; Romania*

JEL classification: Q13, Q16, Q18, O13, M11

INTRODUCTION

Tomatoes represent one of the most important horticultural crops in Europe, both economically and socially, due to their high consumption levels, nutritional value, and contribution to the diversification of diets. At the level of the European Union, the area cultivated with tomatoes in protected structures has increased steadily over the past two decades, and Romania ranks among the main producers in Central and Eastern Europe (Marin et al., 2020). According to Eurostat data, tomato cultivation accounts for a significant share of national horticultural output, remaining one of the most dynamic and profitable branches of Romanian agriculture.

Production in protected areas—greenhouses and solariums—plays a crucial role in ensuring food security, stabilizing farmers' incomes, and reducing seasonal market fluctuations. By allowing continuous production during off-season periods, this system contributes to the reduction of import dependency and to the availability of locally produced vegetables throughout the year. Beyond its economic value, protected cultivation also has a strong social function, by maintaining rural employment and supporting short food supply chains that sustain local communities and promote rural development (Drăghici et al., 2021).

From an environmental perspective, protected cultivation systems represent an efficient adaptation strategy to climate change, offering partial control over critical factors such as temperature, humidity, and light intensity, thereby reducing the risks associated with extreme weather events (Cărbunar et al., 2022). Conventional agriculture involves maximizing yields using industrial products, based on monoculture; monoculture has a significant impact on soil fertility and viability

(Gimbășanu et al., 2022). However, these technological advantages are accompanied by high investment and energy costs, which increase the importance of managerial competence in maintaining economic efficiency and sustainability.

In Romania, the management of tomato cultivation in protected areas has undergone significant transformation since the implementation of the *"Tomata"* national support program, which stimulated investments in greenhouse infrastructure, technology, and high-performance planting material. This program created favorable conditions for the modernization of small and medium-sized farms, the extension of production cycles, and the professionalization of growers (Avasiloaiei et al., 2025). The economic and technological impact of these measures has been visible through the expansion of protected surfaces and the diversification of production systems across the country.

Tomato crop management encompasses a broad range of activities, including production planning, technological selection, cost control, labor organization, and strategic decision-making regarding marketing and investments. According to Mărcuță et al. (2013), the concept of Supply Chain Management (SCM) highlights the need to integrate all business processes—from suppliers to end users—to improve efficiency and competitiveness. This integrated perspective is directly applicable to protected tomato cultivation, where input procurement, production scheduling, and market delivery must operate as interdependent components of the same management system.

In the current context, marked by rising energy prices, labor market volatility, and increasing competition from imported products, the performance of the protected horticulture sector depends heavily on management capacity—the ability to balance costs and revenues, ensure product quality, and adapt to climatic and economic changes. The value chain approach allows the identification of structural inefficiencies that limit competitiveness and reduce the capacity of producers to adapt to market fluctuations (Tudor V., 2018) He current business environment is a volatile one, which makes it difficult for managers when it comes to making objective and reliable decisions. (Mărcuță A. et al, 2024).

Therefore, this paper aims to analyze the evolution of tomato crop management in protected areas in Romania during 2016–2024, by examining key indicators such as surface area, production, yield, and production indices. The research seeks to highlight the extent to which managerial decisions, public policies, and technological adoption have influenced the efficiency, competitiveness, and sustainability of Romania's protected tomato production systems.

MATERIALS AND METHODS

The paper is based on a descriptive–analytical approach to the evolution of tomato cultivation in protected areas in Romania during the period 2016–2024. The data used in the analysis were obtained from the Eurostat database, supplemented with statistical information from the National Institute of Statistics and reports of the European Fruit and Vegetable Market Observatory. The selected timeframe was chosen to capture the effects of the *"Tomata"* national support program and the main economic and structural changes that have influenced the sector in recent years.

The research focused on the following key indicators: total surface area cultivated with tomatoes in protected structures (ha); surface area cultivated in heated greenhouses (ha); total harvested production (1000 t); average yield (t/ha); production index (base year = 2015).

The dataset was processed using comparative statistical analysis methods, emphasizing the annual rate of change and the correlations among variables. Time series data were graphically represented to provide a clearer understanding of sectoral trends and to highlight fluctuations in performance.

The methodological approach combined quantitative analysis with cause–effect interpretation, aiming to identify the influence of economic, technological, and climatic factors on the performance of tomato production in protected areas. The relationship between surface area, production, and yield was examined to assess the efficiency of management decisions applied at the farm level.

Finally, the results were interpreted in a comparative context, by relating Romania's performance to the European Union averages, in order to underline the particularities of national management practices, as well as the main challenges generated by rising production costs and the transition toward sustainable cultivation technologies.

RESULTS AND DISSCUSION

The analysis of tomato crop management in protected areas in Romania between 2016 and 2024 reveals important structural and technological transformations in the horticultural sector. These developments were strongly influenced by public policies, especially the national *"Tomata"* support program, by investments in production infrastructure, and by the broader economic and climatic environment.

Over this period, producers have faced increasing challenges related to energy costs, input price volatility, and labor shortages, which have forced them to adopt adaptive management practices. The high percentage of raw material used directly from the farm can be attributed to the fact that farmers fail to capitalize the production either by processing it into finished products or integrating it into animal feed, due to the lack of processing capacity at farm level (Gimbășanu G/F. et al, 2022). The modernization of irrigation systems, the introduction of high-performance hybrid varieties, and the gradual digitalization of production monitoring have become key tools for maintaining competitiveness. At the same time, regional disparities in productivity and profitability have highlighted the unequal access to technology and financing among Romanian farms.

By correlating production, surface area, yield, and production indices, the study provides a comprehensive view of how farmers adapted their management strategies to changing conditions and how these adaptations affected the efficiency and sustainability of protected horticulture. The results also reflect the capacity of the Romanian horticultural sector to integrate innovation and policy support into practical decision-making, contributing to the long-term viability and resilience of tomato production under protected cultivation. Improving the performance of horticultural chains requires coordinated managerial decisions, targeted investments, and stronger cooperation between farmers and processors. (Tudor V., 2018)

Tomato production in protected areas registered a positive dynamic until 2020, increasing from approximately 21.8 thousand tons in 2016 to a maximum of 31.5 thousand tons in 2020. This growth reflects the expansion of greenhouse and solarium areas supported by the "Tomata" program and the modernization of small farms. After 2021, production began to decrease gradually, reaching around 18.1 thousand tons in 2024. The decline was influenced by higher production costs, reduced financial incentives, and fluctuating climatic conditions affecting unheated greenhouses. Overall, production fluctuated within the range of 18–31 thousand tons, showing a tendency toward stabilization at a lower level.

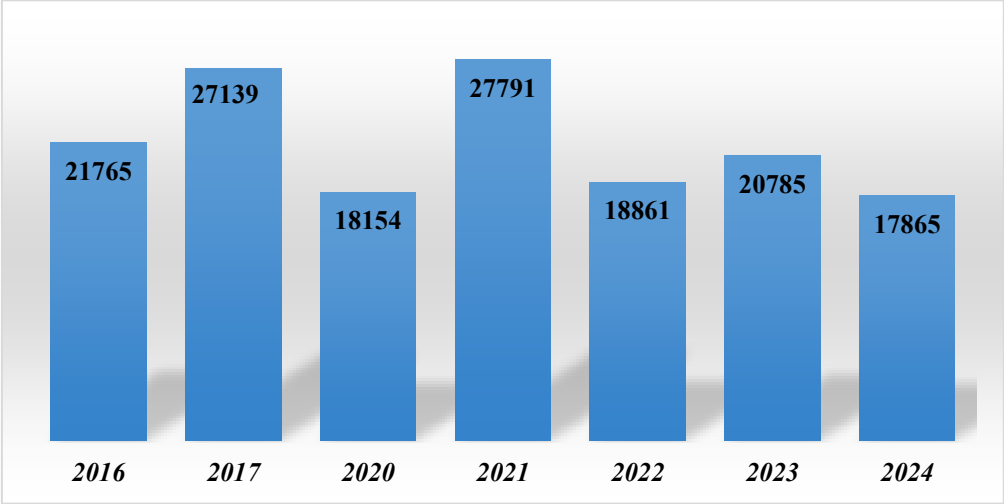

Figure 1. Evolution of tomato production in protected areas in Romania, 2016–2024 (thousand tons)

Source: own processing, Eurostat (apro_cpnh1), 2025

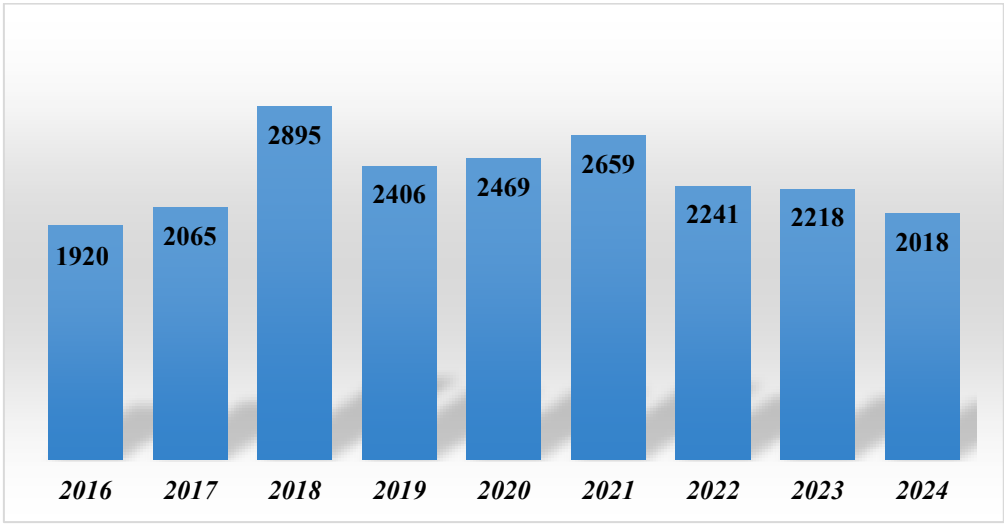

Figure 2. Evolution of the area cultivated with tomatoes in protected areas in Romania, between 2016–2024 (ha)

Source: own processing, Eurostat (apro_cpnh1), 2025

The total surface under tomato cultivation in protected areas increased steadily in the first part of the analyzed period, from approximately 1,920 ha in 2016 to almost 2,900 ha in 2018. This expansion was mainly caused by the implementation of the national "Tomata" program, which encouraged farmers to build or rehabilitate greenhouses and unheated solariums. Access to European and national funding instruments, as well as credit guarantees through the Rural Credit Guarantee Fund (FGCR), further facilitated investment in infrastructure such as irrigation systems, plastic coverings, and microclimate control systems.

Between 2019 and 2021, the total area stabilized around 2,600 ha, indicating a phase of market maturity and the alignment of production capacity with domestic demand. After 2021, however, the total area declined gradually to about 2,000 ha in 2024, as a result of rising input and energy costs, reduced direct subsidies, and increased competition from imported vegetables. The combined effect of these factors led to a contraction in the total protected surface, as smaller producers withdrew from the market and larger farms optimized production on smaller, better-equipped areas.

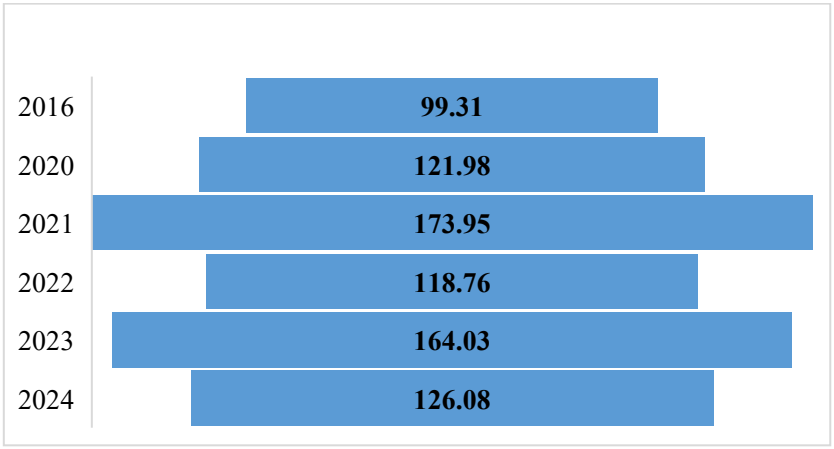

Figure 3. Evolution of the area cultivated with tomatoes in heated spaces in Romania, between 2016–2024 (ha)

Source: own processing, Eurostat (apro_cpnh1), 2025

The area cultivated in heated greenhouses remained a small but strategically important component of the protected horticulture sector. It increased from 99 ha in 2016 to 174 ha in 2021, reflecting the growing interest in early-season production, extended cultivation cycles, and high-yield, technology-based systems. This growth was an effect of greater access to modern heating technologies, automation, and high-performance hybrid varieties, allowing continuous production during the cold season.

After 2021, however, the area cultivated in heated greenhouses declined to about 126 ha in 2024. This downward trend was caused primarily by the sharp rise in energy prices, especially gas and electricity, as well as by the limited financial capacity of medium-sized farms to sustain energy-intensive production systems. High operational costs, combined with dependence on imported materials (heating systems, covering materials, irrigation equipment), discouraged new investments.

As a result, the share of high-tech greenhouses within total protected surfaces decreased, although a technologically stable core of modern enterprises continues to operate, ensuring the continuity of off-season tomato production in Romania.

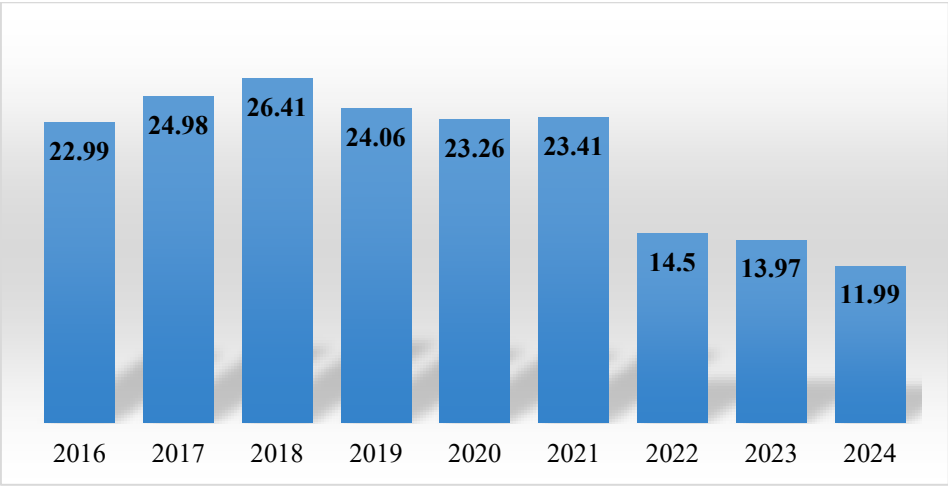

Figure 4. Evolution of tomato crop yield in protected areas in Romania, between 2016–2024 (tons/ha)

Source: own processing, Eurostat (apro_cpnh1), 2025

Tomato yields under protected cultivation increased from 22.9 t/ha in 2016 to a maximum of 26.4 t/ha in 2018, demonstrating improvements in production technology, crop management, and the adoption of hybrid varieties with higher productivity potential. These gains were the direct effect of targeted investments in fertigation systems, drip irrigation, and greenhouse microclimate management, as well as knowledge transfer from EU horticultural practices. Starting with 2020, yields began to decline sharply, reaching only about 12 t/ha in 2024, a reduction of more than 50% compared to the peak value.

This deterioration was caused by a combination of factors: Reduced technological input use, due to higher prices for fertilizers and plant protection products; Lower irrigation efficiency and the limited use of heating systems, especially in unheated solariums; Adverse climatic events, such as prolonged heat waves and droughts, that reduced fruit quality and shortened the production cycle.

The cumulative effect of these challenges led to a significant decline in production efficiency, eroding the competitive advantage of protected tomato cultivation and emphasizing the sector's vulnerability to energy and input price fluctuations. Traditional indicators that reflect economic performance must be replaced by alternative indicators, such as financial ratios or indicators of economic value creation. (Mărcuță A. et al, 2024)

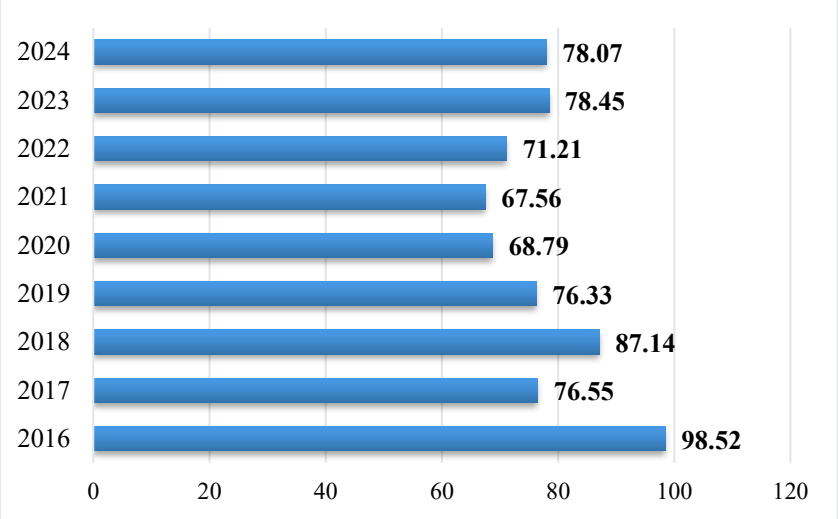

Figure 5. Tomato production index in protected areas in Romania, 2016–2024, (base year = 2015) (%)

Source: own processing, Eurostat (apro_cpnh1), 2025

The tomato production index in protected areas fluctuated significantly throughout the analyzed period, reflecting the combined influence of economic, technological, and environmental factors on production stability.

In 2016, the index stood close to 98 %, indicating that output was almost identical to the base year (2015). Between 2017 and 2018, the index improved modestly, consistent with the observed expansion of protected surfaces and higher yields during that time. However, starting in 2020, the production index declined sharply to approximately 70 %, mirroring the contraction in yield and the gradual withdrawal of small producers from the market. This drop corresponds to the period marked by energy price surges, input cost inflation, and changes in the national subsidy framework, which jointly reduced the profitability of protected tomato farming.

A partial recovery is visible after 2023, when the index rose again to about 78 %, suggesting that producers began adapting through technological streamlining, reduced input use, and a focus on more resilient varieties.

Despite this rebound, production levels in 2024 remained well below those achieved during the 2016–2018 period, highlighting the structural fragility of the sector.

CONCLUSIONS

The analysis of tomato crop management in protected areas in Romania over the period 2016–2024 reveals a strong interdependence between managerial decisions, technological progress, and agricultural policies that have shaped the performance of the horticultural sector. The dynamics of this segment demonstrate that economic and technical results depend not only on the level of investment but, above all, on how resources are planned, coordinated, and optimized through coherent and adaptive management practices.

Based on the data analyzed, three main stages of development can be identified: an expansion phase (2016–2018), marked by the increase in cultivated areas and modernization of infrastructure following the implementation of the *"Tomata"* program; a stabilization phase (2019–2021), when efforts focused on optimizing production cycles and improving efficiency; and a contraction phase (after 2021), influenced by higher energy and input prices and the reduction of direct financial support. This sequence confirms that agricultural management must be viewed as a dynamic process, continuously adapting to economic, environmental, and policy changes.

The findings demonstrate that management efficiency in protected tomato cultivation depends directly on farmers' ability to implement flexible and innovative strategies. Farms that adopted fertigation, automated irrigation, climate control, and digital monitoring technologies were able to maintain higher yields and reduce resource losses. In contrast, those without access to financial support or technical expertise proved more vulnerable, recording significant declines in production and profitability.

The evolution of yields—from a peak of 26.4 t/ha in 2018 to approximately 12 t/ha in 2024—illustrates the importance of management strategies centered on energy efficiency and technological innovation. The decline observed in recent years is not only a consequence of increased production costs but also of lower-quality inputs, extreme climatic conditions, and a shortage of skilled labor. These challenges underline the need to reorient management strategies toward continuous training, knowledge transfer, and the digitalization of production processes.

The study also highlights the growing relevance of integrated management approaches in horticulture. In line with the principles of Supply Chain Management, the competitiveness of an agricultural enterprise depends not only on internal efficiency but also on its ability to integrate all elements of the supply and distribution chain—from input suppliers to the final consumer. Farms that developed cooperative models, partnerships with retailers, or direct marketing platforms demonstrated greater resilience to price volatility and improved market positioning.

At the territorial level, the research reveals significant regional disparities between southern and northwestern Romania, indicating that agricultural policies and investment programs must be adapted to local realities. Unequal access to modern technology, markets, and financial instruments generates competitiveness gaps that can be reduced through integrated policies focused on education, advisory services, and the development of logistics infrastructure.

From a strategic perspective, the future of tomato crop management in protected areas will depend on the capacity of farmers to shift from a volume-based model to one oriented toward value creation and sustainability. Future priorities include reducing the energy footprint, improving water-use efficiency, adopting precision agriculture techniques, and strengthening producer associations to

increase market power and bargaining capacity. Implementing these measures can transform Romania's horticultural sector into a model of regional competitiveness and adaptation to the European Green Deal.

In conclusion, the analyzed period demonstrates that the management of tomato crops in protected areas constitutes a strategic pillar of Romanian agriculture, where success depends directly on the quality of managerial decisions. Effective planning, technological integration, efficiency orientation, and farmer cooperation are essential conditions for building a competitive, resilient, and sustainable horticultural sector capable of responding to the challenges of a rapidly changing economic and climatic environment.

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ANALYSIS OF TRENDS AND PERFORMANCE OF SWEET AND SOUR CHERRY CROP MANAGEMENT IN ROMANIA, COMPARED TO OTHER EUROPEAN UNION COUNTRIES

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Abstract: *The paper aims to analyze the trends and performance of sweet and sour cherry crop management in Romania, compared to other European Union member states, during the period 2020–2024. The research starts from the economic and ecological importance of these fruit species, highlighting their role in diversifying agricultural production and supporting rural development. The methodology was based on the processing of official data from the Eurostat database, and the analysis included all EU-27 member states. Descriptive and comparative analytical methods were applied, such as the calculation of production variation rates, multiannual averages, annual growth rates, and the evaluation of Romania's share in the total production of the European Union. The results reveal a fluctuating evolution of production, influenced by climatic, technological, and managerial factors. Romania holds a medium position among European producers, showing a higher potential in sour cherry cultivation and a lower performance in sweet cherry production. The conclusions emphasize the need to modernize orchards, to accelerate the digitalization of agricultural processes, and to strengthen cooperation among producers in order to enhance the competitiveness of the national fruit-growing sector.*

Keywords *agricultural performance, production management, fruit market, competitiveness, Romania*

JEL classification: Q13, Q16, Q18, O13

INTRODUCTION

The cultivation of sweet and sour cherry holds a strategic position in both Romanian and European fruit-growing sectors, not only due to the economic value of the harvested fruits but also because of their high industrial processing potential and contribution to rural development. These two fruit species significantly diversify horticultural production and support farmers' incomes in hilly and sub-mountainous areas, where pedoclimatic conditions are favorable for orchard development (Soare et al., 2018).

Their importance goes beyond the economic dimension, having an essential ecological component. Recent research highlights the role of entomophilous pollination in ensuring the stability and value of fruit production, which requires an integrated approach to orchard and biodiversity management (Popescu, 2021). In the absence of efficient management of pollinators and environmental factors, yields of sweet and sour cherry crops become vulnerable, directly affecting farmers' competitiveness (Sotirov et al., 2024).

From a technological perspective, the adoption of precision solutions, modern irrigation systems, and mechanization specific to stone fruit cultivation is considered a decisive factor for increasing productivity and reducing risks associated with climatic variability (Beluhova-Uzunova et al., 2020). At the same time, studies on the European sour cherry market show that producers' income stability and price levels are strongly influenced by contractual relations with processors and by the degree of integration into value chains (Kierczyńska, 2021).

Regarding product quality and competitiveness, recent research on Romanian sweet cherry varieties emphasizes the need for correlation between physical attributes and technological parameters, confirming the importance of applied research and innovation in fruit growing (Zoican

& Baicu, 2024). In vitro embryo culture represents an important tool for obtaining viable plant material from genotypes that are difficult to propagate through conventional methods (Asănică A. et al, 2016). In this context, a comparative analysis between Romania and other European Union member states becomes essential to highlight not only production performance but also adaptive management capacity (Trifan et al., 2025). Identifying the strengths and vulnerabilities of the national fruit sector provides the foundation for developing strategic directions aimed at modernizing the industry and increasing the sustainability of sweet and sour cherry orchards. The value chain approach provides a comprehensive analytical framework that highlights the interdependencies between production, processing and marketing activities, emphasizing the need for coordinated actions among all actors involved (Tudor V., 2018)

MATERIALS AND METHODS

The analysis presented in this paper is based on official statistical data provided by Eurostat. The information was collected for the period 2020–2024, corresponding to the most recent complete series available for the indicators related to sweet and sour cherry production in the member states of the European Union.

Methodologically, the research combines descriptive and comparative analytical tools. The study includes: time series analysis, to identify production growth or decline trends; cross-country comparison, ranking countries according to the average production for 2020–2024; percentage variation calculation between 2020 and 2024; determination of the compound annual growth rate, an indicator reflecting performance and production stability during the analyzed period; and assessment of Romania's share in the total production of the European Union, expressed as a percentage.

Data processing was carried out using Microsoft Excel, applying formulas for arithmetic mean, relative variation, and descending ordering. The results were synthesized into thematic tables that illustrate production dynamics for each crop and Romania's position compared to the main European producers (Poland, Italy, Spain, Germany, and Greece).

The methodology follows a quantitative–qualitative interpretation, in which numerical indicators are correlated with explanatory economic, technological, and managerial factors, providing a comprehensive perspective on the performance and competitiveness of Romania's fruit-growing sector.

RESULTS AND DISSCUSION

The period 2020–2024 represented an important transition phase for the European fruit-growing sector, marked by economic, technological, and climatic factors that directly influenced the performance of perennial crops. In this context, the analysis of sweet and sour cherry production trends provides a relevant overview of the adaptability and efficiency of horticultural management, both at the level of the European Union and in Romania.

The years under review were also characterized by post-pandemic market adjustments and by significant input cost fluctuations, which affected both production planning and profitability across many European orchards. Effective production planning in perennial fruit crops requires aligning orchard capacity with technological, climatic and market conditions, ensuring that annual yield objectives are both realistic and economically sustainable. (Tudor V. et Alecu A., 2013)

The data presented in the following tables were processed based on Eurostat statistics and focus on the main trends in annual production, national shares in the total EU output, multiannual averages, and average growth rates.

By correlating these indicators, it is possible to assess not only the competitiveness level of each member state but also the degree of production stability in relation to climatic variability and sectoral support policies. Such comparative evaluation makes it possible to identify structural differences between intensive and extensive orchard systems, as well as the extent to which technological innovation contributes to improving resilience and long-term productivity. Strengthening cooperation among producers and processors is essential for improving product quality, stabilizing prices and increasing the competitiveness of horticultural chains. (Tudor V., 2018)

Table 1. Evolution of sweet cherry production in the European Union and Romania, 2020–2024 (thousand tones)

Country	2020	2021	2022	2023	2024	Average 2020-2024
EU-27	75751.6	74296.7	69811	68037.1	-	71974.1
Belgium	572.74	614.33	599.63	597.56	438.6	564.572
Bulgaria	361.68	404.43	383.9	327.41	339.66	363.416
Czechia	231.63	229.51	251.74	200.62	120.79	206.858
Denmark	52	41.95	34.69	25.37	30.39	36.88
Germany	2351.67	2324.29	2476.34	2286.91	2095.07	2306.86
Estonia	2.58	2.91	6.17	1.75	3.46	3.374
Ireland	19.89	16.28	23.78	22.5	22.52	20.994
Greece	5368.68	4757.98	5289.19	4689.3	5029.45	5026.92
Spain	26186.7	25538.1	18980.6	20150	23771.2	22925.3
France	8839.22	7648.4	9156.42	9315.67	7872.01	8566.34
Croatia	298.37	263.42	279.83	250.53	285.18	275.466
Italy	18995	18347.1	19226.7	17228.5	18518.5	18463.2
Cyprus	132.24	126.88	130.05	116.14	114.09	123.88
Latvia	18.5	12.8	15.02	10.2	18	14.904
Lithuania	64.17	48.45	64.53	47.8	69.67	58.924
Luxembourg	14.83	14.6	13.52	12.35	11.99	13.458
Hungary	1004.38	1130.5	970.37	1076.13	958.73	1028.02
Malta	4.27	4.29	5.16	4.48	3.47	4.334
Netherlands	661.2	625.12	626.6	591.14	554.51	611.714
Austria	694.76	620.1	685.52	565.1	527.75	618.646
Poland	4378.1	4903.6	5178	4744.8	4054.7	4651.84
Portugal	2720.73	3724.77	2898.17	3316.89	3523.41	3236.79
Romania	2468.64	2658.66	2240.99	2217.67	2018.1	2320.81
Slovenia	187.13	112.54	146.74	119.55	135.34	140.26
Slovakia	79.99	78.65	81.27	71.72	86.41	79.608
Finland	10.26	11.6	11.19	11.04	13.36	11.49
Sweden	32.22	35.43	34.85	35.97	34.15	34.524

Source: own processing based on Eurostat data

For Romania, the analysis offers a perspective on the performance of orchard management, highlighting the country's capacity to maintain or increase production relative to the EU-27 average. Comparison with the main European producers – Poland, Italy, Spain, Germany, and Greece – outlines a clear picture of Romania's competitive position within the European stone fruit market.

The analyzed data highlight a fluctuating evolution of sweet cherry production within the European Union, mainly determined by climate change and the adaptability of production systems. During the analyzed period, countries with modern agricultural infrastructure managed to mitigate the effects of weather variability, while those with limited investment in protection and irrigation technologies recorded decreases in yields.

Table 2. Evolution of sour cherry production in the European Union and Romania, 2020–2024 (thousand tones)

Country	2020	2021	2022	2023	2024	Average 2020-2024
EU-27	827.02	842.78	933.16	849.66	762.26	842.976
Belgium	6.58	3.38	9.4	8.05	4.58	6.398
Bulgaria	57.14	57.03	58.18	49.5	53.79	55.128
Czechia	6.73	6.33	6.28	4.77	1.86	5.194
Denmark	2.13	1.95	2.92	2.66	2.62	2.456
Germany	49.99	38.38	48.66	40.16	35.37	42.512
Estonia	0.01	0	0	0	0	0.002
Ireland	0	0	0	0	0	0
Greece	94.37	81.66	86.2	114.16	94.38	94.154
Spain	82.71	126.49	116.6	104.66	121.43	110.378
France	34.71	13.19	37.83	33.67	31	30.08
Croatia	7.3	6.17	8.18	5.23	7.89	6.954
Italy	104.38	93.3	109.04	88.85	81.53	95.42
Cyprus	0.38	0.39	0.39	0.44	0.41	0.402
Latvia	0.1	0.1	0.1	0	0.1	0.08
Lithuania	0.62	0.38	0.64	0.14	0.33	0.422
Luxembourg	0.01	0.01	0.02	0.02	0.02	0.016
Hungary	70.07	69.38	77.47	64.77	74	71.138
Malta	0	0	0	0	0	0
Netherlands	12.3	12.05	11.8	11.49	11.34	11.796
Austria	7.38	6.84	8.26	4.83	8.71	7.204
Poland	206.8	225.7	260.4	237.5	161.2	218.32
Portugal	9.42	24.16	24.87	11.98	7.63	15.612
Romania	71.11	74.93	63.29	65.56	61.01	67.18
Slovenia	2.03	0.19	1.78	0.59	0.8	1.078
Slovakia	0.54	0.61	0.68	0.52	0.91	0.652
Finland	0	0	0	0	0	0
Sweden	0.21	0.18	0.18	0.11	0.15	0.166

Source: own processing based on Eurostat data

In Romania, the general trend indicates a decline in production, caused by a combination of factors: the aging of orchards, insufficient investment in high-performance planting material, and the increasingly frequent impact of drought and frost episodes. The lack of consistent orchard renewal programs and the low degree of producer association have limited farmers' ability to respond effectively to these risks. Compared to the western EU countries, Romania is in a disadvantaged position, where farm management remains predominantly extensive and the integration of modern

harvesting and storage technologies is still limited. Countries with a strong fruit-growing tradition – such as Italy, Spain, and Greece – benefit from a superior organization of the value chain, active cooperatives, and stable market access, which give them greater economic resilience. The success of in vitro culture depends largely on the composition of the culture medium and on the environmental conditions that support embryo development. (Asănică A. et al, 2016). Consequently, the performance of Romanian orchard management can be improved through strategic investments, diversification of cultivars, and the development of post-harvest infrastructure.

The evolution of sour cherry production during the analyzed period reflects a variation pattern determined both by natural conditions and by the economic structure of the European fruit-growing sector. Central and Eastern European countries, where sour cherry cultivation has a long-standing tradition, were affected by extreme climatic phenomena and by the volatility of the processing market. At the same time, states that implemented fruit protection technologies and efficient irrigation systems managed to maintain a stable level of production.

In Romania, sour cherry production was affected by imbalances between the biological potential of orchards and the resources available for their maintenance. The lack of investment in orchard modernization, combined with the fragmentation of farms, has reduced the capacity to apply modern crop management technologies. Furthermore, the strong dependence on annual weather conditions led to significant production fluctuations, which limits income predictability for farmers.

At the comparative level, countries with industrial experience in fruit processing – such as Poland and Hungary – managed to ensure consistent production valorization due to the existence of a well-organized domestic market and functional cooperatives. In Romania, the absence of a nationwide collection and processing infrastructure has diminished competitiveness, increasing dependence on seasonal exports and on volatile prices in the external market.

Table 3. Romania's share in the total European Union production of sweet and sour cherries, 2020–2024 (%)

An	Sweet Cherries Share (%)	Sour Cherries Share (%)
2020	3.26	8.60
2021	3.58	8.89
2022	3.21	6.78
2023	3.26	7.72
2024	-	8.00

Source: own processing based on Eurostat data

Romania's share in the European Union's total production of sweet and sour cherries highlights clear differences between the two crops. In the case of sour cherries, Romania holds a more significant contribution due to its long-standing tradition, favorable climatic adaptability, and relatively low production costs. This position is supported by specialized regions where orchard structure and local expertise ensure stable yields even in years with unfavorable weather conditions.

Conversely, for sweet cherries, Romania's share remains modest, reflecting the small size of commercial orchards and the predominance of low-productivity small farms. Limited investment in high-performing varieties, insufficient disease and pest management, and harvest losses have maintained a weaker position within the European context. The overall trend indicates a slight decline in Romania's contribution, amid growing competition from states that have rapidly modernized their horticultural infrastructure and enjoy easier access to EU markets. Strengthening Romania's role in the European fruit sector requires the implementation of integrated production management focused on technological efficiency, producer cooperation, and the expansion of domestic processing and marketing capacities.

The ranking of European Union countries by the average production of sweet and sour cherries (Table 4) highlights the structural differences between the agricultural economies of Western and Eastern Europe.

Table 4. Ranking of European Union countries by average sweet and sour cherry production, 2020–2024 (thousand tones)

Country	Average 2020–2024 (Sweet Cherries)	Country	Average 2020–2024 (Sour Cherries)
EU-27	71974.0975	EU-27	842.976
Spain	22925.336	Poland	218.32
Italy	18463.172	Spain	110.378
France	8566.344	Italy	95.42
Greece	5026.92	Greece	94.154
Poland	4651.84	Hungary	71.138
Portugal	3236.794	Romania	67.18
Romania	2320.812	Bulgaria	55.128
Germany	2306.856	Germany	42.512
Hungary	1028.022	France	30.08
Austria	618.646	Portugal	15.612
Netherlands	611.714	Netherlands	11.796
Belgium	564.572	Austria	7.204
Bulgaria	363.416	Croatia	6.954
Croatia	275.466	Belgium	6.398
Czechia	206.858	Czechia	5.194
Slovenia	140.26	Denmark	2.456
Cyprus	123.88	Slovenia	1.078
Slovakia	79.608	Slovakia	0.652
Lithuania	58.924	Lithuania	0.422
Denmark	36.88	Cyprus	0.402
Sweden	34.524	Sweden	0.166
Ireland	20.994	Latvia	0.08
Latvia	14.904	Luxembourg	0.016
Luxembourg	13.458	Estonia	0.002
Finland	11.49	Malta	0
Malta	4.334	Ireland	0
Estonia	3.374	Finland	0

Source: own processing based on Eurostat data

Countries with a strong tradition in intensive horticulture, such as Spain, Italy, and Greece, dominate sweet cherry production due to favorable climatic conditions, access to high-yield early varieties, and well-established supply chains. In these states, integrated orchard management and the use of modern harvesting technologies ensure stable and competitive production levels within the European market.

For sour cherries, the leaders are Central European countries – Poland and Hungary – where the crop has a strong industrial orientation. The presence of efficient processing units and a well-developed domestic market has allowed for stable production and full utilization of harvests.

Romania occupies an intermediate position, with an average production lower than that of the leading states but higher than other Eastern European economies. This position reflects an underexploited potential, constrained by limited investment in collection and processing centers and modest integration into European value chains.

Table 5. Average annual growth rate of sweet and sour cherry production in EU member states, 2020–2024 (%)

Country	Sweet Cherries	Country	Sour Cherries
EU-27	-	EU-27	-2.02
Belgium	-6.45	Belgium	-8.66
Bulgaria	-1.56	Bulgaria	-1.50
Czechia	-15.02	Czechia	-27.49
Denmark	-12.57	Denmark	5.31
Germany	-2.85	Germany	-8.29
Estonia	7.61	Estonia	-100.00
Ireland	3.15	Ireland	-
Greece	-1.62	Greece	0.00
Spain	-2.39	Spain	10.08
France	-2.86	France	-2.79
Croatia	-1.12	Croatia	1.96
Italy	-0.63	Italy	-5.99
Cyprus	-3.62	Cyprus	1.92
Latvia	-0.68	Latvia	0.00
Lithuania	2.08	Lithuania	-14.59
Luxembourg	-5.18	Luxembourg	18.92
Hungary	-1.16	Hungary	1.37
Malta	-5.05	Malta	-
Netherlands	-4.30	Netherlands	-2.01
Austria	-6.64	Austria	4.23
Poland	-1.90	Poland	-6.04
Portugal	6.68	Portugal	-5.13
Romania	-4.91	Romania	-3.76
Slovenia	-7.78	Slovenia	-20.77
Slovakia	1.95	Slovakia	13.94
Finland	6.82	Finland	-
Sweden	1.47	Sweden	-8.07

Source: own processing based on Eurostat data

Nevertheless, favorable pedoclimatic conditions and the gradual expansion of modern orchards could turn Romania into a competitive regional actor, provided that management strategies focus on efficiency and cooperation.

The compound annual growth rate of production (Table 5) provides a synthetic picture of the direction and stability of developments in the European fruit-growing sector. For sweet cherries, the differences between countries reflect the degree of farm modernization and the capacity to adapt to increasingly unpredictable weather conditions.

Countries that have consistently invested in infrastructure, irrigation, and harvesting technologies have recorded moderate but steady growth, while those with traditional farm management have faced declines caused by yield losses and the absence of risk insurance mechanisms for climatic events.

For sour cherries, the indicator reveals a tendency toward stagnation or even decline in some Eastern European economies, where small and fragmented farms cannot sustain the necessary investments. Countries that have oriented production toward industrial processing have mitigated annual variations, demonstrating higher managerial resilience.

In Romania, the evolution is modest, influenced by climatic factors and limited financial resources. This situation confirms the need for management based on performance, planning, and digitalization to ensure more efficient use of natural and financial resources.

Overall, the results confirm the high potential of Romania's fruit-growing sector, while also highlighting the urgent need for managerial, technological, and organizational adaptation to transform these advantages into sustainable economic performance.

A key challenge remains the structural modernization of orchards, which requires consistent investment, technological renewal, and professional training. The resilience of fruit farms depends increasingly on their ability to integrate innovation — from precision irrigation systems and digital monitoring to sustainable soil management practices. Such measures can significantly reduce production volatility and enhance the sector's competitiveness at both national and European levels.

Furthermore, the alignment with European agricultural and environmental policies, including the objectives of the Green Deal and the Farm to Fork Strategy, offers Romania an opportunity to reposition its fruit sector toward sustainability and value creation. Strengthening producer organizations, improving post-harvest infrastructure, and promoting short supply chains could generate higher added value and stabilize rural incomes. These actions would not only increase Romania's share in EU fruit production but also ensure long-term adaptability to climatic and market changes.

CONCLUSIONS

The analysis of sweet and sour cherry cultivation during 2020–2024 provides a complex overview of the Romanian fruit-growing sector, positioned between long-standing tradition and the pressing need for modernization. Against the backdrop of climate change and structural transformations in European agriculture, the findings show that the economic performance of these crops increasingly depends on management quality and the degree of integration within value chains.

Romania benefits from favorable pedoclimatic conditions and extensive experience in cultivating stone fruit species, yet productivity remains below potential. The main differences compared with Western EU countries stem from the fragmentation of farms, the limited investment in modern technologies, and the absence of functional cooperative structures. In addition, heavy dependence on weather conditions and insufficient processing infrastructure reduces farmers' income stability and their capacity to capitalize on production.

Compared with the leading states – Poland, Italy, Spain, Germany, and Greece – Romania occupies an intermediate position, with a stronger contribution in sour cherry production and a more modest one in sweet cherries. This position reveals an untapped potential that can be realized through investments in orchard renewal, resistant varieties, efficient irrigation, and digital technologies.

From a strategic perspective, the future of the Romanian fruit sector depends on strengthening farm management, professionalizing human resources, and fostering solid partnerships between producers and processors. An integrated approach based on innovation, sustainability, and cooperation could transform Romania into a competitive regional actor in the stone fruit market. Thus, fruit growing should no longer be viewed merely as a traditional branch, but as a strategic field for rural development and for aligning with the objectives of the European Green Deal.

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DEMOGRAPHIC EVOLUTION OF ROMANIA'S RURAL AREA AFTER THE ACCESSION TO THE EUROPEAN UNION

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Abstract: *The demographic decline in the countryside is obvious from the first reading of official statistical data, but the explanation of gaps between different rural areas is much deeper and has multiple causes. The paper aims to identify the rural demographic trend across regions after Romania's accession to the European Union, and to identify its main causes. The analysis was carried out based on official statistical data series from the period 2007-2023, and the indicators used were selected after an overview of literature on this topic. Currently, there are rural communities with demographic growth, mainly peri-urban and tourist areas, but also depopulated areas or areas under accelerated demographic decline, mainly in remote, isolated areas. The accession to the European Union, besides its positive effects, attracting EU funds with impact upon the development of certain areas, where the population is growing or at most in a slight decline, has also had negative effects among which young population's massive migration, mainly from poor areas, to prosperous EU countries, which has resulted in the depopulation of these rural areas over time.*

Key words: *rural area, demographic evolution, regional disparities*

JEL Classification: *J11, R23*

INTRODUCTION

The rural population, which provides vitality to rural areas, accounted for 44.05% of the total population of Romania in the year 2023 (NIS). This significant proportion highlights the need to focus on maintaining an adequate demographic structure to ensure a balanced and sustainable socio-economic development in the long term. However, the continuous decline of rural population generates substantial imbalances in terms of food security and safety, as well as in terms of maintaining ecological balance and mitigating climate change (MARD, 2020).

The rural demographic evolution is closely linked to the social and economic development of rural areas. The post-accession period marks a new significant phase for the Romanian countryside, through the implementation of the Common Agricultural Policy and European projects with positive effects on the areas that have attracted EU funds.

The demographic processes are characterized by a steady decline of rural population, a trend also noticed across Europe; but the problems of our country mainly come from the intensity of this demographic decline, which manifests differently from one area to another and in certain serious cases may even result in the depopulation of certain areas. The demographic decline in the countryside is the result of the birth rate decline and the increase in the number of elderly people. External migration has also an important role to play in the demographic trajectory of Romania (Gheț ău 2018; Horváth and Kiss 2016; Rotariu, T, Dumănescu, L., Hărăguş, M. 2017).

MATERIALS AND METHODS

In this paper, statistical data series from the National Institute of Statistics (NIS) were used. Starting from the hypothesis that population decline is heterogeneous across regions, and based on the available statistical data, we calculated a series of relevant indicators for the demographic analysis of the Romanian rural area, which were selected following a literature review.

RESULTS AND DISCUSSIONS

Rural population in Romania continues to have a significant share in total population, accounting for 44.05% of total population in 2023, under a steady decline in the period 2007-2023. The analysis of demographic trends reveals that population growth has been largely limited around large urban centers and peri-urban areas or in tourist areas, while most other localities have experienced population losses, resulting from a combination of negative population natural increase and external migration.

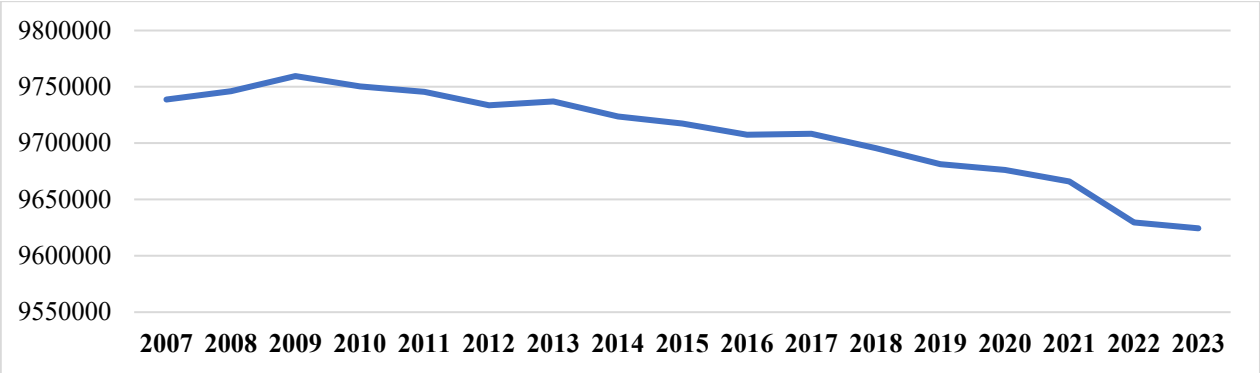

Figure 1. Evolution of rural population at national level, in the period 2007-2023
Source: NIS, tempo online

Thus, even though the rural population has decreased, and the downward trend is maintained, divergent evolutions can be noticed across regions and by counties, as follows:

The largest increases in rural population are found in the development regions București-Ilfov (+64.42%), Vest (+8.04%), Centru (+4.27%), Nord-Est (+2.22%), Nord-Vest (+1.83%); in the counties: București (+64.42%), Timiș (+32.23%), Brașov (+23.34%), Cluj (+19.44%), Iași (+17.88%), Sibiu (+13.39%), Constanța (+13.13%);

The largest decreases of rural population are found in the development regions Sud-Vest (-10.97%), Sud (-9.01%), Sud-Est (-4.90%); in the counties: Teleorman (-21.24%), Olt (-17.32%), Tulcea (-12.85%), Brăila (-11.79%), Mehedinți (-11.54%), Buzău (-11.12%), Ialomița (-11.12%), Gorj (-10.82%), Vaslui (-10.66%), Caraș-Severin (-10.43%), Călărași (-10.03%).

The share of rural population by degrees of rurality is the following: 2.78% in predominantly urban areas, 43.61% in intermediate rural areas and 53.60% in predominantly rural areas. At national level, the trend is negative (-114,427 persons; -1.17%) with population losses in predominantly rural areas (-346,201 persons, -1.17%) and increases in intermediate rural areas (+132,867 persons, +3.27%) and predominantly urban areas (+98,907 persons, +58,57%). The data do not allow for a more granular analysis, but an empirical analysis highlights great discrepancies across counties, and from one community to another, mainly in the predominantly rural areas.

The population size of predominantly urban communes increased by 57.65% in the period 2007-2023, from 5,279 inhabitants/commune in 2007 to 8,368 inhabitants/commune in 2023. The population of intermediate rural communities increased by 2.97%, from 3,587 inhabitants/commune in 2007 to 3,693 inhabitants/commune in 2023, while the population in predominantly rural communities decreased by 6.38%, from 3,199 inhabitants/commune in 2007 to 2,995 inhabitants/commune in 2023.

The most populated development regions are the Nord-Est (2,171,342 inhabitants) and Sud (1,762,816 inhabitants), with a divergent evolution in the analysed period, with a slight increase by +1.69% in the Nord-Est region, and a significant decrease in the Sud region, by -8.70%, with the largest decrease in the Sud-Vest development region (-10.84%).

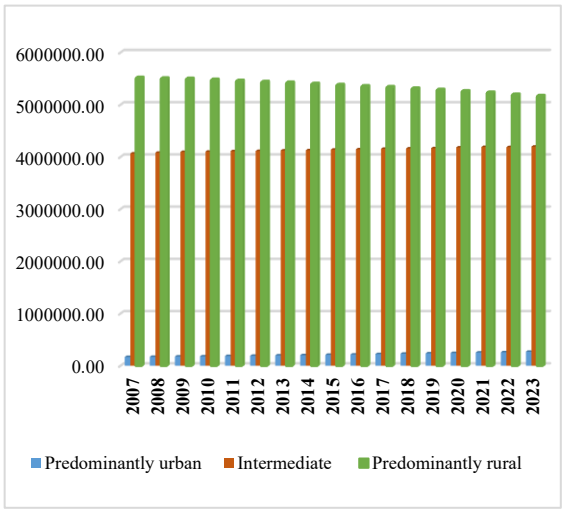

Figure 2. Evolution of rural population by degree of rurality, 2007-2023
Source: NIS, tempo online

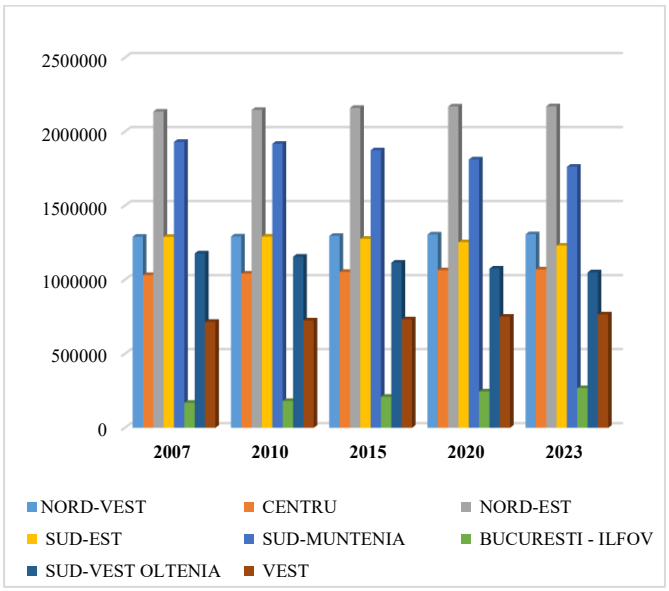

Figure 3. Evolution of rural population by development regions, 2007-2023
Source: NIS, tempo online

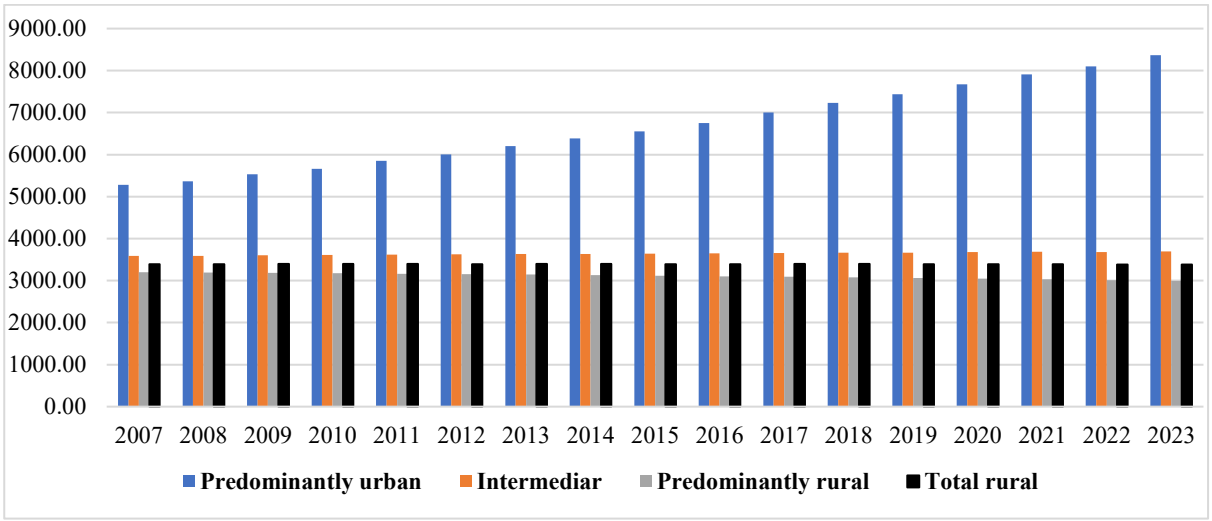

Figure 4. Evolution of average population by degree of rurality, 2007-2023
Source: NIS, tempo online

The rural population is facing a sharp aging trend, mainly in the predominantly rural and intermediate rural communities, and this problem has persisted and intensified in the analyzed period. This can be also noticed from the analysis of two relevant indicators, namely average age and aging index.

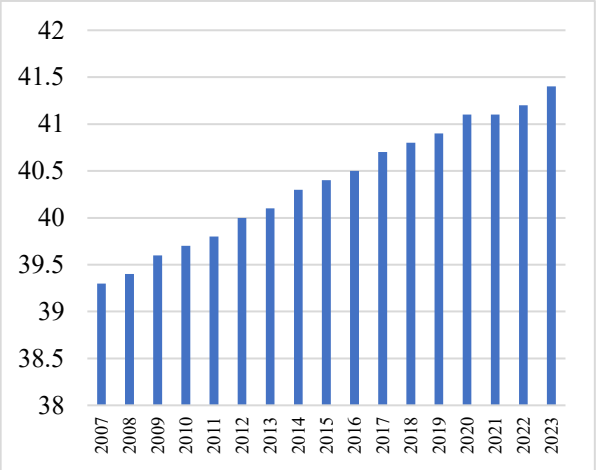

Figure 5. Evolution of average age of rural population at national level, 2007-2023

Source: NIS, tempo online

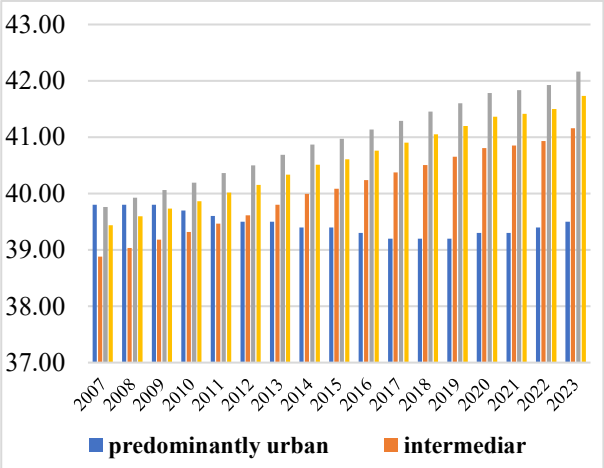

Figure 6. Average age of rural population by degree of rurality, 2007-2023

Source: NIS, tempo online

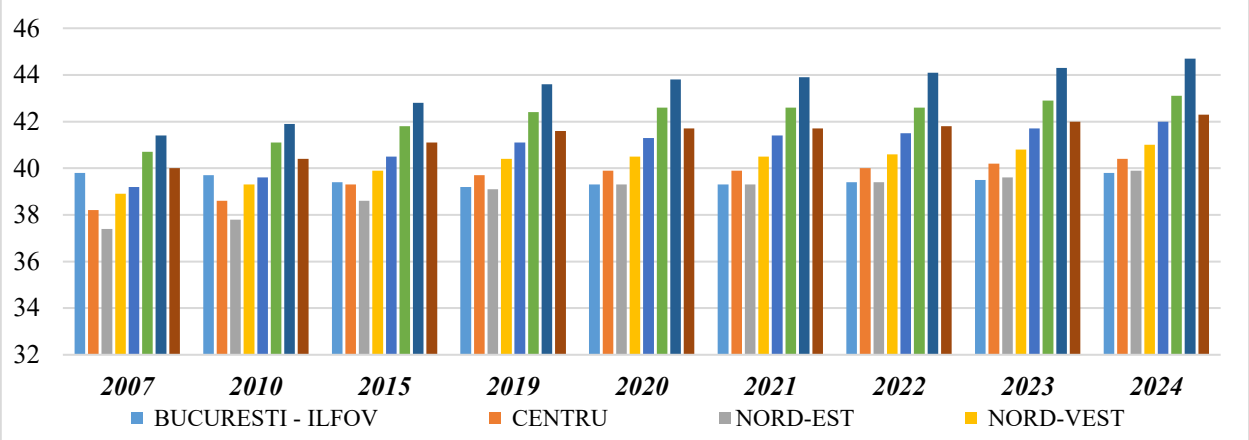

Figure 7. Average age of rural population by development regions, 2007-2023

Source: NIS, tempo online

Average age in rural areas increased from 39.44 years in 2007 to 41.73 years in 2023. The average age decreased only in the predominantly urban communities, from 39.80 years in 2007 to 38.50 years in 2023. The development regions with the highest average ages are Sud-Vest, 44.40 years, Vest 43.18 years and Sud 42.84 years; at the opposite pole we find the regions Bucharest Ilfov, with 39.50 years and Nord-Est, with 39.80 years.

In the investigated period, the population aging index increased significantly at national level from 106.75 in 2007 to 121.58 in 2023. The higher the value of this index, the more the demographic situation is in a fast-aging process, with no prospects for natural recovery. Significant differences can be noticed between the development regions of the country. Thus, there are regions where the value is much under the national average, these are the "young regions" (Bucuresti-Ilfov 79.73; Nord-Est 93.89; Centru 97.40); and "old-aged regions", with values much above the national average (Sud-Vest 171.18, Vest 149.09, Sud 135.32).

An increasing aging index can be noticed across all regions, in the investigated period, except for the region București-Ilfov that has a positive demographic trajectory.

Table 1. Aging index of rural population by development regions, in the period 2007-2023

	NV	C	NE	SE	S	B	SV	V	Total rural
2007	96.87	87.62	85.06	104.38	127.47	118.61	127.72	120.88	106.75
2008	97.89	88.17	85.39	105.44	128.32	116.81	130.34	121.22	107.63
2009	97.78	87.64	85.34	105.70	128.95	113.04	132.37	120.61	107.77
2010	98.56	87.82	85.50	106.00	129.62	109.10	135.18	120.99	108.38
2011	98.05	87.16	84.76	105.43	128.81	103.19	135.93	120.93	107.82
2012	99.19	87.45	85.43	106.00	129.41	99.83	138.81	122.81	108.77
2013	99.81	87.54	85.28	105.52	130.00	95.95	142.63	125.30	109.49
2014	100.91	88.53	86.81	106.59	131.42	92.74	147.04	128.36	111.18
2015	101.79	89.76	88.79	109.89	133.78	91.37	151.17	131.55	113.45
2016	102.89	91.04	90.65	112.25	135.25	88.73	155.28	133.94	115.33
2017	103.65	91.97	92.18	114.15	136.00	85.04	157.67	135.61	116.57
2018	103.73	92.89	93.20	115.21	136.60	82.36	160.32	138.02	117.62
2019	104.06	93.76	93.56	116.59	136.92	80.69	162.80	139.78	118.54
2020	104.40	95.14	94.14	118.83	137.18	80.12	165.85	143.14	119.93
2021	104.15	95.95	94.01	120.05	136.70	79.95	167.53	144.43	120.42
2022	103.15	95.90	92.73	120.38	134.87	79.12	167.92	145.70	119.96
2023	103.84	97.40	93.89	122.49	135.32	79.73	171.18	149.09	121.58

Source: NIS, tempo online

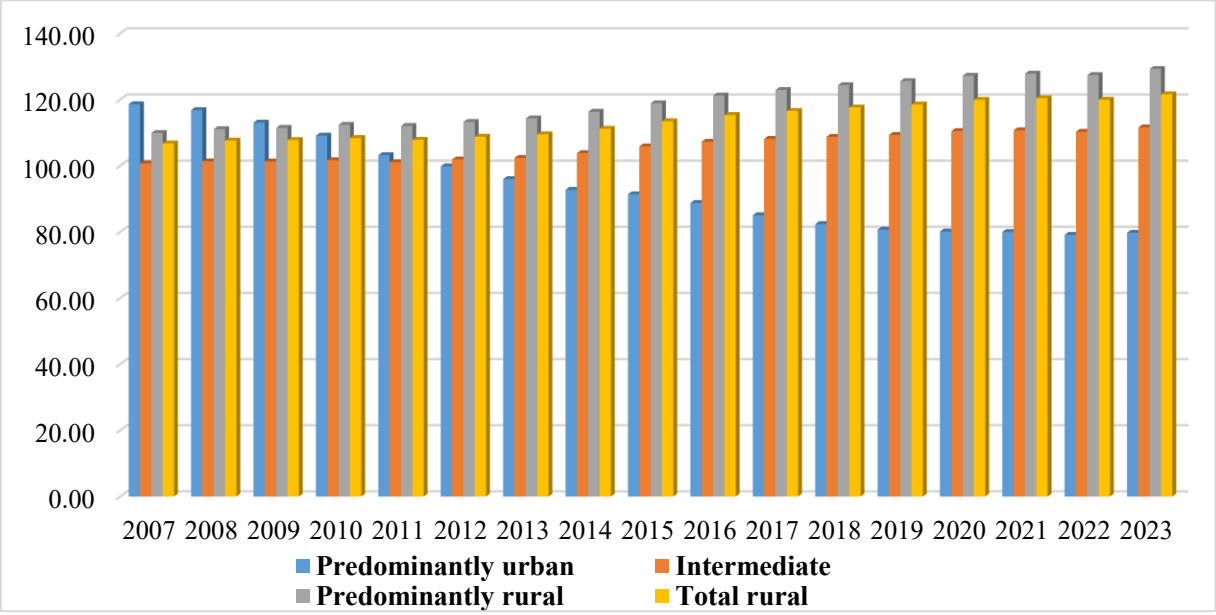

Figure 8. Aging index of rural population by degree of rurality, in the period 2007-2023

Source: NIS, tempo online

By degree of rurality, in 2007, the aging index differences between the three areas were not very large, and their hierarchy was completely different from the current situation. Predominantly urban areas (118.61) had aging index values above the national average (106.75), but in the next period, these decreased to 79.73 in 2023, well below the national average that increased (121.58).

This evolution was generated by the constant migration to peri-urban areas of both the population from other rural areas and from limitrophe urban areas, which significantly decreased the average age of the population in these areas compared to the other areas. In intermediate and predominantly rural areas, the aging index has increased at a faster rate, but in the intermediate rural areas this index increased at a lower rate and remained below the national average. At the same time, in the predominantly rural areas, the demographic aging of the population was more intense (increasing from 109.89 in 2007 to 129.25 in 2023).

The main factors that influence population aging are: life expectancy, population natural increase and migration (Iftimoaei, C., 2019, Tudor, M., 2015, Baciu, I.C., Iftimoaei, C., 2018).

Life expectancy in rural areas is lower than in urban areas, throughout the analysed period. Among the factors that generate a lower life expectancy in rural areas we mention the following: limited access to healthcare services (limited access to hospitals, health clinics and specialist doctors can delay the diagnosis and treatment of diseases, affecting life expectancy), socio-human factors (lower education level, lower incomes and poorer housing conditions have a negative influence on access to healthcare services, on life expectancy implicitly). There are also favourable factors that resulted in the increase of life expectancy in rural areas, in the analysed period, namely: a more active lifestyle in rural areas (regular physical activities and healthy eating) or lower pollution. The pandemic period (2019-2022) experienced a decline, and life expectancy at national level sharply decreased, a trend noticed both in urban and rural areas, after which a period of return to the increasing trend followed.

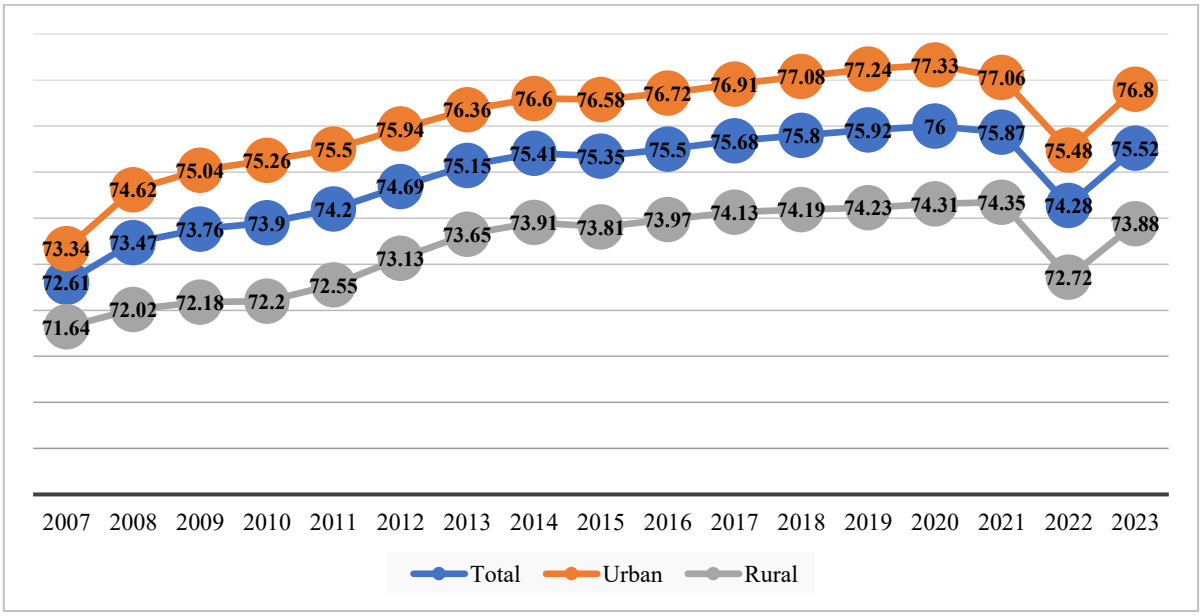

Figure 9. Evolution of life expectancy by residence areas, in the period 2007-2023

Source: NIS, tempo-online

Life expectancy increase, in the period 2007-2023, from 71.61 years in 2007 to 74.01 years in 2023, was mainly determined by the increase of living conditions and healthcare services that have resulted from the modernisation of rural areas in recent years.

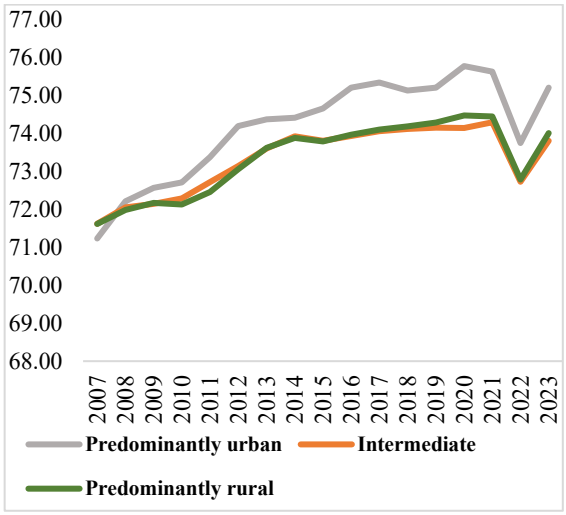

Figure 10. Life expectancy evolution by degree of rurality, in the period 2007-2023

Source: NIS, tempo online

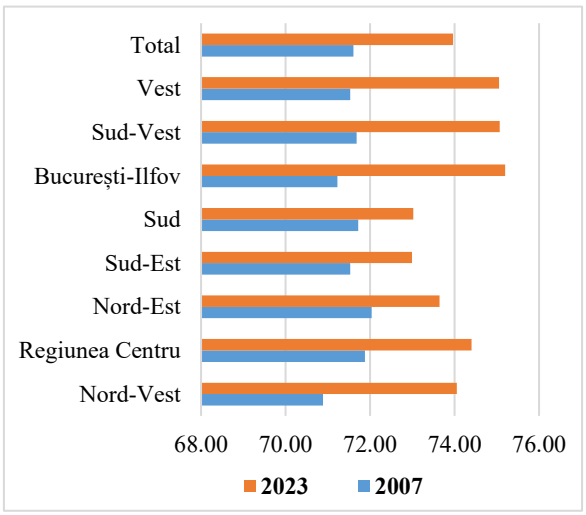

Figure 11. Life expectancy evolution by development regions, in the period 2007-2023

Source: NIS, tempo online

However, there are obvious territorial discrepancies. By the degree of rurality, predominantly and intermediate rural areas do not show significant differences in average life expectancy, following the same overall increasing trend, while predominantly urban areas moved away from the other rural areas, getting closer to the level reached by urban areas. This can be explained by the proximity to urban poles that generate higher incomes, better living conditions (technical and municipal infrastructure, housing), easier access to education and specialised and emergency healthcare services.

The sharp decrease in the population natural increase and the diminution of the gap between the residence areas are immediate effects of the COVID-19 health crisis. After 2019, death rate increased significantly (from 11.8 in 2019 to 13.5 in 2020 and 15.2 in 2021 respectively), with a tendency to recover afterwards (to 12.4 in 2022 and 11.2 in 2023), while birth rate has slightly decreased since 2019, from 9.7 to 9.5 in 2020, while after 2021 the decrease was much higher (from 9.2 in 2021 to 8.3 in 2022, and 7.5 respectively in 2023).

By degree of rurality, the predominantly rural areas and the intermediate rural areas have quite similar values of population natural increase, following the same trajectory in the analysed period. While the predominantly urban areas had also periods, albeit short, with positive values (2015-2019).

The development regions with values of this indicator much under the national average are Sud-Vest -8.36 and Vest -7.88. These regions have a similar evolution, different from the national average and from the other regions.

Even though the gap between development regions has changed in the analysed period, the national trend in population natural increase is followed at the level of each region, and the only region that has an atypical evolution is Bucharest-Ilfov, which also had positive values of natural increase in 2015-2019.

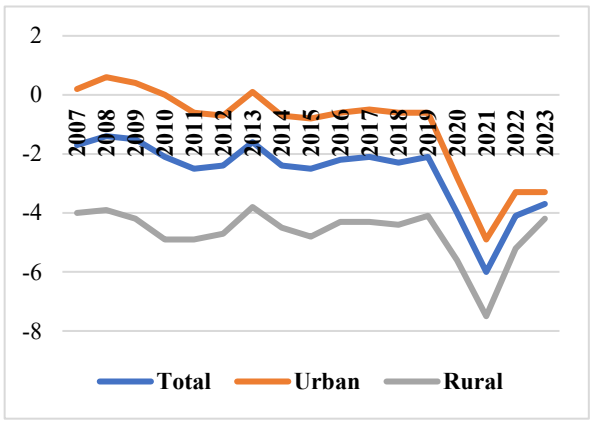

Figure 12. Evolution of population natural increase, by residence areas, in the period 2007-2023
Source: NIS, tempo online

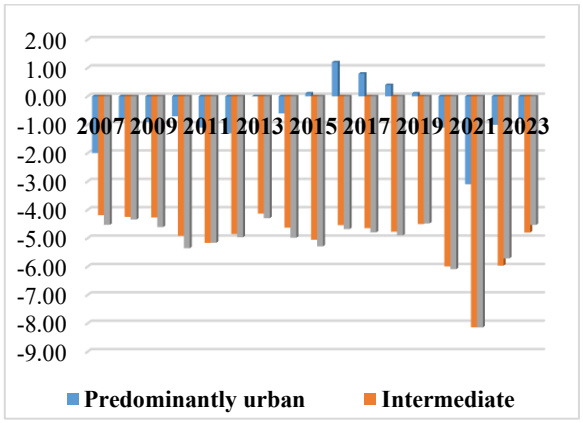

Figure 13. Evolution of population natural increase, by degree or rurality, in the period 2007-2023
Source: NIS, tempo online

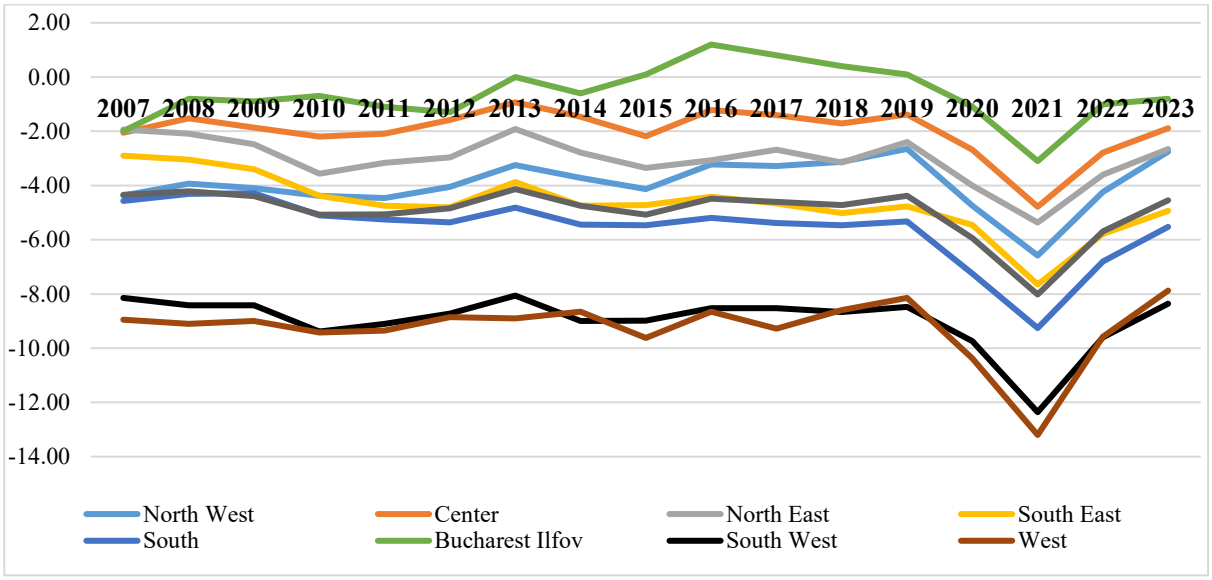

Figure 14. Evolution of natural population increase by development regions, in the period 2007-2023
Source: NIS, tempo online

In the year 2007, the regions București-Ilfov, Centru and Nord-Est started from the same value of this indicator, but had opposite evolutions. The Centru region remains roughly between the other two, following more the trend of the Nord-Est region, while București-Ilfov and Nord-Est had opposite evolutions in the period 2007-2012, and then in 2014-2019, being associated with periods of economic growth in the rural areas neighbouring the capital city. The regions Nord-Vest and Sud also started from the same value, the evolution trends were the same, but they remained the regions with the lowest population natural increase nationwide.

Migration mainly targets the young population, which resulted in the accentuation of rural demographic aging, i.e. demographic decline acceleration and depopulation of rural areas. These migration-induced phenomena are not uniformly manifested in the Romanian countryside, reconfiguring the Romanian village and not only.

There was a migration flow to Western countries in the 1990s, somewhat tempered by internal migration, from cities to villages, of the urban population that lost their jobs (as a result of deindustrialization that resulted in population's return to the villages of origin) (Sandu D., Tufiș P., 2023).

In the last 20 years, migration to rural areas has occurred as a result of the "urbanisation of the countryside", and the peri-urban communes around the big cities have become residential areas for people with jobs in cities.

Population growth was also noticed in certain communes, half of which are in metropolitan areas, three quarters are located less than 15 km from important cities and only 5% are located more than 30 km from a city (Flavius Mihalache, 2015.a.).

In the period 2007-2023, because of urban population's migration in peri-urban communes, increases in the resident rural population were noticed in some counties, among which: Ilfov +64.42%, Timiș +32.29%, Brașov +23.34%, Cluj +19.44%, Iași +17.88%, Sibiu +13.39% and Constanța +13.13% (NIS, tempo online). At the opposite pole, there are counties where both the migration balance and the population natural increase are negative, which results in an accelerated demographic decline (Flavius Mihalache, 2015.b). The counties with the largest decreases in resident rural population are: Teleorman -21.24%, Olt -17.32%, Tulcea -12.85, Brăila -11.79%, Mehedinți -11.54%, Buzău -11.12%, Ialomița 11.12%.

CONCLUSIONS

The coexistence of a high share of rural population with a clear general decline trend and accelerated demographic ageing represents a complex demographic challenge for rural areas in Romania. The uneven territorial distribution of this decline, with certain areas experiencing massive demographic losses, further complicates the adoption of appropriate policy measures. Effective rural development strategies cannot be uniform. They must be highly differentiated and adapted to regional and local contexts. The objective should be to manage decline where this is inevitable and to foster resilience and revitalization where possible.

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THE SITUATION OF HORTICULTURE AND BERRY GROWING IN LITHUANIA – FUTURE PERSPECTIVES

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Abstract: *The monoculture of the agricultural sector that has emerged in Lithuania, where grain farming occupies a significant structural position, has economic and environmental consequences. From an economic point of view, there has been a shift to the cultivation of agricultural raw materials with lower added value, without any intention of processing them within the country. From an environmental point of view, there is a risk of land degradation due to the intensive use of mineral fertilizers, further erosion of land areas arising from agriculturally outdated methods of cultivation. The trend that has developed – the reduction of grasslands, gardens and abandoned land areas – testifies to the consistent influence and impact of the grain farming branch on the entire agricultural structure. This situation is determined both by the existing economic benefits of grain farming and the lack of knowledge that does not encourage alternative farming methods. In order to diversify the agricultural sector, challenges of different scales are encountered. The weakness of family farms, lack of knowledge, and the limitedness of the local market do not encourage the search for new farming methods. This is how the path of selling or renting available land is chosen. One of the ways that would allow family farms, as well as managers of infertile lands, to remain in the market could be the promotion of horticulture. Using these farming methods, complex goals can be achieved - preservation of family farm activities, positive impact on environmental protection, diversification of agricultural production, growth in the number of final products.*

Keywords: *horticulture, berries, economic development, farming, Lithuania*

JEL classification: P28, Q14, R11.

INTRODUCTION

Regional gardening traditions have been formed in Lithuania. They have survived from the horticultural farms established during the Soviet regime. Currently, the basis of gardening in Lithuania is formed by the horticultural farms developed in the 1950s-1990s. These farms mainly grow apples, but there are also farms where mixed horticultural production is grown. The grown harvest is sold in local shopping centers; there are only isolated prospects for processing local production. After Lithuania regained independence, it is noticeable that the practice of gardening in Lithuania is essentially not developing. The basis of the phenomenon is the inability to develop sufficient processing capacities that would allow creating local products with higher added value from processed raw. Growing individual categories allows maintaining the overall dynamics of areas at the current level but does not create a basis for a breakthrough in the growth of horticultural areas.

Benefits of horticulture:

Economic value:

Cost optimization through reduced tillage. Horticultural farming allows the exploitation of seedlings for a longer period. This is fundamentally different from grain farming, in which the land is prepared for new crops once a year, sometimes more often (in case of poor wintering or non-germination). In horticulture, seedlings are planted, and grass is grown between their rows. This situation can continue for 10-20 years, thus eliminating the costs for gardeners to purchase and plant seedlings annually (Klimavičius, 2020). In this case, gardeners incur costs for renewing part of the areas (if necessary), costs for strengthening the material base, as well as costs for maintaining the seedlings.

Higher value-added products are produced. In the case of horticultural farming, there are suitable conditions for local or industrial processing of products within the country. Unlike grain production, which is mass, horticultural raw materials can be used to produce higher value-added food and desserts (Gaur, Verma, Khurana, 2018). Among other things, the price of horticultural raw materials is significantly higher compared to grain production (Sudmeyer et al, 2002). At the same time, the income from a hectare of land planted with a garden is higher than in the case of grain production. The production of higher value-added products requires in-depth knowledge, equipment, storage systems and, most importantly, directions for the sale of products. By solving these problems, significant economic progress of regions can be achieved.

Environmental value:

Less soil erosion due to less frequent tillage. Due to the specifics of horticulture, the need for tillage is significantly lower than in the case of grain farming. Sustainable land use limits the possibilities for soil erosion, when the fertile soil layer can be lost due to adverse weather conditions and improper tillage methods (Šternbergaitė, Čingienė, 2022). This is especially relevant for those regions where land productivity is lower, the terrain is hillier, and the composition of the soil is more diverse. Less frequent tillage allows the formation of new ecosystems based on the diversity of herbaceous plants and insects. The development of horticulture would allow solving the currently emerging environmental problems related to monoculture farming and endangered plant and insect species.

CO_2 absorption. Farming activities carried out in horticulture farms create conditions for capturing carbon dioxide, thus contributing to the reduction of climate change. Less frequent tillage and the presence of herbaceous plant seedlings between rows help capture this gas deep in the ground (Manrique, 2024). In the case of grain farming, CO2 fixation can be carried out without tilling the land, using direct sowing technology, but there is a risk of releasing the accumulated gas due to inappropriate future actions (Lorenz, Lal, 2005). In the case of horticulture, continuous gas absorption is carried out both in the soil and in perennial plantings. In the case of garden renewal, plantings are eliminated, but the garden can be planted directly in the desired location, thus preserving perennial grasses (Rosa-Schleich, Loos, Mußhoff, Tscharntke, 2019).

Social value:

Wide opportunities for short-term and long-term work in rural areas. One of the main actions that hinders investments in horticultural farms is the receptivity to human resources. However, the situation can also be treated as an opportunity to solve sensitive regional problems. The specifics of commercial orchard maintenance require workers and specialists who would constantly contribute to maintaining the proper condition of the plantations. The greatest need for human resources arises during the harvest, during which pickers, transporters, as well as warehouse workers are needed. This creates conditions for temporary employment in the regions - jobs are created for unskilled workers, who are critically important for achieving smooth harvesting and primary processing. This reduces the level of social problems in the regions in the tactical period, the need for social benefits from the state and municipal budgets and also increases revenues to the state budget through taxes paid during temporary employment. Horticultural farms create more long-term jobs than cereal farms, as the degree of automation on horticultural farms is lower than on cereal farms. In addition, harvested produce needs to be stored on farms for longer, which requires more care and resources.

LITERATURE REVIEW

Horticultural activities in Lithuania have been intensively developed for decades, but recently the sector has been experiencing a period of uncertainty. This is related to both unpredictable weather conditions and the competitive environment. In the first case, diversification of plant varieties is carried out in order to reduce the possible consequences of sudden changes in weather conditions. Adaptation to the competitive environment is more complicated due to the characteristics of the internal and external markets. This situation, caused by the lack of cooperation of producers, determines further investment decisions. Irregular state support for the horticultural sector creates a situation where horticultural farms make only the most necessary investments. They ensure the existence and survival of the farm, but not essential positive changes in activity. Actions to increase added value from existing activities are practically not carried out. The factors of development of the horticultural sector are based on the growth of existing farms, with very limited initiatives for the emergence of new farms based on business principles. This is due to the large amount of initial investment and the time required to obtain a yield that would ensure the economic viability of the farm.

The features of horticulture are analyzed through the specifics of the activities of existing horticultural farms. When studying the situation of existing farms, geographical interest is taken into account - the project team inspected and interviewed horticultural farms located throughout Lithuania. In-depth interviews were conducted with 30 owners of horticultural farms, whose area of activity exceeds 20 ha. In principle, a general conclusion was reached that horticultural farms are specialized, adapted to the implementation of horticultural activities. With additional encouragement and the necessary knowledge, they would be inclined to engage in agricultural and horticultural activities in non-priority areas where it is difficult to achieve high horticultural results. In those areas, more intensive development of small livestock farming should be considered as an alternative. The use of synergy is currently hindered by frequent spraying of certain seedlings, which also has a partial effect on the grass in the inter-rows. The development of organic production is hindered by the imbalance in prices of certified and traditional production, as well as the lack of demand for certified production in the domestic market. All these nuances form the main features of the horticultural sector, which are presented in the following subsections (Table 1).

Currently, certain branches of berry farming are experiencing a breakthrough. This is related to a much simpler start-up compared to fruit trees, a faster start of a stable income stream, and the ability to start production of the final product faster. In addition, berry farms have more favorable conditions for storing production - a smaller warehouse area is required. However, there are also fundamental differences related to the need for even faster harvesting, the impact of climate change. In addition, there are fundamental problems related to the sale of production. The lack of cooperative structures does not allow concentrating production quantities and selling them at the highest price. A favorable circumstance for berry farms is the possibility of retail trade in markets and trading places, since the delivery of production does not require significant resources.

Table 1. Main features of horticulture

Feature	Main aspect	Source
Highly specialized farms that do not fully utilize the synergy potential.	Due to a lack of both knowledge and motivation - farms do not devote time to qualitative farm development across the spectrum of expanding agricultural production	Viškelis, 2013

Feature	Main aspect	Source
Low level of preventive infrastructure.	Due to the current situation in horticultural farms and the constantly felt uncertainty of operations, investments in certain infrastructure units are postponed or not considered. One of such directions is networks that allow protecting future harvests from bird attacks.	Ludwig-Ohm et al, 2023
Difficulties in coping with sudden changes in weather conditions, especially during flowering	Late spring frosts, which have prevailed in recent years, have a significant negative impact on the economic viability of farms.	Thaler, Eitzinger, Trnka, Dubrovsky, 2012
Spraying of plantations, limiting activities in the inter-row area	In the case of conventionally grown fruit trees, spraying is a necessary procedure to achieve the quantity and quality of the harvest.	Vecelytė et al, 2020

The features of agriculture and berry farming are analyzed through practical examples of berry farms. They highlight the main elements that berry farm's face. These elements allow to identify the fundamental differences between berry growing and other branches of agriculture.

Table 2. Main features of berry growing

Feature	Main aspect	Source
Higher level of production diversification	In the case of small and medium-sized berry farms, a tendency is often seen that farms develop several directions of berry farming.	Brennan et al, 2014/
Simplicity of the level of preventive infrastructure	To protect lower plants, correspondingly lower supports are used, on which nets are later hung.	Webb, Darbyshire, Goodwin, 2014
The necessity of irrigation systems	The installation of irrigation systems requires initial and maintenance investments, since they are essentially used throughout the season. The current development of berry farms is chaotic also due to the fact that there are opportunities to use groundwater under preferential conditions.	Thaler, Eitzinger, Trnka, Dubrovsky, 2012

During the in-depth interview, 15 berry growing farms with an operating area exceeding 5 ha were surveyed. After evaluating the data obtained, it is stated that, from a general point of view, it may be difficult to harmonize the separate concepts of conventional (organic) agriculture and berry growing. The fundamental differences in activities visible in them would not allow achieving the desired synergistic effects, reflected through the prism of economic profitability.

However, the lack of compatibility of concepts does not reduce the environmental and social value created by the berry growing sector. This confirms the necessity of such a farming method in today's Lithuanian agricultural structure. The main features of berry growing are presented in Table 2.

The positively characterized features of the berry-growing sector form favorable prospects for farms engaged in the specified activity. The elimination of essential problems related to the lack of competencies would allow further catalyzing development. The essential advantage of the berry-growing farm is the opportunity for a small household to develop profitable activities, ensuring economic viability. Medium and large berry growing farms almost inevitably have to follow the path of processing, as this allows creating greater added value, while reducing the influence of raw material prices and seasonality.

RESULTS AND DISSCUSION

The main parameters of horticultural activities are focused on investment and operational elements. This aims to systematize the reasons why, apart from institutional support, horticultural activities in the broad sense are not widely cultivated. When compiling the list of parameters, the experience of horticultural farms already existing in Lithuania is used, while expanding them with the possibilities of carrying out combined agricultural and horticultural activities. The purpose of systematizing the parameters is to objectively assess the possibilities of fundamentally changing the structure of the agricultural sector in Lithuania in the short term. Due to the specific factors related to the receipt of the first income from horticultural activities, the application of the agricultural and horticultural concept is necessary in order to ensure the economic viability of farms in the short term. The parameters are essentially based on quantitative indicators.

The need for significant costs for planting a new garden. Unlike in the case of crop production, significant investments in horticulture go to the acquisition of seedlings. After surveying market participants, an indicative amount was identified for planting one hectare of seedlings – from 30 thousand. EUR. These investments are made mainly based on own funds, since support schemes or funds from financial institutions for such projects are generally unavailable or irregular. Planting perennial seedlings was encouraged as a means of establishing young farmers, but in the case of horticulture, the essential nuances associated with the appearance of the first harvest were not considered.

The need for economies of scale. When carrying out horticulture activities, it is necessary to develop numerous garden areas to both receive stable income and diversify risks through a variety of plant varieties. This is one of the fundamental differences between horticulture and berry growing in Lithuania. After surveying horticultural business entities, it was concluded that the profitable area of a garden starts from 15 ha. Comparing this number with the area of crop cultivation, it is possible to derive the equivalent –1 ha. of gardens equals 10 ha. of crop cultivation area. Estimating the necessary volume of activity and the size of the initial investment, the prospects for the emergence of new fruit tree areas become complicated. Walnut trees have more prospects, the care of which is somewhat simpler, and the periods of harvesting and storage are not strict.

Waiting for the first income. After planting an orchard, a certain period is necessary (depending on the type of orchard) when the orchard will allow to receive income from the sold production. Until that time, compensatory mechanisms through direct payments prevail. On average, the first operating income from fruit trees must be waited for at least 3 years. In the case of walnut trees, some of their species begin to yield a harvest only in the 7-9th year of growth. This limits farmers' ability to change their activities to more environmentally friendly ones in the short term, as it can lead to financial uncertainty for the farm. In this case, agricultural-horticultural initiatives would be appropriate to comprehensively develop the horticultural farm and accelerate the payback of the main investments.

Infrastructure for storage is necessary. Due to the high yield of fruit trees in kind, it is necessary to develop appropriate infrastructure for storing the harvest in addition to the orchard capacity. According to the current market situation, it is impossible to fully apply the "just-in-time" (JIT) concept, when the produce leaves the farm just after it has been picked. In the case of smaller farms, the produce can be stored for even longer, adapting to the needs of traders. After receiving three commercial offers from suppliers, it can be stated that the development of a warehouse suitable for horticulture can cost at least 230 EUR/m2. At the same time, when installing the warehouse infrastructure, it is necessary to include refrigeration capacities. They are needed in order to preserve the quality of the produce, while diversifying the flow of income from the sold produce.

Orchard fencing is required. In order to develop small-scale livestock farming activities and prevent damage caused by wild fauna, priority orchard areas are fenced. This measure protects gardens from certain potential damage, but this investment is not considered a priority. However, in the development of agricultural and horticultural activities, this infrastructure can properly serve as an animal protection measure. In this case, a positive economic and environmental impact would be achieved, since polluting agricultural machinery would no longer be used for inter-row mowing. At the same time, economic value would be created by realizing the increment obtained during small-scale livestock farming. According to the three commercial offers received, the price of a fence designed to protect seedlings and animals could reach from EUR 1,200 per hectare.

Based on the parameters compiled, it can be stated that the development of individual horticultural activities requires large initial financial and especially time costs. Direct conversion from, for example, a crop farm to a horticultural farm is essentially impossible, because the development of the latter branch of the economy, although it requires large initial investments, begins to bring stable income only after 3-4 years. In this case, an intermediate form of agricultural-horticultural activity would be carried out, when synergies are not exploited, but mixed agriculture is developed. Table 3. presents systematized information on the main parameters of the horticultural business, on the basis of which investment decisions or decisions to change the direction of farm activities are made.

Table 3. Basic horticultural parameters

Investments in seedlings, EUR/ha	Minimum profitable farm size, ha	Time to generate stable income	Warehouse price, EUR/m2	Fence price, EUR/ha	Investments in nets (in special cases), EUR/ha
30000	15	After 3-4 y.	200	1200	10000

The breakthrough of horticulture in Lithuania is limited by large initial investments, difficult attraction of external financing, lack of support from structural funds for the emergence of horticultural farms. In addition, qualitative factors contribute to this - lack of dissemination of knowledge about the advantages of horticulture, lack of adaptation of public structures to the development of alternative agriculture. The solution of these factors would first create conditions for the development of horticulture and later include the most relevant agricultural and horticultural activities.

The main parameters of berry growing are formed analogously to the case of horticulture. The main quantitative aspects are distinguished, which are inevitable when striving to switch to berry growing activities. Compared with horticulture, there are significant differences. In this way, the idea of this work to analyze horticulture and berry growing activities separately is once again confirmed.

The main one is that in the case of berry growing, it is necessary to vertically expand the sector, increasing the production of the final product and export volumes as much as possible. In this case, the impact of a small market is not significantly felt compared to the case of horticulture due to the possibility of simpler processing, storage and transportation of the final product. In the long term, for some crops, especially blueberries, growers who do not have processing capacity may withdraw from the market due to overproduction. If the farmer have a priority to enter the berry sector and expand the market in quantitative and qualitative terms, it is necessary to take into account the main parameters.

Absence of minimum area restrictions (in the case of certain crops). Berry growing is favorable for the smallest farms, since with proper cultivation of berries, it is possible to harvest for at least several months from a relatively small area. The dominant small berry farm holdings in Lithuania (from 0.5 to 1.9 ha) show that family farms can achieve economic profitability despite area restrictions (Auželienė, Survilienė, 2023). The essential condition is quick harvest realization, avoiding the development of refrigeration capacities. Unlike in the case of orchards, some types of berries (e.g. strawberries) can be grown in greenhouses. This would allow to increase the income of the farm, since such berries would be presented to the market earlier than when grown in open ground. In the case of larger berry bushes (e.g. currants, cranberries), a larger area of land will be required. However, the cultivation of the latter crops will primarily create challenges in the sale of production, since these berries are more widely consumed in Eastern markets. When developing new berry orchards, it is first necessary to secure sales routes and understand the technological principles of berry cultivation (number of seedlings, soil, care, etc.).

Costs of planting a berry orchard. Compared to horticultural farms, the costs of planting a berry orchard are somewhat lower. In the case of strawberries, when 50 thousand seedlings are needed per hectare, the wholesale price of this quantity could reach 25 thousand EUR (Penseberryfarm, 2025). It can consider this amount as a base when talking about initial investments in seedlings. This amount is used to evaluate certified propagation material, which in turn has positive resistance and yield characteristics. Seedlings can be purchased from both local and foreign propagators. In the latter case, in order to achieve a competitive price, it is necessary to purchase seedlings in larger quantities (enough to plant at least 10 ha). It is also necessary to consider that berry species popular in Western Europe may not be suitable for Lithuania due to climatic conditions. Depending on the type of berry, planting periods are different, so in this case it is necessary to first acquire knowledge related to the development of a berry farm. After that, investment decision-making will be of higher quality for the farmer.

Fast investment turnover. In the case of berry growing, the first income from production can be obtained within a calendar year from the time of planting. This concept allows the smallest farms, whose economic size does not reach the minimum requirements, to carry out activities that ensure the livelihood of the family farm. At this stage, it is necessary to distinguish between small and medium-sized farms. In the case of small farms, when sales are carried out immediately after the moment of harvesting, the main farm investments consist of planting the land area with plants suitable for berries. Investment turnover is ensured by trading in designated areas or online. This avoids expenses for industrial refrigeration capacities, and demandable production is sold, essentially avoiding waste (Shopulatovna, 2023). Certain production residues are possible, but they can be processed into berry products without significant investments. The competitiveness of small farms largely depends on how much berry cultivation will further expand, especially in certain types of berries.

Infrastructure needs for medium-sized farms. In the case of medium-sized farms, infrastructure development will become an inevitable necessity in the long term in order to maintain complexity. The main infrastructure groups in a medium-sized berry farm:

Irrigation systems to increase yields. Scientific research has shown that in the case of irrigation, berry yields can increase by up to 30 percent. (Jabet, Caron, Lambert, 2016). Summarizing the two commercial offers received, the average price of irrigation systems can reach 2000 EUR/ha.

Storage facilities with refrigeration. For medium and large farms, the development of combined storage and refrigeration infrastructure becomes an inevitable necessity. As in the case of orchards, the development of a warehouse suitable for berry growing can cost at least 200 EUR/m2. It ensures such a temperature regime that allows for the maximum extension of the growing time of unprocessed berries.

Processing capacities. In order to achieve higher added value and meet the needs of the domestic market, the development of processing solutions will be necessary in the long term. A key factor is how this infrastructure will be developed. It would be more beneficial for both farmers and the state to rely on the concept of cooperation, when the creation of cooperative structures is encouraged. It would make sense for such entities to allocate state funding for the development of infrastructure. At the same time, this would create conditions for small farms to sell surplus production to a berry-growing cooperative. Investments in processing capacities are individual - they depend on the type of production desired, production area, production efficiency, etc. There is synergy with the existing infrastructure - production capacities are usually developed next to already built warehouses for raw materials and finished products.

Systematized parameters of berry growing are presented in Table 4. Unlike horticulture, direct conversion from a crop farm to a berry farm is theoretically possible. The main circumstance that hinders the practical implementation of this idea is the huge need for human resources during berry picking. It is calculated that on average 1 ha. area of berry farm requires 4-5 berry pickers. Given the difficult demographic situation in the regions, obstacles to immediate immigration, the emergence of medium and large berry farms is severely limited. In this case, it is most useful to develop the concept of cooperation, strengthening the existing berry processing capacities, thus creating higher added value products. In the long term, in-depth research is necessary to answer the question of where cooperative farm structures could be established that would develop high-performance berry farming activities.

Table 4. Main parameters of berry growing activity

Investments in seedlings, EUR/ha	Minimum profitable farm size, ha	Time to generate stable income	Warehouse price, EUR/m^2	Investments in nets, EUR/ha
0.15	> 25000	1 y.	200	5000

Although the concepts of berry growing and traditional agriculture are difficult to reconcile, the potential of berry growing in the country is largely untapped. This applies to both the volume of raw material cultivation and the possibilities for processing. The development of berry growing would significantly improve the regional environmental situation, but before that it is necessary to resolve the issues of sustainable water use. A significant breakthrough in berry growing would be promoted by the development of cooperation, when berry processing would be concentrated in large regional centers. This, at the same time, would allow avoiding possible overproduction, which is real when assessing the dynamics of the cultivation of some berries in recent years.

CONCLUSIONS

The potential of agriculture-berry growing and agriculture-horticulture in Lithuania is sufficient to encourage diversification of business risks. Horticulture can be combined with small livestock due to the synergy created by grazing medium or low-density orchard areas. Berry growing has partial synergy potential through the formation of non-processable products with snail farming. In the case of agriculture-berry growing, processing capacities must be strengthened, thus increasing the added value created on the farm.

This would allow both to create more added value and to fully respond to the environmental interests of the state. In the case of agriculture-forestry, the benefits created for the state are manifested through a reduction in the intensity of agricultural land by implementing environmental protection measures. Agroforestry practice would allow achieving these goals if the area ratio were determined taking into account the environmental and economic balance.

The main obstacle to this goal is the need for economies of scale and the absence of compensation mechanisms in the short term. This will hinder the development of agroforestry, especially in the case of small farms.

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CERTIFICATION OF FRESH AND PROCESSED BERRIES - DYNAMICS AND IMPLICATIONS ON THE RURAL ECONOMY

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Abstract: *The paper analyzes the potential of certified mountain berries in the sustainable development of mountain areas in Romania. The study investigates certification trends, territorial distribution and product evolution based on data from the National Register of Mountain Products (2018–2025). The results show a concentration of certifications in counties such as Maramureș, Vâlcea, Bacău and Gorj, with a preference for fresh fruits. Although certifications initially increased, a decrease has been observed in recent years, indicating the need for effective public policies. The paper highlights the role of certification in supporting the rural mountain economy, protecting biodiversity and promoting authentic local products. The study provides directions for the sustainable valorization of mountain resources in modern agriculture.*

Keywords: *certification, mountain products, forest fruits, rural development*

JEL classification: Q1, Q13, Q18, O13

INTRODUCTION

In recent years, the sustainable development of mountain areas has become a topic of interest in agri-food economic research, due to the vulnerability of these regions and their essential role in the conservation of biodiversity, natural resources and cultural heritage (FAO). Certified mountain food products are considered key tools for valorizing local resources, financially supporting farmers and increasing competitiveness on the market. In the specialized literature, the issue of communication mechanisms towards consumers, regulated by Regulation (EU) No. 1151/2012, as well as the reduction of information asymmetries on the market (EU Regulation No. 1151/2012, Grunert, 2005) is frequently analyzed.

The analysis of works indexed in the Web of Science (WOS) shows that, from 1975 to the present, 103 articles have been published that address the subject of forest fruits, especially raspberries, blueberries and sea buckthorn. Of these, 33 have been published in the last 10 years alone, representing approximately one third of the total. This development highlights a growing scientific interest in these species, especially in the current context, marked by concerns about health, sustainability and rural development.

Berries are of particular importance due to their high content of antioxidants, vitamins, minerals and bioactive compounds, being recognized for their beneficial properties on human health, including in the prevention of cardiovascular, metabolic and degenerative diseases. These fruits play an essential economic and ecological role in mountainous and rural areas, where they can represent a source of income for small producers and contribute to the conservation of biodiversity and traditional landscapes. The increase in the number of scientific publications in the last decade highlights not only the potential of berry products for the functional food market, but also the need for a better understanding of production and marketing chains in the context of sustainable agriculture.

Some studies highlight the fact that certified products are perceived by consumers as having a high added value and contribute to their brand loyalty (Belletti, Marescotti & Touzard, 2017, Aprile, Caputo & Nayga, 2012).

On the other hand, other research indicates a low level of knowledge of these products, which diminishes the effect of trust in the institutions responsible for certification. Regarding consumer motivations, the specialized literature emphasizes both functional reasons, such as food safety and nutritional quality, and symbolic motivations, such as supporting the local community or ethical considerations, related to respect for tradition (Cei, Defrancesco & Stefani, 2018).

Berries are characterized as small, fleshy, with intense aromas and flavors, coming either from spontaneous flora or from specialized crops, and are frequently consumed both fresh and in processed form. In recent years, interest in these fruits has increased significantly due to their nutritional value and high content of bioactive compounds with antioxidant properties, such as polyphenols, vitamins and minerals. The nutritional composition of berries is complex, they are valuable sources of essential nutrients, such as phosphorus, potassium, calcium, magnesium, iron, manganese, copper, sodium and aluminum. The regular intake of these elements in the diet is essential for maintaining the health of the population, as they participate in numerous fundamental physiological and biochemical processes.

Also, some of these minerals, such as copper, iron, manganese and selenium, are known for their antioxidant effects, contributing to the functional properties of foods (Llorent-Martínez, Spínola & Castilho, 2017). Due to their high antioxidant capacity, berries are consumed both fresh and processed. However, under improper storage conditions, their valuable components can deteriorate quickly (Okatan, Urfali, Bulduk, Sagbas & Ercisli, 2025). Berries can be consumed fresh or processed into various food products, such as jams, marmalades and juices. Due to their high content of natural pigments, flavonoids, phenolic compounds, antioxidants, fiber, minerals and vitamins, these fruits are distinguished by a superior nutritional profile compared to many other fruit categories. Naturally, blackberries are low in cholesterol, saturated fat, sodium and calories, which gives them important beneficial properties, especially in reducing the risk of cardiovascular disease and cancer (Daugovish, Gaskell, Ahumada & Howell, 2021).

MATERIALS AND METHODS

To carry out this research, a descriptive and analytical approach was used, based on both bibliographic sources from the specialized scientific literature and secondary data from official sources. A central component of the analysis was represented by the information available in the National Register of Mountain Products, managed by the Ministry of Agriculture and Rural Development (MADR), which includes certified products from the mountainous areas of Romania.

The data extracted from the register were analyzed for the period 2018–2025, with a focus on products obtained from forest berries, both in fresh and processed form (jam, jam, syrup, juice).The information was centralized and classified by year, type of produce (fresh and processed), and was subsequently correlated with the fruit species, year of certification and territorial distribution at county level.

The geographical representation was based on aggregated data per county, highlighting areas with a high number of certified products, as well as poorly represented or absent regions. In addition to the quantitative analysis, a qualitative interpretation of the factors that may influence the level of certification was carried out – such as local traditions, agroecological potential, the existence of processing infrastructure or the level of information of producers.

The quantitative analysis was completed by consulting relevant scientific literature, published in international databases (such as Web of Science), in order to frame the results in the context of current research on agri-food sustainability, responsible consumption and the valorization of mountain resources.

RESULTS AND DISCUSSIONS

The scientific paper was funded by the ADER 22.1.5 project - Research on the Economic impact, food security and food safety in mountain agriculture in Romania as a follow-up to the implementation of EU Strategies: Green Deal–Farm to Consumer. Stage Study of profitability and economic efficiency of certified products. The National Register of Mountain Products, managed by the Ministry of Agriculture and Rural Development (MADR), is an official instrument for recording and promoting authentic products specific to the mountainous areas of Romania. It aims to protect the identity and traditional values of products made in these territories, ensuring compliance with clear criteria regarding origin, production methods and authenticity. By being included in the register, producers benefit from official recognition, increased visibility and opportunities for promotion on the market, and consumers have a guarantee of the quality and authenticity of the products purchased, while contributing to supporting the local economy in mountainous areas. Registered products are subject to strict standards regarding provenance, quality and tradition, being protected against falsification or abusive use of the name "mountain product". The register is updated periodically, usually at least once a month, according to MADR regulations and internal administrative procedures, to reflect new entries or changes.

According to the data available on August 31, 2025, 4,527 products were registered in the National Register of Mountain Products, of which 222 belong to the "vegetable products" category. Of these, 90 are fresh fruits (such as blueberries, sea buckthorn, currants, cranberries, blackberries and raspberries), and 22 are processed products, such as jam, jam, juice or syrup. These figures highlight not only the diversity of natural resources in mountain areas, but also the significant potential for the exploitation of forest fruits in their fresh or processed form, within a sustainable food system oriented towards local, healthy and quality products.

Between 2018 and 2025, a total of 112 forest berry products were registered in the National Register of Mountain Products, of which 90 are fresh fruits and 22 are processed products, such as jam, jam, syrup or juice. The evolution of these registrations reflects a fluctuating interest in the valorization of these natural resources, with a peak in certifications in 2020–2021, followed by a sharp decline in the following years.

As for fresh fruits, the most frequently registered are blueberries (38 products), raspberries (28) and blackberries (14), indicating a focus on well-known and easily commercially exploitable species. Other fruits, such as currants, sea buckthorn and cranberries, are poorly represented, with only a few products registered in total, although they have a high nutritional and therapeutic potential. This uneven distribution can be attributed to difficulties related to harvesting, preservation, lack of developed markets or knowledge about certification.

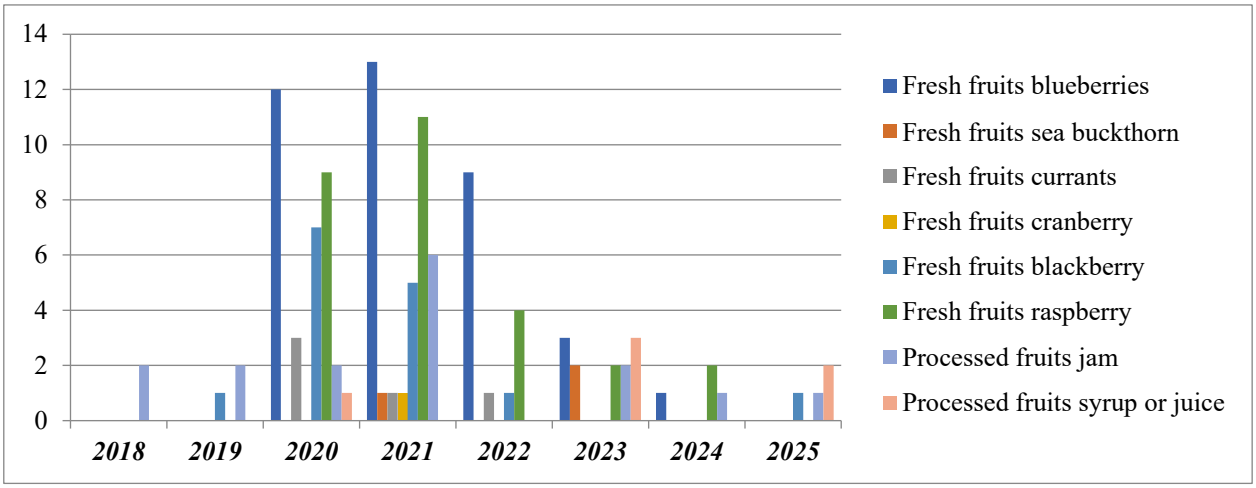

Figure 1. Distribution by types of fresh and processed berry products
Source: National Register of Mountain Products, accessed September 8, 2025

The year 2020 marks a significant increase in certifications, with 31 fresh products registered, and in 2021 a maximum of 32 is reached. Subsequently, the number of products gradually decreases, reaching only 1 fresh product in 2025. This downward trend can be explained by the exhaustion of a first wave of interested producers, possible administrative difficulties, lack of continuous incentives or market challenges. As for processed products, they remain consistently underrepresented, with a total of only 22 registrations in eight years. Most were registered in 2021 (six products) and 2023 (five products).

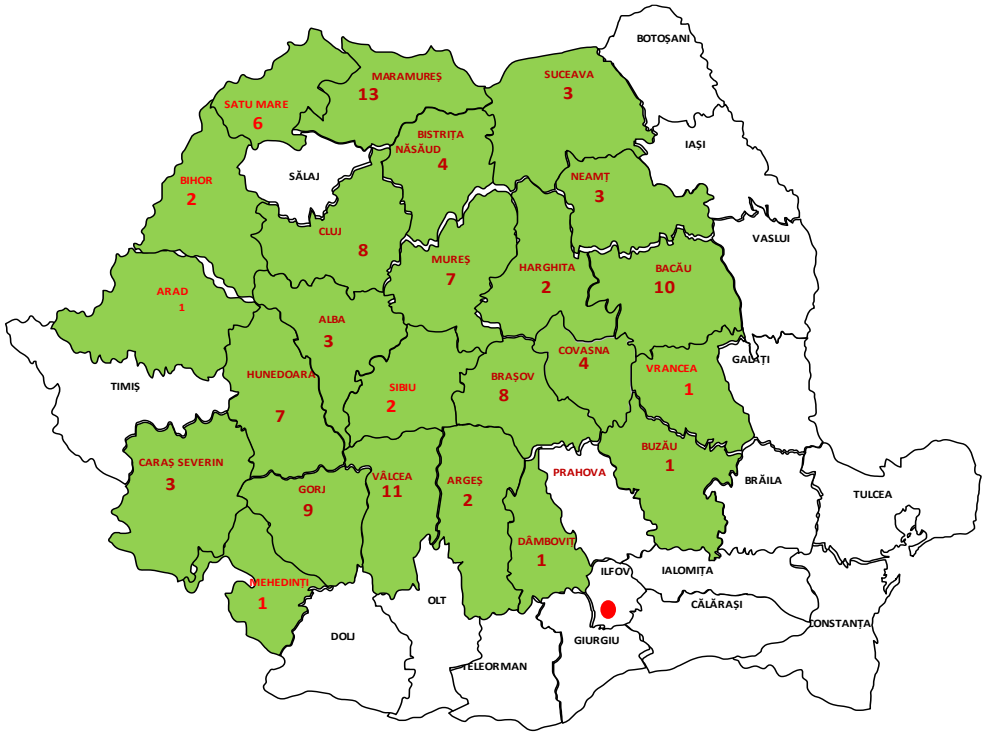

Figure 2. Geographical representation of certified products – berries and processed berries
Source: National Register of Mountain Products, accessed September 8, 2025

In 2022 and 2024, certifications of processed products were absent or minimal. This suggests an insufficient valorization of mountain fruits through processing, although products such as jam, syrup or juice offer an extended shelf life and can generate higher economic value for producers.

The causes may be the lack of processing infrastructure at local level, limited access to financing, or difficulties encountered in complying with certification requirements for processed products.

Overall, the analysis highlights the fact that, although forest fruits represent an important segment within mountain vegetable products, their potential is not fully exploited, especially in terms of processing and diversification of marketing forms. To revitalize this trend, concrete support measures for processors, simplification of certification procedures, promotion of lesser-known species and development of short supply chains that facilitate access of mountain products to consumers would be necessary.

The data highlights an uneven territorial distribution of certified products based on berries, reflecting significant differences between counties in terms of the level of valorization of mountain resources, certification capacity and involvement of local producers. The counties with the most certified products are Maramureș (13 products), Vâlcea (11 products), Bacău (10 products), Gorj (9 products), Brașov and Cluj (with 8 products each). These counties stand out through a greater diversity of certified fruits and/or by the inclusion of processed products in their portfolio, which suggests the existence of better developed value chains and a consolidated tradition in the mountain agri-food sector. For example, in Maramureș blueberries predominate (10 products), and in Gorj raspberries stand out (8 products), which indicates local specializations. Several counties appear with only one certified product, including: Arad, Argeș, Dâmbovița, Mehedinți, Buzău, Vrancea.

In these cases, the presence of certification is marginal, which may reflect an untapped potential or barriers to access to the certification system. Other counties with mountainous terrain are completely missing from the table, which could suggest a lack of information, institutional support or infrastructure necessary for processing and promotion. Regarding the typology of products, blueberries are the most certified fruit, with a presence in 14 counties, most in Maramureș (10), Mureș (4), Brașov (5), Bistrița-Năsăud (3) and Vâlcea (2), then raspberries which are certified in 8 counties, most in Gorj (8), Bacău (3), Cluj (3) and Mureș (3), and blackberries are certified mainly in Vâlcea (4) and Harghita (3). Other fruits, such as currants, sea buckthorn and cranberries, are poorly represented, with only a few counties where they are certified.

As for processed products, most are found in Bacău, Vâlcea, Brașov and Alba counties, indicating the existence of local processing capacities or initiatives to diversify products by extending the shelf life and increasing added value. The geographical representation of certified products based on wild berries shows a strong concentration in the mountainous counties in the center and north of the country, especially in the Eastern and Southern Carpathians. This distribution is not accidental and reflects the favorable pedoclimatic conditions for wild berry crops, as well as a certain agricultural tradition, oriented towards the picking, cultivation and processing of these fruits. However, the fact that a significant part of the mountainous counties has either a very low number of certified products, or does not appear at all, indicates a significant untapped potential. The reasons can be diverse: from the lack of information for producers about the benefits of certification, to difficulties related to logistics, the lack of associative structures, processing infrastructure or administrative support necessary to complete the procedures.

The geographical map of mountain berry product certification reflects both areas where natural potential has been transformed into an economic opportunity and areas where this potential remains latent. Better territorial valorization would require integrated measures, such as expanding information campaigns, financial support for local processing, facilitating access to certification and encouraging mountain cooperatives. Thus, forest berries could contribute even more significantly to the sustainable development of mountain regions in Romania.

Certification of mountain berry products represents an important opportunity for the development of the rural economy, especially in vulnerable mountain regions. By officially recognizing the quality and origin of the products, local farmers can access wider markets and obtain higher prices, which stimulates the income and economic stability of rural communities. In addition, certification contributes to the sustainable valorization of natural resources, promoting responsible agricultural practices and the conservation of local biodiversity. On the other hand, involvement in the certification system can boost product diversification and innovation in processing, which adds value to products and extends their shelf life. This aspect is essential for increasing competitiveness in the face of increasingly demanding markets and for attracting a segment of consumers interested in local, healthy and authentic products. At the same time, better organization of producers, institutional support and facilitating access to financing and infrastructure are necessary conditions for expanding certification and increasing the number of certified products.

Without these measures, the economic potential of mountain forest berries risks remaining underexploited, and territorial disparities may increase, negatively affecting regional cohesion and development. In conclusion, the certification of mountain forest berries can become a driving force for revitalizing the rural mountain area, contributing to sustainable economic growth, environmental protection and strengthening local cultural identity.

CONCLUSIONS

The analysis highlights a growing interest in the period 2020–2021 for the certification of mountain products obtained from forest berries, followed by a significant decline in the following years. With a total of 112 products registered in eight years, of which 90 fresh and 22 processed, a concentration of certifications is evident on some better-known species (blueberries, raspberries, blackberries), while other valuable fruits, such as sea buckthorn or cranberries, remain poorly represented. The geographical distribution highlights a significant imbalance, with a concentration of certifications in the counties of Maramureș, Vâlcea, Bacău, Gorj, Mureș and Cluj, while other mountain counties have a very low number or are completely absent from the register. This situation indicates differences in the capacity to mobilize local resources, the degree of information of producers, the existence of processing infrastructure or the availability of the necessary administrative support.

Forest fruits, through their nutritional, economic and ecological potential, can play an essential role in the sustainable development of mountain areas. However, their exploitation remains limited by a series of structural and institutional obstacles. For an efficient use of this potential, a coherent strategy is needed that includes simplifying certification procedures and increasing accessibility for small producers, supporting investments in local processing infrastructure, to encourage product diversification and increasing added value, information and training campaigns dedicated to mountain producers on the advantages of certification and market opportunities, encouraging associative forms and cooperatives, which can increase the efficiency and competitiveness of small farms in mountain areas. Certified mountain forest fruits have the potential to become a strategic element in consolidating the green economy and in the sustainable revitalization of the mountain rural space in Romania. Through their exceptional nutritional characteristics, high added value and direct link to local territorial identity and traditions, these products can stimulate the development of short supply chains, support rural entrepreneurship and contribute to the diversification of the mountain economy.

However, in order for this potential to be fully exploited, it is essential that public policies are oriented towards creating a framework conducive to the certification, production and marketing of mountain products. This involves simplifying administrative procedures, supporting associative forms and producer cooperatives, expanding local processing infrastructure, and increasing the level of information and education of producers and consumers. Moreover, the integration of certified mountain forest berries into national and European strategies on healthy eating, environmental protection and regional development could contribute not only to increasing the economic resilience of rural communities, but also to preserving biodiversity, traditional landscapes and cultural heritage in mountain areas. In a context marked by climate change, rural depopulation and food security challenges, mountain berries can become an important catalyst for a fair and sustainable ecological transition.

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