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The Proceedings is prepared as the result of the scientific research supported by the Ministry of Science, Technological Development and Innovations of the Republic of Serbia.

The Proceedings includes selected articles presented at the International Scientific Conference – Sustainable Agriculture and Rural Development IV, which was held in Belgrade on December 14-15th, 2023.

In the Proceedings are included scientific papers from Serbia, along with the invited and other scientific papers from abroad, prepared by foreign authors, which are IAE, Belgrade associates, and whose institutions have close scientific, professional and technical cooperation with the IAE, Belgrade.

The Proceedings addresses the wider audience by being scientifically and practically focused on all segments of sustainable agriculture and rural development, but also biotechnology and digitalization in agriculture.

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PLENARY SECTION

INVESTIGATING SOME POSSIBLE IMPACTS OF ENERGY USE ON AGRICULTURAL SECTOR DEVELOPMENT

Andrei Jean Vasile[1], Luminita Chivu[2], Mile Vasić[3], Madalina Ionescu[4]

Abstract

Recent trends, developments and challenges in the contemporary agricultural sector have highlighted the need to investigate the impact of energy use and prices on the development of a sustainable agricultural sector. Energy has a dual importance for agriculture, being not only an economic efficiency issue but also an environmental issue. The massive mechanization of farming practices and production has led to a related increase trend in energy consumption in the sector, which is a critical factor in shaping future competitive advantages. The paper examines some of the possible impacts of energy consumption on the development of the agricultural sector from different perspectives. It identifies realities, trends and paradigms. The results provide relevant insights for both practitioners and policy makers.

Key words: *agriculture, energy consumption, intensity; volatility, fuels.*

Introduction

In contemporary agricultural practices, the use of energy stands as a cornerstone, profoundly impacting various aspects of the sector and this indispensable relationship, however, brings with it a spectrum of implications, both positive and negative, which extend far beyond mere operational efficiencies including in the European Union (EU). The utilization of energy in agricul-

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ture has spearheaded unprecedented advancements in production efficiency, enabling higher yields, mechanization, and the ability to cultivate previously unfeasible lands. This revolution has been instrumental in feeding a rapidly growing global population and sustaining the agricultural economy and the reliance on energy, particularly on non-renewable sources presents not only significant environmental but also energy security concerns. The extensive and impactful use of fossil fuels in the agricultural sector advances also the environmental issues, which threaten the very agricultural productivity it seeks to enhance. Additionally, the dependence on energy makes the agricultural sector vulnerable to fluctuations in energy prices, which can have far-reaching effects on the cost of food production, market prices, and ultimately, global food security.

The multiple and versatile impacts of energy use and pricing on the agricultural sector are profound and far-reaching, influencing every aspect of agricultural practices and outcomes. This relationship not only dictates the cost-effectiveness and efficiency of agricultural production but also shapes the sector's sustainability, technological advancement, and global market dynamics. By examining how fluctuations in energy prices affect agricultural inputs, mechanization, irrigation, processing, and transportation, we can gain insights into the vulnerabilities and opportunities within the agricultural sector. Additionally, the exploration of energy's role in agriculture extends to its influence on food prices, the adoption of renewable energy sources, and the push towards sustainable farming practices. The transition to an energy-intensive agricultural sector is a key issue in current research and raises important questions in terms of resource use, environmental sustainability and economic impact.

Recent studies have examined trends, limitations, structure and volume of renewables production, the impact of agricultural practices on natural resources, and energy consumption patterns within the EU. Fanelli (2020) classified EU countries into four distinct agro-ecosystems based on their use of energy, pollution factors, and impact on natural resources. Brodny et al. (2020) aimed to categories EU countries into groups determined both by the structure and volume of the renewable energy production (RES). Streimikiene (2021) critically discusses the link between sustainable, climate-smart agriculture and sustainable energy concepts, crucial for understanding how agricultural practices can be aligned with broader environmental objectives, especially in the context of EU climate change commitments. Also, Domagała (2021) assesses the economic, energy and environmental efficiency of agriculture in EU Member States in 2019 using the DEA model. Becker (2008) has made an important contribution to the understanding of the role of energy production from biomass, in particular biofuels, in the market for renewable energy. Becker (2008) has contributed to the understanding of the role of biomass energy production, particularly biofuels, within the renewable energy market, integrating economic and environmental perspectives and using the CAPRI model to analyze the implications of increasing biomass energy production according to European and global objectives.

Various comprehensive impact analyses have revealed the effects of energy targets on the agricultural sector, particularly on rural incomes. This aspect is of crucial importance for the understanding of the socio-economic impact of energy intensive agriculture. Chapman et al. (1991) argue that the main threats to sustainable agricultural growth, such as pollution and resource depletion, come primarily from energy use in non-agricultural sectors, highlighting the interlinked nature of energy use in different sectors and its indirect impact on agriculture. Peters (2011) examined the relationship between energy costs and biofuel growth paths and suggested that rising energy tariffs could lead to increased biofuel consumption, exceeding certain energy benchmarks and resulting in higher prices for agricultural products.

The review also acknowledges the contribution of Banse et al. (2011) and others in this area, further enriching our understanding of the complex interactions between energy use, agricultural practices, and environmental impacts. Taghizadeh-Hesary et al. (2019) investigated the correlation between energy and food prices in eight Asian economies using a Panel-VAR model. Their findings indicate that agricultural food prices increase in response to fluctuations in oil prices, highlighting the vulnerability of agricultural markets to energy market dynamics.

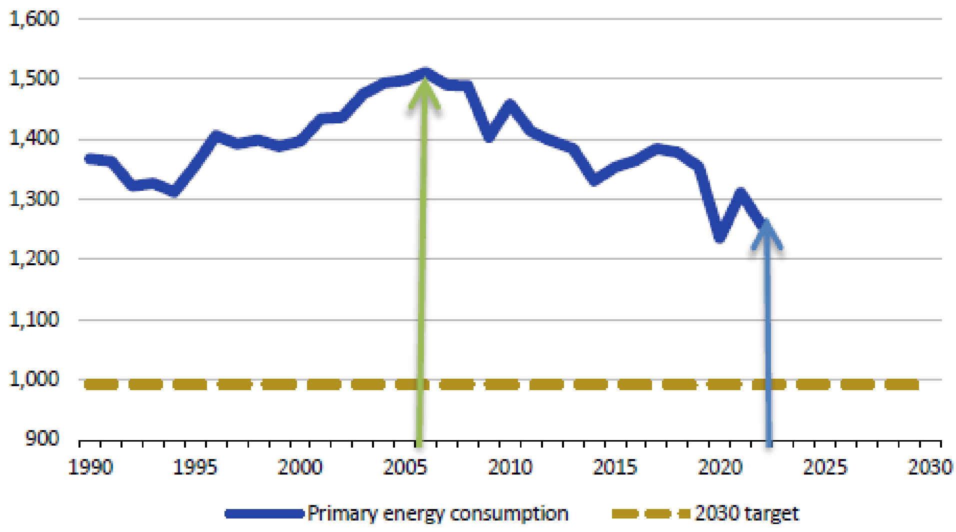
The review highlights a gap in studies on energy use in greenhouse production, pointing out the scarcity and fragmentation of reliable data. Paris et al. (2022) propose a framework for determining energy use in greenhouse agriculture to improve understanding of energy dynamics and contribute to the green transition in agriculture. Current and changes in agricultural energy use in EU countries have been the subject of a study by Rokicki et al. (2021). Komarnicka et al. (2021) demonstrate that the agricultural sector is the economic sector which registers a high level of energy consumption concentration, particularly in countries with a significant agricultural industry, such as France and Poland. Simionescu et al. (2022) evaluates the impact of renewable energy use on economic growth in twenty three EU Member States during the period of 1990 to 2020, highlighting the importance of renewable energy in achieving sustainable development and advocating a sectoral approach to formulate effective recommendations for each sector. Brodny et al. (2021) discuss changing relationships between agricultural methods, energy use and sustainability in an EU framework. Together, these studies presented above offer a detailed insight into the energy dynamics of EU agriculture and highlight the diversity of energy consumption patterns, the environmental impact of agricultural practices and the potential for renewable energy sources.

This article aims to analyze these diverse impacts, understanding that energy is a critical driver in the evolution and future trajectory of agricultural development. The research provides an extended comparative view on the multiple possible relationships generated among energy use in agricultural sector and its broader economic sectorial implications by examining a range of indicators related to the consumption of energy and the use of renewable in the EU agriculture.

EU distance and target for primary energy consumption

The implications and consequences of the energy targets for the agricultural sector, especially in terms of energy efficiency, are highlighted by the analysis of the EU's distance and target for primary energy consumption. This aspect has become critical in understanding the socio-economic dimensions of energy policies, as they directly affect livelihoods in rural communities. A first step in understanding the impacts of energy use on agricultural sector development is to analyze the progress and challenges faced by EU in moving towards a greener energy portfolio in the perspective of the 2030.

Figure 1. Distance to 2030 target for primary energy consumption in EU



Source: Eurostat, (2023)

As part of its wider sustainability and climate change initiatives, the European Union (EU) has drafted and imposed targets in determining the reduction in consumption of primary energy by the year of 2030. The Figure 1 describes the distance to the 2030 target for primary energy consumption provides a visual representation of the EU's progress and challenges in this regard. The figure illustrates the trajectory of primary energy consumption in the EU from 1990 to the present.

The consumption levels during the early 1990s reflect the EU's initial energy demand before the adoption of more aggressive energy efficiency measures and the growth of renewable energy sources. From 1990 onwards, primary energy consumption experienced a gradual increase, peaking at approximately 1,500 by the early 2000s. This evolution can be attributed to economic growth, increased industrialization, and a higher standard of living across the member states. However, this upward trend was not uniform. Starting at slightly above 1,300 (in unspecified units), the line shows a gradual increase, peaking near 1,500 before descending with some volatility. The 2030 target is set ambitiously at 1,000, representing a significant reduction from the current consumption levels.

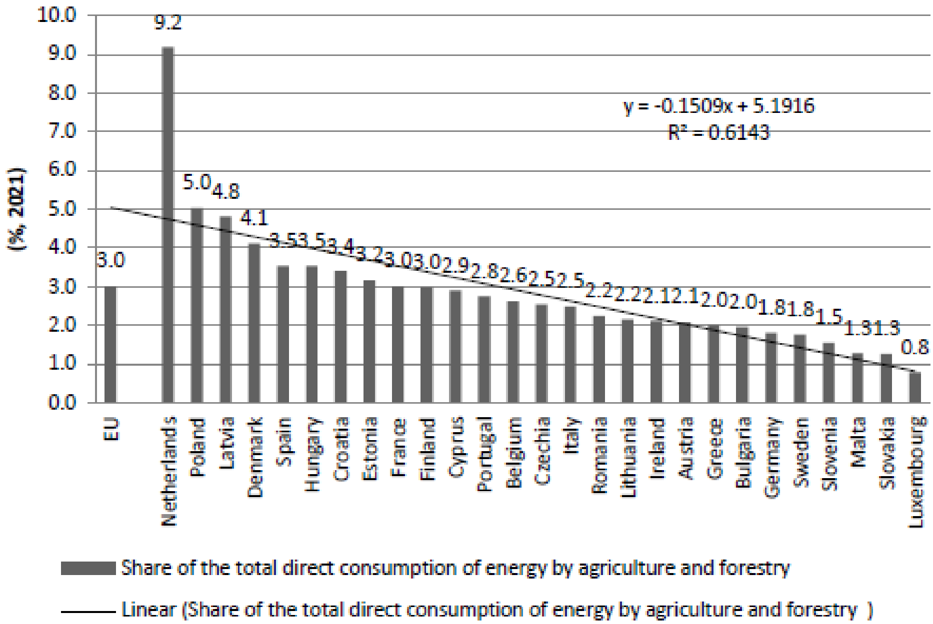
The peak of consumption appears around the mid-2000s, which may correlate with periods of economic growth and industrial expansion. However, post-peak, there is a noticeable trend towards reduced consumption, which aligns with increased efficiency, the adoption of renewable energy sources, and heightened public awareness of energy conservation. Despite these efforts, the graph indicates that as of the latest data point, the EU's primary energy consumption remains well above the 2030 target. The descent towards the goal is not consistent, with periods of reduction followed by minor increases. The dip around 2020 is particularly notable and may be attributed to factors such as policy interventions, technological advancements, or external events impacting energy usage, such as economic downturns or global crises. The data suggests that while the EU has made progress in reducing primary energy consumption, there is still a significant gap to bridge to meet the 2030 target.

Energy consumption on the development of the agricultural sector

The energy use in agriculture transcends the mere operation of machinery, embracing a broad spectrum of activities such as irrigation, crop planting and harvesting, pest management, and the transportation of goods. This extensive use of energy is crucial in the manufacture of agrochemicals and fertilizers. Intriguingly, the patterns of energy consumption in this sector show considerable variation globally, influenced by factors like the degree of mechanization, crop types, and local farming techniques.

The extended analysis of the Figure **2,** which illustrates the percentage share of total direct energy consumption by agriculture and forestry in EU countries for the year 2021, reveals several points of interest when considering energy use in these sectors.

Figure 2. Share of the total direct consumption of energy by agriculture and forestry, 2021



Source: Eurostat, (2023a), (online data code: nrg_bal_s)

The Fig.2 reflects regional variations in agricultural practices and energy sources. Northern and Eastern European countries like Latvia and Poland have higher shares, which could be due to the types of crops grown, the climatic conditions requiring more energy for heating, or the prevalence of older, less efficient technologies. Conversely, several Southern European countries like Greece and Malta show lower shares, which might be due to the natural climate being more conducive to agriculture without additional energy input, or perhaps a smaller relative size of these sectors in their economies. Countries with lower percentages, such as Germany, Sweden, and Luxembourg, may have more energy-efficient farming practices, or their governments may have implemented policies encouraging energy conservation and the use of renewable energy sources in agriculture and forestry. The differences might also reflect a shift towards other sectors that are not as energy-intensive.

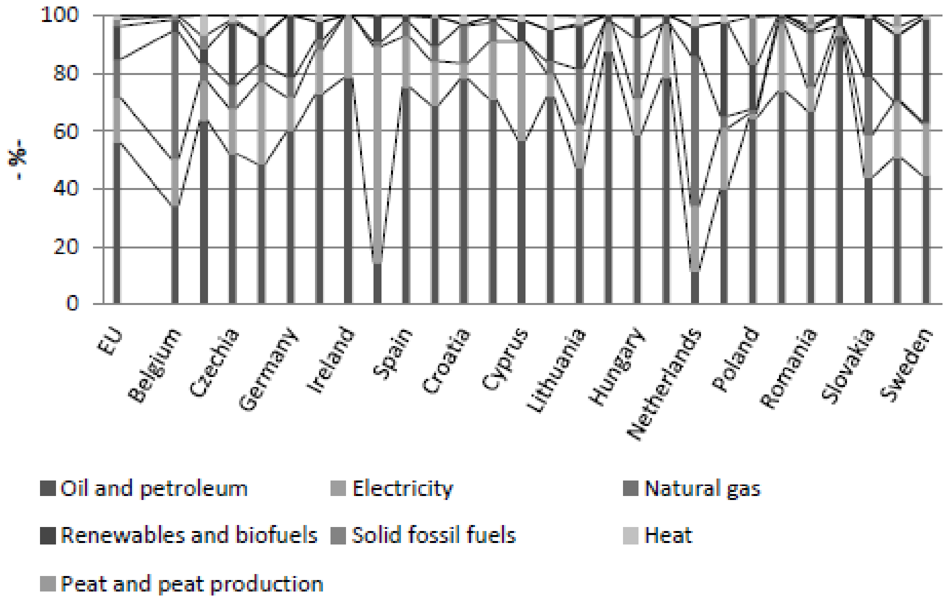
The presence of outliers like the Netherlands suggests unique national circumstances. Poland and Latvia follow with 5.0% and 4.8% respectively. Luxembourg's position at the lower end could be due to the country's small size and the predominance of other sectors over agriculture and forestry, leading to a lower overall energy consumption share for these sectors.

The Netherlands leads significantly with a 9.2% share. This high percentage could be attributed to the country's intensive agriculture practices, including large-scale greenhouse farming that requires substantial energy for heating and lighting. The Dutch agricultural sector is known for its high productivity and export orientation, which might contribute to its higher energy consumption relative to other EU countries. Compared with EU average several countries, such as Poland, Latvia, and Denmark, report higher-than-average energy consumption shares, suggesting that their agricultural and forestry practices might be more energy-intensive or that these sectors hold a larger portion of their overall energy consumption profile. As we move through the list of countries, the data show a general decrease in the share of energy consumption. The negative slope of the trend line suggests that there is a pattern where countries with a smaller energy consumption share by agriculture and forestry follow those with larger shares. The linear regression line plotted over the bars, with the equation $y = -0.1509x + 5.1916$, suggesting a negative trend, meaning that as one moves from left to right on the chart, the percentage share generally decreases. With an R-squared value of 0.6143, the trend line suggests a moderate correlation indicating that approximately 61.43% of the variance in the percentage share of energy consumption by agriculture and forestry can be explained by the country's position in the sequence and almost 40% of the variability is due to other variables not included in this simple linear model.

Direct Energy Consumption and the Fuel Mix Share in the EU agriculture and forestry

The dynamics of energy consumption by the agriculture and forestry sectors are crucial indicators of sustainability and economic priorities within the EU. The fuel mix share in this sector highlights the reliance on various energy sources and the potential for sustainable practices. In the figure 3 is presented a comparative analysis of fuel mix percentages across EU member states, offering insight into their energy consumption patterns. The figure 3 presents a complex landscape of energy usage, with notable variations in the reliance on different fuel types. Oil and petroleum dominate in several countries, underscoring a traditional dependence on fossil fuels. Electricity, as a versatile energy source, shows a substantial presence across the board, indicating a shift towards more flexible and potentially renewable energy inputs. The use of solid fossil fuels and natural gas varies significantly, suggesting diversity in energy infrastructure and technological adaptation.

Figure 3. Fuel mix share of the direct consumption of energy by agriculture and forestry (%, 2021)



Source: Eurostat, (2023a) (online data code: nrg_bal_s)

The data presented in Figure 3 offers a country-by-country breakdown of the fuel mix share in agriculture and forestry across the European Union, offering a window into the diverse energy strategies adopted by different nations. The choice of energy source directly impacts both the productivity and sustainability of agriculture and forestry. While fossil fuels may offer immediate benefits in terms of power output and efficiency, their long-term implications include increased greenhouse gas emissions and a detrimental impact on soil and forest health. A key observation is the varied but growing percentage of renewables and biofuels. This reflects a conscious move towards reducing the carbon footprint of agriculture and forestry, aligning with the EU's broader climate goals. The use of renewables also suggests an investment in new technologies and a commitment to sustainable practices. The consumption level of renewables including biofuels is a positive trend observed in countries like Austria and Romania. This shift demonstrates progress in reducing dependence on non-renewable resources and mitigating the effects of climate change, which is essential for the long-term sustainability of the sectors.

Conclusions

The agricultural sector in the European Union (EU) has a diverse landscape in terms of energy usage and environmental impact. The agricultural sector in the EU Member States is significantly influenced by the Common Agricultural Policy (CAP). The energy mix presented in the article is a snapshot of the EU's current state of energy consumption. While the reliance on traditional fossil fuels remains substantial, the presence of renewables and biofuels is a positive indication of the ongoing shift towards sustainable energy. The integration of energy considerations into the CAP and the focus on renewable energy sources are milestones in achieving sustainable agriculture development goals. While some countries exhibit a forward-thinking approach by integrating renewables, others still have strides to make in reducing their reliance on traditional energy sources. As the sectors evolve, a concerted effort towards sustainable energy consumption will be vital in ensuring the longevity and environmental compatibility of agriculture and forestry.

Transitioning to a sustainable energy mix is fraught with challenges, including economic costs, technological barriers, and the need for infrastructure development. However, the opportunities for innovation in energy efficiency and sustainable practices present potential for long-term environmental and economic benefits. Initiatives such as biomass energy, solar-powered operations, and wind energy integration in agricultural and forestry operations can pave the way for a greener future.

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REVEALING COMPARATIVE ADVANTAGES IN THE CHINA-SERBIA AGRICULTURAL TRADE

Vasilii Erokhin[1], *Gao Tianming*[2]

Abstract

Against the background of the growth of trade and economic ties between Serbia and China in recent decades, the role of the agriculture in shaping the trade turnover may seem modest. The Serbia-China agricultural trade faces a number of imbalances that do not allow farmers to leverage their competitive advantages. There is a need to identify those commodity categories that might increasing trade turnover. The paper analyzes the Serbia-China agricultural trade in 2000-2022 to identify, compare, and match comparative advantages of the two countries. The study employs the sequential calculation of the index of concentration of foreign trade, the index of diversification of foreign trade, the index of market concentration of foreign trade, and the index of structural changes. The obtained index values are then compared with the values of the revealed comparative advantages index. A number of sectors are identified in which the comparative disadvantages of one country can be compensated by the comparative advantages of another so that to increase the Serbia-China trade in food and agricultural products.

Key words: *Agriculture, comparative advantage, competitive advantage, trade.*

Introduction

Against the background of the growth of trade and economic ties between Serbia and China in recent years, the role of the agriculture in shaping the trade turnover of the two countries may seem modest. As of 2022, mutual agricultural trade amounted to $49.8 million, which is only 0.8% of the total Serbia-China trade turnover (UNCTAD, 2023). However, in view of the need to diversify and develop foreign trade relations, cooperation in the sphere of

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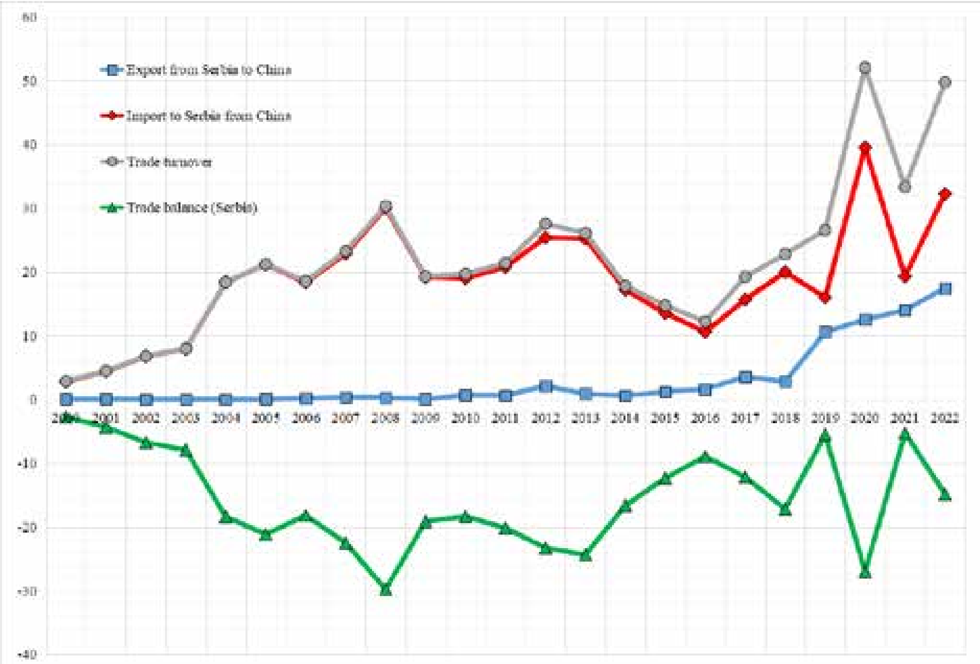
agriculture obviously carries considerable potential. Serbia is a net importer of agricultural products from China (Figure 1). Nevertheless, since 2018, Serbia's agricultural exports to China have been growing steadily, which allows to estimate the export potential of the Serbian agriculture to China to be significantly higher than the current $17.5 million.

Figure 1. *Serbia-China agricultural trade in 2000-2022, $ mln.*



Source: authors' development based on UNCTAD (2023)

Studies have shown that the Serbia-China agricultural trade suffers from a number of imbalances (Jovičić et al., 2020; Erokhin & Gao, 2021; Dimitrijević et al., 2023), which do not allow agri-food companies of both countries to efficiently implement their competitive advantages. Thus, Serbian farmers seek to increase their exports to Chinese market, but the obstacle is high veterinary and phytosanitary quality standards set by China. A strategic goal for Serbia is to boost trade in processed food products in its exports to China. On the contrary, according to Chinese estimates (Huang & Yang, 2017), it is more profitable for China to purchase agricultural raw materials for its subsequent processing in the country. Serbia uses various regulatory measures to stimulate the processing of agricultural raw materials within the country. For its part, China is interested in investing in joint processing enterprises, but with certain benefits for Chinese companies. Also, the high cost of transporting agricultural products and the technical limitations of transport communications between China and Serbia are obstacles to the growth of trade turnover.

In a situation of limiting influence of various factors, it is relevant to identify those commodity items that could promote the potential for increasing trade turnover. The study aims at analyzing agricultural trade between Serbia and China since 2000 to reveal the comparative advantages of the two countries and compare them.

Materials and Methods

One of the most commonly used approaches to assessing advantages of territories in international trade is the Revealed Comparative Advantages (RCA) index (French, 2017; Grancay et al., 2022). It is based on the Ricardo's assumption on differences in various kinds of capacities of countries (both natural and acquired) that affect the country's competitiveness on the global market (Balassa, 1965). However, a number of studies (Shuai & Wang, 2011; Edjah et al., 2022; Li & Pan, 2023) have shown that in agricultural markets, estimates of advantages obtained solely on the basis of RCA may be rather inaccurate due to certain limitations of the index, such as volatility of advantages due to the market environment (Anderson, 2020) or trade protectionism (Arisoy, 2020) or the influence of production specialization patterns on competitiveness of countries in trade (Kang, 2018; Smutka et al., 2018). To improve the accuracy of the comparative advantage assessment, it is advisable to match the RCA values with the parameters of the market environment and production in dynamics, taking into account changes in these parameters over time.

The study employs the stepwise calculation of the indexes of product concentration and diversification, market concentration, structural change, and revealed comparative advantages (Table 1):

1. Product Concentration Index shows the extent to which foreign trade of a country is focused on a narrow set of commodities, rather than being distributed more evenly among a wider portfolio of goods. The index values vary within the [0;1] interval. The higher the index the more country's exports (imports) is concentrated on certain goods.

2. Product Diversification Index shows to what extent the portfolio of country's foreign trade deviates from the portfolio of world's exports and imports. The index values vary within the [0;1] interval. A higher value indicates a more significant difference in the structure of exports (imports) of a country from the world's exports (imports).

3. Market Concentration Index shows whether the market for a good is limited to several countries or is more evenly distributed among many markets. The index values vary within the [0;1] interval. A higher index value indicates a higher concentration of trade in the export (import) market.

4. Structural Change Index characterizes the share of the market occupied by exporters (importers) of a good and shows how that share is different from that in 1995 (basis). The index values vary within the [0;1] interval. A higher index value indicates a more significant change in market shares among exporters (importers) in the reporting year compared to the baseline.

Table 1. *Indexes used in the study*

Index	Formula	Parameters
Product Concentration Index (export)	$H_j = \frac{\sqrt{\sum_{i=1}^{N}\left(\frac{X_{ij}}{X_j}\right)^2} - \sqrt{\frac{1}{N}}}{1-\sqrt{\frac{1}{N}}}$	• X_{ij} - exports of good i from territory j; • X_j - total exports from territory j; • N - number of goods exported by territory j.
Product Concentration Index (import)	$H_j = \frac{\sqrt{\sum_{i=1}^{N}\left(\frac{M_{ij}}{M_j}\right)^2} - \sqrt{\frac{1}{N}}}{1-\sqrt{\frac{1}{N}}}$	• M_{ij} - imports of good i to territory j; • M_j - total imports to territory j; • N - number of goods imported to territory j.
Product Diversification Index (export)	$EMDI_j = 1 - \frac{\sum(\lvert h_{ij} - h_i \rvert)}{2}$	• h_{ij} - portion of exports from territory j to territory i in the export's portfolio of territory j; • h_i - share of territory i in total imports of the world
Product Diversification Index (import)	$IMDI_j = 1 - \frac{\sum(\lvert h_{ij} - h_i \rvert)}{2}$	• h_{ij} - share of imports to territory j from territory i in the import's portfolio of territory j; • h_i - portion of territory i in total exports of the world.

Index	Formula	Parameters
Market Concentration Index (export)	$H_i = \dfrac{\sqrt{\sum_{j=1}^{N}\left(\frac{X_{ij}}{X_i}\right)^2} - \sqrt{\frac{1}{N}}}{1-\sqrt{\frac{1}{N}}}$	● X_{ij} - exports of good *i* from territory *j*; ● X_i - world's total exports of good *i*; ● *N* - number of exporting countries.
Market Concentration Index (import)	$H_i = \dfrac{\sqrt{\sum_{j=1}^{N}\left(\frac{M_{ij}}{M_i}\right)^2} - \sqrt{\frac{1}{N}}}{1-\sqrt{\frac{1}{N}}}$	● M_{ij} - imports of good *i* to territory *j*; ● M_i - world's total imports of good *i*; ● *N* - number of importing countries.
Structural Change Index	$H_i = \dfrac{\sum_{j=1}^{n}\left\|S_{ij}^{1} - S_{ij}^{0}\right\|}{2}$	● - share of trade in good *i* in GDP of territory *j*, base year; ● - share of trade in good *i* in GDP of territory *j,* report year; ● *n* - number of countries where product *i* is traded.
Revealed Comparative Advantage index	$RCA_{Ai} = \dfrac{\frac{X_{Ai}}{\sum_{j\in P} X_{Aj}}}{\frac{X_{wi}}{\sum_{j\in P} X_{wj}}}$	● P - products set; ● - exports of good *i* from territory A; ● - world's total exports of good *i*; ● - total exports of territory A; ● - world's total exports.

Source: authors' development

The obtained index values are then compared with the RCA values. Territory A enjoys an RCA in trade in good X when the ratio of exports of good X from territory A to the total exports of all goods of this territory exceeds the same ratio for the world as a whole. If RCA>1, territory A has an RCA in trade in good X, while RCA<1 shows a comparative disadvantage.

Results and Discussion

The calculation of parameters of concentration and diversification of foreign trade separately for China and Serbia found Serbian exports to be more concentrated compared with a fairly wide China's export portfolio (Table 2). The number of export commodity items in Serbia has grown markedly since the early 2000s, while the export concentration indicators are lower than the corresponding parameters in China. This fact definitely designates an advantage of the country in terms of potential market coverage. A similar situation is observed in the sphere of imports. Serbia's a imports have diversified, the concentration of imports in certain positions has decreased, although the number of traded categories of goods has increased only slightly. In general, Serbia has significantly improved its involvement in international trade in recent years.

Table 2. *Parameters of diversification and concentration of foreign trade in China and Serbia in 2000-2022*

Indicators	2000		2010		2020		2022	
	CN	RS	CN	RS	CN	RS	CN	RS
Export								
Number of products	254	210	255	240	255	246	256	246
Product concentration	0.077	0.100	0.107	0.077	0.100	0.078	0.101	0.081
Product diversification	0.457	0.578	0.451	0.541	0.385	0.496	0.398	0.498
Import								
Number of products	258	242	258	247	258	250	257	247
Product concentration	0.099	0.131	0.141	0.149	0.178	0.097	0.183	0.103
Product diversification	0.367	0.400	0.363	0.356	0.398	0.330	0.379	0.332

Source: authors' development based on UNCTAD (2023)

Trade in agricultural products is characterized by a rather high degree of concentration (Table 3). A number of producing countries are net exporters of agricultural products (in particular, Serbia for some categories of crops and livestock products), while the largest importers substantially depend on the supply of certain food items to ensure their food security (including China for cereals, oilseeds, and meat). At the same time, structural changes for most categories of agricultural products in recent decades are not as radical as one might expect. According to the 2022 data, the values of the index of structural changes above 0.5 were recorded only for oilseeds and oleaginous fruits (largely due to the rapid growth of imports by China), cereals, and flour from wheat and meslin (Table 4).

The calculation of the RCA index for 31 product items separately for Serbia and China made it possible to identify significant differences in the advantages of the two countries, i.e., potential niches for increasing trade turnover.

Thus, Serbia enjoys strong comparative advantages in such positions as preserved fruit (RCA = 16.551), maize (5.765), meal of flour of wheat and meslin (5.521), and other cereal meals (4.485) and preparations (2.270) (Table 5).

A comparison of the RCA values of the two countries shows a significant advantage of Serbia over China in trade in most grain crops (maize, barley, wheat), meat and meat products, processed food products (flour, cereal preparations, edible products), and horticulture products (fruit, vegetables, and preparations and juices thereof). Export of these products from Serbia to China has a potential to be increased substantially. In turn, China has pronounced comparative advantages over Serbia in trade in fish and aquatic products, crustaceans and mollusks, rice, and tea and mate. An increase in imports of these goods to Serbia will definitely contribute to the optimization of the structure of trade between the two countries based on relative differences in productivity and mutual complement of comparative advantages.

When using the RCA index in measuring advantages of products, industries, or countries in global markets, one should take into account that comparative advantages do not automatically ensure competitiveness. Competitiveness is the feature of a country to successfully compete in international markets. It provides for an increase in the efficiency gains in the spheres of production and exchange in the country in the long term (Kumar, 2022). Comparative advantage is a reflection of specialization of a country and the state of trade regime in a market devoid of external influences and distortions. A pure comparative advantage is based on variations in relative efficiency of territories with no external trade (Edjah et al., 2022; Zhang & Sun, 2022). In the Serbia-China agricultural trade, however, such distortions play a significant role (phytosanitary barriers, underdeveloped transport and logistics infrastructure, etc.). Alternatively, competitiveness is a parameter of a position of a territory in the market distorted by a range of internal and external factors. The dynamic nature of competitive advantages in the free market is emphasized by many scholars, including Han (2017), Sorokin (2020), and Khanal and Uttam (2022), among others.

Accordingly, promising areas of the competitiveness-related research in the sphere of agricultural trade should include approaches to assessing changes in RCA affected by trade policy and non-tariff restrictions, including quality standards for agricultural products. Since comparative advantages are no equal to competitiveness, the RCA index has its limitations in determining the competitive positions of certain categories of goods. It identifies advantages, but not their sources (Xie, 2019). In agriculture, this limitation of the method makes it difficult to distinguish natural advantages (such as increasing the competitiveness of agricultural producers through innovations or increasing yields) and acquired advantages (such as government subsidies or market interventions). Discovering the sources of advantage is important for the food sector, in which government policies may distort business environment and influence the parameters of competitiveness of individual producers (Mgeni et al., 2018; Arisoy, 2020). In particular, the government can offer subsidies to local farmers, support their export activities, adjust customs regulations, and apply non-tariff regulatory measures to boost the competitiveness of certain goods (Arskiy, 2022; Khairullina, 2023). In such cases, the RCA index shows advantage of a country in trade, but the actual competitiveness is distorted.

Conclusion

Summing up the results of the study, the authors emphasize niche sectors in the food trade between Serbia and China in which the comparative disadvantages of one country can be compensated by the comparative advantages of another. The list of products for which the combination of the revealed comparative advantages may result in an increase in mutual trade turnover includes cereals (wheat, barley, corn), oilseeds (soybeans, rapeseed), fish and crustaceans, preserved fruit and vegetables, meat and meat products, and tea. In relation to grain crops and oil seeds, it seems necessary to ensure that Serbian products comply with China's phytosanitary requirements, which still can hardly be met by a majority of farmers. It is also necessary to ensure the recognition of the results of customs control, to establish registers of enterprises for mutual trade, to simplify quality control and quarantine supervision, and to unify customs clearance procedures. To increase the import of fish and seafood to Serbia, the two countries should improve the digitalization of customs clearance and introduce digital permits for the export of fish and deep-processed fish products from China. However, in order to form an objective picture of not only the availability of advantages, but also the sources of their occurrence and their implementation within the specific framework of administrative regulation of trade, it is advisable to adjust the RCA estimates for the parameters of concentration and diversification of production and trade, structural changes of market patterns, and competitiveness.

Appendix

Table 3. *Market Concentration Index of food products in 2000-2022*

Products	2000		2010		2020		2022	
	Exp	Imp	Exp	Imp	Exp	Imp	Exp	Imp
Meat and meat preparations	0.205	0.213	0.188	0.145	0.183	0.198	0.192	0.175
Milk and dairy products	0.225	0.127	0.201	0.103	0.197	0.126	0.185	0.124
Butter and other fats	0.240	0.216	0.260	0.154	0.281	0.149	0.282	0.154
Cheese and curd	0.255	0.208	0.230	0.172	0.222	0.157	0.224	0.145
Eggs	0.298	0.180	0.288	0.228	0.258	0.164	0.247	0.142
Fish, fresh, chilled, frozen	0.148	0.277	0.172	0.176	0.173	0.161	0.183	0.167
Crustaceans and mollusks	0.141	0.364	0.150	0.266	0.205	0.251	0.231	0.270
Fish, prepared, preserved	0.231	0.288	0.253	0.215	0.217	0.221	0.227	0.237
Wheat	0.343	0.108	0.260	0.092	0.249	0.094	0.258	0.092
Rice	0.291	0.106	0.314	0.100	0.331	0.088	0.368	0.097
Barley	0.290	0.220	0.247	0.325	0.228	0.248	0.269	0.197
Maize	0.537	0.190	0.422	0.162	0.322	0.136	0.350	0.147
Other cereals, unmilled	0.448	0.338	0.327	0.230	0.348	0.303	0.346	0.479
Meal and flour of wheat	0.164	0.094	0.174	0.125	0.177	0.126	0.218	0.132
Other cereal meals and flour	0.262	0.088	0.182	0.109	0.161	0.148	0.157	0.153
Cereal preparations	0.194	0.158	0.172	0.135	0.156	0.152	0.142	0.152
Vegetables	0.216	0.190	0.199	0.157	0.198	0.175	0.190	0.170
Vegetables, preserved	0.204	0.197	0.221	0.158	0.220	0.154	0.222	0.155
Fruits and nuts	0.174	0.182	0.160	0.160	0.144	0.169	0.140	0.176
Fruit, preserved	0.143	0.219	0.165	0.194	0.148	0.194	0.143	0.206
Fruit and vegetable juices	0.209	0.205	0.188	0.178	0.180	0.186	0.167	0.207
Sugar and honey	0.133	0.118	0.247	0.091	0.188	0.112	0.190	0.110
Coffee	0.184	0.241	0.207	0.205	0.181	0.181	0.191	0.190
Cocoa	0.304	0.214	0.283	0.210	0.299	0.203	0.301	0.198
Chocolate	0.205	0.173	0.200	0.141	0.198	0.143	0.195	0.142
Tea and mate	0.259	0.151	0.242	0.122	0.267	0.112	0.258	0.113
Spices	0.168	0.190	0.199	0.148	0.231	0.156	0.218	0.152
Feedstuff for animals	0.231	0.128	0.219	0.111	0.180	0.100	0.190	0.102
Margarine and shortening	0.155	0.136	0.182	0.104	0.191	0.106	0.182	0.149
Edible products	0.189	0.110	0.155	0.096	0.155	0.132	0.153	0.127
Oil seeds	0.402	0.223	0.380	0.410	0.407	0.429	0.417	0.436

Source: authors' development based on UNCTAD (2023)

Table 4. *Structural Change Index of food products in 2000-2022*

Products	2000		2010		2020		2022	
	Exp	**Imp**	**Exp**	**Imp**	**Exp**	**Imp**	**Exp**	**Imp**
Meat and meat preparations	0.141	0.143	0.281	0.237	0.319	0.392	0.331	0.417
Milk and dairy products	0.131	0.182	0.284	0.293	0.328	0.356	0.364	0.363
Butter and other fats	0.171	0.177	0.248	0.285	0.212	0.349	0.221	0.350
Cheese and curd	0.110	0.154	0.223	0.234	0.263	0.262	0.278	0.295
Eggs	0.145	0.189	0.251	0.276	0.269	0.336	0.316	0.341
Fish, fresh, chilled, frozen	0.132	0.097	0.278	0.243	0.326	0.315	0.344	0.352
Crustaceans and mollusks	0.151	0.124	0.226	0.262	0.409	0.353	0.438	0.399
Fish, prepared, preserved	0.175	0.103	0.283	0.209	0.379	0.332	0.386	0.359
Wheat	0.135	0.236	0.276	0.317	0.383	0.318	0.476	0.339
Rice	0.188	0.301	0.232	0.329	0.304	0.283	0.345	0.305
Barley	0.216	0.252	0.375	0.280	0.437	0.400	0.488	0.319
Maize	0.202	0.189	0.353	0.243	0.556	0.313	0.535	0.328
Other cereals, unmilled	0.149	0.277	0.303	0.280	0.298	0.523	0.362	0.605
Meal and flour of wheat	0.256	0.388	0.472	0.513	0.477	0.537	0.554	0.535
Other cereal meals and flour	0.198	0.291	0.297	0.388	0.414	0.436	0.432	0.469
Cereal preparations	0.126	0.182	0.191	0.230	0.246	0.269	0.305	0.307
Vegetables	0.137	0.129	0.178	0.240	0.235	0.287	0.259	0.318
Vegetables, preserved	0.138	0.116	0.189	0.185	0.218	0.230	0.231	0.261
Fruits and nuts	0.105	0.121	0.178	0.206	0.284	0.278	0.300	0.330
Fruit, preserved	0.136	0.093	0.227	0.212	0.289	0.290	0.305	0.337
Fruit and vegetable juices	0.154	0.125	0.194	0.172	0.276	0.190	0.315	0.265
Sugar and honey	0.154	0.165	0.366	0.228	0.363	0.262	0.374	0.264
Coffee	0.160	0.092	0.284	0.117	0.334	0.201	0.308	0.207
Cocoa	0.157	0.134	0.108	0.152	0.118	0.174	0.136	0.188
Chocolate	0.166	0.148	0.227	0.208	0.267	0.248	0.272	0.275
Tea and mate	0.165	0.163	0.196	0.227	0.288	0.267	0.312	0.283
Spices	0.152	0.110	0.265	0.206	0.315	0.273	0.309	0.289
Feedstuff for animals	0.143	0.114	0.193	0.219	0.254	0.307	0.259	0.318
Margarine and shortening	0.270	0.399	0.276	0.399	0.307	0.457	0.310	0.477
Edible products	0.193	0.149	0.235	0.193	0.301	0.312	0.324	0.309
Oil seeds	0.158	0.251	0.250	0.513	0.336	0.599	0.422	0.610

Source: authors' development based on UNCTAD (2023)

Table 5. *Revealed Comparative Advantages index of food products in China and Serbia in 2000-2022*

Products	2000		2010		2020		2022	
	CN	RS	CN	RS	CN	RS	CN	RS
Meat and meat preparations	2.280	4.891	0.841	2.961	0.464	2.697	0.575	1.543
Milk and dairy products	0.091	0.788	0.015	2.108	0.014	1.538	0.012	1.476
Butter and other fats	0.003	0.181	0.013	1.059	0.003	0.660	0.004	0.562
Cheese and curd	0.003	0.410	0.000	0.860	0.000	1.314	0.000	1.107
Eggs	0.580	1.318	0.269	0.389	0.207	0.531	0.263	0.672
Fish, fresh, chilled, frozen	1.546	0.022	1.074	0.018	0.669	0.148	0.604	0.142
Crustaceans and mollusks	1.231	0.019	1.014	0.004	0.746	0.008	0.613	0.001
Fish, prepared, preserved	3.779	0.155	2.006	0.265	1.389	0.152	1.527	0.119
Wheat	0.001	3.699	0.000	4.154	0.000	2.149	0.000	2.885
Rice	2.216	0.052	0.193	0.035	0.240	0.015	0.235	0.020
Barley	0.001	0.383	0.008	0.886	0.000	1.955	0.000	2.942
Maize	3.060	8.938	0.014	21.876	0.001	16.076	0.000	5.765
Other cereals, unmilled	0.530	0.528	0.312	0.703	0.061	0.167	0.030	0.201
Meal and flour of wheat	0.641	0.691	0.254	14.645	0.092	6.077	0.049	5.521
Other cereal meals, flour	0.324	16.276	0.031	10.943	0.007	3.685	0.007	4.485
Cereal preparations	0.229	4.783	0.164	3.957	0.112	2.363	0.117	2.270
Vegetables	1.641	2.757	1.024	2.038	0.707	1.150	0.707	1.071
Vegetables, preserved	2.645	5.620	1.702	2.931	1.213	1.774	1.210	1.935
Fruits and nuts	0.325	0.677	0.316	2.205	0.358	1.805	0.261	1.745
Fruit, preserved	2.352	54.194	1.382	26.975	0.879	16.042	0.855	16.551
Fruit and vegetable juices	0.565	3.278	0.633	4.014	0.266	2.937	0.362	3.466
Sugar and honey	0.434	0.186	0.182	8.260	0.212	1.810	0.210	1.852
Coffee	0.038	0.005	0.044	0.126	0.034	0.623	0.035	0.531
Cocoa	0.112	0.072	0.046	0.092	0.016	0.171	0.009	0.154
Chocolate	0.040	5.510	0.053	5.033	0.063	1.885	0.081	2.847
Tea and mate	2.892	0.406	1.061	0.134	1.534	0.187	1.501	0.150
Spices	1.510	4.675	1.240	3.373	0.974	0.892	0.700	0.746
Feedstuff for animals	0.377	2.871	0.320	1.925	0.228	2.602	0.232	2.687
Margarine and shortening	0.247	6.124	0.028	2.407	0.039	1.081	0.029	1.190
Edible products	0.868	2.428	0.385	2.294	0.373	1.802	0.415	2.233
Oil seeds	0.736	0.080	0.109	0.853	0.078	2.102	0.059	0.803

Source: authors' development based on UNCTAD (2023)

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DOES CATTLE PRODUCTION AFFECT GLOBAL WARMING?[1]

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Abstract

In all developed countries, an efficient livestock and cattle production sector is required to ensure a consistent supply of high-quality food. According to recent publications, the global livestock business accounts for 14.5% of total anthropogenic emissions, with the cattle sector contributing to 65%. Although it contributes to total emissions, the livestock sector has the potential to mitigate climate change by 14% to 41%. It is important to emphasize that the animal production sector is critical to food production, which is essential to human survival. However, the reliability of these estimations is frequently called into question. There is currently a particularly active campaign against the livestock and cattle production sectors, and it is critical to identify the interest groups behind it and their reasons. The issue must be asked: would there be a drive for artificial or vegan "meat" if there was no intense campaign against livestock farming as the claimed cause of climate change?

Key words: *cattle production, greenhouse gas emissions, artificial meat, veganism.*

Introduction

Animal production is a crucial component of the agriculture industry, but it has an important impact on the environment. Historically, animal production systems were designed to turn waste materials and other resources with limit-

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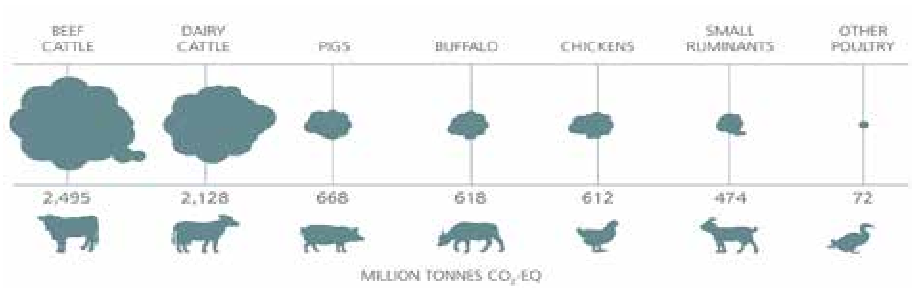
ed alternative uses into edible items and other goods and services. During that period, the relatively small size of animal production systems had a negligible impact on the environment. However, as demand for animal-sourced food grows, the sector has become more intense. As a result, the industry has grown more demand-driven and rapidly growing, eventually leading to the current situation in which it competes with other industries for natural resources. This increase in demand has also resulted in higher environmental repercussions, with the cattle sector frequently cited as being notably resource-hungry.

Given the continuing expansion of the sector to ensure food security for the growing world population, there is an urgent need to reduce its emissions and environmental impact. According to estimates, total greenhouse gas (GHG) emissions from animal production supply chains were approximately 7.1 Giga tonnes of CO2-eq/year in 2005, accounting for 14.5% of all anthropogenic emissions (49 Giga tonnes CO2-eq in 2004). The animal production supply chains produce 2 Giga tonnes CO2-eq of CO2/year or 5% of anthropogenic CO2 emissions, 3.1 Giga tonnes CO2-eq of CH4/year or 44% of anthropogenic CH4 emissions, and 2 Giga tonnes CO2-eq of N2O/year or 53% of anthropogenic N2O emissions, according to IPCC reports (IPCC, 2007).

In terms of species, cattle account for the majority of animal production sector emissions, accounting for approximately 4.6 Giga tons CO2-eq, or 65% of total sector emissions. At the same time, pigs, poultry, buffaloes, and small ruminants have far lower amounts of emissions, ranging from 7% to 10% of sector emissions (FAO, 2013; Figure 1).

Figure 1. GHG emissions related to animal species



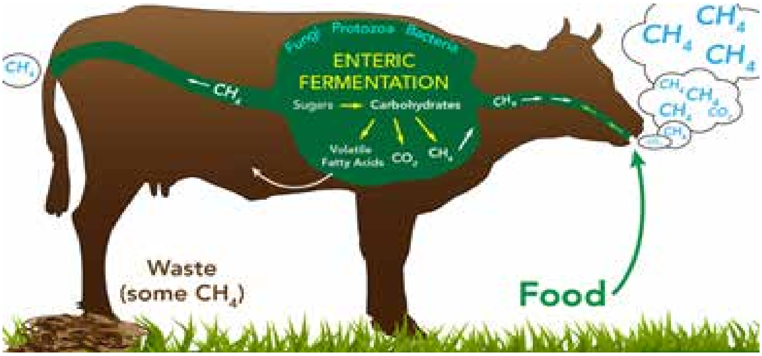
Source: FAO, 2013

When it comes to commodities, beef contributes 2.9 Giga tonnes of CO2-eq or 41%, while cattle milk contributes 1.4 Giga tonnes of CO2-eq or 20% of total sector emissions. These commodities are followed by pig meat, with 0.7

Giga tonnes of CO2-eq (9%), buffalo milk and meat (8%), chicken meat and eggs (8%), and small ruminant milk and meat (6%) products (FAO, 2013).

The main source of greenhouse gas emissions in ruminant production systems is feed fermentation in the rumen (Figure 2) and feed production. Furthermore, pasture-based production systems produce more greenhouse gases compared to farm-based production systems.

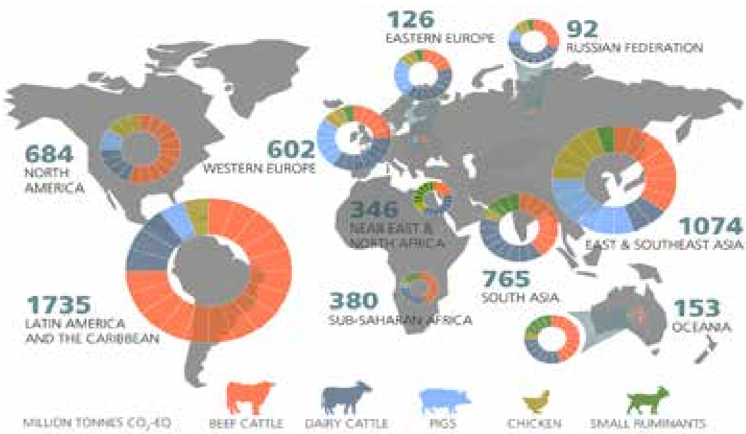
Figure 2. Presentation of gas production in cattle



Source: LTS, 2020

Regional emissions and production profiles fluctuate greatly, and the variances can be attributable to the variable shares of ruminants or non-ruminants in total animal production, as well as alterations in production (and emission) intensities between regions.

Figure 3. Regional GHG emissions related to animal species



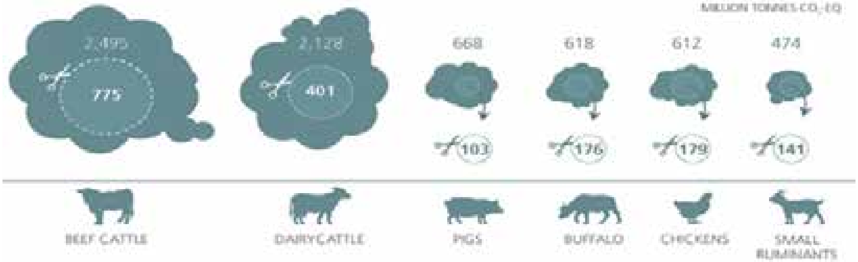
Source: FAO, 2013

The highest level of emissions, with 1.7 Giga tonnes CO2-eq, is caused by the specialized production of beef in the Latin American and Caribbean regions. The lowest emission levels were estimated in Eastern Europe, Oceania, and the Russian Federation, with emissions totalling around 0.1 Giga tonnes CO2-eq. (FAO, 2013, Figure 3).

The intensities of greenhouse gas (GHG) emissions in animal production systems vary significantly between farmers, particularly for ruminant products, as well as pork and chicken meat and eggs. This variation results from a variety of agroecological factors, methods of farming, and supply chain management. According to the FAO (2013), such variation occurs both inside and between agricultural systems. Interestingly, the differences between producers with the highest and those with the lowest emission intensity provide an opportunity to find an adequate mitigation option.

It is generally observed that the lower the productivity, the higher the GHG emission per kilogram of product (Gerber et al., 2011.). For instance, in ruminant production systems, productivity has a strong negative connection with emission intensity. Moreover, higher GHG emissions are mostly caused by reduced feed digestibility, which results in increased enteric and manure emissions, poorer farming practices, and lower slaughter masses. Furthermore, slower growth rates result in more emissions per kilogram of meat produced, but higher age at slaughter leads in a longer life and higher emissions. The global animal production sector contributes to anthropogenic GHG emissions. However, it can also deliver a significant share of the necessary mitigation effort, according to the FAO (2011). Mitigation potential estimates are based on the wide gap in emission intensities that exist globally, regionally, within production systems, and in agroecological regions, as reported by the FAO (2013). The mitigation potential ranges from 14 to 41%, depending on the chosen species, system of production, and geographical location.

Figure 4. Mitigation potential regarding the animal species



Source: FAO, 2013

Does total livestock and cattle production really affect global warming?

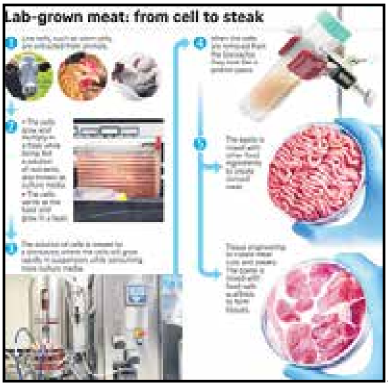
The livestock industry in Europe is a major contributor to greenhouse gas emissions, producing more emissions than all cars and vans in the region combined (Greenpeace, 2020). The same report also stated that the rise in the dairy and meat production over the past ten years has made livestock production sector an important contributor of overall emissions.

Similarly, Ecopeanut (2021), highlighted the negative impact of the livestock industry on the environment, such as emissions, water consumption, deforestation and land clearing, and land occupation. The organization suggested that if people switched to vegetarianism or hunting, 14.5% of all human-related emissions could be offset. However, this solution raises other questions, such as whether there are enough resources to produce plant-based food for the growing human population.

Advocating for the complete extinction of domestic animals, as some lobbies do, would have disastrous long-term effects for the quality and structure of arable land, which cannot be regained by any known substitute to manure. This would directly and automatically threaten existing plant productivity while increasing the number of impoverished people worldwide. In some areas, traditional livestock breeding with acclimatized plant crops is the only viable choice because wheat and corn do not grow. The elimination of domestic animals would also result in significant population migrations, famine, and regional destruction.

Picture 1. Climate crime – the main suspect; the 'solution' to the problem – artificial meat

How and why did we go from producing the most fundamental requirements of all living things, food, to being labelled as those who are destroying the planet?



Artificial meat

'Cultured meat, produced in bioreactors without the slaughter of an animal, has been approved for sale by a regulatory authority for the first time. The development has been hailed as a landmark moment across the meat industry' (Guardian, 2020).

Artificial meat, also known as lab-grown meat, in vitro meat, or synthetic meat, is a product made by cultivating muscle cells in a nutritional serum and helping them to form muscle-like fibers. By applying tissue engineering technologies to the synthesis of muscle for consumption as food, cellular agriculture has set up a new path for manufacturing items normally derived from animals. There are two types of cellular agriculture: tissue engineering-based and fermentation-based. *Tissue engineering-based* cellular agriculture uses cultured meat and leather systems, in which cells or cell lines are extracted from living animals and tissue-engineered generate consumable tissue. The starting material, or cells, can be taken from an animal utilizing a biopsy process or a genetically engineered cell line. *Fermentation*-based cellular agriculture does not include the utilization of living animal tissues. Instead, products are manufactured through fermentation of bacteria, algae, or yeast that have been genetically engineered with recombinant DNA to make organic compounds. These molecules can subsequently be used to create common animal products like gelatine, casein (used in milk), and collagen (used in leather). While cultured meat is an early-stage technology with potential benefits and challenges, there are concerns about its environmental impact. ***The emission, water consumption, and footprint of artificial meat production are still unknown***, and there are no scientific estimates of the extent to which meat production will contribute to the reduction of GHG emissions. Therefore, the claim that artificial meat will save the globe from greenhouse gas emissions is not supported by scientific research. However, it is estimated that the financial turnover on the artificial meat business would reach 140 billion euros within the next several years.

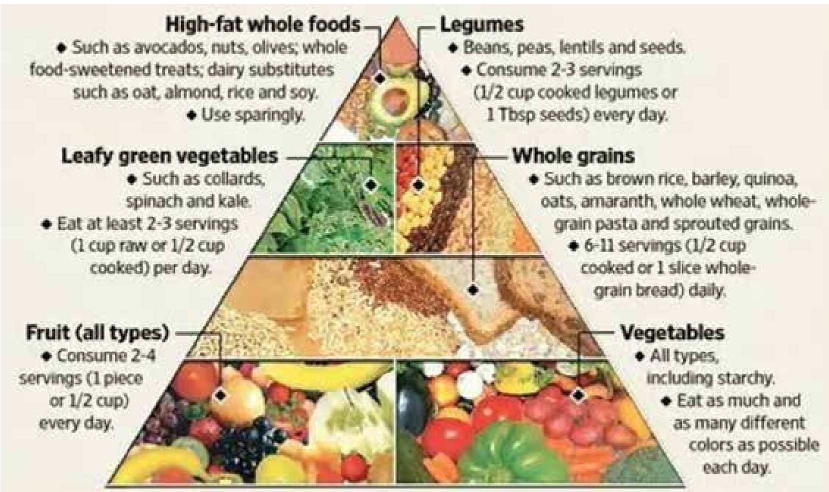
Picture 2. Artificial meat

WOULD YOU CONSUME ARTIFICIAL 'MEAT' IF THERE WAS NO AGGRESSIVE CAMPAIGN AGAINST LIVESTOCK PRODUCTION AS THE CAUSE OF CLIMATE CHANGE?

Plant based diet

As people become more conscious about their health and the environment, plant-based diets have gained popularity in recent years. A plant-based diet is predominantly composed of plant-derived foods such as whole grains, legumes, nuts, seeds, and fruits and vegetables, with little or no animal products (BDA, 2023). While there are several various types of vegetarians, they all prefer to eat plant-based cuisine for a variety of reasons.

Picture 3. A plant-based diet – a food pyramid



Source: Plant-Based, 2023

Many people choose to eat a plant-based diet for a variety of reasons, including personal preference, health concerns, ethical considerations (such as not wishing animals to be harmed), concerns about the environment (based on the belief that animal production has a significant environmental affect), and beliefs related to religion. However, other research suggest that consuming insufficient amounts of animal-based meals may have negative implications. Studies conducted in Guatemala on mothers and new-borns (Casterline et al., 1997) and school-age children (Rogers et al., 2003) demonstrated that little or no consumption of animal-source foods can result in a high vitamin B12 deficiency, resulting in insufficient dietary intake. Severe folate (vitamin B9) and cobalamin (vitamin B12) deficits can have a major negative influence on brain development in infancy and raise the risk of depression in adulthood (Black, 2008). It is also crucial to note that adequate folate intake during pregnancy can minimize the risk of neural tube abnormalities (NTDs) in babies, but severe cobalamin deficiency can impair adolescent behavioural and psychoeducational performance (Black, 2008). Deficits in folate and cobalamin are primarily associated with malabsorption or a vegetarian diet. Black (2008) stated that vitamin B12 insufficiency can have negative consequences on newborn growth, cognition, integration into society, and appearance of depression.

Adopting a plant-based diet is frequently regarded as a more sustainable dietary option due to its possible good environmental effects. Plant production takes fewer resources than animal production, including land, water, and energy which results in a lower carbon footprint and reduced greenhouse gas emissions. In addition, fewer resources are required for plant production, which leads to the conservation of natural resources, ecosystems, and biodiversity.

However, it is vital to highlight that plant-based diets rely mainly on soya derivatives like tofu and tempeh, which are primarily produced in Brazil and India. Unfortunately, this has resulted in significant deforestation and loss of habitats in these regions. According to a new study by Jordan et al. (2022), over 400 square miles (1,000 square kilometers) of Amazon rainforest have been removed during the last ten years in order to expand soya-growing plantations in the Brazilian state of Mato Grosso. Similarly, palm oil, a key component of a plant-based diet, is primarily manufactured and imported from Indonesia, Malaysia, Thailand, and Nigeria, where regional ecosystems have been devastated by destruction of forests and biodiversity loss.

Millions of hectares of forest are cleared for palm oil cultivation, destroying habitat for numerous species. Furthermore, the palm oil business has faced several charges of human rights breaches, including underage labor, wide-spread sexual abuse and rape, and contamination with hazardous pesticides (Trauger, 2022).

Picture 4. Deforestation in Borneo

Source: Future Environment Defenders, 2023

Picture 5. Plant-based meat

WOULD YOU CONSUME PLANT-BASED 'MEAT' IF THERE WAS NO AGGRESSIVE CAMPAIGN AGAINST LIVESTOCK PRODUCTION AS THE CAUSE OF CLIMATE CHANGE?

Conclusion

According to current studies, the global livestock sector produces 14.5% of total anthropogenic greenhouse gas emissions, with the cattle sector contributing with 65%. Furthermore, the livestock sector has a great potential for mitigating climate change having a mitigation potential of 14–41%, depending on the specific species, system of production, and farming area. We are currently witnessing a very aggressive campaign against the agricultural production sector, especially livestock production, but we have to ask ourselves which lobbies are behind the campaign and for what reason.

The answer is not difficult to find, let's ask ourselves if we would ever think of consuming artificial or vegan "meat" if there was not an aggressive campaign against livestock production, and especially cattle production as the cause of climate change?

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AGRICULTURAL COOPERATIVES IN THE FUNCTION OF IMPROVEMENT OF MARKET POSITION OF FARMERS IN VOJVODINA

Jelena Nestorov Bizonj[1]

Abstract

Cooperative movement in Vojvodina has a long and rich history. Agricultural cooperatives have been, since their beginnings to today, the predominant type of cooperatives. Considering the long tradition of agricultural production in Vojvodina, as well as the fact that the largest part of the cultivated land is owned by family agricultural holdings which are small, organizing farmers into cooperatives has been the imperative way of improving their market position.

Organizing farmers into cooperatives and merging their offer and demand through joint market appearance, improves their market position, in comparison to an independent market appearance. Equipping cooperatives with property and other capacities directly affects the scope of services a cooperative can offer to its cooperative members, for the purpose of improving their market position to the greatest extent.

Key words: *agricultural cooperatives, farmers, market position.*

Introduction

According to the data obtained from the International Cooperative Alliance, there are more than 1 billion cooperative members in about 3 million cooperatives in the world today. Cooperatives employ an estimated 10 % of the total global workforce. Vojvodina is one of the regions with the longest cooperative tradition in the world. The first cooperative in Vojvodina was founded in 1846 in Bački Petrovac. It was called Gazdovský spolok. The first modern cooperative established in Vojvodina was the third in Europe and in the whole world. The tradition of uniting farmers in cooperatives in Vojvodina has been preserved to this day, in different countries and socio-economic systems, which had a huge impact on the quality and quantity of cooperative organisation through history.

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In times of modern economy, market economy and strong competition in the market of agricultural food production, domestic farmers face great challenges. Small agricultural holdings are dominant in the Republic of Serbia, 77,7 % of which have the size of up to 5 hectares, according to 2012 census of agriculture data. Apart from the small size, an average agricultural holding in Serbia mainly has extensive and non-specialised production, low productivity and therefore lack economic strength for independent market positioning.

In the Vojvodina region, the average of used agricultural holding is 10,9 hectares, which is twice the average state level. However, agricultural holdings in Vojvodina are also characterised by extensive and non-specialised production and are mainly engaged in crop growing and small number of cattle per agricultural holding.

The existing structure of agricultural holdings in terms of size and other characteristics requires their organisation in agricultural cooperatives, for the purpose of joint market appearance in order to obtain better economic effects from their production compared to an independent market appearance. Simply by uniting supply and demand of farmers through agricultural cooperatives, their competitive position in the market improves. Whether the economic effects for farmers conducting their business through a cooperative are limited to the benefits of unifying the supply and demand of all cooperative members, or whether these effects can be greater, depends largely on the land ownership and other capacities, which will be discussed in more detail below.

Characteristics of agricultural cooperatives in Vojvodina

Cooperative Union of Vojvodina is the institution which represents the interests of cooperatives in Vojvodina. There are 462 active agricultural cooperatives and 20 cooperatives of other type, members of Cooperative Union of Vojvodina. Considering that 90% of the registered agricultural cooperatives in Vojvodina are members of Cooperative Union of Vojvodina (hereinafter referred to as ‘CUV’), data obtained from the CUV will be used in this paper as a representative indicator about cooperative movement in Vojvodina.

In the Republic of Serbia cooperatives are formed and do business according to The Law on Cooperatives (Official Gazette of the Republic of Serbia, no. 112/2015). According to the Law, a cooperative is a legal entity which is a special form of organization of physical persons (cooperative members) that realizes its economic, social, cultural and other interests by operating on cooperative principles, and that manages and controls the operations of the cooperative. In agriculture, cooperatives are formed as agricultural or farming cooperatives which can be either general or specialized (fruit, vegetable, livestock, beekeeping etc.)

Agricultural or farming cooperatives are the most dominant type of cooperative organization, and make 95% of the CUV members. If the number of agricultural cooperatives that are actively operating is compared with the number of settlements (468) in Vojvodina, it can be concluded that on average, there is a good coverage of cooperative organizations, while there are settlements where there are no registered or active cooperatives, or in some settlements there are more than one.

Cooperative members and cooperators of cooperatives are mainly farmers with small or medium - sized land. In Serbia's cooperatives, it is typical for a large number of farmers to regularly establish cooperator relationships with cooperatives, i.e. arrange contracted production and services with cooperatives annually. That way, farmers gain the status of cooperators, not cooperative members, as they are not members of cooperatives who manage and control the operation of the cooperative.

More than 100.000 people are directly involved in cooperatives in Vojvodina, as cooperative members, cooperators or employees. Of the mentioned number, about 2.500 people are employed in cooperatives (without counting the additional seasonal workforce for temporary jobs). There are around 10.000 farmers who are members of cooperatives in Vojvodina, while most farmers maintain cooperator relationship with cooperatives. Deviations in the number of employees, members and cooperators of the cooperatives are large.

The main activities of agricultural cooperatives include arranging production via contracts, on the land owned by cooperative members or cooperators, as well as the purchase of agricultural products. In addition to the aforementioned activities, cooperatives that own land most often cultivate their land.

According to the data obtained from the Survey about the structure of agricultural holdings, 2018. –Agricultural Holdings According to the Production Type and Economic Size (Paraušić, V., Roljević, S. & Subić, J., 2019.), more than half of family agricultural holdings in Vojvodina, i.e. 53,3% are specialized in field crops, and mixed family agricultural holdings which produce crops and have livestock make 20,2% of family agricultural holdings. Taking this information into account, it can be concluded that field crops are dominant in the agriculture of Vojvodina. Whether a cooperative will be general or specialized (e.g. fruit, vegetable, livestock, etc.) is directly conditioned by the structure of production and needs of its members. Considering the low level of specialized production on family agricultural holdings of cooperative members, as well as the domination of field crops in Vojvodina, most cooperatives and their members do their business in the area of field crops, as stated in the data about the type of production in agricultural holdings in Vojvodina.

From the data obtained from the CUV, about the cooperative production on the land owned by cooperatives, it is visible that it is almost identical to the structure of production of their cooperative members and cooperants.

On the cultivated land owned by cooperatives, more than 96% is under field crops, while vegetable growing covers a little more than 2% of the area, and fruit growing a bit more than 1%.

With regard to field crops, the most commonly cultivated crops are maize and wheat, followed by sunflower and soybean. Apple dominates in fruit production, while pepper (mostly used as paprika spice, and then for eating) dominates in vegetable production. Contracted production and procurement of livestock units, between cooperatives and their members or farmers outside the cooperative, as well as livestock farming that cooperatives do for themselves in their ownership is meagre in cooperatives in Vojvodina. For example, today only 10 cooperatives contracts production of livestock for their cooperants or cooperative members or purchase pigs, and most former cooperatives' farms have ceased to exist, and only a few bigger ones are active today.

Property of agricultural cooperatives in Vojvodina and the need for investments

Of the total number of agricultural cooperatives in Vojvodina, most do not have their assets. Agricultural land and other real property (storage capacities, and other) possess around 120 cooperatives, making that just above 25% of the total number of agricultural cooperatives. Cooperatives that own immovable property, as a rule, also have moveable property (agricultural machinery and other). Some cooperatives without immovable property do have moveable property.

Collective property ownership was the dominant type of ownership until 2016, in terms of immovable property used by cooperatives. One consequence of the unresolved ownership relations in cooperatives was the lack of investments in new immoveable property, in cases when there was a need and possibility for new investments, due to the uncertainty of the future status of the property. (Nestorov Bizonj, J., Franci, A., & Lovre, K., 2016.). The Law on Cooperatives from 2015 prescribed the method of converting collective into cooperative property ownership. After prescribing cooperative ownership on cooperative properties, in 2016. onward, there have been increased investments in cooperatives.

Apart from agricultural land, agricultural cooperatives in Vojvodina have vast storage facilities (silos, store buildings, warehouses, cold storages, etc.), where they store products of cooperative members, co-operators and their merchandise. Facilities for finalizing production and processing are owned only by a few cooperatives in Vojvodina. Some cooperatives also have agricultural supply stores, petrol stations, restaurants, cafés, and others. Cooperative agricultural machinery is comprised of tractors, combine harvesters, telehandlers, additional farming equipment, and others, used for cultivating land owned by cooperative members and co-operators, as well as the land owned by cooperatives.

Cooperatives that have immovable and movable property employ the most workforce in cooperative movement. They also have more members and co-operators than average. These cooperatives usually have a much higher turnover and a higher profit, compared to those without assets.

The cooperatives' need for investing in immovable and movable property is large. According to the CUV data and survey conducted in 2021 that included 165 cooperatives in Vojvodina, as many as 128 cooperatives (78%) expressed the need to invest. The biggest number of cooperatives (106) stated the need for procuring machinery (tractors, harvesters, telehandlers, and others). 81 cooperatives expressed interest in investing in storage facilities (store buildings, silos, cold storages, and others). Only 15 cooperatives said there was a need for investment in facilities for production finalisation and processing, and 25 cooperatives had interests in procuring irrigation systems. Most cooperatives express an interest in more than one type of investment.

Cooperative potential for the purpose of the improvement of market position of farmers in Vojvodina

Via joint demand of cooperative members for raw materials used for production, more favorable procurement conditions could be achieved in terms of achieving better raw materials prices. Better prices could be achieved by joint sales of cooperative members through cooperatives, and also bigger amounts of merchandise could be placed on a wider market. What the effects of unifying the supply and demand of cooperative members through cooperatives will be, depends on several factors. The number of cooperative members and the quantity of products on the market are crucial factors in creating better market conditions. Cooperatives with many members and cooperators can achieve much better economic effects in terms of economies of scale.

Besides these factors, providing necessary facilities for cooperatives is important, in order to create a better market position. When cooperatives have storage capacities, the possibility of storing products for cooperative members is created, and there are also better conditions for the sales of stored products, all of which gives cooperative members a strategic advantage, in comparison to farmers who do not have this possibility.

In terms of the arranged production between the cooperative and cooperative members, cooperatives with machinery provide land cultivation services and other types of service to their members and cooperants. Technological and economic profitability of cooperative machinery use on agricultural holding owned by cooperative members, and cooperants is incomparably greater than the procurement of machinery done by agricultural holding independently. Savings in terms of machinery service costs are important for the reduction of production inputs. As an example, like it is stated in the Calculation of the wheat production price for 2023, made by the CUV experts in June 2023, the participation of the costs of mechanical operations for wheat cultivation marked 40% of the total wheat production costs.

Along with the owned property, for the successful business run of cooperatives and cooperative members, the workforce in cooperatives has an important role, especially high - quality management and experts. The transfer of knowledge and technologies between cooperatives and cooperative members is one of the essential elements of development in agricultural production. Cooperatives that employ experts in the field of agriculture and other professions are able to influence the improvement of the production process of cooperative members and cooperants through the transfer of knowledge and advisory support.

The total potential of the cooperative for improving the market position of the cooperative depends on the degree of liquidity of the cooperative and the available own financial resources, as well as the potential of the cooperative for obtaining external sources of financing. The financial capacity determines whether the cooperative will be able to invest in a new property, which would enable its members better business conditions. The possibility of the employment of experts and high - quality management is also determined by financial potentials. Finances also have an impact on cooperative development on the market, in terms of procurement, sales and investments done when the market conditions are most favorable for cooperatives and their members.

The lack of financial resources is the main reason why many cooperatives have not invested in needed property and workforce, and because of that cannot achieve their full potential and improve the market position of farmers who do business with them.

Credit conditions in banks have been extremely unfavorable for agriculture in recent years, and there is also a problem of credit potential for some cooperatives. State subsidies for cooperatives are quite limited when considering cooperative needs. Only one ministry of the Republic of Serbia has had a subsidy program for investments, specially created for cooperatives. One limitation for achieving a greater cooperative potential is the tax policy, which has not recognised the specifics of cooperative organisation.

Conclusion

By organising farmers in cooperatives and jointly acting on the market via cooperatives, the market position of farmers is improved, and their bargaining power is increased. Using the potential of cooperatives for the improvement of market position of farmers in Vojvodina varies, depending on the number of cooperative members and cooperants, and the number of products they trade via cooperatives, as well as the financial capacities of cooperatives, which is in correlation with the property, workforce and other resources they own.

More than 1/4 of cooperatives in Vojvodina have property and storage capacities that are in the function of the cooperative members' needs, and hence achieve positive business results and high annual turnover, all of which enables cooperative members a better market position, in comparison to other farmers who do business outside cooperatives. Cooperatives that do not have their property, and do not have many cooperative members and lack financial capital, the potential for cooperative business is not sufficiently used, even though their members have advantage on the market, in comparison to farmers outside cooperatives.

To use the cooperative potential on a higher level and improve the market position of cooperative members, a larger number of government subsidies for cooperatives and their members is needed. Increasing subsidies for investments in cooperatives is of key importance for the improvement of cooperative potential. Apart from the aforementioned, subsidies and other incentives for agricultural production should be available for all the land which is cultivated and owned by cooperatives and their members, i.e. for all livestock unit or other types of production. Currently, subsidies for both cooperatives and their members are limited to 20 hectares of agricultural land owned by them, while all the production and turnover are done legally by cooperatives, and represent a segment of agriculture which contributes to the state budget the most.

Increasing the knowledge about the cooperative movement and recognising its potential are necessary for providing better state and other types of incentives, as well as for the promotion of cooperative organisation amongst independent farmers, as many of them still do not form a part of the cooperative system, which has a negative impact on their market position and bargaining power. By improving the cooperative potential, positive effects would be achieved for both farmers and agriculture in general, and would contribute to the state budget and national food security.

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THE INFLUENCE OF FOREIGN DIRECT INVESTMENTS ON THE IMPROVEMENT OF AGRIBUSINESS[1]

Marijana Joksimović[2]

Abstract

The financial situation in the world like a result of Covid-19 and the war in Ukraine have a great impact on foreign direct investments (FDI) and thus on the improvement of agribusiness in the European Union and the Republic of Serbia. In the paper, the author investigates the impact of FDI on the improvement of agribusiness. In order to draw adequate conclusions, the data used in the paper are official data of the Food and Agriculture Organization of the United Nations (FAOUN) and the United Nations Conference on Trade and Development (UNCTAD). The time series used in the paper includes data relating to the period from 2017 to 2023.

Key words: *Foreign direct investment, Agribusiness, European Union, Republic of Serbia and Economy.*

Introduction

The financial situation like a result of Covid-19 and the war in Ukraine have a great impact on FDIs of agribusiness in the European Union and the Republic of Serbia. Tax incentives, stimulus packages, and eased bureaucracy are just some of the measures that economies use to attract FDI and are competitive in relation to others. (Joksimovic et al., 2017, Mitrović et al., 2014; Medina, 2022). The authors explore the influence of FDIs on the improvement of agribusiness.

The research method used in the work is descriptive analysis, the induction method and the deduction method, as well as the analysis of the content of the available literature and the set subject and goal of the research. In order to achieve adequate research results, authorized data from the field of agribusiness were used in the work. All data used to 2022 in the paper are presented in annual time series except for the data from 2023 in the paper are monthly.

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Data for this paper was include from the database of the Food and Agriculture Organization of the United Nations (FAOUN) and the United Nations Conference on Trade and Development (UNCTAD) and other relevant research papers. The analysis also included figures about FDI inflow and outflow for European Union and Serbia, which were examined from 2017 to 2022.

Ranking of countries by agriculture in the world

The China is best agricultural producing countries in the world in 2023. China is expected to remain the world's top agricultural producer in 2023, with a projected output of $1.14 trillion.

At the table no. 1, the author shows top eight agricultural producing countries in the world in 2023.

Table 1. Top agricultural producing countries in the world

Rang	Country
1.	China
2.	United States
3.	Brazil
4.	India
5.	Russia
6.	France
7.	Mexico
8.	Japan

Source: *Author from data Food and Agriculture Organization of the United Nations*

On the table 2, the author shows best countries exports in billions in 2022 in the world.

Table 2. Best country agricultural exports in billions in 2022 in the world

Country	Exports (in billions)
United States	$118.3
Netherlands	$79
Germany	$70.8
France	$68
Brazil	$55.4

Source: *Author from data Food and Agriculture Organization of the United Nations*

The best country agricultural exports in the world in 2022 is United States with $118.3, another place is Netherlands with $79, takes the third place Germany with $70.8, it is in fourth place France with $68, and it is in fifth place Brazil with $55.4.

Table 3. The Best country with staples that feed the world

Commodity	Leading country	% of Global Exports
Corn	United States	26% ($7.6 billion)
Fish	China	9.2% ($6.6 billion)
Palm Oil	Indonesia	51% ($10.4 billion)
Rice	Thailand	34.5% ($6 billion)
Soybeans	United States	50.5% ($16.5 billion)
Wheat	United States	18% ($5.4 billion)

Source: *Author from data Food and Agriculture Organization of the United Nations*

If we look at the staples that feed the world (rice, corn, wheat, beans, lentils, and animal proteins), countries like the United States, Germany, Canada, Brazil, and Thailand feature more prominently, see more on the Table 3.

Economic indicators

The financial situation like a result of Covid-19 and the war in Ukraine in 2022 has an impact on the whole world. Great impact on changes in the real estate market and interest rates, by the increase in price food, high inflation and food shortage which resulted in problems in world. The decline in the standard of living of the population was great. Although the war in Ukraine it has spread and swung the whole world. (Jaiswal, et al., 2020). The crisis has a great impact on the slowdown of the economy of the EU and Serbia.

At the table 4, the author provide an overview of the main economic indicators of the European Union in 2022 and 2023 that give a cross section of the economy in the European Union.

Table 4. European Union - Economic Indicators

Overview	Last	Reference	Previous	Period
Stock Market	4261	4236	points	Aug/23
GDP Growth Rate	0.3	0	percent	Jun/23
GDP Annual Growth Rate	0.6	1.1	percent	Jun/23
Unemployment Rate	6.4	6.4	percent	Jun/23
Inflation Rate	5.3	5.5	percent	Jul/23
Inflation Rate MoM	-0.1	0.3	percent	Jul/23
Interest Rate	4.25	4	percent	Jul/23
Balance of Trade	23030	-304	EUR Million	Jun/23
Current Account	36.77	-12.46	EUR Billion	Jun/23
Current Account to GDP	-1	2.3	percent of GDP	Dec/22
Government Debt to GDP	91.5	95.4	percent of GDP	Dec/22
Government Budget	-3.6	-5.3	percent of GDP	Dec/22
Business Confidence	-0.09	0.06	points	Jul/23
Manufacturing PMI	43.7	42.7	points	Aug/23
Services PMI	48.3	50.9	points	Aug/23
Consumer Confidence	-16	-15.1	points	Aug/23
Retail Sales MoM	-0.3	0.6	percent	Jun/23
Corporate Tax Rate	23	23.2	percent	Dec/22
Personal Income Tax Rate	42.9	43	percent	Dec/22

Source: https://tradingeconomics.com/euro-area/indicators

At the table 5, the author provide an overview of the main economic indicators of the Serbia in 2021, 2022 and 2023 that give a cross section of the economy in the Serbia.

Table 5. Serbia - Economic Indicators

Overview	Last	Reference	Previous	Period
Currency	108	108		Aug/23
Stock Market	894	892	points	Aug/23
GDP Growth Rate	-0.2	0.6	percent	Mar/23
GDP Annual Growth Rate	1.7	0.7	percent	Jun/23
Unemployment Rate	10.1	9.2	percent	Mar/23
Inflation Rate	12.5	13.7	percent	Jul/23
Interest Rate	6.5	6.5	percent	Aug/23
Balance of Trade	-664	-812	USD Million	Jun/23
Current Account	-340	-185	USD Million	Jun/23
Current Account to GDP	-6.9	-4.3	percent of GDP	Dec/22
Government Debt to GDP	55.1	56.5	percent of GDP	Dec/22
Government Budget	-3.3	-4.6	percent of GDP	Dec/22
Corporate Tax Rate	15	15	percent	Dec/23
Personal Income Tax Rate	10	10	percent	Dec/21

Source: https://tradingeconomics.com/serbia/indicators

Everything stated in the paper based on the collected data points to the slow economic growth of both observed economies. The European Union and the Republic of Serbia have great benefits for FDI in agribusiness. Both economies have many investment benefits of FDI in agribusiness.

Research results

The collected data regarding FDI in both economies aims to determine the extent to which FDI affects the economic growth of both observed countries. Maximizing the profits and efforts of the richer and more powerful countries to increase their wealth by using natural and human resources to other countries (Mitrović et. al., 2014).

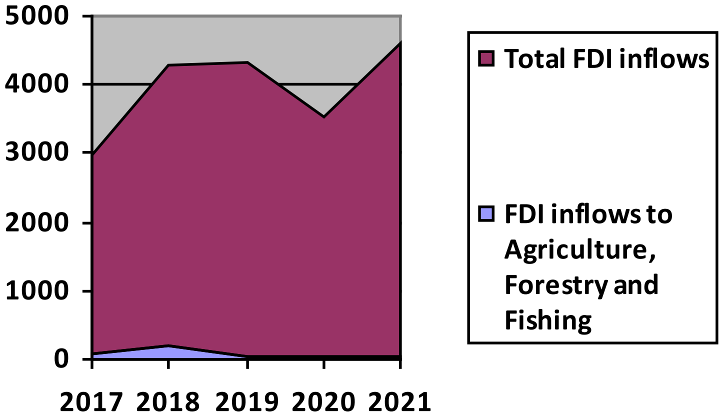
Due to its specificity, FDI in the practice of other countries can be seen as a factor of particular importance for the further growth and recovery of the economy (Joksimovic et al., 2017).

Table 6. FDI in Serbia inflows to Agriculture, Forestry and Fishing and Total FDI inflows in Serbia 2017-2021, Value in million USD

FDI inflows to Agriculture, Forestry and Fishing and Total FDI inflows in Serbia 2017-2021, Value in million USD					
Year Area SERBIA	**2017**	**2018**	**2019**	**2020**	**2021**
FDI inflows to Agriculture, Forestry and Fishing	81.295.77	178.584.3	53.892.31	56.392.51	49.791.3
Total FDI inflows	2.878.573	4.091.385	4.271.15	3.470.997	4.569.052

Source: Author from data http://unctadstat.unctad.org/

Chart 1. FDI inflows to Agriculture, Forestry and Fishing and Total FDI inflows in Serbia 2017-2021, Value in million USD



Source: Author from data http://unctadstat.unctad.org/

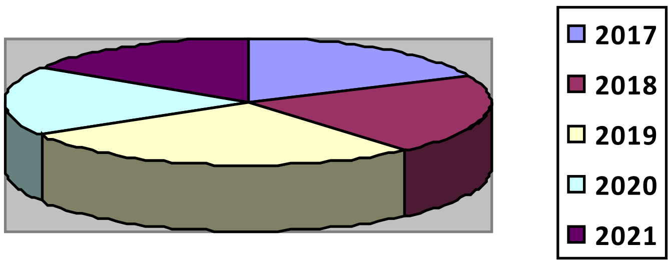
At the table no. 6, we can see the Serbia inflows to Agriculture, Forestry and Fishing and Total FDI inflows and Total FDI inflows in Serbia, Value in million USD from period 2017 to 2021. The amount of FDI in Serbia varies yearly.

Table 7. Total FDI inflows in European Union (27)2017-2021, Value in million USD

Total FDI inflows in European Union (27)2017-2021, Value in million USD					
Year Area European Union (27)	**2017**	**2018**	**2019**	**2020**	**2021**
Total FDI inflows	292.163.6	334.205.2	441.914.7	290.665.9	255.658.5

Source: Author from data http://unctadstat.unctad.org/

Chart 2. Total FDI inflows in European Union (27) 2017-2021, Value in million USD



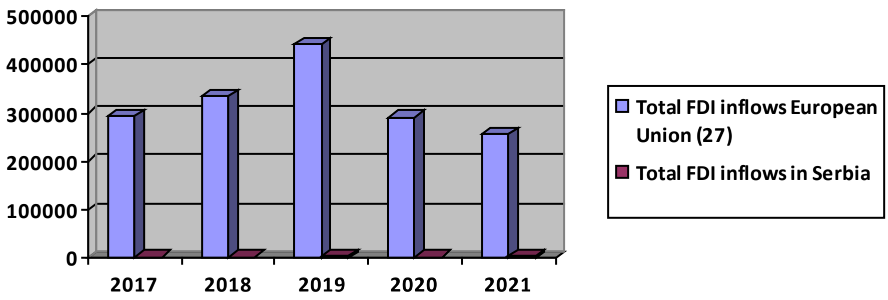
Source: Author from data http://unctadstat.unctad.org/

At the table 7, we can see the amount of FDI in EU varies yearly. The amount of FDI in European Union varies yearly.

Table 8. Total FDI inflows in Serbia and European Union (27)2017-2021, Value in million USD

Total FDI inflows in Serbia and European Union (27)2017-2021, Value in million USD					
Year Area	**2017**	**2018**	**2019**	**2020**	**2021**
Total FDI inflows European Union (27)	292163.6	334205.2	441914.7	290665.9	255658.5
Total FDI inflows in Serbia	2878.573	4091.385	4271.15	3470.997	4569.052

Chart 3. *Total FDI inflows in Serbia and European Union (27)2017-2021, Value in million USD*



At the table no. 8 and chart no 3, we can see the total FDI inflows in Serbia and European Union (27) from period 2017 to 2021, value in million USD varies yearly. The amount of FDI in European Union and Serbia varies yearly.

Conclusion

From the analysis of the influence of FDIs on the improvement of agribusiness in European Union and Republic of Serbia based on the data presented in the paper, the economies can be concluded: that both economies are attractive for investors in agribusiness. The favorable geopolitical situation benefits both economies. Extremely strong position in major markets. Due to low taxes, good macroeconomic stability and low labor costs are key components for successful fundraising. Finding a way to attract funds in the form of FDIs is a key factor for improving the economy in agribusiness.

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MULTI-RESISTANCE OF *CERCOSPORA BETICOLA* TO MBC, DMI AND QoI FUNGICIDES AND IMPACT ON MANAGAMENT[1]

Nenad Trkulja[2], Anja Milosavljević[3]

Abstract

Cercospora leaf spot (CLS) caused by Cercospora beticola in Serbia occurs annually causing severe yield losses of sugar beet, which requires intensive use of fungicides. Over the last decade we have observed unsatisfactory control of CLS at the main sugar beet groving regions. Sugar beet production in Serbia was faced with dramatic decrease in efficacy of fungicides intended for Cercospora beticola control. CLS management over the years included intensive use of three groups of fungicides with different modes of action i.e. benzimidazole (MBC), triazole (DMI) and strobilurin (QoI), consequently imposing C. beticola resistance selection pressure. Multi-resistant populations to QoI, DMI and MBC were detected. The genetic basis underlying the resistance was tested by characterizing the cyt b, CYP51 and ß-tubulin genes, associated with resistance to QoI, DMI and MBC fungicides, respectively. Isolates that were resistant to QoI fungicides had the G143A mutation within the cyt b gene. Characterization of CYP51 gene revealed seven diverse haplotypes; however, no correlation with sensitivity or resistance to DMI fungicides could be identified. Resistance to MBC fungicides was associated with presence of the E198A mutation in the ß-tubulin gene of all resistant isolates. Depending on the resistance development three multi-resistant phenotypes were identified: MR1 - resistant to QoI and DMI fungicides, sensitive to MBC fungicides; MR2 - DMI and MBC resistant, sensitive to QoI; and MR3, resistant to all three groups (QoI, DMI and MBC) of fungicides. This finding provides a new insight on development of multi-resistance of C. beticola to MBC, QoI and DMI fungicides which had a strong impact on CLS managament.

Key words: *sugar beet, cercospora leaf spot, multi-resistance, fungicides, efficacy*

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Introduction

Fungus *Cercospora beticola* Sacc. causes the most destructive foliar disease of sugar beet (*Beta vulgaris* L.) worldwide, Cercospora leaf spot disease (CLS) (Holtschulte 2000). Yield losses can be up to 50% in areas with favorable conditions for disease development, most importantly high relative humidity and daily temperatures (Byford 1996). In Serbia, weather conditions are mostly favorable for CLS development during groving season of sugar beet becouse it is cultivated in northern part of country. Considering those factors, epidemic level of disease development is possible in some years. Growers are in need to use more fungicides (Karaoglanidis et al. 2002) in order to protect crops from disease development and losses in yield and sugar content, becouse disease is mainly managed by using different groups of fungicides and resistant cultivars with crop rotation. Three groups with different modes of action are used in control of CLS in fields: methyl-2-benzimidazole carbamate (MBC), steroldemethylation-inhibiting (DMI) and quinone outside inhibitor (QoI) groups (Trkulja et al. 2015). Increase in fungicide use brought dramatic decrease in efficacy of products and rapid *C. beticola* resistance development.

Benzimidazoles (MBC) are in use in Serbia from 1970s, with rapid resistance development that as a consequence had record of first resistant isolates just three years after first application in field of sugar beet (Marić *et al*. 1976). MBCs are site-specific fungicides with high risk of resistance development (Davidse 1986). Consequently, use of some MBC fungicides was reduced to one application per year (Marić et al. 1984), but it still did not stop increase in resistance population which was up to 80-90% during 2000s (Trkulja et al. 2009) and went over 90% in past years (Trkulja et al. 2013, 2015). Resistance to MBCs can vary in degrees and is based on single nucleotide polymorphism (SNP) of different codons in the ß-tubulin gene (Ma and Michailides 2005), and in Serbia it is detected at codons 167 and 198 (Trkulja et al. 2013).

Triazoles (DMI) were introduced in late 1970s for control of CLS after resistance to MBCs was confirmed (Byford 1996). Characteristic polygenic mechanism allowed moderate risk of resistance development and good protective and curative characteristics, which promised high efficacy in control of CLS (Brown et al. 1986). Continuous use of this group of fungicides led to increase of resistance development, ranging from low to high (Karaoglanidis and Thanassoulopoulos 2002; Karaoglanidis and Ioannidis 2010). Beginning of 1980s those fungicides were introduced in Serbia and their use was very successful (Marić *et al.* 1984) but in recent years resistance developed in all sugar beet groving regions (Marić et al. 1976; Trkulja et al. 2009, 2015). Mechanism of resistance to DMI fungicides is based on mutations connected to CYP51 gene (Ziogas and Malandrakis 2015), mostly combination of multiple mutations of gene and as result have numerous resistant haplotypes (Cools and Fraaije 2012).

Strobilurines (QoI) fungicides were introduced in CLS management in Serbia in 2007 but only in mixtures where trifloxystrobin gave high control with cyproconazole (Trkulja et al. 2015). Mode of action is based on inhibition of mitochondrial respiration by binding at the Qo site of *cytochrome* b gene (Bartlett et al. 2002). Resistance in *C. beticola* isolates is connected to mutation in *cyt b* gene where one amino acid is changed to another and QoIs can not bind to target site, therefore fungus is resistant to fungicide (Edin and Torriani 2012). There are multiple possible codons for mutation development of *Cyt* b gene (Gisi et al. 2002) but strongest is mutation on position 143, non-synonymous mutation of glycine to alanine (G143A) (Malandrakis et al. 2006; Bolton et al. 2013). Resistance to QoI fungicides is recorded by Birla et al. 2012 in Europe and in United States by Bolton et al. 2013, while in Serbia it is first registered in 2017 (Trkulja et al. 2017). QoI fungicides were overused with intensive application trough years, multiple time in same year which lead to development of resistance to all QoI a.i., since it is cross-resistant group of fungicides.

Multiresistance (MR) is occurrence when same isolate is resistant to two or all three groups of fungicides used in CLS management in sugar beet and this is first time ever detected by Trkulja et al. 2017 in Serbia. Three different phenotypes were established (MR1, MR2 and MR3), where first two were resistant to two groups of fungicides and third phenotype represents population of *C. beticola* resistant to all three groups of fungicides.

Methodology

When first symptoms of cercospora leaf spots were detected in fields, leaves affected with sporulating lesions of *C. beticola* were collected. Samplings and monitoring of disease were conducted from commercial sugar beet fields at all three main sugar beet growing regions in Serbia – Srem, Backa and Banat (Table 1).

Main three groups of fungicides (MBC, DMI and QoI) used to control *C. beticola* disease in fields were tested and used in this study. During commercial field monitoring, in order to determine level of sensitivity to all fungicide groups used in disease control, leaves with symptomatic spots or lesions, with sporulating spores, were collected from each growing region. Total number of leaves collected was about one hundred isolates. Leaves collected this way were then transferred to laboratories in portable refrigerators where follow-up tests were done.

Upon arrival in laboratories, spores from infected leaves were transferred to Potato Dextrose Agar (PDA) media which allows them to germinate. Next day, after 24h incubation period on media, using microscope apparatus we determined germinated single spores and using precise laboratory tools we transferred segments of media with those single spores to new Petri dishes amended with PDA media. Thus, we obtained clean and monosporial (single conidia) isolates of *C. beticola*, with precise knowledge of prior used fungicides in each field for disease control. Isolates were than incubated in dark on 25°C for further growing and tests.

Methode used to determine sensitivity levels was measuring of radial mycelial growth of *C. beticola* on PDA media. Fungicides from MBCs used were active ingredients (a.i.) carbendazim and thiophanate methyl for which discriminatory concentration was DC=1 mg/l. Same concentration (1 mg/l) was discriminatory for DMIs a.i. used in laboratory tests, flutriafol and tetraconazole. Monosporial cultures of *C. beticola* isolates that were 14 days old were used from which 5mm plugs were transferred on fungicide amended PDA media and on control PDA media without fungicide added. After incubation of 7 days in dark, at 25°C, mycelial growth was measured. Resistant isolates were ones that had relative growth greater than 50% compared to control, while those that had growth lower than 50% were considered sensitive. QoIs used in tests trifloxystrobin and pyraclostrobin for which discriminatory concentration was 5 mg/l. Sensitivity was measured by method of conidial germination and isolates with germination greater than 50% comparing to control were considered resistant, and those with lover than 50% growth rate were sensitive.

Additionally, special molecular tools were used to determine resistance to QoIs, MBC and DMI fungicides and 10 collected isolates from each region were characterized on gens level. Genes analyzed were those responsible for *C. beticola* resistance development. Trkulja et. al (2017) described PCR-RFLP method for *cytochrome b* gene (*cyt b*) characterization, and we use this tool to detect resistance to QoI fungicides. To detect high resistant population of MBC fungicides we used PCR-RFLP method, and to detect low and medium resistant populations specific mutation PCR protocol was used, as described in Trkulja et. al (2013).

Table 1. Number of tested isolates from three main sugar beet regions of Serbia with sampling year.

Region of Serbia	Number of isolates per year of sampling	
	2016	**2017**
Srem	106	108
Bačka	101	104
Banat	102	103

Trial field experiments were additionally done in all three growing regions during two consecutive years (2016 and 2017). Fungicides used in the study were commercial formulations of protective and single site fungicides, from all three groups, QoIs, DMIs and MBCs from different manufacturers, water suspensions in recommended doses (Table 2.). Layout of trial field plots was arranged in accordance with highest experimental practices, using complete randomized block design in four replicants. Width of each plot was 6m (12 rows of sugar beets) by 16,5m long, considering that there has to be 100 sugar beet plants in each row. Taking in account possibility of drift when each treatment applied, which lead to mixing of different treatments in outer rows, and making sure we get correct results from this field experiment, we distanced each plot from one another by 1m from all sides. Control plots were completely untreated, also placed random in trial field. Additionally, only leaves from middle rows were collected for further analyzes.

Determination of adequate time for start of fungicide application is directly connected to threshold of disease presence on leaves. Wolf and Wereett (2002) described method, moving diagonally through field trial we collected hundred leaves, but only those from central part of rosette. Almost all canopy of sugar beet plants has to be touching or overlapping with canopy of adjacent row. We followed weather data and DIVs in order to know when appropriate conditions for disease development were obtained, started monitor appearance of first spots and first application was approved only when there was incidence of at least 5% of sugar beet plants with symptoms of *C. beticola* on its leaves. Once first application was done, following two were set for intervals of 14 days apart from each other. Application of fungicides was done using a T4 sprayer (Bellspray, Inc., USA), with 4 atm pressure. Fungicide solution was mixed in accordance with recommended doses and for each plot in sprayer bottles in volume of three litres in order to cover whole plot surface area. Efficacy was than measured by subtraction of disease severity in treated plot from disease severity in control, which is than divided by disease severity in control, and final result was in percentages.

Table 2. Field testing treatments single fungicides and mixture of fungicides different mode of actions

Single formulations			
Commercial name	**Active ingredient (group of fungicide[1])**	**Manufacturer**	**a.i. g/ha**
Dakoflo 720	chlorothalonil (PRO)	Galenika phytopharmacy	1440
Galofungin T	thiophan-ate-methyl (MBC)	Galenika phytopharmacy	225
Sekvenca	difenoconazole (DMI)	Galenika phytopharmacy	100
Impact 25	flutriafol (DMI)	Cheminova	62.5
Zato	trifloxystrobin (QoI)	Bayer Crop Science	150
Retengo	piraclostrobin (QoI)	BASF	150

[1] PRO-protective; MBC - benzimidazoles; DMI - demethylation-inhibiting fungicides; QoI-strobilurin

Results with Discussion

During two years of trials and sensitivity monitoring (2016 and 2017) in all sugar beet growing regions in Serbia (Banat, Backa and Srem) frequencies of *C. beticola* resistant isolates were determined to all three groups of fungicides applied in control of disease (MBC, QoI and DMI).

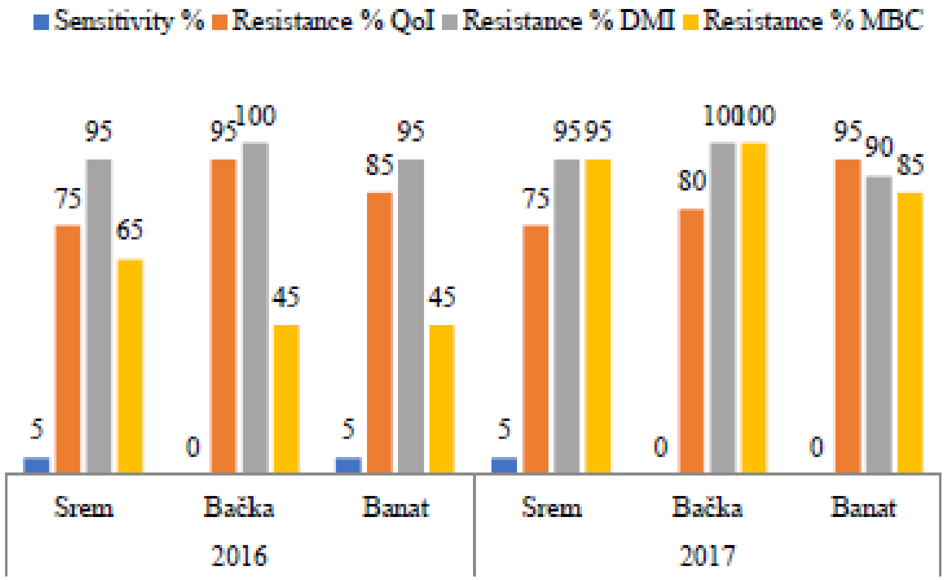
Frequency of resistance at region of Srem in 2016 to QoI, DMI and MBC were 75%, 95% and 65%, respectively. During next growing season monitoring conducted at the same region revealed same level of resistance to QoI (75%) and DMI (95%) fungicides and increasement in resistance population of MBC fungicides from 65% to 95%. At region of Bačka frequencies of resistance detected in the 2016 to QoI, DMI and MBC were 95%, 100% and 45%, respectively. Sensitivity monitoring from next year revealed slight decrease in resistance to QoI from 95% to 80%, while resistance to DMI remained unchanged at high level 100% and resistance to MBC grew rapidly compared to the previous year from 45%

to 100%. At the third region Banat, detected resistance populations in the 2016 to QoI, DMI and MBC were 85%, 95% and 45%, respectively. The results in next 2017 year indicated slight increase in resistant populations to QoI from 85% to 95%, while resistance to DMIs slightly decreased from 95% to 90%. In the case of MBC fungicides population udergone great changes from 45% to 85% frequency of resistace. Sensitive population was almost disappeared from sugar beet fields with maximum presence of 5% (Graph 1).

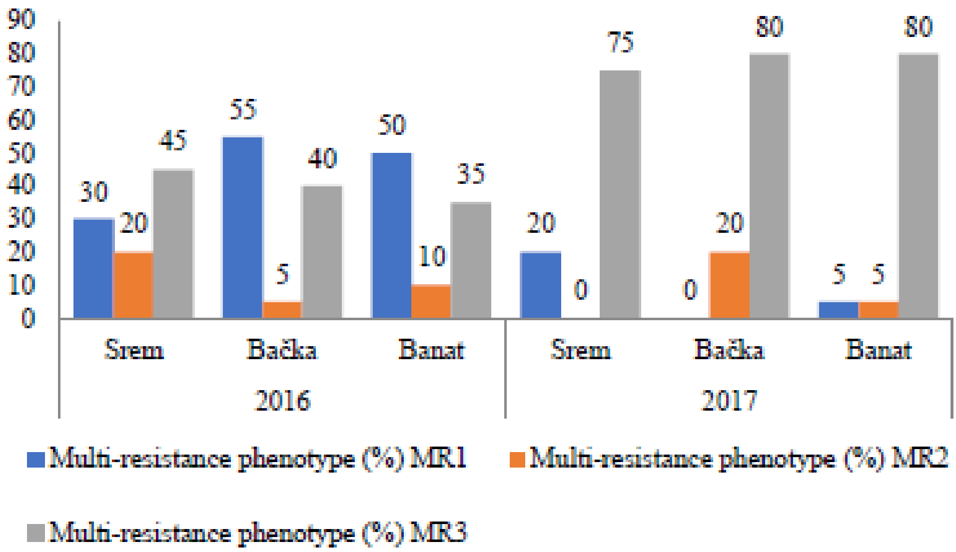
Obtained reuslts point to high presence of resistant population to all modes of action which were intensively used during few previous years in sugar beet fields for control of *C. beticola*. It is noticable that resistant population was high for QoIs and DMIs during 2016 monitoring, while there was significant percentage of sensitive population towards MBCs. Frequency of resistance to MBCs was 45%-65%, and rest of population (35%-55%) was sensitive to fungicides with same mode of action. Previous test of sensitive population towards those fungicides indicated very high percentage of resistant population (Marić et al. 1976; Trkulja et al. 2013). However, later examinations showed that trend of sensitivity towards MBCs change in favor of sensitive population (Trkulja et al. 2016). This phenomenon of increase towards MBCs is at the same time followed by increase of resistance towards QoI fungicides and forming of multiresistant population of *C. beticola* in sugar beet field in Serbia (Trkulja et al. 2017). Established frequency of *C. beticola* resistance to QoI and DMI in both years was very high and did not have significatn changes comparing to previously conducted research (Trkulja et al. 2009; 2015; 2017).

Results indicate presence of multiresistant population in high percent. Multiresistant phenotype MR1 with resistance towards QoI and DMI fungicides and sensitive to MBCs was detected in Srem region with 30%, 55% in Backa region and 50% in region of Banat during 2016. Phenotype MR1 in next year (2017) had tendency of decrease with frequency of 20% in region of Srem, it totally disappeared from region of Backa, and in Banat it had significant decrease with presence of only 5% in total population. Phenotipe MR2 resistant to DMI and MBC fungicides, and sensitive to QoI fungicides was present in lower percentage than other two phenotypes MR1 and MR3, and its presence was highest in region of Srem – 20%. Presence of this phenotype in Backa and Banat regions were 5% and 10%, respectively.

Graph 1. Percentage of sensitive populations and frequency of resistance to QoI, DMI and MBC fungicides.



Graph2. Percentage of multi-resistance *C. beticola* to QoI, DMI and MBC fungicides.



Research done in following year of 2017 indicates on trend of decrease of this phenotype appearance, in region of Srem it disappeared, in Banat it cut in half (5%), while in region of Backa increased to 20%. Multiresistant phenotype MR3, which is most complicated kind of multiresistance detected in *C. beticola*, during 2016 was present with frequency of 45%, in region of Backa was 40%, while in Banat region it was 35%. However, next year 2017 frequency of this phenotype, which implies resistant populations to QoI, DMI and MBC modes of actions significantly increased in all three of sugar beet growing regions, Srem, Backa and Banat, 75%, 80% and 80%, respectively.

Mechanism of of resistance at QoI was explained by Bartlett et al. 2002 as process which eventually lead to ATP reduction and energy losses through processes of mitochondrial respiration inhibition with binding on Qo site at cyt b which is followed by disruption of electron transfer in bc1 complex. Resistance is developed when there is mutation on cyt b gene detected by substitution of one amino acid with another, thus fungicide can not bind with target site (Edin and Torriani, 2012). There are 7 different single nucleotide polymorphism (SNP) of different codons in *cyt b* gene (Gisi et al. 2002) of which 2 are most relevant in practical resistance appearance and finally the most frequent one and the strongest is mutation 143 where glycine is substituted with alanine (Malandrakis et al. 2006; Bolton et al. 2013). Molecular characterization determined presence of mutations on all samples that were resistant during sensitivity analyses on discriminatory concentrations of fungicides. Analyses of *cyt b* gene responsible for resistance of QoI fungicides discovered G143A mutations at all isolates with lover sensitivity to QoI fungicides, thus confirming that resistance mechanism is same as in previous experiment (Trkulja et al. 2017).

DNA sequence of the β-tubulin gene is used for detection of resistance to MBCs. One amino acid replacement was a glutamic acid to alanine change at position 198 (codon GAG to GCG) and the second replacement was a novel point mutation of phenylalanine (TTC) to tyrosine (TAC) at position 167. Detection of sensitive and LR/MR genotipes is utilized by PCR-RFLP assay using a BsaI restriction site which is absent in the HR genotype. A mutation-specific PCR assay was developed for the diagnosis of LR/ MR genotype based on a mutation from T to A at codon 167, which is unique to this genotype. With help of protocol for detection of high, moderate and low population it is determined that only high resistance population was present. This finding indicates that population is highly resistant to MBC fungicides, which is in accordance with previous analyses of *C. beticola* population in Serbia (Trkulja et al. 2013; 2017).

Analises of CYP51 gene confirmes diversibility of genes, but it can not be conected with levels of resistance and sensitivity of *C. beticola* opulation to DMI fungicides in biological tests for population sensitivity.

Experiments conducted in fields indicate to decrease of efficacy of all fungicide groups/modes of actions which were affected by resistance appearance in population (Table 3. and 4.). Fungicide Galofungin T in first experimental year, 2016, as representative of MBC fungicides group had significantly higher efficacy than QoI (Zato, Retengo) fungicide, as well as from DMI fungicide Impact 25. This align with frequency of resistant population of *C. beticola* determined for MBC fungicides, which is significantly lower comparing to those of QoI and DMI fungicides. Fungicide from DMI group, Sekvenca, was at same level of efficacy as Galofungin, which indicates to differences inside this group towards resistance development. Experiments during 2017 indicated to change of efficacy of fungicide Galofungin T, as a consequence of increase of resistant population of *C. beticola* towards this group of fungicides in fields. Fungicides from QoI group stayed at low level of efficacy to control disease, where significant difference in efficacy of two different fungicides from DMIs (Sekvenca, Impact) was present during this year too (Table 3. and 4.).

Analysis of efficacy showed that preventive fungicide Dakoflo 720 had higest efficacy in both experimental years. This finding undoubtedly confirms that population of *C. beticola* is significantly affected by resistant population and that mechanisms were skipped through mutations present in resistant populations.

Table 3. Efficacy of fungicides to control *C. beticola* at region Srem and Banat 2016 year.

No.	Commercial name	Srem: Inđija		Banat: Stari Tamiš	
		Disease severity	Efficacy (%)	Disease severity	Efficacy (%)
1	**Dakoflo 720**	22.3	**76.3**	17.7	**78.7**
2	**Galofungin T**	60.2	**36.1**	48.3	**41.9**
3	**Sekvenca**	62.3	**33.8**	56.2	**32.4**
4	**Impact 25**	79.4	**15.7**	72.3	**13.0**
5	**Zato**	76.2	**19.1**	69.1	**16.8**
6	**Retengo**	74.6	**20.8**	67.2	**19.1**
7	**Control**	94.2	**-**	83.1	**-**

Table 4. Efficacy of fungicides to control *C. beticola* at region Srem and Banat 2017 year.

No.	Commercial name	Srem: Golubinci		Banat: Stari Tamiš	
		Disease severity	Efficacy (%)	Disease severity	Efficacy (%)
1	**Dakoflo 720**	12.3	**81.7**	16.7	**77.6**
2	**Galofungin T**	57.5	**14.4**	59.6	**20.2**
3	**Sekvenca**	42.1	**37.3**	44.3	**40.7**
4	**Impact 25**	55.2	**17.9**	54.8	**26.6**
5	**Zato**	53.8	**19.9**	53.2	**28.8**
6	**Retengo**	52.6	**21.7**	52.6	**29.6**
7	**Control**	67.2	**-**	74.7	**-**

Conclusion

Most significant fungicides for control of most important pathogen on sugar beet, *C. beticola*, comes from three groups – QoI, DMI and MBC. Consequence of many years of use in a row of single-site fungicides, population of *C. beticola* became resistant and this resistance was in high percentage.

Determined frequency of resistance was high towards QoI, DMI and MBC fungicides during 2016. QoI was from 75% to 95%, DMI 95%-100%, while for MBC it was from 45% to 65%. Following year of 2017 brought no significant changes in case of QoI and DMI fungicides, but resistance significantly increase in case of MBC, 85% - 100%. This significant change in resistance level could be consequence form increased use of fungicides from MBC group during previous years in control of *C. beticola*.

Aftermath of high frequency of resistance to all three modes of actions, multiresistance appeared. Three multiresistant phenotypes were selected, MR1, MR2 and MR3. MR1 – resistance to QoI and DMI; MR2 – resistance to DMI and MBC; MR3 – resistance to all three groups, QoI, DMi and MBC.

Frequency of multiresistant population in 2016 was significant and it was for MR1 from 30% to 55%, MR2 from 5% to 20% and finaly for MR3 from 35% to 45%. During following 2017, increase was recorded for MR3 multiresistant population 75% to 80%, while MR1 decreased from 5% to 20% and MR2 stayed at the same level.

Mechanism of resistance to QoI fungicides is based on mutation on G143A on *cyt b* gene. Genetic basis for resistance appearance to MBC fungicides is based on E198A mutation on β-tubulin gene. Resistance to DMI fungicides is based on CYP51 gene but does not have clear connection to it yet.

Efficacy of fungicides for *C. beticola* control are in direct connection with appearance of resistance. Highest efficacy was achieved with application of preventive fungicide, while single site fungicides had significantly lower efficacy in comparison to before multiresistance appeared.

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ADDING VALUE IN SHEEP FARMING THROUGH THE DEVELOPMENT OF ALTERNATIVE PRODUCTS

Radivoj Prodanović[1], *Dragan Ivanišević*[2]

Abstract

The goal of the research was to identify opportunities and strategies for improving sheep farming through the development of alternative products, with a special focus on creating additional value. The research was based on a qualitative method, using interviews. Interviews were conducted with farmers involved in sheep farming, who were also engaged in the development of alternative products. The results indicate that selling sheep is not the most profitable option, and it would be good to find alternative ways to generate income from sheep farming. Opportunities to create additional value include: processing sheep meat, selling breeding animals, and using sheep in rural tourism. The conversation highlighted that, in addition to the conventional production of meat, milk, cheese, leather, wool, and wool products, there is potential for profitability through meat processing and integrating sheep into tourism. Other recommendations emphasized focusing on specific high-value-added products, such as dried lamb and other processed goods, or even utilizing sheep for therapeutic purposes. There are numerous added values for consumers arising from the development of alternative sheep farming products. People would bring their children to the countryside and have higher-quality food, as sheep meat, or lamb, is a culinary specialty. Diversifying production and adding value in sheep farming can contribute to sustainable economic development in rural communities and strengthen competitiveness in the agro-industrial sector.

Key words: *sheep farming, added value, alternative product.*

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Introduction

Sheep farming represents a significant segment of agricultural production in many regions of the world. In recent years, sheep farming has gained popularity in Serbia, although production has been stagnant for some time. The number of sheep in 2022 was 1,721,000 (RZS, 2022), indicating a slight upward trend compared to the past 10 years. The increase in the number of sheep and sheep breeders makes sheep farming a current topic in society.

There are many ways to generate income from sheep farming. In addition to traditional products like meat, milk, and wool, there is untapped potential to add value to sheep production through the development of alternative products. Diversifying production can open up new perspectives for economic sustainability and competitiveness in sheep farming. For example, there are producers who sell most of their products abroad, but there are also those who earn from selling sheep wool, while the majority make a profit from selling various variations of sheep meat. Selling live animals is not the most profitable option, so it would be beneficial to find a better avenue for selling sheep products.

It is not uncommon for farmers to process their own agricultural products and sell them directly to consumers. This adds value to the products and creates a good opportunity for increasing revenue. Research shows that producers who process their own primary raw materials are generally much more optimistic about their future, despite facing initial challenges in starting the business.

In Serbia, there are many small sheep breeders whose production is inherently organic. It is sad to note that the domestic food industry is not very interested in processing such products. The demand for authentic processed organic food in Serbia is based on the experience of distributors. Additionally, there is an evident lack of processors, and the range of products offered on the market is quite modest. This situation presents an opportunity for those producers who want to contribute to expanding the range of products in the domestic market. Therefore, we wanted to explore how value can be added to sheep production through the development of alternative products. Through this work, we aim to provide concrete recommendations and guidelines for producers who want to leverage the full potential of sheep farming through diversification and the development of alternative products.

Improving sheep production, especially in hilly and mountainous areas, is set as an important priority in agrarian policy, as the goal is to retain the population in rural areas. Hence, various strategies are being devised for the development of animal husbandry, particularly sheep farming, in line with the aforementioned objective.

Literature review

Agricultural producers add value to their products through processing or direct marketing, enabling an increase in revenue (Teahan, 2015). For an enterprise to create added value, it must be well-versed in legal regulations. More importantly, acquiring basic knowledge of marketing concepts is crucial as it forms the foundation for creating added value (Holland and Wolfe, 2000).

It is important to distinguish between value-added and added value. Value-added is production minus intermediate consumption (Johnson and Noguera, 2012). This work focuses on added value, defined as the value added to the consumer through the product, consisting of relevant benefits and features. Added value can be seen as a simple benefit that compels the buyer to purchase the product (Dahl and Fridh, 2019).

For farmers, it is important to achieve higher profits by adding value to their product, making it distinct from others. Many farmers add value to their products by processing raw materials, designing packaging, and directly marketing their products. They engage in product development and differentiation, thereby creating new value for the consumer (Holland and Wolfe, 2000).

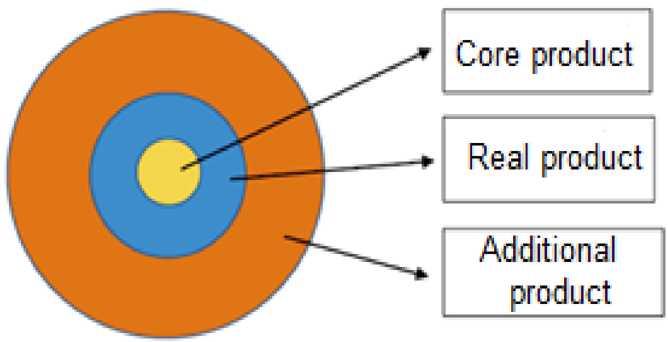
It is crucial to understand the opportunities and what you aim to create as added value (Dalton et al., 1999). Before creating added value, there must be a demand for the product. It is necessary to meticulously research consumer preferences and expectations (European Commission, 1998).

Kotler stated, “Anything that can be offered in the market to attract attention, induce purchase, and consumption can be considered a product” (Armstrong and Kotler, 2015). For a company to continue operating, it is necessary to elevate the quality and further develop its products (Kotler et al., 2009).

In general, every product has three levels: the core product, the actual product, and the augmented product (Figure 1). Understanding these different levels aids in creating a consumer-oriented product. Establishing contact with the consumer and understanding their desires, needs, and expectations is crucial (Kotler et al., 2009).

The customer is essentially buying the benefit of the product, which is the core product. The core must be valuable to the customer, as it motivates them to purchase a specific product (Bruch and Ernst, 2011). The actual product is the so-called second level, which includes the product's quality, special features, style, brand identity, and packaging (Alervall and Saied, 2013).

Figure 1. Three product levels



Source: Kotler et al. (2009)

The most important characteristic of a product is its quality. Juran defines the quality of a product or service as a set of features that enable the satisfaction of identified or expected consumer needs (Miladinović, 2007). One of the additional values sought by consumers is quality or the confidence that the product is good and meets expectations (Kotler et al., 2009).

Each product has its unique characteristics, which typically influence the price. Product design is crucial for catching the consumer's attention. The brand is what protects the product from other competitors. Packaging is one of the most important parts of the product, and it must be recognizable, prominent, memorable, and encourage consumers to purchase the product (Psodorov, 2019).

Recently, the third level of the product, the augmented product, has generated significant interest. The main purpose of this level is to enhance competitive advantage. Based on the added value of the product, the consumer makes their choices (Bačevac et al., 2015).

One way to add value to a product is through the development of differentiated products. Many small organic farms have embarked on the path of processing their own raw materials to add value to their products. Small producers can offer many more specialty products that take into account local traditions, which they can sell at higher prices compared to industrial products (Milošević and Milovanović, 2012).

Product development is a lengthy, complex process that requires dedication (Hauser and Dahan, 2007). Product development primarily pertains to creating a new product, but it can also involve the improvement of an existing product (Buntak et al., 2015).

A crucial factor in product development is the consumer, who is guided by their desires and needs in their purchasing motive (Kotler et al., 2009). Based on this, market-driven product development should take precedence over production-driven product development. Market research and consumer behavior analysis serve as a kind of guarantee for the success of a new product. Consumer needs and expectations, economic situations, and purchasing capabilities are identified (Armstrong and Kotler, 2015).

The entire product development process is associated with several principles. The first approach views the consumer as a key player in product development. The consumer is not interested in a new product, but rather a new solution to a problem. According to the second principle, it is important to differentiate the product, which has a varying level of novelty for each individual. This product may already be in the market, but it could also be a completely new product in the market. In the third principle, understanding the degree of innovation is crucial. Generally, a new product may already exist in the market, but there are always opportunities to gain a competitive edge over other producers (Čirjak et al., 2012). Small producers have an advantage over large producers. They can connect products with local tradition and offer more unique products, making their goods competitive in the market (Angelkova, 2012).

Goal, research methodology, and interviewee profile

The goal of the research was to identify opportunities and strategies for improving sheep farming through the development of alternative products on the farm, with a special focus on creating additional value.

The research was based on a qualitative method, using interviews as the primary research technique. Interviews were conducted with farmers engaged in sheep farming, who were also involved in the development of alternative products.

We believed that sheep breeders could provide valuable insights into the market situation, especially regarding product placement. Additionally, they are usually aware of the obstacles when introducing new or alternative products to the market.

The study included six sheep producers who are to some extent involved in product development. Some of the interviewees are members of the recently established Association of Sheep Breeders of Serbia or are actively involved in the association's activities. Sheep breeder A operates in Batajnica and has approximately 1,000 head of basic flock. Sheep breeder B operates in the Begeč district and has around 200 sheep. Sheep breeder C has a basic flock of about 150 sheep and also operates in Begeč. Sheep breeder D operates in the broader area of the municipality of Temerin and has about 50 sheep. Sheep breeder E has a basic flock of nearly 100 head, and his operational area is the municipality of Vrbas. In the municipality of Čelarevo, there is sheep breeder F, whose basic flock consists of 300 head. All the interviewees have been involved in sheep farming for at least 5 years and are well acquainted with production technology, challenges, and market trends.

We asked the respondents about the products they offer on the market. Below is the profile of sheep breeders who are also involved in the development of their own products.

- ✓ Breeder A, in addition to live animals, sells tanned sheepskin, lamb meat, sheep sausages, milk, and cheese.
- ✓ Breeder B sells, in addition to live animals, lamb meat, milk, and cheese.
- ✓ Breeder C mainly sells only live animals for meat.
- ✓ In contrast, respondent D, in addition to live animals and lambs, sells processed products of sheep and lamb meat, cheese, and milk. They also sell tanned skins, unwashed wool, and breeding animals.
- ✓ Breeder E also sells breeding animals, tanned skins, sheep cheese, and lambs.
- ✓ Sheep breeder F sells breeding animals, live animals for meat, wool, lamb meat, cheese, and milk.

We wanted to find out from the sheep breeders what product development opportunities they see, what breeds they raise, and which options would be most profitable. Through the interviews, we also aimed to learn about potential consumers of different products and what additional value they would gain from alternative products. We sought to learn more about marketing possibilities: how consumers would perceive new products and what obstacles there might be for their market positioning. Additionally, we asked the respondents to evaluate sheep as one of the tourist attractions.

Results and Discussion

During the research, it became clear to us that breeders generally do not process sheep meat, but some of them believe that it could be a profitable business option.

Table 1. Product development possibilities

Product development possibilities	A	B	C	D	E	F
Sale of tanned sheepskin	Yes	No	No	Yes	Yes	No
Sheep wool for sale	No	No	No	Yes	No	Yes
Sale of wool products	No	No	No	No	No	No
Sale of breeding animals	Yes	No	No	Yes	Yes	Yes
Sale of live animals	Yes	Yes	Yes	Yes	Yes	Yes
Sale of raw lamb meat	Yes	Yes	No	Yes	Yes	Yes
Sale of processed lamb (e.g., sausages, canned meat, smoked meat)	Yes	No	No	Yes	No	No
Sale of sheep milk and cheese	Yes	Yes	No	Yes	Yes	Yes

Sheepskin is sold with a considerable price range: at a minimum price of €30, but the price of sheepskin can go up to €100. The reason for this price variability is primarily the quality of the skin, size, and sheep breed. The price of wool is not significant and does not cover the cost of shearing. Prices for wool products depend on the nature of the product and the technology used in their production. They are usually handmade and therefore have a higher price. Purebred animals are sold on the domestic market for €300. Sheep breeders sell their live animals for meat. In the case of rams, the maximum price per kilogram was €2. In the case of ewes, the price is lower. The average price per kilogram of live animals sold for meat is €1.5. The price of lamb meat varies greatly and ranges from €6 to €8. According to the research, the minimum price of smoked lamb and processed sheep meat is €10/kg. Additionally, the average price of sheep sausage is €10/kg.

Respondents A and E sell tanned sheepskin and consider it one of the potential product development opportunities. Respondent D noted that it is quite difficult to sell tanned sheepskin because there is a lot of skin offered below cost. Additionally, many skins are of poor quality and are sold as “non-genuine” sheepskin.

Only sheep breeders D and F see the sale of wool as a potential product development opportunity. Others believe that wool sales are low, and more importantly, there is not a high demand for wool. Sheep breeders A, B, and F believe that selling wool products is an opportunity for product development for small producers. Other respondents who do not see this as a viable product development opportunity pointed out that this activity is too time and labor-intensive and requires a certain level of specialization.

According to sheep breeders A, D, E, and F, the sale of breeding animals is also a good business opportunity. Respondent D believes it to be the most profitable, at least on his farm. He also emphasizes that the domestic animal market is quite unstable and is not the same every year. This opportunity also requires larger investments in breeding animals to produce high-quality and capable offspring that can be sold as breeding animals. Respondent E also believes that selling breeding animals may be the most profitable option.

All respondents confirmed that one of the main and currently most important product development opportunities for small producers is the sale of their animals, both in the domestic and international markets. Respondent C stated that selling live animals is one of the easiest ways to earn money. Selling live animals abroad is based on the experience of respondent B, who engages in the highest volume of marketing activities.

The sale of raw lamb meat is seen as a product development opportunity for small producers only according to sheep breeders D, E, and F. According to shepherd F, selling raw lamb meat is the most profitable. Respondent E relied on his experience and stated that raw lamb meat is also one of the most sought-after products. In addition to sheep breeders D, E, and F, breeder B also sees the sale of processed lamb as one of the potential product development opportunities. Respondent D stated that one of the successful options for product development would definitely be the sale of processed lamb, but the farm must have strong motivation and dedication to the business.

According to the respondents, there are several added values in sheep products. It was emphasized that lamb meat is healthy and that people derive emotional value from high-quality homemade food. Wool and sheepskin products also have a preventive effect against rheumatic diseases. Sheep farming products contribute to better health, warmer bodies, and a closer connection to nature. In the case of breeding animals, the added value would be better offspring and higher productivity.

Respondents pointed out a variety of obstacles to introducing new products to the market. Some of these obstacles include: cheap competitive products, price, quality, lack of time for product development, lack of customers or unstable demand, quantities, expensive logistics, and food safety requirements, as well as the risk of disease, among others.

In addition to product placement-related obstacles, there are various regulations that hinder product development. Shepherd C emphasizes that most regulations regarding meat and food handling do not distinguish between small and large producers, making it difficult for small producers to establish slaughterhouses due to strict requirements.

Other opportunities for product development in sheep farming certainly exist. Respondent A suggested that a way to value horns could be found. According to sheep breeder D, family days could be organized for urban families, as many urban children have never actually seen a live sheep. One interesting idea was practical training for sheep shearing and hay preparation. Respondent E emphasized the need to focus more on developing specific high-value-added products, such as lamb snacks and canned lamb products. Sheep breeder F noted that sheep could be used more as enhancers, and a good solution would be to use sheep for therapeutic purposes.

The perspective of sheep farming is determined by the sale of the final product. If you sell live sheep, profitability is low. If you sell the final product directly to the consumer, the earnings are much better. One respondent gave an example that one 40 kg lamb can be sold for about €75, as a carcass for about €100, and as a processed product for about €140. According to him, the profitability of sheep farming is not tied to the size of the flock, but to the chosen direction of production. In the case of breeding animals, quality still plays a crucial role. In contrast, in the case of a production flock, the size of the flock is important. Respondent A stated that the profitability of sheep farming does not depend on volume, but on knowledge, production system, available resources, the ability to produce food for sheep, and the potential for optimization of nutrition. Sheep breeder B believes that a smaller flock with higher added value is more profitable than a large flock with lower added value.

ne opportunity for product development in sheep farming is the use of sheep in tourism. Sheep breeder A confirmed that sheep would be suitable for tourism purposes. For example, when it comes to experiential tourism, visitors need to be explained many aspects. When it comes to just observing sheep, they should be well-fed and sheared on time. The respondent emphasized that the breed is not important, but more sociable sheep should be chosen. Sheep breeder B revealed that sheep on a tourist farm are very suitable as landscape guardians and live animals, as part of the experience offered by the tourist organization. Sheep breeder C was in favor of using sheep in tourism. He revealed that showcasing his production is desirable because it increases consumer awareness and trust in the producer. If the consumer sees the entire production process, there is a higher likelihood, according to shepherd F, that they will buy products from that farm. It is also important to consider which sheep breed is more sought after. According to producer D, sheep are equally suitable for farm tourism, just like any other animal. However, it is not enough to just show the animals, tourists should be offered various activities. Sheep breeders E and F believe that using sheep in farm tourism is a positive trend, as many people have never seen a sheep before. They also believe that the idea of a demonstration group is good, as too much attention would divert the entire flock. It would certainly be nice to observe sheep in their natural environment.

In addition to the product development ideas we proposed, we received some ideas from sheep breeders about opportunities to create additional value. These additional value-adding suggestions are: valuing the horns (A); organizing family days showcasing activities related to sheep (D); focusing on the production of high-value-added products (E); using sheep for therapeutic purposes, as they have a calming effect on humans (F).

Conclusion

Creating additional value through the development of alternative products enables increased profitability. Product development is a lengthy process that must be continuous.

The research results indicate that there is untapped potential for diversification in sheep farming, which can bring significant added value to both farmers and consumers. Meat processing, sale of breeding animals, and incorporating sheep into rural tourism have proven to be promising strategies for creating additional value.

Respondents have identified that, in addition to selling meat, milk, cheese, breeding animals, wool, hides, and wool products, there could be a focus on meat processing, improving the quality of sheep, as well as utilizing sheep in rural tourism. It would be beneficial for urban families to bring their children to the farm, where various family days related to sheep are organized. Additionally, there is merit in focusing specifically on the production and direct marketing of high-value-added products, such as dried lamb, canned lamb, and lamb-based products. The suggestion of using sheep for therapeutic purposes has also been put forward.

When consumers make a purchase, they seek added value in the product. It is important to discover what consumers expect and what producers can offer them. The findings indicate that the most substantial opportunities for generating added value revolve around lamb processing, the sale of breeding animals, and incorporating sheep into farm-based tourism.

Consumers stand to benefit from numerous added values, thanks to suitable product development opportunities for local farms. People can introduce their children to nature. They can adopt healthier eating habits. Lamb provides a change in the daily menu. Lamb undoubtedly offers people a taste experience and contributes to the diversification of the dining table. Diversification in sheep farming is crucial for increasing competitiveness and sustainability. Through the development of alternative products, farmers have the opportunity to utilize their resources in innovative ways. This encourages economic development in rural communities, contributing to the sustainability of the agro-industrial sector.

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NEW APPROACHES TO INVESTMENT DECISIONS ON AGRICULTURAL HOLDINGS[1]

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Abstract

Managers of agricultural holdings often have to make decisions related to investments in fixed assets. The most common approach to evaluate investment effectiveness is application of discounting methods, such as Net Present Value (NPV) and Internal Rate of Return (IRR). Nevertheless, it is known that these methods face certain issues, primarily when it comes to evaluation of mutually exclusive projects. At the same time, one of the most important concerns is related to reinvestment rate which is applied for NPV and IRR calculation. Therefore, this research deals with possibilities and problems of using some innovative investment evaluation approaches, primarily Modified Internal Rate of Return (MIRR). Authors discussed an example of investment in fixed assets specific for agricultural production to analyze reinvestment rate assumptions and its influence on investment decisions. At the same time, authors recognized a need to question basic assumption related to MIRR approach, and discussed possible solutions to the problem.

Key words: *capital budgeting, managerial decisions, NPV, IRR, MIRR, reinvestment rate.*

Introduction

Managers of agricultural holdings often have to make decisions related to investments in fixed assets and working assets. There are two basic approaches to investment evaluation – "traditional methods" and discounting methods.

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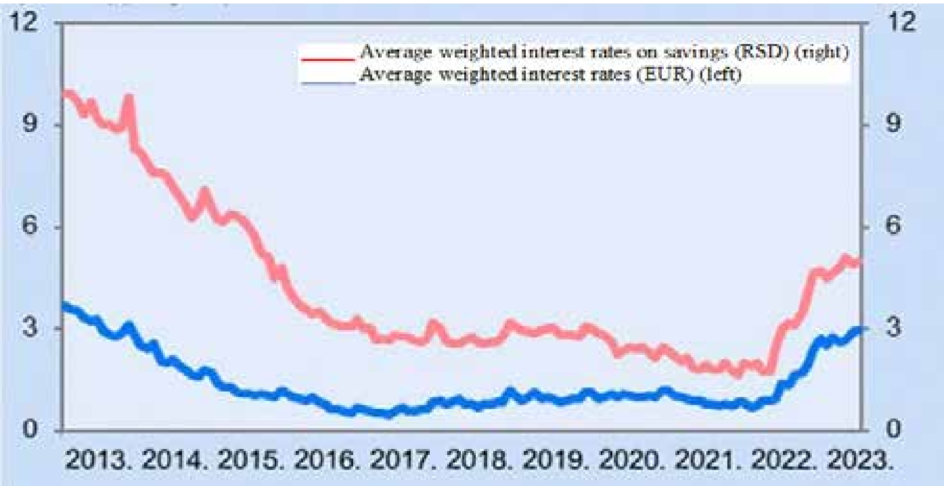
While traditional methods primarily assume payback period and accounting rate of return, most common discounting methods are Net Present Value (NPV), Internal Rate of Return (IRR) and Discounted Payback Period (Gogić, P., 2014). Traditional methods are usually applied when an investment is small and has short economic life span (while, at the same time interest rates are at low level). On the other hand, discounting methods consider time value of money, and therefore they are more appropriate when initial investment outlay is high and economic life of an investment is long (level of interest rates also significantly influences the results of the analysis) (Ivanović, S., 2013). According to Ivanović, S. (2020), capital budgeting methodology is constantly improving and developing, so that it evolved from rather simple analysis (such as risk adjusted discount rate, certainty equivalent, sensitivity analysis) to more complex approaches, such is real options approach. Scenario analysis, decision tree analysis (Nastić et al., 2020), Monte Carlo and Latin hypecube simulations (Ivanović, L., 2018) and fuzzy approach should not be neglected, as well. At the same time, more complex approaches in capital budgeting analysis are related to certain problems, such as use of specialized software, level of theoretical knowledge needed for their application etc.

While investment analysis is developing towards very complex approaches, it is still based on well know indicators (primarily NPV and IRR). At the same time, there are some basic issues concerning IRR, therefore IRR is (according to Kierulff, 2012) "limited decision tool". Issues related to evaluation of mutually exclusive projects using NPV and IRR are significant; while one of the most important problems is related to reinvestment rates. It is well known that NPV and IRR use different reinvestment rates. When NPV is calculated – reinvestment rate equals discount rate (net cash flow is reinvested at discount rate). On the other hand, when IRR is calculated – reinvestment rate equals IRR. According to Kierulff (2008), when calculating NPV and IRR management is "locked into assumptions about how free cash flows will be reinvested, thereby giving an unrealistic view" of an investment's real potential. Nevertheless, Modified Internal Rate of Return (MIRR) takes into account reinvestment rate, and can overcome some of IRR drawbacks (Hurley et al., 2014; Ivanović et al., 2015; Souza Rangel et al., 2016; Thomas, 2017; Qi et al., 2022). One of the ways to express possible levels of reinvestment rate in Serbian conditions is to use average interest rates on savings (Figure 1). The data indicated significant variation of interest rates (primarily for savings in RSD, but also for EUR) during period from 2013 to 2023.

Figure 1 *Interest rates on savings in RSD and EUR (%)*



Source: National Bank of Serbia, 2023

The goal of this research is to analyze economic efficiency of an investment in purchase of agricultural land, while discussing influence of reinvestment rate on MIRR (as well as relation between IRR and MIRR). Investments in agricultural land in Serbia were also discussed by Todorović et al. (2011), Todorović et al. (2012) and Todorović and Ivanović (2012).

Material and methods

The main source of data for this research was Republic geodetic authority of the Republic of Serbia, offering information concerning land prices per counties (regions) as well as per municipalities. The research was focused on Autonomous Province of Vojvodina, as the most important crop production region in Serbia. The municipality in question (municipality of Kovačica) is situated in central part of APV (Južnobanatski county). Level and trend of land prices for various counties were observed for six year period (from year 2017 to year 2022). For municipality of Kovačica, authors presented statistical data on land prices, as well.

Standard approach to investment evaluation is related to NPV and IRR methods, while discounting Payback period could be used as an additional methodological support for decision making process. On the other hand, increasingly used MIRR is sometimes applied instead of IRR, because it solves problem of realistic reinvestment rate as well as issue of multiple IRR`s. Reinvestment rate assumed by MIRR is usually cost of capital, but it could differ, as well (which is discussed by this research).

Results and discussion

During observed period prices of agricultural land have recorded increasing trends in all observed counties (Table 1) while the highest land prices were recorded in Južnobački county.

Table 1. Average price of agricultural land in Vojvodina (EUR per ha)

Year	2017	2018	2019	2020	2021	2022
Severnobački county	8,650	9,200	9,450	9,350	9,650	10,800
Severnobanatski county	6,100	7,000	7,300	7,300	7,550	8,500
Srednjobanatski county	6,200	6,650	6,850	7,100	7,100	8,150
Zapadnobački county	7,400	7,850	8,300	8,500	9,500	10,700
Južnobanatski county	5,750	6,200	6,500	7,050	7,550	8,900
Sremski county	7,700	8,150	8,700	9,300	9,800	12,250
Južnobački county	10,150	10,100	10,300	10,500	11,600	13,400

Source: Republic geodetic authority of the Republic of Serbia, 2020 and 2023

Average price of land in Kovačica municipality were higher comparing to entire Južnobanatski county, recording in the same time big difference between minimal and maximal values (Table 2).

Table 2. Data for agricultural land prices in Kovačica municipality in year 2022

Indices	Values
Median	9,800 EUR per ha
Average (mean)	11,300 EUR per ha
Mode	7,700 EUR per ha
Min	2,300 EUR per ha
Max	22,800 EUR per ha
Coefficient of variation	43.00
N	260

Source: Republic geodetic authority of the Republic of Serbia, 2023

Cash inflow (CIF) was determined on the basic of interview with agricultural producers in the area of Kovačica municipality. Having in mind that the investment in purchase of agricultural land is oriented to lending instead of producing crops, cash inflow equals to rent received per one hectare of agricultural land (Table 3).

Table 3. Investments in agricultural land in Kovačica municipality

Year	Initial investment	CIF	COF	Salvage value	NCF
0	11,300	0	0.00	0	-11,300.00
1	0	435	70.61	0	364.39
2	0	435	70.61	0	364.39
3	0	435	70.61	0	364.39
4	0	435	70.61	0	364.39
5	0	435	70.61	0	364.39
6	0	435	70.61	0	364.39
7	0	435	70.61	0	364.39
8	0	435	70.61	0	364.39
9	0	435	70.61	0	364.39
10	0	435	70.61	11,300	11,664.39
				NPV	1,218.73
				IRR	3.22%
MIRR (discount rate 2%, reinvestment rate 2%)					3.07%
MIRR (discount rate 2%, reinvestment rate is IRR)					3.22%
MIRR (discount rate 2%, reinvestment rate 3.5%)					3.26%

Source: Authors` calculation

Cash outflow (COF) was calculated on the basis of official data of Kovačica municipality concerning taxes related to agricultural land owned by family farms (Municipality of Kovačica, 2014 and 2022). Net cash flow (NCF) from the investment considers not only CIF and COF but also salvage value of the investment (which equals initial cash outlay). While NPV is determined assuming discount rate of 2% (approximate level of interest rate on savings in EUR), for calculation of MIRR authors applied a range of reinvestment rates (lower and higher than IRR).

The value of NPV indicated that investment in agricultural land is economically efficient, while the same conclusion can be reached considering level of IRR. Nevertheless, IRR is very low, just slightly higher than 3%, which leads to the conclusion that the investment is efficient only because it is financed from equity (equity financing caused low level of discount rate). Therefore, it could be stated that investments in agricultural land would not be economically efficient if credit dominates in structure of financial sources (due to significant increase of interest rates).

The results of the research also indicated that MIRR offers more information to managers comparing to IRR:

- If reinvestment rate is lower than IRR – MIRR $<$ IRR;
- If reinvestment rate is equal to IRR – MIRR = IRR and
- If reinvestment rate is higher than IRR – MIRR $>$ IRR.

Similar conclusions concerning relations between IRR and MIRR were reached by other authors, such as Hurley et al. (2014), Souza Rangel et al. (2016) and Yankovyi et al. (2022). Having in mind that reinvestment rate is adjusted to real level of interest rates (or some other projects representing possible reinvestment opportunities) MIRR provides better insight in real profitability of investments (comparing to IRR).

On the other hand, some authors recognized a need to question basic assumption related to MIRR approach. For example, Brealey et al. (2011) stated that "any investment rule that is affected by the manager's tastes, the company's choice of accounting method, the profitability of the company's existing business, or the profitability of other independent projects will lead to inferior decisions". Similarly, some authors (Speranda and Speranda, 2019) stated that replacement of IRR with MIRR methodological approach "does not present the solution but avoidance of the problem" of multiple IRR's. At the same time, MIRR does not solve all the problems related to IRR, therefore requiring certain adjustments (Cary and Dunn, 1997). Except for MIRR there could be other approaches developed to deal with IRR flaws (Xie and Chen, 2021):

- external rate of return;
- modified external rate of return;
- generalized external rate of return;
- average internal rate of return;
- generalized internal rate of return and
- capital flow conversion method.

Therefore, it is possible to conclude that there is a need for methodological approach which will solve IRR flows. Nevertheless, there is ongoing discussion weather MIRR methodology is acceptable or other methodological solutions may be more effective.

Conclusion

The results of the analysis revealed that investments in agricultural land aquisition (as a source of rent) are primarily motivated by expected increase in land price, not by income from rent. Although use of MIRR offers a lot of additional information to farm managers, there are some opposite opinions related to use of this method. In other words, certain authors suggest application of different innovative methods (other than MIRR), while there is also an opinion that fundamental assumptions related to MIRR calculation are questionable. Further research should be directed towards deeper discussion of other methodological alternatives to IRR and MIRR approach.

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SOCIALLY RESPONSIBLE STATE BUSINESS AND AGRICULTURAL LAND RESTITUTION PROCEDURE[1]

Snežana Cico[2], Ljiljana Rajnović[3]

Abstract

In this paper, the authors analyze the conditions and procedure for returning confiscated agricultural land to the previous owners, that is, their heirs, and the state's attitude towards the said procedure. The obligation to return the land represents a kind of correction of the injustice that was done to the previous owners, and in this connection a just compensation of the owner of the restitution. However, based on the analysis of cases and publicly available information, the authors determined that it cannot be said that the state is consistent in respecting the principle of justice, when considering the amount of state land in local self-government units that are eligible for return in the restitution procedure and quantity intended for return. Considering the obligation of socially responsible behavior in all, including in this procedure, all business entities, and especially the state, which should be an example of respecting the rules of social responsibility and morality, the authors came to the conclusion that the state must show much more conscientiousness and fairness in return procedures confiscated property.

Key words: *socially responsible business, the state's attitude towards restitution, restitution, agricultural land, property.*

Introduction

The domestic public hears and reads about the obligation of socially responsible business every day. One hears and reads about state initiatives regarding responsible and sustainable business and transparent management, then initiatives and projects of the third sector (civil society) regarding the application of responsible behavior in the community, but also initiatives, projects

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and activities of the real sector. At the same time, the state refers to small, medium and large companies, starting from its own position, it seems that it is the state that always and uncompromisingly respects and implements the rules of its own socially responsible business. However, very little information can be found about the state's activities in the area of socially responsible business. The authors believe that the best way to learn about the respect for socially responsible behavior of the state in the procedures for returning agricultural land is based on the analysis of existing cases, data of interested parties available in the media and public data available through the websites of local self-government units (JLS).

The return of confiscated property is an issue that imposes on Serbia the indirect obligation to return the property to the persons from whose ancestors it was confiscated and is one of the mandatory conditions related to the European integration of a country that is interested in becoming a member of the European Union. Protocol No. 1. with the European Convention on Human Freedoms and Rights does not create for the signatory states, any general obligations or restrictions regarding the restitution of property (right to restitution, scope of restitution and conditions) that was taken from the former owners before they ratified the Convention. That issue is left to the states to solve themselves (Judgment of the European Court of Human Rights).

Restitution is a complex issue from the not-so-distant past of the communist period, from a time that entailed: reshaping, collectivization and nationalization of human consciousness and private property.

That idea, regardless of the fact that it was based on the then legally valid normative framework, had an aggressive appearance directed by the state, which acted with the power of its ius imperium, degrading human freedoms and property rights. Therefore, restitution is, in every country where it is carried out, a major state project based on law. In addition, the real will of the current government is necessary, which not only returns the property to the former owners, but also definitely introduces a new philosophy of private property whose protection, until restitution is implemented, will continue to be only declarative (http://projuris. org/denacionalizacija.html), only on paper (Rajnović, et al 2020).

Research method and data sources

The data used for research in this paper were obtained by analyzing the case of a request for the return of agricultural land in the restitution procedure. Information related to data on available land for return in the observed LGU in Vojvodina from publicly available information via the Internet and other means of information.

The main goal of this paper is to show the socially responsible behavior of the state in the process of returning agricultural land in relation to the restitution of the restitution. In order to collect and evaluate relevant information, the following methods were used:

- case analysis, which refers to the return of agricultural land,
- the synthesis method was used to summarize the conclusions, while giving recommendations for the application of good rules in this area.

From the analysis of all collected data and the fact that Serbia is predominantly a rural country, which is important for the entire economy, and the fact that property rights are guaranteed by the Constitution, the authors came to the knowledge that the state did not have a fair relationship with the holders of the right to land restitution, that there was the possibility of returning quality land in much shorter terms.

Research results

About the state and socially responsible business

There are various definitions of socially responsible business. There is no single definition that is universally accepted. They largely depend on national development strategies and strategic development priorities of individual countries. In this sense, and depending on the achieved level of development of individual countries and the fundamental needs of society, certain countries will emphasize the necessity of achieving economic goals, while others will emphasize the importance of environmental or social goals. Thus, definitions of socially responsible business will also differ, because socially responsible business is a micro-aspect of sustainable development, and the development of the real sector largely depends on national development priorities.

In 2011, the European Commission changed its initial definition of socially responsible business to a new, simpler and more adapted to modern changes in society, according to which socially responsible business is the responsibility of business entities for the effects of their business on society. The organization World Business Council for Sustainable Development (WBCSD) describes socially responsible business as the continuous commitment of business entities to contribute to sustainable economic development by improving the quality of life of their people and their families, as well as the local community in particular.

International Business Leaders Forum (IBLF5) defines socially responsible business as the application of responsible business practices that facilitates the achievement of social, private, ecologically sustainable development by maximizing the positive impact of private property on society, while minimizing negative effects (Pavić-Rogošić, 2016).

Therefore, socially responsible business is actually a derivative of sustainable development. It should be emphasized that sustainable development presupposes the successful integration of economic growth, environmental protection and the quality of relations and development of society (social cohesion) (Rajnović, Lj., (2013). This connection of socially responsible business and sustainable development is clearly shown in the image below.

Figure 1. *Functions of socially responsible government management.*

Source: Author's work.

Certainly, the materialization of sustainable development requires a change in behavior patterns in all segments of activity of all economic entities, and above all the state as the creator of behavior on the market, that is, a fundamental revision and change of values (Drljača 2012). In this way, the fundamental starting points of socially responsible business were argued in great detail in science in such a way that four crucial responsibilities of business entities in society were distinguished and shown through the pyramid of responsibilities (Carroll 1991) as follows:

- Economic - business profitability as the foundation on which everything rests
- Legal - operate in accordance with the law
- Ethical - to work justly, properly, honestly and responsibly towards stakeholders
- Philanthropic - giving to and in the community

This demarcation of the fundamental responsibilities of business entities is very often used in discussions about socially responsible business, although another approach is also very practical (Elkington, 1998). year by discussing the measurement of business success through three perspectives: people, planet and profit.

Very often, the mentioned approach is also called “3P”. Based on this, a Venn diagram was presented in 2023 showing three key domains of corporate responsibility – economic, legal and ethical corporate responsibility (Carroll & Schwartz, 2003). From this, it is clear that philanthropic activity is omitted, but not completely, because this difference from the originally defined pyramid of responsibility is argued in such a way that the philanthropic activity of economic entities is largely connected with economic success, but also with ethical business, so it is considered that as it is not necessary to separate it out.

And no less important is to distinguish defensive from offensive social responsibility. In the first case, business entities most often start undertaking some socially responsible activities when they have already caused some kind of problem in society. Offensive social responsibility presupposes the proactive responsible action of business entities in society and a pre-planned strategy of socially responsible activities that business entities will undertake in the coming years. In that case, business entities take care every day that their business does not negatively affect their internal and/or external interest groups and behave as a good citizen who does not function in isolation but together with all other constituents in the community in which they operate.

Restitution of agricultural land

The most problems in the restitution procedure were during the return of agricultural land, which was owned by the state in all LGUs throughout Serbia, much more than the land claimed in the restitution procedure. The state has prepared parcels intended for restitution, whereby large and best areas of agricultural land are exempted from restitution. The treatment of holders of restitution rights was not the same. Quality land was returned to some in one piece, while the majority were offered low-quality land, a large number of small plots, far from each other, as a result of which there was (http://www.agronews.rs/drzava-iz-restitucije-izuzela -the best-of-land/) starting numerous court proceedings, or the holders accepted it only to get as much as possible (Rajnović, et al 2020).

Due to an insufficiently allocated fund for the restitution of the land, the holders of the restitution are placed in an unequal position. Those who were offered inadequate land were harmed, their right to fair restitution and the principle of equality was violated, while there is a sufficient fund of state land that can be subject to restitution.

In terms of determining the possibility of returning agricultural land in the restitution procedure, the authors analyzed the state of the existing state land fund in relation to the amount that is claimed in the restitution procedure in the JLS Ruma in Vojvodina. In 2016, based on public data published on the Administration's website, there was a total of 7,207,4594 hectares of arable agricultural land in the observed LGU. Based on the Agency's public data, the holders of restitution claimed 1,248,1484 hectares, which represents only 17.32% of the total available state fund. In all neighboring LGUs, the percentage of restitution claim holders was approximate.

Regardless of the above, part of the restitution holders received quality agricultural land, while others, with the threat of rejection of the request for land return by the Agency, were forced to take low-quality land, several small plots, distant from each other. This clearly discriminated against a large number of restitution holders. In addition to the above, the procedures take too long, which violates the right of the restitution holders to resolve their claims within a reasonable time, which is guaranteed by the Constitution of the Republic of Serbia. The authors believe that the basis of such confrontations between the state and the holder of restitution lies in the state's lack of will to return quality land.

In the case analyzed by the author, the Agency for Restitution (Agency) did not dispute the ownership of the previous owner, it made a conclusion on the expert opinion, accepted the expert opinion, and then unfoundedly made a decision rejecting the request for return with a contradictory explanation in which it does not dispute that the predecessor was owner, but states that the previous owner was not previously registered as the former owner of the plot of the old survey, but that the plot in question was subsequently entered in the same land register insert, based on the decision of the authorities at the time, so that it was then transferred to the ownership of the agrarian interested party.

Therefore, although it is indisputable that the predecessor was the owner of the disputed plot, which can be seen from the then land title (which contains information about the plot and the plot owner) and in addition to the accepted expertise that it determined itself, the Agency, after conducting all the evidence, refused to return the land. Also, in the part of the title deed, it is correctly stated that the plot was seized and assigned to an agrarian interested party, who, in accordance with the rule of legal succession, could acquire the rights that the predecessor had, namely the ownership of the plot.

At the time of confiscation of property, it was not even necessary for the person to be previously registered as the former owner of the plot of the old survey. The subject of confiscation was also off-book property, which the Agency accepted and returned property to other applicants, so with the aforementioned decision, the Agency put the applicants in a discriminatory position compared to others, which is illegal and immoral on the part of the state authority entrusted with the right to return the property.

Right to property

The right to property, the right to inherit as its derivative, and in this connection the right to restitution of previously confiscated property is considered a personal right at the same time, guaranteed by the Constitution of Serbia and other regulations. Property rights aim to achieve human dignity through ensuring the economic independence of individuals (Paunović, Krivokapić, Krstić, 2018). In order to realize economic rights, the state is obliged to intervene in economic life, protecting the economically weaker from the economically stronger in order to avoid abuses and unwanted consequences of the liberal economy. In the case of the return of agricultural land, numerous holders of restitution rights encountered an unfair attitude of the state towards their constitutionally guaranteed rights.

Conclusion

Scientists correctly concluded a little less than a century ago that the right to property has changed its legal nature and that property is no longer a right that exclusively serves the interests of the owner. In the exercise of his right, the owner is obliged to take into account the interests of the whole, because the use of private property to the detriment of the whole is prohibited.

It is clear, therefore, that the right to property has long since been deprived of its limitlessness, primarily for the purpose of protecting the public interest. Due to such a changed understanding of property, it no longer represents an absolute, unlimited right. There is, however, no general agreement on where the border is that the state must not cross, especially in cases of deprivation of property rights. The authors believe that in numerous procedures for the return of confiscated land, the state exceeded the limit of its powers in a negative sense and significantly damaged the rights of persons in the procedure for the restitution of agricultural land.

However, almost all countries in which property was confiscated after the Second World War have already carried out the restitution procedure in any case in a shorter period than Serbia, which depends not only on the adopted regulations but also on the real political and social will, which is reflected in the consistent implementation of constitutional principles and laws. Serbia is still carrying out the restitution procedure, and the most problems are in procedures whose subject is the return of agricultural land. Any solution cannot lead to results in practice if they are not implemented consistently, that is, if everyone is not equal before the law and the constitution. This brings us back to the rule of law, which is a prerequisite for all changes and realization of individual rights of restitution holders.

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IMPACT OF RESEARCH AND DEVELOPMENT INVESTMENT ON MEDIUM-SIZED AGRICULTURAL ENTERPRISES' BUSINESS SUCCESS IN SERBIA[1]

Sonja Đuričin[2]

Abstract

Research and development (RnD) investment marks a company's initial foray into fostering innovation. Through RnD, companies have the chance to enhance existing processes and create novel business processes, products, and services. Innovative processes, products, and services bestow a competitive edge, result in time, and resource savings, and promote diversified operations, rendering businesses less vulnerable to market fluctuations. The research objective is to assess how RnD investments affect the success of medium-sized agricultural businesses in the Republic of Serbia between 2020 and 2021. The research centers on the examination of the primary financial indicators of medium-sized agricultural enterprises (Intermediate-scale businesses in the agricultural sector/ or ISB-AS) in 2020-2021. The performance value was determined by applying financial analysis. The data were collected from the official financial reports of all intermediate-scale businesses in the agricultural sector that are registered in the Republic of Serbia. The research is grounded in the hypothesis that medium-sized agricultural enterprises, which allocate resources to RnD, achieve superior financial indicators compared to the average performance observed among all medium-sized enterprises. The research findings have practical implications for policy development in this area and are of great importance to business leaders in developing operational and strategic business goals.

Key words: *RnD, intermediate-scale businesses in the agricultural sector, financial indicators, business success*

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Introduction

Small and medium-sized enterprises (small and intermediate-scale businesses/or small and ISBs) play a vital role in economic development, job creation, poverty alleviation, and the overall growth of economies. Their significance is evident in various aspects such as employment generation, innovation, and their contribution to the digital economy (Beraha & Đuričin, 2022). Therefore, fostering the growth and development of small and ISBs is essential for promoting economic prosperity and stability (Beraha & Đuričin, 2020).

Although the most modest in terms of participation in the overall structure of economic companies and small and ISBs sectors, intermediate-scale businesses, according to key development indicators, represent the fundamental drivers of economic growth. Considering the accessible data, intermediate-scale businesses in the small and intermediate-scale businesses sector account for 0.7%, generating 48% of exports, 40% of imports, 29% of employment, 30% of turnover, and 33% of GVA (Đuričin & Stevanović, 2021). According to the research by Đuričin and Stevanović, the classification of intermediate-scale businesses found that 7% is registered in the agriculture, forestry, and fishing sector (sector A).

The research objective is to assess how RnD investments affect the success of medium-sized agricultural businesses in the Republic of Serbia between 2020 and 2021. The research centers are the primary financial indicators of intermediate-scale businesses in the agricultural sector in 2020-2021. To determine whether investments in research and development affect financial performance, the analysis is broadly set. The subject of the analysis is the primary financial indicators of intermediate-scale businesses in the agricultural sector, which are categorized into two groups: those investing in research and development and those that do not. Additionally, the values of primary financial indicators of all intermediate-scale businesses registered in the Republic of Serbia were considered. By applying quantitative and qualitative financial analysis methods, research results were obtained, leading to a conclusion.

Theoretical Background

Small and intermediate-scale businesses are crucial for local economic development, playing a significant role in job creation, poverty alleviation, and economic growth (Gherghina et al., 2020). They contribute to the growth of economies, promote employment, equitable income distribution, and better living standards (Kilimvi, 2023). Moreover, small and intermediate-scale businesses are considered crucial for the sustained economic development of nations, especially in the long run, as they have a better opportunity than other enterprises for sustained economic development (Le & Sarason, 2018). The findings from various studies also reveal a significant relationship between the operation of small and intermediate-scale businesses and economic growth in developing nations (Obi et al., 2018). Medium-sized enterprises, as part of the small and intermediate-scale businesses, are particularly important for the economic growth and competitiveness of regional economies (Hrivnák & Moritz, 2021). They contribute significantly to the growth of economies and are crucial for developing various sectors, such as agribusiness (Kilimvi, 2023).

Investing in RnD has a significant impact on the success of enterprises' operations. Increasing RnD investment is crucial for the sustainable development of the manufacturing industry, indicating a positive correlation between RnD investment and business success (Zhou et al., 2021). Furthermore, significant RnD investments in the high-tech industry can have a positive and lagged effect on firm performance, further supporting the notion that RnD investment contributes to long-term success (Chen et al., 2019).

The literature highlights the importance of internal expenditures on RnD in enhancing innovation capability, which in turn contributes to overall business success (Sudolska & Łapińska, 2020). Additionally, Pan et al. (2021) discussed the relationship between supply chain financing, RnD investment, and companies' innovation efficiency, indicating that RnD investment intensity is crucial for promoting innovation performance (Pan et al., 2021).

The role of innovation in the primary financial indicators of agricultural enterprises is evident in the study by (Li & Zhong, 2023), which explored the impact of green innovation and technological innovation on the financial indicators of listed agricultural companies in China (Li & Zhong, 2023). Additionally, Usman et al. (2021) highlighted the dependence of RnD innovation adoption in the agriculture sector on producers' willingness to adopt, knowledge capital spillovers, and financial capacity (Usman et al., 2021). These findings underscore the significance of RnD and innovation in shaping the financial indicators of agricultural enterprises. Additionally, Asare & Essegbey (2016) emphasized the significant contribution of agricultural RnD investments to economic growth, agricultural development, and poverty reduction in developing countries (Asare & Essegbey, 2016).

Research has shown that RnD investments play a crucial role in enhancing a firm's competitiveness and long-term performance (Sharda, 2022). Additionally, there is a significant positive correlation between RnD expenses and operating performance (Liu et al., 2019). This suggests that RnD activities can contribute to improving a company's financial indicators metrics such as Return on Assets (ROA), Return on Equity (ROE), and Return on Sales (ROS).

Data and Methodology

The aim of the research was achieved by methods of quantitative and qualitative financial analysis (Đurićin & Beraha, 2021; Đuričin et al., 2018). By applying financial analysis methods, the calculation of financial indicators was carried out, based on conclusions about the business success of all intermediate-scale businesses in the Republic of Serbia, ISBs registered in the agricultural sector, and ISBs in the agricultural sector investing in research and development were derived. The financial performance, based on which a comparative analysis was conducted, includes representative indicators of profitability and the financial position of the companies. Representative indicators of profitability are ROA, ROE, and ROS, while representative indicators of the financial position are the Current Ratio, Solvency Ratio, and Proportion of Obligations in Overall Funding Resources (POLFR). The period covered by the analysis is between 2020 and 2021.

Regarding the ISBs registered in the territory of the Republic of Serbia and ISBs in the agricultural sector, the subject of analysis is the financial indicators calculated based on data disclosed in the financial reports publicly available on the website of the Serbian Business Registers Agency (SBRA). Aggregate financial statements were prepared for analysis for all ISBs registered in the territory of the Republic of Serbia, as well as for ISBs registered in the agricultural sector. In the case of intermediate-scale businesses in the agricultural sector investing in research and development, the subject of analysis is the financial indicators calculated based on data obtained from Dun & Bradstreet Company d.o.o.

The values obtained through this analysis were interlinked and synthesized to understand their interactive dynamics. This synthesis method revealed the relationship between different performance values, enabling conclusions to be drawn regarding the influence of research and development on the success of medium-sized enterprises.

Results and Discussion

From 2020 to 2021, research and development expenses were recorded by 1,019 and 996 enterprises respectively. The number of enterprises investing in research and development in the Republic of Serbia decreased in 2021 by 2% compared to 2020.

Among the total number of enterprises that invested in research and development between 2020 and 2021, small enterprises were the most numerous. Between 2020 and 2021, on average, 62% of small enterprises invested in research and development. In the observed period, among the total number of companies investing in research and development, ISBs on average accounted for 22%, while large and micro-enterprises accounted for 10% and 7% respectively.

The largest number of enterprises investing in research and development were registered in the manufacturing sector (32%), wholesale and retail trade; repair of motor vehicles and motorcycles (trade) (24%), and professional, scientific, and technical activities (9%).

From the entirety of enterprises investing in research and development between 2020 and 2021, 3% were registered in the agriculture sector. This also represents 0.30% from the entirety of registered ISB-AS in the Republic of Serbia. The number of companies investing in research and development remained unchanged at 29. In 2021, compared to 2020, the number of companies decreased by 3, but simultaneously, 3 new companies started investing in RnD. Out of the total 29 agricultural companies investing in RnD, 18 are small, 3 are micro, 6 are medium-sized, and 2 are large enterprises.

Out of 6 companies in the agriculture sector that invested in RnD in 2021, 4 companies also recorded these investments in 2020. The highest percentage of medium-sized agricultural companies investing in RnD was observed in the activity of Cultivation of cereals (except rice), legumes, and oilseeds (50%). Represented by 17% each in the total number of medium-sized companies investing in RnD are companies from three different activities: Pig farming, Poultry farming, and Freshwater aquaculture. The value of investments by medium-sized agricultural companies in RnD is, on average, less than 1% of their capital value and does not exceed 2% of the gross profit achieved in the current year. Out from the entirety of ISB-AS investing in RnD, 80% are registered in the Vojvodina Region, and 20% in the Belgrade Region.

Intermediate-scale businesses in the agricultural sector that invested in RnD between 2020 and 2021 are operating both liquidly and profitably. Among the enterprises that invested in RnD in both years, there was an observed increase in liquidity. However, it cannot be concluded that investing in RnD directly led to an improvement in the value of all analyzed financial performances of the enterprises. Drawing such a conclusion would not be accurate given the short period under analysis and the existence of other factors within the business process that could influence the value of financial performance. For instance, among the enterprises that recorded investment in RnD in both years, 50% experienced an increase in solvency, 75% saw a decrease in indebtedness, 25% observed a growth in ROA (Return on Assets), 50% saw an increase in ROE (Return on Equity), and 25% experienced growth in ROS (Return on Sales).

Table 1. Primary financial indicators of ISBs that invest in RnD, 2020-2021.

Enterprises	Period	Current ratio	Solvency ratio	POLFR (%)	ROA	ROE	ROS
A	2020.	1.17	2.63	41.36	3.78	7.00	18.07
	2021.	5.57	2.86	39.23	2.39	4.41	8.77
B	2020.	2.78	7.19	21.91	7.33	14.79	9.20
	2021.	36.69	6.13	19.03	12.06	17.39	8.72
C	2020.	1.56	2.90	39.87	3.01	5.79	9.63
	2021.	3.45	2.14	49.41	2.99	6.24	12.50
D	2020.	1.24	1.72	63.65	7.89	23.81	9.15
	2021.	1.28	1.73	62.30	3.37	9.66	3.06
E	2021.	1.81	2.29	67.90	2.57	12.22	1.35
F	2021.	19.96	11.79	8.99	11.77	13.71	8.09

Source: The calculation of authorship according to Dun & Bradstreet Company d.o.o. data

If we compare the values of the financial performances of all intermediate-scale businesses registered in the Republic of Serbia with the values of the performances of Intermediate-scale businesses in the agricultural sector that invest in RnD. It can be concluded that medium agricultural enterprises investing in RnD record:

- A higher level of liquidity between 2020-2021.
- A higher level of solvency between 2020-2021.
- A lower degree of indebtedness, except for 30% of ISB-AS investing in RnD.
- A higher level of ROE, except for 16% of ISB-AS investing in RnD.

- A higher level of ROS, except for 30% of ISB-AS investing in RnD.
- A lower value of ROA for all, except for 16% of ISB-AS investing in RnD.

Table 2. Primary financial indicators of intermediate-scale businesses registered in the Republic of Serbia and in the agricultural sector, 2020-2021.

Intermediate-scale businesses	2020.	2021.
Current Ratio	1.23	1.16
Solvency ratio	1.62	1.66
POLFR	59	59
ROA	3.83	4.13
ROE	7.63	8.02
ROS	3.83	4.00
Intermediate-scale businesses in the agricult. sector	2020	2021
Current Ratio	1.53	1.47
Solvency ratio	2.10	2.16
POLFR	42	45
ROA	3.01	2.57
ROE	5.13	4.61
ROS	5.51	3.94

Source: The calculation of authorship according to data from the SBRA

If we compare the financial indicators values of all intermediate-scale businesses in the agricultural sector with the performance values of intermediate-scale businesses in the agricultural sector that invest in RnD, it can be concluded that the medium-sized agricultural enterprises investing in RnD record:

- Higher levels of liquidity, except for the 16% of ISB-AS investing in RnD. Even in these medium-sized agricultural enterprises, there is a noticeable growth in the current ratio in 2021 compared to 2020.
- Higher levels of solvency, except for the 16% of ISB-AS investing in RnD. Even in these medium-sized agricultural enterprises, there is a noticeable growth in the solvency ratio in 2021 compared to 2020.
- Lower levels of indebtedness, except for the 60% of ISB-AS investing in RnD.
- Higher levels of Return on Assets (ROA) between 2020-2021.

- Higher levels of Return on Equity (ROE) between 2020-2021.
- Higher levels of Return on Sales (ROS), except for the 30% of ISBAS investing in RnD.

Pratama et al. (2019) confirmed that RnD has a positive effect on a company's financial performance. External factors also influence the relationship between RnD and liquidity. For instance, Standert (2020) found that debt to equity ratio significantly impacts RnD spending, indicating that financial structure affects RnD investment decisions. However, it is necessary to note here that if investment in RnD is secured through national support measures, then an increase in indebtedness is expected. Businesses utilizing co-financing are in a more favorable position with banks. These enterprises are viewed as lower risk by financial institutions, resulting in a higher likelihood of loan approval compared to businesses without co-financing (Li, et al., 2018). "In addition, enterprises that co-finance part of their business activity through the programs apply for smaller bank loans, which increases their chances" (Đuričin et al., 2022). These enterprises also demonstrate increased revenue growth, further facilitating their access to bank loans (Kanwal & Eyisi, 2022). Accordingly, the conclusion drawn is that the impact of investing in RnD on the value of financial indicators is conditioned by the funding source for these investments.

The relationship between RnD and a company's financial performance, as measured by ROA, ROE, and ROS, is complex and influenced by various financial, operational, and external factors. While RnD investments can potentially contribute to improved financial performance, the interplay of multiple factors necessitates a comprehensive analysis to understand their combined impact.

It is important to note that the impact of RnD on financial indicators is multifaceted and can be influenced by various factors. For example, Dimitropoulos (2020) highlighted that RnD investments are a significant determinant of corporate development and sustainability, indicating the potential positive impact of RnD on profitability during crises. Nandy (2022) highlighted that ROE and ROI are comprehensive measures of a firm's profitability, indicating the significance of these metrics in evaluating the impact of RnD activities on financial performance. Sari et al. (2021) demonstrated that liquidity, debt to equity ratio, and turnover ratios significantly affect ROE, indicating the complex interplay of financial metrics on profitability.

Conclusion

The RnD that a small number of intermediate-scale businesses in the agricultural sector invest in RnD. Although drawing conclusions from such a small sample is not acceptable, it is an undeniable fact that the obtained results correspond and align with the outcomes of earlier research on this subject conducted by numerous other scientists. This study shows that in the Republic of Serbia, as well as in other economies, investing in RnD has positive effects on the financial indicators of companies.

What sets this research apart from existing studies in this field is its focus on medium-sized enterprises, along with a comparative analysis of the financial indicators values among all medium-sized enterprises, medium-sized agricultural enterprises, and intermediate-scale businesses in the agricultural sector that invest in RnD. Considering that it has been established that intermediate-scale businesses in the agricultural sector that invest in RnD, in a larger number of cases, exhibit better financial indicators than other ISBs but without a consistent trend, future research should be based on a longer time frame encompassed by analysis.

In this regard, the credibility of concluding the cause and dynamics of the analyzed performance values would be increased. Research resulting in concrete data obtained through scientific methods should be the basis for creating public policies that would enable a higher level of investment by ISBs in RnD. Creating specific policies to enhance RnD in intermediate-scale businesses is justified due to several specificities among entities in the small and intermediate-scale businesses, which are caused by their size. Additionally, policies that would exclusively relate to the operations of ISBs are crucial from the perspective of their managers. Within a regulated framework of operations, they would more easily decide to invest in RnD, leading to an increase in the number of innovative medium-sized companies.

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ECONOMIC ASPECTS OF MILK PRODUCTION AND COTTAGE CHEESE AS A TRADITIONAL DAIRY PRODUCT ON FAMILIY FARMS IN SERBIA[1]

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Abstract

Serbia's advantageous natural conditions favor livestock production, particularly cow's milk production, with an annual average of 1.5 billion liters, primarily from small farms. However, only 35.1% of the total milk production undergoes processing. Research focuses on the economic aspects of milk production and its transformation into cottage cheese on family farms. A model for traditional milk product production on family farms was developed and analyzed using analytical calculations based on variable costs. The results revealed a €0.23 difference in production cost per liter between raw and processed milk, and a €0.65 difference in selling price. The study suggests that farms with up to 15 dairy heads should consider milk processing and product finalization. This research sheds light on the potential benefits of processing milk on family farms, offering valuable insights for the dairy industry in Serbia.

Key words: *economic aspects, dairy farms, milk production and processing, competitiveness, production costs.*

Introduction

Potential for livestock production in The Republic of Serbia, particularly in cow's milk production, has been the subject of a recent scientific study. In 2018, official statistics reported a total of 424,155 dairy cows in Serbia, establishing the country as a regional leader in dairy cow numbers. The majority of milk production

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comes from small family farms, with over 59% of producers having one to two cows, delivering an average of 19.4 liters of milk per day. A further 35% of farms have three to nine cows, and nearly 95% of milk farmers operate small family farms with a maximum of nine dairy cows. The primary constraint on increasing cow numbers in most family farms is the fragmentation of households and limited resources for animal feed production. To enhance economic outcomes, milk processing into traditional products with added value is recommended. These products, which are nutritionally valuable, can be sold at local markets or on family farms and could contribute significantly to rural tourism development.

The ongoing migration from rural to urban areas and the large number of abandoned villages in Serbia raise questions about the economic sustainability of rural life and the potential for increasing farm incomes. Farm structure survey of agricultural producers in 2018 suggested that the total population of Serbia is expected to decrease to below 7 million (Farm structure survey, 2018). This is due to population outflow, which occurs as an increase in urban inhabitants at the expense of rural areas, as well as the emigration of young people abroad. The share of rural population in the Republic of Serbia has been declining since World War II, and it is anticipated that the 2021 Agricultural Census will show that the share of rural population is at around 35% (Mitrović, 2015). Furthermore, the migration of young people from villages to cities contributes to population aging. This phenomenon has been already seen in Western Europe, where migration has been used to repopulate previously depopulated areas.

An analysis of agricultural activities in the Republic of Serbia from 2000 to 2017 reveals that crop production is the dominant activity, accounting for 52% of the production value. This type of production is typically extensive and does not require a significant workforce. Cattle breeding represents only 13.2% of the production value. A 2018 Farm structure survey indicated that the total number of farms is 12% lower compared to the 2012 Census of Agriculture. Despite a 45% increase in economic size to €8,610 in 2018 compared to the 2012 results, the value of production generated by farms in EU countries is four times higher than in Serbia (EUROSTAT, 2016). It is estimated that only 15% of the production value remains as profit and work compensation, resulting in minimal average monthly salaries for farmers.

Regional indicators in Serbia show that the highest incomes are achieved in farming in the region of Autonomous Province of Vojvodina, while the largest number of livestock farms are located in Šumadija and Western Serbia. The total amount of processed milk in Serbia is 524.1 million liters per year, representing only 35.1% of the total raw milk production in 2018, which was approximately 1.5 billion liters (Ministry of Agriculture, Forestry and Water Management, Veterinary Directorate, 2019). Introducing appropriate technology for processing milk into traditional dairy products within family farms, such as various types of cheese, could significantly increase the value of milk and the profitability of milk production. These traditional dairy products are recognizable on the market, which provides the opportunity to create significant added value (Popović Vranješ, 2015).

Processing milk into traditional dairy products contributes to the diversification of rural economy and the income of the rural population through additional activities, whether or not related to food production or processing, can positively impact overall economic growth and the preservation of rural areas. This could significantly increase the value of milk and thus the profitability of milk production (Popović, Vranješ et al., 2017). This diversification can enlarge farm income, improve living standards, and reduce household vulnerability to income fluctuations. The high dependence of the rural economy on agriculture and its insufficiently diversified economic structure has been identified as a key cause of rural poverty in Serbia. One of the main causes of rural poverty in Serbia is the high dependence of the rural economy on agriculture and insufficiently diversified economic structure (Janković and Novakov, 2019). Furthermore, some authors (Chaplin, Davidova and Gorton 2004, according to Janković et al., 2014)

Diversification is viewed as a process of reducing dependence on agriculture, influenced by various factors at the farm, local community, regional, and societal levels. Household characteristics, education, skills, access to finance, infrastructure, and social capital are identified as key factors influencing the degree of diversification in rural areas.

A research study focused on the economic aspects of milk production and processing into cottage cheese on small family farms, with the aim of analyzing the potential for increasing farm income through milk processing into traditional products.

Materials and methods

The paper presents the analysis of economic results of milk production and its processing into cottage cheese in small processing units on family farms during 2017. Production data regarding quantity as well as economic outcomes of such small processing units were collected through the conducted field survey. Data from the publications of the Statistical Office of the Republic of Serbia, STIPS and EUROSTAT were used to track the current state of the sector in question in Serbia and abroad.

Direct costing method, a method covering not all, but only variable costs was used, and although not entirely comprehensive, it still is a quick and efficient indicator for comparing different production lines and selecting the most cost effective one (Tomić et al., 2013). It can be used to assess economic sustainability of the technology applied and the results which are thus obtained (Subić et al., 2015; Nielsen et al., 2015). It is a simpler calculation than the one covering also obtained fixed costs calculation (full analytic cost calculation), which requires to involve also fixed costs for individual production lines, so to calculate not only direct, but also overhead costs. Therefore, the full analytic calculation does tend to be complicated for the majority of uneducated and unobliged farmers from small family farms.

This research aims to observe thoroughly the economic side of milk production and processing into cottage cheese in small processing premises on family farms with a processing threshold of up to 200 liters of milk daily. Both of these so called production lines were observed from the aspect of production capacity and economic effects achieved on the representative farm which solely deals with (is specialized) in raw milk production.

One of the milestones of the research was to calculate the costs of liter of raw milk produced, as well as the costs done for processing of this milk into traditional dairy produce – cottage cheese, and assess the economic results of both products. Direct costing method was used for the analysis, since it is most used when analyzing economics on family farms which are not obliged to keep records of costs done and results achieved. The general equation of direct costing calculation is the following (Andrić, 1998; Gogić, 2014):

$$PV - VC = GM$$

with the following meaning:

PV – Total production value in specific production;
VC – Total variable costs for each production line;
GM – Gross margin (gross financial result).

Results with Discussions

Through the analysis of the results obtained through the field research, and through the use of direct costing as a methodology tool, a farm model was set up and used to analize the achieved of economic efficiency in milk production and processing. The farm model derives as an average value taken from 242 farms out of the surveyed sample. The farms in the sample are located in 68 municipalities all over Serbia.

Table 1. Starting indicators in the model

Number of dairy cows	12	Cows
Average age of dairy cows	5	Years
Average milk yield	4,211	lit/head
Average euro exchange rate	121.34	RSD
Production year	2017	

Source: Authors' calculations

Table 2 shows the individual items that production value and variable costs in milk production are made of.

Table 2. Gross margin of the variable costs in milk production

Description	Quantity	Unit	Unit price (€)	Total (€)	Per head (€)
A. Production value					
Milk sold to the dairy	50,536	lit	0.23	11,661.51	971.79
Male calves sold	6 head		593.37	3,560.24	296.69
Female calves sold	2	head	461.51	923,03	76.92
Heifers sold	2	head	1,500.00	3,000.00	250.00
Culled cows	2	head	803.53	1,607.05	133.92
Milk premium	50,536	lit	0.06	2,915.38	242.95
Subsidy for milking cows	12	head	206.03	2,472.39	206.03
Manure				988.96	82.41
Production value (Total A)				**27,128.56**	**2,260.71**
B. Variable costs					
Feed				11,940.85	995.07
Labour				2,707.27	225.61
Energy and fuel				540.03	45.00
Contract work				765.00	63.75
Other				385.76	32.15
Variable costs (Total B)				**16,338.91**	**1,361.58**
C. Gross Margin (A-B)				**10,789.66**	**899.14**

Source: Authors' calculations

Out of the production value structure, as the most important elements can be viewed: annual milk production per dairy cow (4.211 liters), as well as the total quantity of milk produced during the lactation (for 12 cows 50,536 liters transferred to processing plants). Other significant included were: calve value, heifer value, weaned cows and manure value.

The prices used to calculate the gross margin result were the current market prices at the time of the survey. With that said, the average price of male calves was € 593.37 per animal, female calves € 461.51, heifers € 1,500, culled cows € 803.53, manure € 82.41 per 10 tons. Included within total production value, were also subsidies obtained in the exact production. Those subsidies are made up of incentives for breeding dairy cows of € 206.03 per cow, and a premium for delivered milk of € 0.06 per liter of milk sold.

Production value structure was as follows: sold milk income (about 43%), sale of livestock 33.51%, subsidies received 19.86% and manure sold 3.64%.

The structure of variable costs was made up of: animal feed, hired labor, fuel and energy, costs of services (costs of veterinary services, insemination costs and selection costs), as well as other cost items (bedding straw, medicines, issuing milk tickets, selling tickets, costs of consumables - detergents, disinfectants, towels, small tools).

The cost of animal feed is the single largest item of the production cost, with about 73%, or in absolute sum € 11,940.85. These consist of three items: feed for dairy cows, feed for heifers and concentrated feed for calves. Payed labor is the second most burdening cost in this calculation - with the share of 17%.

Table 3. Critical values in milk production

Description	€(lit)/head
Expected yield/average milk production (EY)	lit 4,211
Expected price (EP)	€ 0.23
Subsidies (s)	€ 448.98
Variable costs (VC)	€ 1,362
Critical price: CP = (VC – s) / EY	€ 0.22
Critical yield: CY = (VC – s) / EP	lit 3,968
Critical variable costs: CVC = (EY x EP) + s	€ 1,418

Source: Authors' calculations

The critical values calculation enables a view into possibility of profitability of milk production, and shows the exact point at which it starts becoming unprofitable.

This research shows it is clear how the workload is extremely low, i.e. 0.01 €. Critical values for price, yield and variable costs were calculated only for milk production, without including income from the sale of livestock, which makes 33% of the total income. For determining critical values shown in Table 3, sensitivity analysis was used.

Table 4 gives the production structure and deriving variable costs in processing milk into traditional dairy products - cottage cheese.

Table 4. Gross margin of the variable costs in milk processing into traditional milk products - cottage cheese

Description	Quantity	Unit	Unit price (€)	Total (€)	Per head (€)
A. Product					
Cottage cheese	12,032	kg	2.88	34,652.16	2,887.68
Curd	38,504	lit	0.01	385.04	32.09
Male calves sold	6	head	593.37	3,560.24	296.69
Female calves sold	2	head	461.51	923.03	76.92
Heifers sold	2	head	1,500.00	3,000.00	250.00
Culled cows	2	head	803.53	1,607.05	133.92
Subsidy for milking cows	12	head	206.03	2,472.39	206.03
Manure				988.96	82.41
Production value (Total A)				**47,588.87**	**3,965.74**
B. Variable costs					
Feed				11,940.85	995.07
Labour				4,512.12	376.01
Energy and fuel				1,337.36	111.45
Contract work				765.01	63.75
Other				385.76	32.15
Costs of transport				741.04	61.75
Rental costs at market stalls				1,279.05	106.59
Packing for cheese products				1,804.85	150.40
Rennet				198.33	16.53
Salt				89.25	7.44
Variable costs (Total B)				**23,053.62**	**1,921.14**
C. Gross Margin (A-B)				**24,535.25**	**2,044.60**

Source: Authors' calculations

The production value in Table 4 consists, of the value of cottage cheese, as well as of byproduced whey. The average market price of cottage cheese is € 2.88, multiplied by 12,032 kg of cheese produced thus the value of € 34,652.16 is obtained. Annual production of whey is 38,504 liters, which is multiplied by the market price of € 0.01 that gives a value of € 385.04.

The costs of processing milk include: rennet, salt, market packaging, electricity, water, labor involved in milk processing, transportation to the market and stand rental.

Rennet, salt and packaging costs amounted to € 2,092.43. Costs of water used in processing are included in the amount of fuel and energy (Table 2.). Transportation costs were calculated bearing in mind that farmer brings the products to the green market twice a week, with about 600 kilometers total distance covered, which then multiplied by diesel price of € 1.29 per liter amounts to € 741.04 annually. Green market stand rent varied depending on the exact town from which the data was surveyed, but as an average value the amount of 329.65 € was taken for the renting a stand annual. Additional daily rent of the stand, which is paid extra, was also taken into account and has averaged around 10 €, giving the total cost of stand renting at € 1,279.05.

Labor cost obtained in milk processing were calculated to the amount given in Table 2, in which additional paid labor for work in processing and in product placement was included. It is obvious from the survey that, 6 hours of work per day were spent for milk processing and marketing of dairy products, on average, which burdens the calculation with € 1,804.85 annually. Tables 5 show the calculation of critical values in the production of cottage cheese.

Table 5. Critical values in the production of cottage cheese

Description	€(kg)/head
Expected yield/average milk procession (EY)	kg 1,003
Expected price (OP)	€ 2.88
Subsidies (s)	€ 206.03
Variable costs (VC)	€ 1,886
Critical price: CP = (VC – s) / EY	€ 1.68
Critical yield: CY = (VC – s) / OP	kg 583
Critical variable costs: CVC = (EY x OP) + s	€ 3,098

Source: Authors' calculations

Production of cottage cheese and most of other traditional dairy products is not dependent on market changes. The price of the cheese can be reduced by 1.2 €, while keeping the positive margin value. Sensitivity analysis, gave similar results, and was done as a controlling mechanism for the previously obtained critical values.

Table 6. Comparative analysis of milk production and processing

Row. no.	Comparative analisys of milk production and procession	Amount (€/lit)
1.	**Parameters of milk production and procession**	
1.1.	Production price per litter of milk	0.21
1.2.	Production price with premium	0.29
1.3.	Financial result per litter of milk sold	0.08
2.	**Parameters of production and sales of processed milk**	
2.1.	Production price of processed milk	0.45
2.2.	Prices of the sold processed milk	0.94
2.3.	Financial result per litter of processed milk	0.49
3.	**Difference**	
3.1.	Difference in the price of produced and processed milk	0.24
3.2.	Difference in price of raw and processed milk	0.65
3.3.	Difference in financial result	0.41

Source: Authors' calculations

Finally, a comparative analysis of milk production and processing based on the given parameters, was conducted, showing the financial result per liter of sold/processed milk. Out of the surveyed sample, when it comes to *milk production*, the average production price per liter of milk was € 0.21, while the selling price per liter of milk with included premium, was € 0.29, with financial result of € 0.08 per liter of milk sold. In milk processing, i.e. *production of cottage cheese*, the average production price per liter of processed milk is € 0.41, and the average selling price per liter of processed milk for the product is € 0.94, giving the per liter of processed milk in this model of 0.49 €.

Per liter of raw and processed milk the difference between the production prices was € 0.24, while difference between the selling prices was € 0.65 with the difference in the final financial result of € 0.41.

Conclusions

Cow milk production in Serbia is predominantly done on small family farms with a maximum of up to 9 dairy cows. One of the main limiting factors for increasing family farms size in the Republic of Serbia, measured by the number of cows is the fragmentation of parcels, low productivity, i.e. limited resources for animal feed production.

Through the introduction of required technology, significant quantities of milk could be processed into traditional dairy products on the farms themselves, so that various types of cheese and other dairy products that could be successfully marketed and valorized. This can significantly increase the value of milk produced and thus enhance the profitability of milk production.

Traditional dairy products are produced with the use of unique technology and are characterized by specific traits, determined by the distinct features of the locations where the milk is produced and processed. They are recognizable and valued amongst consumers, which opens up the possibility of creating significant added value.

Production results of raw milk production on a small farm, obtained in this research (Table 2.), lead to the following conclusions:

- positive gross margin was achieved (€ 10,789.66 / basic herd, i.e. € 899.14 / milking cow, i.e. € 0.21 / liter of raw milk);
- Production value achieved after selling milk, cattle and manure is 1.66 times higher than variable production costs;
- the feed costs comprise the largest share in variable costs (73 %).

Production results of cottage cheese production recorded on a small farm (Table 4.), lead to the following conclusions:

- positive gross margin was achieved (€ 24,535.25 / basic herd, i.e. € 2,044.60 / milking cow, i.e. € 0.41 / liter of milk);
- production value achieved after selling milk, cattle and manure is 2.06 times higher than variable production costs;
- the feed costs comprise the largest share in variable costs (53%), followed by the processing costs (28%).

Comparison of the two activities - raw milk production and production of traditional dairy products on annual level, and observation of the results shown in Table 6, shown not only that the selling prices of dairy products are significantly higher than prices of raw milk, but also that resulting profits are higher when milk is processed. Moreover, when comparing the production price of raw milk of € 0.21 and the selling price of € 0.29, a question arises whether the financial result gained of € 0.08 can cover fixed costs in milk production. The situation in processing is quite different, where it is clear that the difference in the result per liter of processed milk of € 0.49 can certainly cover fixed costs. The total difference in the result is 0.41 € per liter of processed milk, i.e. 41 € cents per liter of milk remains a positive difference when the agricultural producer processes own milk into traditional dairy products, in particular - cottage cheese. When the obtained result is multiplied by the total quantity of milk produced, an income of € 20,719 (0.41 € * 50,536 lit) could be gained.

The results of the research undoubtedly show very high economic efficiency of milk processing into traditional dairy products.

The results obtained in milk processing fully cover the production fixed costs and, moreover, also leave a certain Surplus that can be used for new investments on the farm. It should be mentioned that this type of processing milk into the traditional dairy products is most suitable for farms with around 12 milking cows.

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WORKING SECTION

THE ECONOMIC CHARACTERISTICS OF AGRICULTURAL HOLDINGS IN THE REPUBLIC OF SERBIA[1]

Aleksandar Miljatović[2], Veljko Vukoje[3], Veljko Šarac[4]

Abstract

The aim of this study is to analyse and evaluate the trend of basic production and economic indicators of agricultural holdings in the Republic of Serbia. The focus is on the comparative analysis of agricultural holdings according to type of farming. The study is based on the Serbian FADN data from 2017 to 2021. The results showed that the farm net value added per annual work unit and family farm income per family unit both had a strong growth tendency. Specifically, these indicators increased in comparison to the previous year by as much as 63.9% and 78.6%, respectively, while the increase was even higher compared to 2017, 198.5%, and 226.6%, respectively. The highest values of the analysed indicators were recorded in the field crop faming system, followed by poultry and pig production. On the other hand, holdings specialising in grazing livestock had the worst results, because of the extensive production they were involved in and the fact that these holdings are located in the mountains and in areas with natural constraints.

Key words: *comparative analysis, agricultural holdings, farm net value added, family farm income.*

Introduction

The basic business entities involved in agricultural production in the Republic of Serbia (RS) are: (1) individual agricultural holdings, (2) agricultural enterprises and cooperatives, and (3) entrepreneurs. According to the last Census of Agriculture (*www.stat.gov.rs*), individual agricultural holdings (AH) are

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definitely the most numerous, numbering approximately 628 thousand of all AH (*Cvijanović et al., 2014*). In the relative share, individual holdings represent about 99% of the total entities in agriculture.

Individual agricultural holdings occupy approximately 2.8 million hectares of the utilised agricultural area (UAA), which represents 82.2% of total UAA in the RS (Ševarlić, 2015). Their contributions are reflected in the improvement of the overall quality of life, employment, and socialization of the rural population. Individual holdings are often the only business entities in which the rural population earns an income. *Davidova et al. (2005)* point out that individual holdings in general are less productive than agricultural enterprises, especially in Eastern European countries. However, their significance is greater and is reflected in the overall development of rural areas, where agriculture represents the dominant activity. The improvement of economic characteristics of agricultural holdings can have a significant impact on the overall development of agricultural activity in the RS.

Agricultural holdings are mostly not obliged to keep records about their business, with the exception of VAT taxpayers (*Individual Income Tax Law, ar. 43*) and/or holdings included in the FADN[5] sample. An agricultural holding needs to be market-oriented (commercial) in order to keep records of any kind. A commercial agricultural holding is considered a holding which puts its own products of a certain value on the market and achieves an income on that basis. In domestic conditions, commercial agricultural holdings are the ones with a standard output value higher than 4,000 euros per year (*www.fadn.rs*).

The FADN system, which collects basic production, economic, and financial data about agricultural holdings, exclusively takes into consideration commercial holdings. In the RS there are about 200 thousand commercial holdings. The FADN collects data from about 2 thousand holdings in the sample based on which diverse analyses can be conducted. In this paper, the focus is on the basic production and economic indicators of agricultural holdings in the RS. The main aim of the study is to analyse and evaluate the state and trends of basic production and economic indicators of agricultural holdings based on type of farming.

5 FADN (the Farm Accountancy Data Network) – monitors farms' income and business activities (*https://agriculture.ec.europa.eu*)

Materials and methods

The study is based on FADN data. The paper studies the period from 2017 to 2021, so only agricultural holdings which were found in the sample during the entire studied period were considered. The total number of holdings active during entire analysed period, after eliminating AH with extreme values, is 801.

The comparative analysis of the achieved results for agricultural holdings was conducted according to type of farming. Agricultural holdings are divided into 8 basic type of farming, with respect to the official FADN methodology and concerning the specifics of agriculture in the RS and the aims of the study. Hence, agricultural holdings are divided into the following types of farming: (1) Field crops (FC), (2) Milk production (MP), (3) Other grazing livestock (GL), (4) Mixed crops-livestock (CL), (5) Horticulture (HOR), (6) Vineyards and fruits (VF), (7) Specialist pigs (PG), and (8) Specialist poultry (PL).

In the sample structure, FC holdings are dominant with a share of 39.2%, followed by MP holdings with 20.0%, and CL with 14.0%. The lowest share in the structure was noted for holdings specialising in pig production and horticulture. Their share in the sample is 1.7% and 3.0%, respectively.

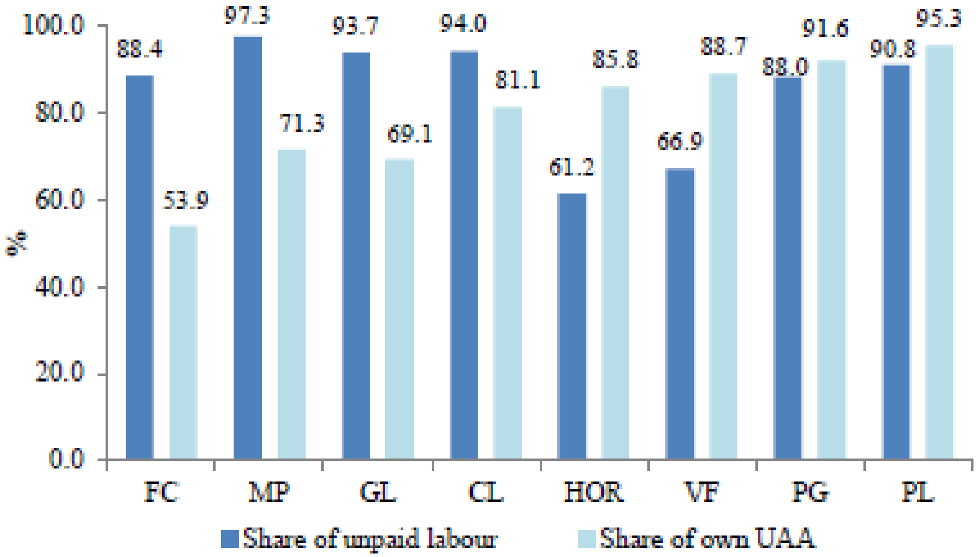
The achieved results of the agricultural holdings were evaluated using basic indicators of productivity and profitability. In the FADN methodology, the farm net value added (FNVA) per annual work unit (AWU) was used as an indicator of productivity, while family farm income (FFI) per family work unit (FWU) was the most frequently used indicator of profitability (*MAFWM, 2021*). Beside the aforementioned indicators, the basic production resources of agricultural holdings were presented: the total labour input (unpaid and paid) and UAA (own and rented).

In the paper, next to aforementioned methods, standard instruments of descriptive statistics were used: the mean, median, interquartile difference, and interquartile difference coefficient.

Results

Labour input and UAA represent the basic production resources of agricultural holdings. Labour input is expressed in AWU, whereby one AWU is the equivalent of the total yearly working hours of one person with full-time engagement. In the RS, one AWU amounts to 1,800 working hours. Agricultural holdings in the RS from 2017 to 2021 had 1.9 AWU on average. The labour input on agricultural holdings in the RS had a noticeably declining tendency. Specifically, hired labour amounted to 1.8 AWU in 2021, which is approximately 3.3% lower than the previous year, and about 8.0% lower compared to 2017. Hired labour on agricultural holdings could be unpaid (family member work) and paid. The share of unpaid labour input is dominant in domestic holdings and on average was 88.7% in the studied period. The highest percentage of unpaid labour input of 97.3% was recorded in MP holdings, followed by CL and GL holdings with 94.0% and 93.7%, respectively (*Chart 1*). On the other hand, HOR and VF holdings had the lowest share of unpaid labour input (61.2% and 66.9%, respectively).

Chart 1. Proprietary structure of labour and UAA according to type of farming, 2017-2021



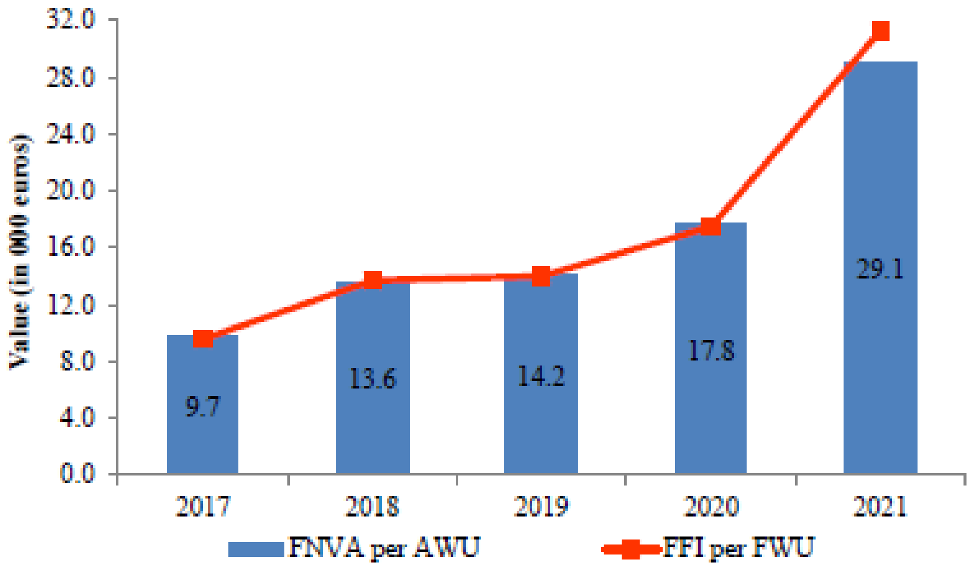
Source: Author's calculation based on FADN data

In the case of UAA, agricultural holdings in the RS had 29.0 ha of the agricultural land on average. UAA was slightly increased in the studied period. In 2021 the holdings had 29.7 ha of land on average, which is about 2.2% higher than during the previous year, and about 2.1% higher than in 2017. If the proprietary structure is compared, it is obvious that own land had a larger share in comparison to rented in the period from 2017 to 2021. Namely, the average share of own land was 68.9%. Agricultural holdings which had a dominant share of own land were PL, PG, and VF with a share of 95.3%, 91.6% and

88.7%, respectively (*Chart 1*). Contrary to that, FC and CL holdings had the smallest share of own land of 53.9% and 69.1%, respectively.

The basic economic characteristics of agricultural holdings are indicators of productivity and profitability. Both indicators had a clear tendency of growth (*Chart 2*). FNVA per AWU amounted to 29.1 thousand euros in 2021, which represents an increase of 63.9% in comparison with the previous year, and an increase of as much as 198.5% compared to 2017. FFI expressed in FWU increased by about 78.6% compared to the previous year, and as much as 226.6% compared to 2017.

Chart 2. Basic economic indicators of agricultural holdings from 2017 to 2021



Source: Author's calculation based on FADN data

According to type of farming, FC holdings had the highest FNVA on average, 28.9 thousand euros per AWU (*Tab. 1*). FC holdings also had the highest median of the studied indicator, which implies the highest labour productivity in this holding after eliminating extreme values. Then come PL and PG holdings with a FNVA of, on average, 18.7 and 15.9 thousand euros, respectively. In PL holdings, the impact of extreme values is a bit stronger, because the median of the studied indicator is significantly lower than the mean value, unlike in PG holdings.

Table 1. Descriptive statistics of FNVA per AWU of agricultural holdings according to type of farming, 2017-2021

Type of farming	Mean	Median	Interquartile difference		Interquartile difference coefficient (%)
			I quartile	III quartile	
FC	28.9	17.4	7.2	38.0	68.3
MP	7.9	5.9	3.6	10.1	47.8
GL	6.6	5.2	2.4	9.1	58.0
CL	9.4	6.3	3.7	11.7	52.1
HOR	9.6	7.8	4.4	12.0	46.5
VF	8.6	6.7	3.9	11.1	48.5
PG	15.9	14.0	4.7	23.2	66.4
PL	18.7	10.4	4.0	30.9	77.1

Source: Author's calculation based on FADN data

The lowest FNVA, on average 6.6 thousand euros per AWU, was noted for GL holdings (*Tab. 1*). What is even more worrying is the fact that a quarter of the GL holdings had an FNVA per AWU lower than 2.4 thousand euros (I quartile). MP holdings also had a relatively small FNVA per AWU compared to the other types of farming. Specifically, MP holdings on average had 7.9 thousand euros of FNVA per AWU, while a quarter of these holdings had value lower than 3.6 thousand euros. Relatively high data variability is recorded for every type of farming, which was expected, bearing in mind the huge differences in the economic size of the agricultural holdings.

The FFI analysis, which represents indicators of profitability, provides very similar results. Specifically, holdings specialising in field crop production had the highest FFI by far, on average 27.6 thousand euros per FWU (*Tab. 2*). The median value of this indicator is also the highest for FC holdings and implies that half of these AH had a FFI higher than 15.6 thousand euros. The value of the third quartile indicates that a significant number of FC holdings (25%) had a FFI higher than 36.1 thousand euros per FWU. PL holdings followed FC holdings with an average FFI value of 21.3 thousand euros per FWU. However, the median value of this indicator is much lower (11.7 thousand euros), which indicates that one half of the holdings had an FFI per FWU noticeably below average. HOR holdings had a very high FFI per FWU (19.7 thousand euros), unlike FNVA per AWU (9.6 thousand euros). The significant share of the paid labour input could be the main reason of the disproportion in the HOR holdings, which is not a part of the calculation of the second indicator (FFI per FWU). A similar situation was noted for VF holdings.

Table 2. Descriptive statistics of FFI per FWU of agricultural holdings according to type of farming, 2017-2021

Type of farming	Mean	Median	Interquartile difference		Interquartile difference coefficient (%)
			I quartile	III quartile	
FC	27.6	15.6	5.9	36.1	71.7
MP	8.0	6.0	3.5	10.2	49.3
GL	6.7	5.3	2.2	9.5	61.9
CL	9.6	6.6	3.7	12.4	54.4
HOR	19.7	11.8	5.2	19.5	57.6
VF	12.4	8.6	4.3	16.5	59.1
PG	18.3	15.3	4.9	27.5	69.8
PL	21.3	11.7	3.8	33.0	79.6

Source: Author's calculation based on FADN data

On the other hand, both the smallest FFI per FWU and indicator of productivity were recorded for GL holdings. Specifically, these holdings had an FFI of 6.7 thousand euros on average per FWU with a relatively high data variability of 61.9% (*Tab. 2*). One half of the GL holdings had a FFI lower than 5.3 thousand euros per FWU, while as many as one quarter had a profitability indicator value below 2.2 thousand euros. In general, agricultural holdings involved in livestock production (GL and MP), along with mixed crops-livestock holdings, had the lowest indicators of productivity and profitability. These are mostly holdings with a very low asset turnover (*Miljatović et al., 2020; Miljatović and Vukoje, 2022*). The fact that these holdings often are found on mountains and areas with natural constraints and are managed by older farmers, who usually are not ready to be innovative in production, could be named the main reason for the considerably lower indicators of productivity and profitability (*Hloušková et al., 2022*). Also, their intention to continue the tradition of agricultural production undoubtedly does not allow them to quit agriculture, even when the AH they manage has very low economic indicators (*Contzen, 2017*).

Conclusion

Total labour input on agricultural holdings in the RS did not change significantly in the studied period. The slight decrease of labour input is primarily the result of higher labour productivity because of the technical improvement of the holdings, which is not characteristic of agriculture solely, but also of other industries. Agricultural holdings noted quite high shares of unpaid labour, which is not only the case in HOR and VF holdings. On the other hand, the UAA of the holdings indicated a slight tendency of growth, whereby own land is dominant in the proprietary structure. Agricultural holdings specialising in field crops are the AH with the highest share of rented land.

FC holdings have the best indicators of productivity and profitability. Specifically, these AH record the highest average FNVA per AWU and the highest FFI per FWU. They are followed by holdings specialising in poultry and pig production, while HOR holdings had quite a high FFI along with an extremely low FNVA per AWU. The reason could be the high share of paid labour input in HOR holdings, which are included in the calculation of the FNVA per AWU, but not in the calculation of the FFI per FWU.

By far the lowest indicators of productivity and profitability were noted for holdings specialising in other grazing livestock, as expected. Apart from them, holdings specialising in milk production and mixed crops-livestock also had very low values of the analysed indicators. While interpreting the results, it is necessary to consider the limitations of the study objectively. The main limitation is primarily related to the omission of the economic size of the agricultural holdings as the analysis criterion. Specifically, AH were not divided into economic size classes because the analysis was conducted based on relative indicators, whereby absolute indicators of productivity and profitability were divided by the labour input (i.e. total and unpaid). Nevertheless, considering the limitations, it is clear that GL holdings are among the most endangered, mostly due to the fact that they are extensive holdings from remote rural areas with natural constraints. Leaving agriculture production is often not possible for them, because they do not have an alternative for employment since they are mostly run by older farmers with very low qualifications. The survival of GL and other extensive holdings is very important for the preservation of rural areas and their further development, wherefore the scientific community and rural policy creators should deal with this problem more seriously in the future.

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SUSTAINABLE FAMILY FARMING IN THE EUROPEAN UNION

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Abstract

This study investigates the many aspects of sustainable family farming in the European Union (EU) framework. Given the prevailing global challenges such as food security, biodiversity depletion, and climate change, this study aims to investigate the role of family farms within the agricultural framework of the European Union in fostering sustainability, resilience, and socioeconomic advancement. The study takes a broad approach, integrating quantitative and qualitative techniques to examine social dynamics, economic viability, environmental practises, and policy implications in addition to other important facets of sustainable family farming. The project aims to uncover best practices and issues experienced by family farmers in the EU by synthesising data from many sources, including agricultural research, case studies, and policy papers. This will help to shed light on the specifics of sustainable agriculture in this environment. The research will also take into account how EU assistance programmes and policies affect family farms' adoption of sustainable farming practices. Furthermore, the study will examine any possible overlaps or conflicts involving sustainable agriculture and more general EU policy objectives, such as the European Green Deal and the Common Agricultural Policy (CAP). The research's conclusions are anticipated to add to the body of knowledge on sustainable agriculture by shedding light on the particular difficulties encountered by family-owned farms in the EU and making suggestions for changes to legislation and other actions. In the end, the study aims to deepen its understanding of the complex interplay between sustainability and family farming, offering a basis for well-informed policy development and decision-making in the drive for a more resilient and environmentally sound agricultural sector in the European Union.

Key words: *farming, sustainability, environment, policy, objectives.*

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Introduction

The Food and Agriculture Organization (FAO) of the United Nations, as delineated in its 2020 publication, defines a family farm as an agricultural enterprise managed and operated by a household, wherein the predominant share of labor is contributed by members of that particular household. In the European Union (EU), family farms represent the predominant category of farms, covering a diverse spectrum of holdings. This includes small, semi-subsistence farms relying solely on family labour, as well as farms supplementing their income through other gainful activities. Furthermore, family involvement remains significant even in larger, more productive farms within this classification.

Family farming is a predominant feature of agriculture in the European Union (EU), constituting approximately 93% of all farms across the member states (Eurostat, 2023). These family farms play a central role in the EU's agricultural landscape, not only in terms of the sheer number of holdings but also in their significant contributions to agricultural employment. Additionally, while they have a slightly lesser impact on the total cultivated land area and the overall value of agricultural output, their influence remains noteworthy (Eurostat, 2023). The prevalence of family farms extends throughout all EU countries, with particularly high proportions found in Greece, Romania, and Poland, each boasting around a 99% share of all farms (Eurostat, 2023). The European Union, with its diverse agricultural landscape and a rich tapestry of rural communities, recognizes the need for a paradigm shift towards sustainable farming practices. As outlined in the European Green Deal and the Farm to Fork Strategy, the EU envisions a future where agriculture operates within planetary boundaries, emphasizing environmental stewardship and resource efficiency (European Commission, 2019; European Commission, 2020a). The role of family farming in achieving these objectives cannot be overstated, as it forms the backbone of the EU's agricultural sector, contributing significantly to its socio-economic fabric (European Parliament, 2018).

The importance of family farming in the EU is multi-faceted. Firstly, it serves as a vital source of agricultural employment, contributing to the sustenance of rural communities. Furthermore, family farming promotes the adoption of sustainable and resilient agricultural practices, emphasizing the sector's commitment to environmental considerations. The familial structure of these farms, being the primary workforce for the majority of agricultural endeavours, ensures that the agricultural sector maintains its status as a key economic driver in the region (Davidova & Thomson, 2013). However, family farming in the EU confronts various challenges, including market volatility, the impacts of climate change, and issues related to intergenerational farm succession (Davidova & Thomson, 2013). Addressing these challenges and securing the ongoing success of family farming necessitates coordinated efforts at both the EU and national policy levels. Such initiatives should aim to foster a more sustainable and resilient agricultural sector in the EU.

Sustainable family farming encompasses a holistic approach that integrates ecological, social, and economic dimensions to ensure the long-term viability of agricultural systems. It prioritizes environmentally friendly practices, such as agroecology, organic farming, and biodiversity conservation, while also fostering community engagement and social inclusivity (FAO, 2014). The commitment to sustainable family farming aligns with the EU's vision for a resilient and inclusive agricultural sector that balances productivity with environmental preservation (European Commission, 2020b).

The intersection of agricultural pursuits with environmental challenges, such as soil degradation, water pollution, and the emission of greenhouse gases, is a common occurrence. Sustainable family farming, facilitated by the adoption of agroecological practices like crop rotation, cover cropping, and integrated pest management, serves to alleviate these adverse effects while concurrently promoting soil fertility and biodiversity enhancement (Pretty et al., 2006). This environmentally conscious approach aligns with the EU's biodiversity and climate objectives, contributing to the preservation of natural resources (European Environment Agency, 2021). Beyond environmental considerations, sustainable family farming plays a pivotal role in shaping vibrant rural communities. It promotes social cohesion, fosters local entrepreneurship, and contributes to the diversification of rural economies (De Schutter, 2014). Additionally, by emphasizing short food supply chains and direct relationships between producers and consumers, sustainable family farming enhances food security and creates economic opportunities for small-scale farmers (European Parliament, 2018).

As the EU strives to navigate the complexities of a rapidly changing world, sustainable family farming emerges as a cornerstone for building resilient and regenerative agricultural systems. This introduction sets the stage for a comprehensive exploration of the various facets of sustainable family farming in the European Union, shedding light on its importance for environmental conservation, societal well-being, and economic prosperity.

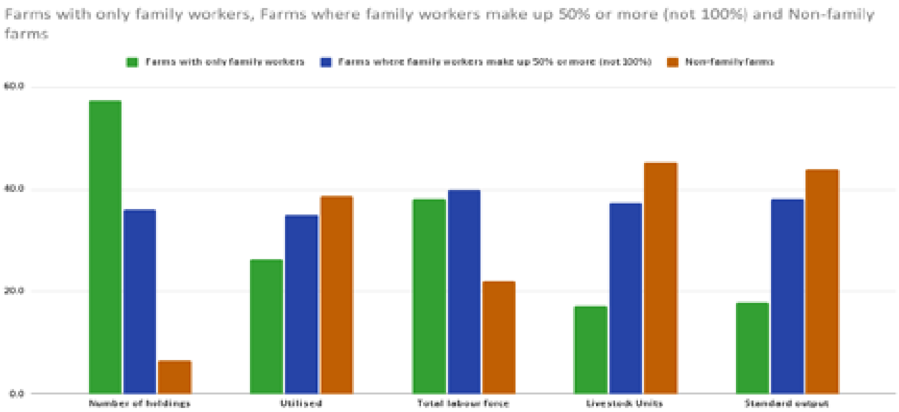
Structural profile of farms - analysis for the EU

In 2020, the European Union (EU) comprised approximately 9.1 million farms, with an overwhelming majority, estimated at 93%, falling under the classification of family farms. These family farms operate as familial enterprises, characterized by the intergenerational transfer of farming responsibilities. Consequently, family farms constitute the predominant structural framework of EU agriculture, not only in terms of numerical representation but also in their substantial contribution to agricultural employment. Additionally, family farms exert a notable influence, albeit to a lesser extent, in the cultivation area and the economic value of their agricultural output.

For the purposes of this article, the term 'family farm' is defined in accordance with the working definition provided by the Food and Agriculture Organization (FAO). Henceforth, the term designates farms managed by families, wherein at least 50% of the agricultural workforce is composed of family members. In essence, a family farm is operated by a household, predominantly relying on labor from within that household. Further delineation distinguishes between farms exclusively reliant on family labor and those where family workers constitute at least 50%, but not 100%, of the labor force.

Approximately 57% of EU farms were exclusively managed by the holder and family members, while an additional 36% featured family labor contributing at least half of the total labor input. Non-family farms represented a mere 7% of the total farm landscape in the EU in 2020, as illustrated in *Figure 1*. These proportions exhibit minimal deviation from those documented in the Agricultural Census of 2010.

Figure 1. Family farming in the EU, 2020



Source: Eurostat

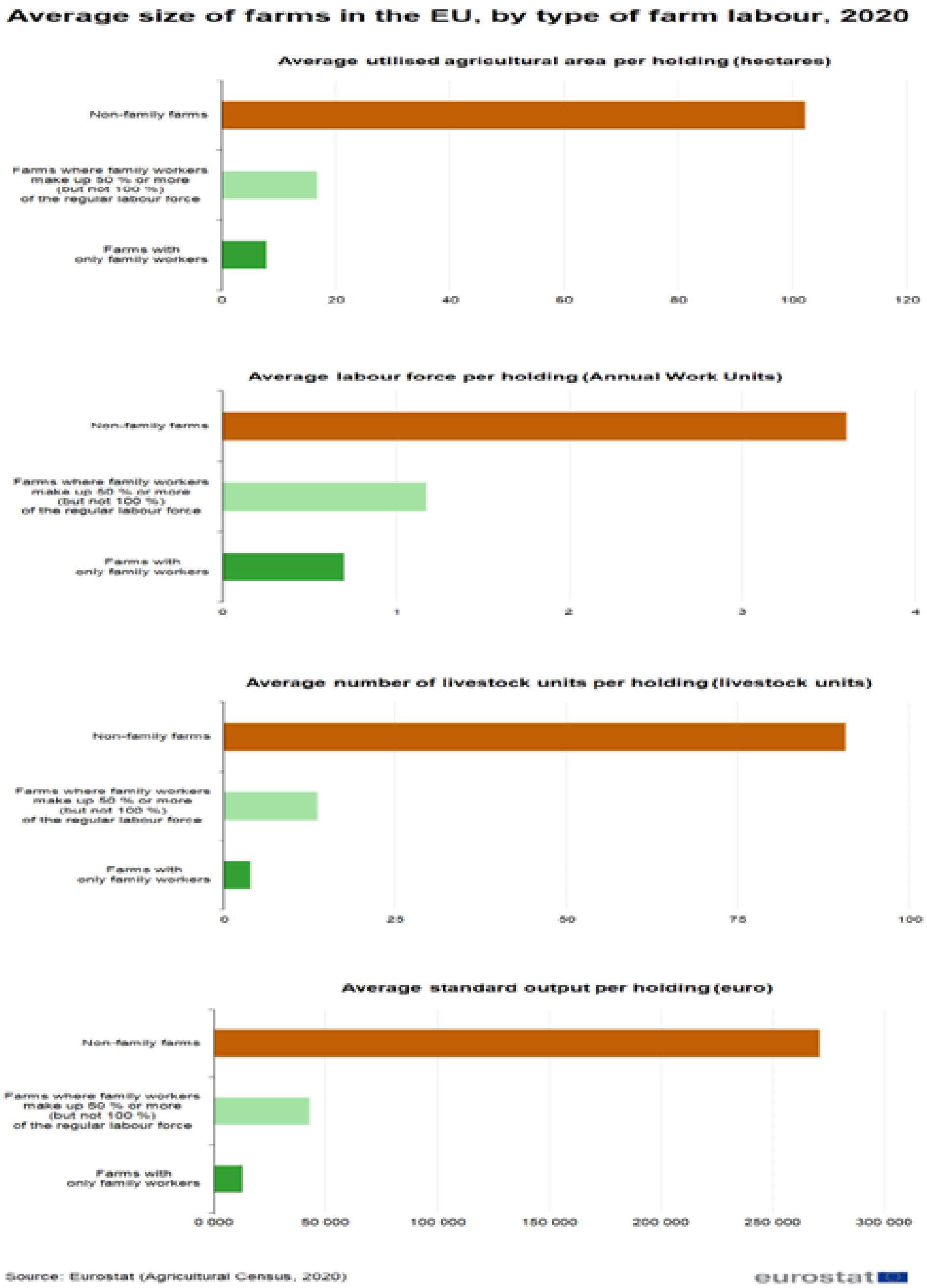
The attribution of agriculture within the European Union (EU) to a predominantly family farm structure is supported by their predominant proportions across fundamental parameters, including land, labor, capital, and economic dimensions. In the year 2020, family farms held a predominant position in various crucial sectors: constituting approximately 61% of the utilized agricultural area (UAA), equivalent to 157.4 million hectares; comprising the majority of the overall agricultural labor force, accounting for approximately 78%; representing the majority of livestock units, constituting around 55%; and contributing the majority of standard output, approximately 56%.

Conversely, non-family farms, although constituting merely 7% of the total number of farms in the EU in 2020, exhibited a disproportionately high share in pivotal agricultural facets. These non-family farms accounted for approximately 39% of the total land used for agricultural production, around 22% of the total labor force, roughly 45% of livestock units, and approximately 44% of the standard output.

Noteworthy differentials emerged between family and non-family farms, with the former being more prevalent but consistently smaller in scale. Family farms in the EU tended to exhibit smaller average sizes in terms of land use (approximately 11 hectares), livestock holdings per farm, labor force size, and economic scale. In stark contrast, non-family farms tended to be characterized by larger average land use (around 102 hectares), greater livestock units, larger labor forces, and heightened economic output.

The average size of a farm in the EU stood at approximately 17 hectares in 2020. This average, however, conceals substantial differentials, particularly evident between family farms (averaging around 11 hectares) and non-family farms (averaging approximately 102 hectares). Highlighting this apparent dichotomy in the EU farming structure, non-family farms maintained an average of approximately 85 more livestock units than family farms relying solely on family labor. Furthermore, non-family farms employed an additional three full-time individuals on average and exhibited an economic output approximately twenty times higher than family farms exclusively reliant on family workers, as depicted in Figure 2.

Figure 2. Average size of farms in the EU, by type of farm labour (hectares, annual work units, livestock units and euro), 2020



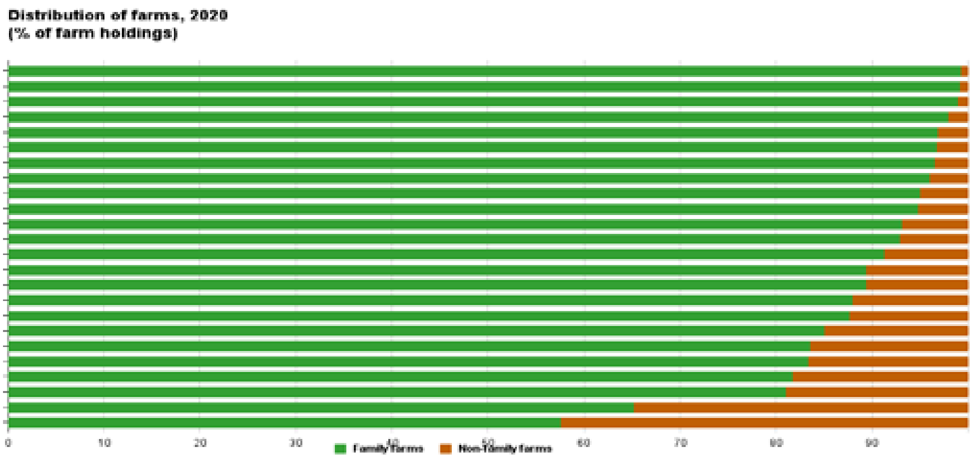
Source: Eurostat (Agricultural Census, 2020)

Structural profile of farms - analysis of EU Member States

Within the European Union (EU) in the year 2020, among the 9.1 million farms, a substantial proportion of nearly one-third (31.8%) were located in Romania, as depicted in Figure 2 of the comprehensive analysis on farms and farmland in the EU. Noteworthy concentrations of farms were also observed in Poland (14.4%), Spain (10.1%), and Italy (12.5%), each representing more than one-tenth of the total farm distribution.

Family farms constituted a substantial majority, representing at least 80% of all farms in nearly all EU Member States in 2020, as depicted in Figure 3. The exceptions to this trend were Estonia (approximately 65%) and France (approximately 58%), where the prevalence of non-family farms within the total farm composition markedly increased from 2010.

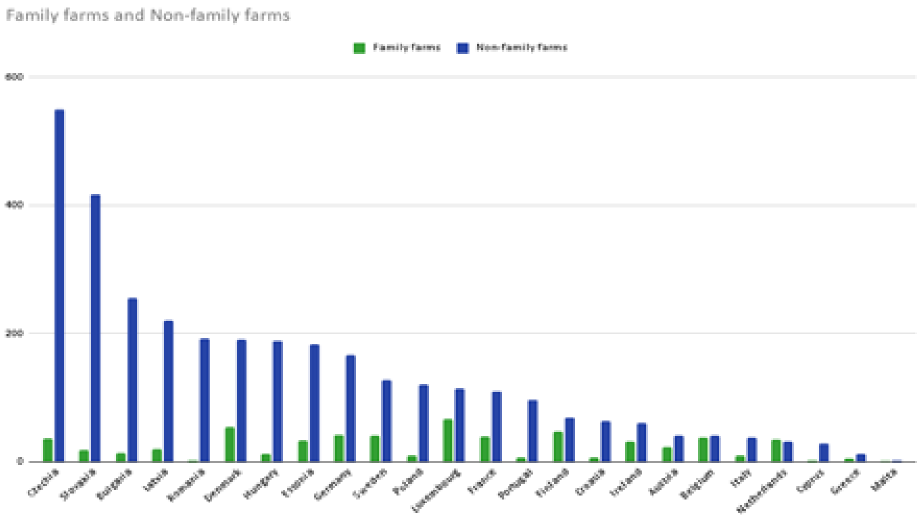
Figure 3. Distribution of farms, 2020 (% of farm holdings)



Source: Eurostat (Agricultural Census, 2020)

Typically, family farms exhibited markedly smaller sizes in terms of their utilized agricultural area, with exceptions observed in Belgium and the Netherlands where distinctions were minimal in 2020 (Figure 4). The starkest disparities were evident in Czechia, where the average size of a non-family farm reached approximately 550 hectares, in stark contrast to the 37 hectares typical of a family farm.

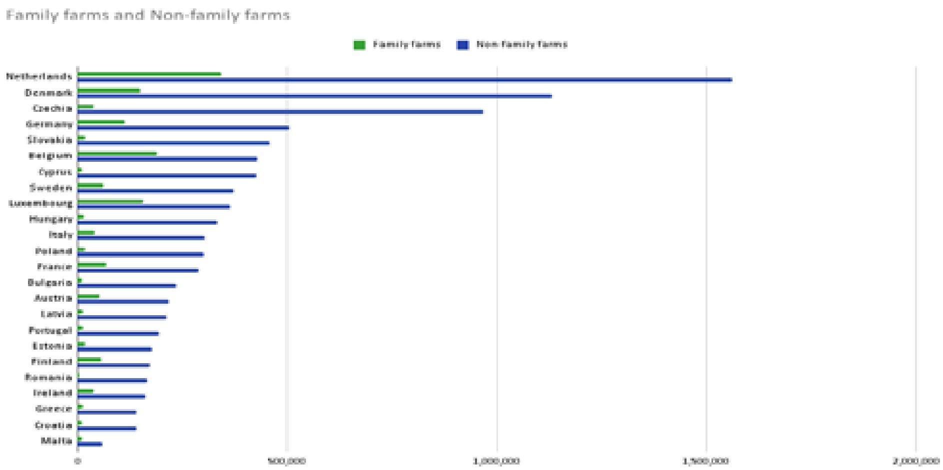
Figure 4. Average (mean) size of farms in Member States, 2020 (hectares, family and non-family farms)



Source: Eurostat (Agricultural Census, 2020)

Similar disparities were reflected in economic terms (Figure 5). For instance, in Romania, the average economic output of a family farm amounted to EUR 2,750 in 2020, juxtaposed with an average of EUR 165,456 for non-family farms, suggesting that numerous family farms in Romania could be characterized as subsistence-oriented.

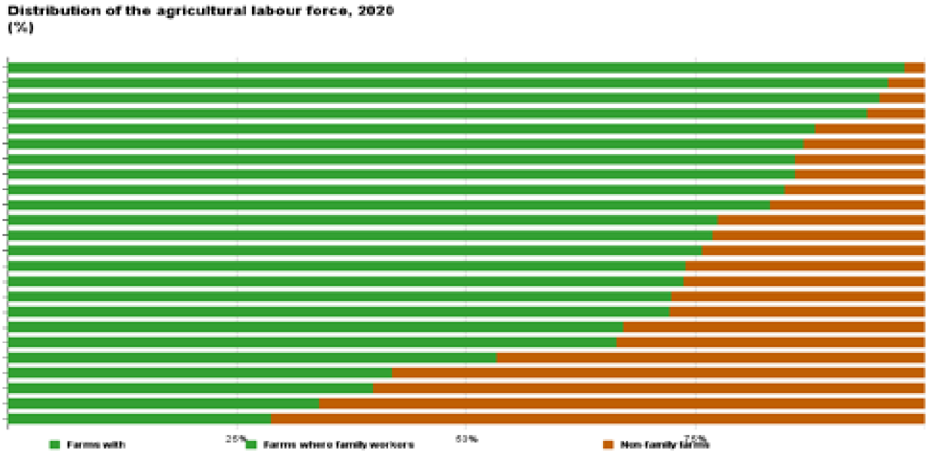
Figure 5. Average economic size of farms in Member States, 2020 (EUR, family and non-family farms)



Source: Eurostat (Agricultural Census, 2020)

The predominant share of labor employed for agricultural activities occurred on family farms in the majority of Member States, except for Estonia (42%), France (40%), Czechia (34%), and Slovakia (29%), as delineated in Figure 6.

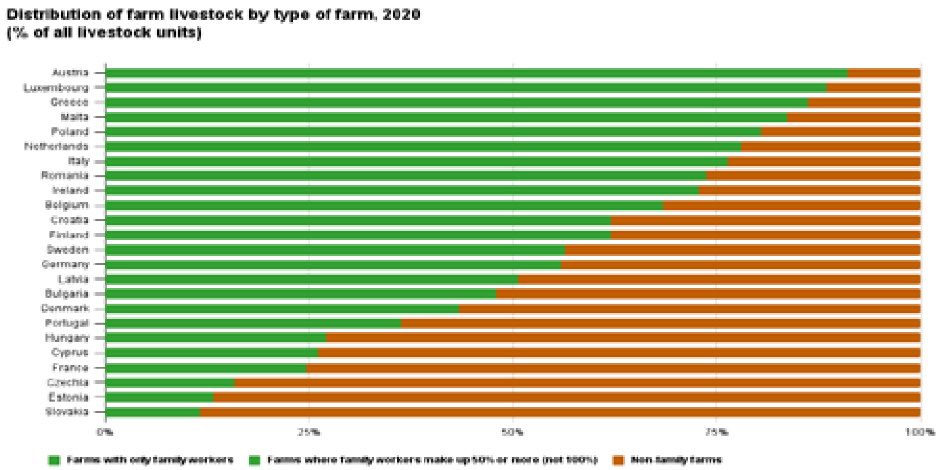
Figure 6. Distribution of the agricultural labour force, 2020 (%)



Source: Eurostat (Agricultural Census, 2020)

In the realm of livestock rearing, family farms played a predominant role in most Member States, exceeding 80% in Austria, Luxembourg, Greece, and Malta (Figure 7). In stark contrast, family farms in Slovakia, Estonia, and Czechia were responsible for less than 25% of livestock rearing.

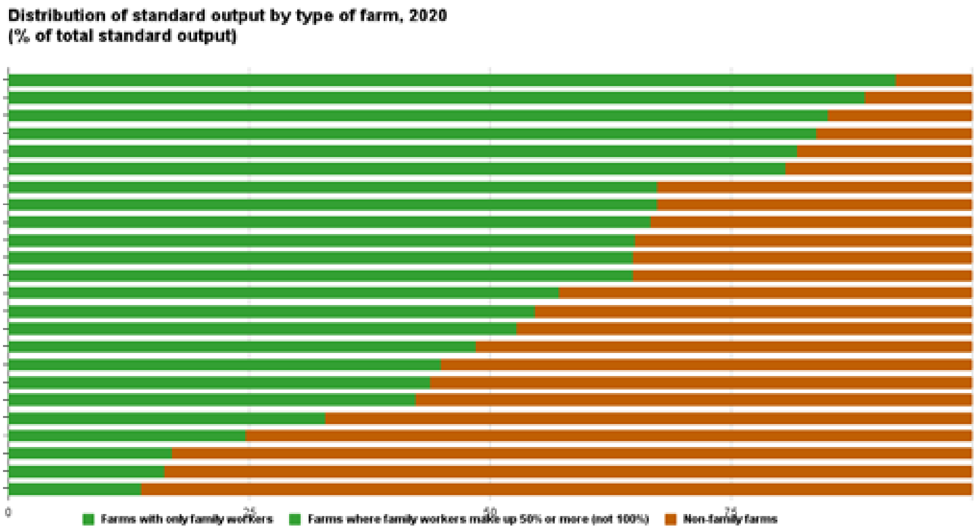
Figure 7. Distribution of farm livestock by type of farm, 2020 (% of all livestock units)



Source: Eurostat (Agricultural Census, 2020)

An additional crucial facet in farming pertained to the top-heavy age structure, or inverted age pyramid, of farm managers, as elucidated in the Statistics Explained article on farmers and the agricultural labor force. Moreover, family farms contributed significantly to the overall value of agricultural output across numerous Member States, constituting more than 80% of the standard output in Greece, Malta, Luxembourg, Poland, and Austria, as delineated in Figure 8. However, family farms played a diminished role, contributing less than 25% of the standard output in Slovakia, Estonia, Czechia, and France.

Figure 8. Distribution of standard output by type of farm, 2020 (% of total standard output)



Source: Eurostat (Agricultural Census, 2020)

Benefits of Family Farming

Sustainable family farming plays a crucial role in the European Union's agricultural landscape, contributing to environmental conservation, rural development, and food security. This form of agriculture emphasizes responsible and efficient resource management, promoting long-term viability for both farmers and the environment. This page explores the multifaceted benefits of sustainable family farming in the European Union, drawing on research and expert insights.

Sustainable family farming practices prioritize environmental stewardship, employing techniques that minimize negative impacts on ecosystems. Crop rotation, agroforestry, and organic farming are examples of strategies that enhance biodiversity and soil health (Hassan, 2018). These practices help mitigate soil erosion, reduce water pollution, and enhance the resilience of agricultural landscapes (Buckwell et al., 2019).

Furthermore, sustainable family farming often involves the use of precision agriculture technologies, such as GPS-guided machinery and data-driven decision-making. These technologies contribute to more efficient resource use, minimizing waste and reducing the environmental footprint of farming operations (European Commission, 2020).

In the European Union, sustainable family farming is integral to rural development, playing a pivotal role in maintaining vibrant and resilient rural communities. These farms serve as economic engines, providing employment opportunities and supporting local businesses (Buijs et al., 2021). The continuation of family farming traditions contributes to the preservation of cultural landscapes and helps prevent rural depopulation (Van Huylenbroeck et al., 2017). Moreover, sustainable family farming fosters social cohesion by maintaining close ties between farmers and their communities. Local markets, community-supported agriculture, and direct sales initiatives strengthen the bond between producers and consumers, creating a sense of shared responsibility for sustainable food systems (De Schutter, 2014).

Additionally, sustainable family farming enhances food security by promoting diversified and resilient agricultural systems. Crop diversity and the implementation of integrated farming practices play pivotal roles in fostering a resilient and secure food supply, diminishing the susceptibility of agriculture to pests, diseases, and adverse weather events (FAO, 2019). Additionally, local food systems associated with family farming provide fresher and higher-quality produce, contributing to improved nutrition and health outcomes for consumers (IFOAM EU, 2018). To maximize the benefits of sustainable family farming, supportive policies and initiatives are crucial. The European Union has recognized the importance of sustainable agriculture through its Common Agricultural Policy (CAP). The CAP allocates funds to support environmentally friendly practices, rural development, and the transition to more sustainable farming systems (European Commission, 2021).

In conclusion, sustainable family farming in the European Union offers a range of benefits encompassing environmental conservation, rural development, food security, and quality. By prioritizing responsible and efficient resource management, these farms contribute to a more resilient and sustainable agricultural sector, aligning with the broader goals of the European Union's agricultural policies.

Challenges of Sustainable Family Farming

Sustainable family farming is a cornerstone of agriculture in the European Union (EU), contributing significantly to food security, rural development, and environmental preservation. However, despite its pivotal role, family farming faces numerous challenges that threaten its long-term sustainability. This article explores some of the key challenges encountered by family farmers in the EU, drawing upon relevant literature and expert opinions.

One of the primary challenges for sustainable family farming in the EU is economic pressure. Economic factors such as fluctuating commodity prices, rising input costs, and limited access to financial resources pose significant challenges to family farmers. According to a report by the European Parliament (2019), family farms often operate on slim profit margins, making it difficult for them to invest in sustainable practices and adapt to changing market conditions. Moreover, the Common Agricultural Policy (CAP), which governs agricultural subsidies in the EU, has been criticized for not adequately addressing the needs of small and medium-sized family farms. As noted by Sutherland et al. (2020), the CAP's distribution of subsidies may disproportionately benefit larger farms, exacerbating economic challenges for smaller family-owned operations.While sustainable farming practices are crucial for environmental conservation, family farmers in the EU face obstacles in implementing these practices. Climate change, soil degradation, and water scarcity are pressing concerns that affect the viability of family farming. The EU's Farm to Fork Strategy aims to promote sustainable agriculture, but achieving widespread adoption of eco-friendly practices remains a challenge. A study by Smith et al. (2021) highlights that small family farms may lack the resources and knowledge needed to transition to more sustainable farming methods. The integration of agroecological approaches requires investments in research, education, and infrastructure, which are often beyond the reach of family farmers.

The issue of succession planning is a critical challenge for sustainable family farming in the EU. As highlighted by the European Economic and Social Committee (EESC, 2022), an ageing farming population and the lack of interest among younger generations in pursuing a career in agriculture jeopardize the continuity of family farming. The absence of proper succession plans may lead to the abandonment of family farms or their consolidation into larger, less sustainable entities. Additionally, globalization and changing market dynamics present additional challenges for family farmers in the EU. The competition with larger, more industrialized farms, both within and outside the EU, can make it difficult for family farms to access markets and obtain fair prices for their products. According to a report by Eurostat (2020), small-scale family farmers often struggle to meet the stringent quality and quantity requirements imposed by global supply chains. Sustainable family farming is indispensable for the EU's agricultural sector, but various challenges threaten its viability. Economic pressures, environmental sustainability, succession planning, and market access are among the key issues that demand attention from policymakers, researchers, and stakeholders. Addressing these challenges requires a multifaceted approach, combining targeted policies, financial support, and educational initiatives to empower family farmers and ensure the longevity of sustainable agriculture in the European Union.

Conclusion

In conclusion, the landscape of sustainable family farming in the European Union (EU) is characterized by its multifaceted nature, encompassing diverse dimensions such as size, economic output, labor dynamics, and livestock rearing. The prevalence of family farms as the predominant agricultural model, constituting approximately 93% of the total farms in 2020, underscores their pivotal role in shaping the agricultural sector across EU Member States. While family farms dominate in terms of sheer numbers, disparities exist in their sizes when compared to non-family farms. Family farms, on average, tend to be smaller both in terms of utilized agricultural area and economic output. This variation is particularly pronounced in certain Member States, highlighting the need for nuanced policy considerations that account for regional differences. The age structure of farm managers, exhibiting a top-heavy pattern, poses a significant challenge and emphasizes the importance of fostering generational renewal within the agricultural sector. Addressing this demographic imbalance is crucial for ensuring the long-term sustainability and resilience of family farming. The distribution of labor across family farms demonstrates their central role in providing employment opportunities, contributing to rural livelihoods, and supporting local economies. However, regional variations in labor dynamics necessitate tailored approaches to address specific challenges faced by family farms in different contexts. Livestock rearing, a vital component of sustainable agriculture, sees family farms playing a predominant role in many EU Member States. Yet, the disparities in livestock contribution across regions indicate the need for targeted initiatives to enhance the sustainability of family-based livestock operations. As the EU continues to navigate the complexities of agricultural sustainability, policymakers and stakeholders must consider the unique attributes and challenges associated with family farming. Encouraging and supporting sustainable practices, promoting innovation, and addressing the demographic and economic dimensions are essential for nurturing the resilience and longevity of family farming in the European Union. Through collaborative efforts, a balanced and sustainable future for family farming can be realized, ensuring its continued contribution to the socio-economic fabric of the EU.

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NON-STANDARD FORMS OF EMPLOYMENT IN THE ROMANIAN AGRICULTURE

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Abstract

In traditional agricultural countries such as Romania, employment in agriculture is still high. This article examines the ways in which employment relationships in the field of agriculture are translated into contractual forms, particularly because the specificity of agricultural activities necessitates the use of non-standard forms of employment, to ensure flexibility and to respect the seasonal nature of work. However, excessive flexibility may have negative effects on the security of employment relationships and the career management of workers. Additionally, non-standard forms of employment are associated with lower-skilled occupations and are used to a significant extent for vulnerable groups, such as young people and women. For these reasons, a scrutiny of the types of contracts and the number of employees involved in this type of employment relationship is necessary and could contribute to improving the legislative framework, aiming to enhance the legal situation of employees involved in agricultural activities.

Key words: *employment, flexibility, agriculture, vulnerable work.*

Introduction

At the global level, the agriculture sector employs about 874 million workers – more than any other industry. While agriculture provides a livelihood, many workers experience decent work deficits and a week legal protection. Globally, an important number of the worker are not under any contractual form. On the other side, even the waged agricultural workers frequently experience unstable and/or temporary employment; receive very low wages; and often work in unhealthy work conditions. At national level, in Romania the agriculture sector is considered to be one of the priority sectors of the economy, but faces difficulties related to the supply of skilled labour and unfair compe-

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tition. Thus, the ratio of workers in agriculture versus total occupied labour force is significantly higher in Romania than the EU level.

Table 1. Ratio of workers in agriculture versus total occupied labour force in EU 27 and Romania

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
EU 27	5,42	5,26	5,05	4,77	4,65	4,48	4,33	4,29	3,78	3,65
Romania	29,25	28,35	25,59	23,1	22,78	22,31	21,24	20,51	11,75	11,25

Source: Romanian National Institute of Statistics & Eurostat

The aim of the article is to analyse the situation of the legal forms used to express the employment relationship in agriculture, in order to enable the development and implementation of appropriate measures for the protection of the workforce and thus contribute to reducing the existing difficulties in the sector.

From a methodological point of view, statistical data provided by Eurostat and the National Institute of Statistics (INS) were used to determine both standard and non-standard forms of employment relationships. The study used the descriptive statistics tools and the following definitions (according to INS):

Employee (EE) - a person who works on the basis of an employment contract in an economic or social establishment or with private persons, in return for remuneration in the form of a salary.

Employer (ER) - a person who exercises his occupation in his own establishment, employing one or more employees.

Self-employed person (SEP) - a person who works in his/her own establishment or in an individual business, without employing any employees, whether or not assisted by unpaid family members. This status applies to self-employed entrepreneurs such as occasional day labourers, individual farmers or those working in agricultural associations.

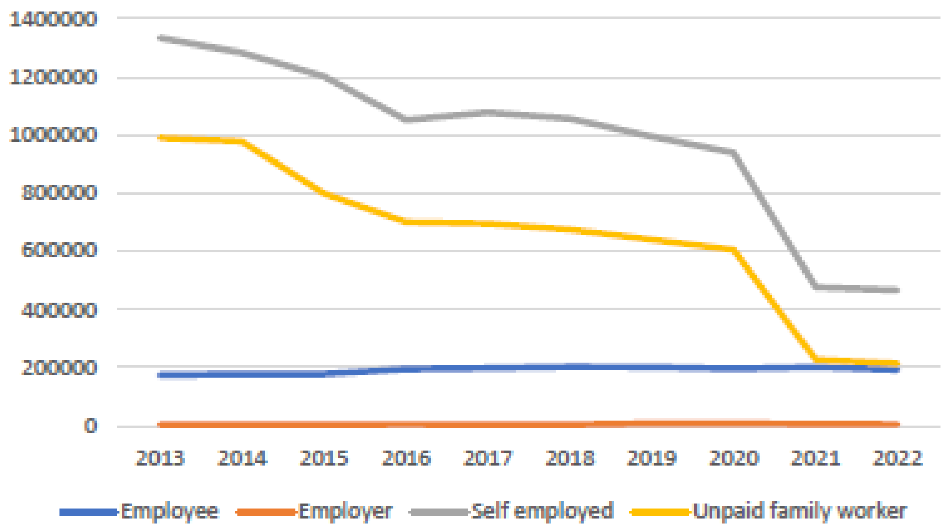
Unpaid family worker (UFW) - a person who works in a family business run by a family member or relative, for which he/she does not receive remuneration in the form of salary or payment in kind.

It is relevant to point out that the undeclared work is not included in the national statistics, even if it constitutes a social phenomenon that significantly affects work in agriculture.

Workers in agriculture

In Romania, work in agriculture is characterised by the fact that there is still a significant manifestation of traditionalism, in that agricultural activities are carried out with family members, in a climate of legal and social vulnerability.

Chart 1: Forms of work in agriculture



Source: *Romanian National Institute of Statistics*

Table 2. Forms of work in agriculture (thousand)

Year	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
EE	173,9	177,6	177,8	193,9	198,2	202,2	200,7	195,1	201,0	191,7
ER	3,8	3,9	4,4	4,9	3,8	4,3	8,8	8,7	7,0	5,7
SEP	1333,2	1283,3	1202,4	1052,2	1077,6	1056,2	993,9	938,3	476,8	467,1
UFW	989,8	977,1	799,3	700,8	695,2	675,3	639,4	604,8	226,5	213,8

Source: Romanian National Institute of Statistics

The drop observed in 2021 is mainly due to a change in the definition of the categories self-employed and unpaid family worker.

As revealed by the descriptive statistics, in 2022, out of the 878.389 workers in agriculture, only 191.749 employment contracts were registered, which means that 79% of the workers were not protected by the labour law. Out of this reduced number of workers, only 140,876 (73,5%) were employed in rural area, while 50,873 (26,5%) were employed in urban area, most probably carrying out administrative and management activities related to agricultural enterprises. It follows, therefore, that the measures taken both at the level of specific legal protection and at the level of the minimum wage remain rather ineffective as far as the agricultural workforce is concerned.

For more than 10 years, the labour force issue has been, as pointed out by the ILO, that „the classic stereotype of full-time permanent job, with fixed hours, and a defined-benefit pension on the completion of a largely predictable and secure career path with a single employer, however desirable it might appear, is an increasing infrequent reality" (ILO 2013, p. 13). The non-standard forms of employment are considered to offer more flexibility to the contractual relationship and to be more adapted to the characteristics of current economic activity. These forms of employment cover work that falls outside the scope of a standard employment relationship, which itself is understood as being indefinite employment in a subordinate employment relationship, performed full-time.

Standard employment relationship

Under Romanian law, the standard employment contract is an indefinite-term contract, with working time of 8 hours per day and 40 hours per week. The Labour Code allows, for certain sectors of activity, to establish, by collective or individual negotiations or by specific normative acts, a daily working time of less or more than 8 hours. (Labour Code, Article 115(1)). The maximum legal working time may not exceed 48 hours per week, including overtime. By way of exception, working time, including overtime, may be extended beyond 48 hours per week, provided that the average number of hours worked, calculated over a reference period of 4 calendar months, does not exceed 48 hours per week. This reference period may be extended, under the conditions laid down by law and collective bargaining, to 6 and 12 months respectively. (Labour Code, Article 114). Given that agricultural activity is mostly seasonal, there is undoubtedly an interest in extending the reference period to at least 6 months. In this way, for those employment contracts concluded for an indefinite period, both the flexibility required by the specific nature of the activity and the security of the employment relationship can be ensured.

Part-time employment contract

For those activities that do not require the employee to work full time, the law provide the possibility to conclude a part-time contract. In accordance with the definition provided by the Labour Code (Article 103), a part-time employee is an employee whose number of normal working hours, calculated weekly or as a monthly average, is less than the number of normal working hours of a comparable full-time employee. Since the Labour Code has transposed the Part-Time Work Directive (Directive 97/81/EC), the part-time employee enjoys the rights of full-time employees, under the conditions provided by law and the applicable collective labour contracts.

The law (Article 105 para. (1) Labour Code) requires, however, that this type of contract must include certain specific mandatory clauses concerning working time and the distribution of working hours; the conditions under which working hours may be changed; the prohibition of overtime except in cases of force majeure or for other urgent work to prevent accidents or to eliminate their consequences.

Moreover, the acceptance of an employee at work exceeding the working hours established in the individual part-time employment contracts constitutes undeclared work (Article 15^1(d)) and is punishable by a fine of between 10,000 RON (2,000 Eur) and 15,000 RON (3,000 Eur) for each person so identified, not exceeding a total of 200,000 lei (40,000 Eur). The purpose of the prohibition of overtime is to prevent abuses of part-time employment contracts where the job or working conditions require full-time contracts (Țiclea, 2020). However, this prohibition and the significant amount of the fine reduce the flexibility of this type of contract, which has the effect of reducing its application.

Furthermore, both in agriculture and in other sectors of activity where the level of pay is low, the use of part-time employment contracts is negatively impacted by the legal provisions concerning the establishment of the minimum level of social security and health insurance contributions. Thus, according to Articles 146 (5^6) and 168 (6^1) of the Tax Code, the social insurance contribution and the health insurance contribution payable by individuals who earn income from wages or equivalent income under a full-time or part-time individual employment contract may not be less than the level of the social insurance contribution calculated on the gross minimum basic wage in force in the month for which the social insurance contribution is due, corresponding to the number of working days in the month in which the contract was active.

So, although it is designed by law to ensure both the flexibility required by the employer's activity and the security of the employment relationship, there are a number of negative factors that discourage the use of part-time contracts in agriculture.

Fixed term employment contracts

The seasonal nature of agricultural activity leads, at least from a theoretical point of view to the priority implementation of a special type of employment contract, the fixed-term contract. The Labour Code provides for this type of contract, but only as an exception to the standard contract defined in Article 12 and mentioned above. The exceptional nature of this contract has the effect of establishing a set of limited conditions under which its conclusion is legal and a strict legal regime.

Thus, among the cases in which it is allowed to conclude such a contract, the one mentioned in the Article 83 lett.. b) and c), respectively the increase and/or temporary change in the structure of the employer's activity and carrying out seasonal activities, is specific to agriculture (Preduț, 2019).

The individual fixed-term employment contract may not be concluded for a period of more than 36 months, and no more than three individual fixed-term employment contracts may be concluded successively between the same parties. However, it should be noted that, according to the definition of the law, only individual fixed-term employment contracts concluded within 3 months of the termination of a fixed-term employment contract are considered successive contracts. Thus, in agriculture, the natural distance between seasons allows a new contract to be concluded more than three months after the end of the previous one, and thus the perpetuation of fixed-term employment over a longer period of years.

However, as the statistical data show, fixed-term employment contracts do not have a significant numerical impact in the agricultural sector, as in cases where the employment relationship is dependent on the seasonal activity actually performed, much more vulnerable legal forms, in terms of the protection of employees' rights, are preferred.

Occasional Day Labourers

In accordance with the INS definition, occasional day labourers are part of the self-employed category, but their legal status is much closer to that of an employee, as they perform work, under the authority of a beneficiary, in return for remuneration. Moreover, since the advent of Law 52/2011 on the exercise of certain activities of an occasional nature carried out by day labourers (Law 52/2011), the doctrine has shown that day labourers are part of an employment relationship (Ținca, 2011), under an atypical employment contract (Dumitru, 2015).

The employment relationship concluded between the two parties is not expressed in written form (Article 3 in Law 52/2011), the essential elements of the contractual relationship being established without the possibility of proving them. The electronic register of day labourers, the only written document, contains only data on the identification of the parties, the field of activity and the place of performance of the activities, the number of hours worked, and the remuneration established, respectively received.

Minimum protection clauses are established by law, i.e. that the duration of casual work is a minimum of one day, corresponding to 8 hours of work, and that the daily duration of a day labourer's work may not exceed 12 hours. Also protective, in order to limit the abuse of this type of employment relationship and to encourage the conclusion of a standard employment contract, are the following legal provisions. Thus, a day labourer may not carry out agricultural work for the same beneficiary for more than 180 days in any calendar year. In addition, the beneficiary may not use a person for more than 25 calendar days continuously in day labourer-type activities, and if the work carried out by the day labourer requires a longer period, a fixed-term employment contract must be concluded (Article 4 para. (8) of Law No 52/2011).

In turn, a person may not work on a daily basis for more than 180 days in a calendar year, regardless of the number of beneficiaries or their representatives.

The amount of remuneration is determined by direct negotiation between the parties, although the freedom of the day labourer's consent is limited by his precarious legal status. It is precisely for this reason that the law stipulates that the amount of gross hourly pay agreed between the parties may not be less than the value/hour of the guaranteed gross basic wage (Article 11).

However, it should be pointed out that the legislator has chosen to limit the protection offered to day labourers by the fact that the activity carried out does not give the day labourer the status of insured person in the public health system or in the insurance system for accidents at work and occupational diseases.

As precarious work affects vulnerable categories of workers, the law lays down express provisions for the protection of minors. Thus, a minor day labourer who is able to work will be able to work 6 hours a day, but not more than 30 hours a week, and will not work at night. Another provision only lays down general principles, without clearly defining its limits: minor workers, i.e. minors aged 15 years or more and 18 years or less, shall only work as day labourers in activities which are suited to their physical development and abilities, provided that their right to physical, mental, spiritual, moral and social development and their right to education are not thereby violated and their health is not impaired (Article 3 para.(4)). The law does not stipulate who is competent or obliged to determine which "activities are appropriate to their physical development" or to assess minors' aptitudes. It follows, therefore, that in fact the only provisions which provide real protection for minors are those relating to the limitation of working hours and the prohibition of night work.

Moreover, further statistical analysis is needed on the number of minors involved in such work and further research regarding the actual situation in which they work, both from a legal point of view and in terms of the actual activities carried out, in order to assess the impact of precarious work in agriculture on their development.

Unpaid family workers

The work performed by a person in a family business run by a family member or relative, for which he/she does not receive remuneration in the form of salary or payment in kind is still one of the widespread forms of work in the agricultural sector. In 2022, 24.3% of the total number of agricultural workers were included in this category. From a labour law point of view, we consider that at least part of the cases in this category could be qualified as undeclared work. We refer in particular to those situations where the person for whom the work is performed can be considered to be a professional who runs a business, „enterprise" in the sense of the Article 3 para. (3) of the Civil Code, and who, in relation to his or her own family member, is an employer.

In such cases, the family relationship should be backed up by an employment law relationship, through the conclusion of one of the forms of employment contract provided for by law.

State efforts to combat undeclared work should be coordinated with a more detailed statistical analysis of the types of employment relationships falling into the latter category, a.i. unpaid family worker, in order to be able to identify their characteristics as accurately as possible and determine the proportion of undeclared work.

Gender balance and employment in agriculture

A final point we would like to make is the issue of women's work. As has been pointed out both in ILO documents (ILO 2015) and in doctrine, although a considerable number of elements of the food and agricultural supply chain rely on women workers, they are particularly and inherently more at risk of exploitation and are more vulnerable. The statistical data analysed showed that there is an imbalance between the distribution of women and men in the four categories analysed.

Table 3. Employment by gender in 2022

	Workers in agriculture	**Employment contract and employers (EE&ER)**	**Unpaid family workers (UFW)**
Men	591,171	161,906	73.187
Women	287,218	35,550	140.647

Source: *Romanian National Institute of Statistics*

Thus, while in the "privileged" categories, where employees enjoy a legally protected status, women represent only 18%, in the most legally vulnerable category, unpaid family workers, the proportion of women is 66%. All the more reason, therefore, to take appropriate measures to protect this last category of employees, adapted to the social and legal realities identified and measured statistically.

Conclusions

Although the labour relations discourse in recent years has focused on increasingly sophisticated issues such as the dematerialisation of work, platform working and teleworking, the evidence presented in this article suggests that basic reforms are still needed, at least in agriculture. These reforms must ensure that as many workers as possible are given real legal protection by moving to contract work or setting up their own small businesses. As envisaged in the paper, an important number of Romanian workers are involved in the agricultural sector, but only a reduced number benefit of a regulated legal regime.

There is also a need for better knowledge of the real data on the number of minors involved in agricultural activities, especially in non-standard forms of employment, and for legal measures tailored to the real situation.

Reforms are also needed with regard to women's work, by creating a social, educational and legal framework enabling them to move out of the category of family unpaid worker and into an employment relationship that provides them with legal protection.

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TAX ASPECT OF THE ACCOUNTING OF PERENNIAL PLANTINGS

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Abstract

Taxable profit is determined by applying the provisions of the Law on Profit Tax. It primarily depends on the amount of accounting profit before taxation. In the Republic of Serbia, obligees of the implementation of the Law on Accounting apply three different accounting regulations (IFRS, IFRS for SMEs and Rulebook for micro and other legal entities) which treat fruit-bearing plants (which include most perennial plantings) in different ways.

This difference affects the earlier or later recognition of gains or losses related to fruit-bearing plants, and thus affects the periodic allocation of income tax liability and consequently affects cash flows.

The aim of this paper is to express that by choosing the appropriate accounting regulations, tax expenses and liabilities can be managed, and consequently the related cash flows, which can contribute to a more successful business of the entity. In our work, we use basic scientific methods: the method of analysis and synthesis, the inductive and deductive method, the method of description and the method of comparison.

Key words: *perennial plantings, fruit-bearing plants, profit tax, accounting regulation, IFRS*

Introduction

Perennial plantings include orchards, vineyards, hop farms and other fruit-bearing perennial plantings, trees and perennial bushes that are not kept primarily for the purpose of yielding, that is, the production of agricultural products in the sense of harvesting fruits. How important perennial plantings

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are, is also shown by the support of the state for the establishment of perennial productive plantings.

For example, “incentives for raising production plantings, which include support for programs related to the establishment of new intensive production plantings with modern vine cultivation technology, with a treillage, as well as land preparation for raising production plantings “ (Radović, Vasiljević, Pejanović, 2018 .). From an accounting point of view, perennial plantings are a type of biological assets.

The most important characteristics of **perennial plantings** are:

- their raising takes several years, so in that sense, a perennial plantings needs several years to start bearing fruit crops in full capacity;

- during the raising of perennial plantings, some plantings reject the yield, i.e. their partial exploitation can be carried out (for example, an apple tree begins to bear fruit crop from the second year, and the full fruit crop is given only in the fifth year).

In the Republic of Serbia, business entities that keep business books and prepare financial reports in accordance with the ***Law on Accounting*** (“Official Gazette of the RS”, no. 73/2019 and 44/2021 (other law)) apply three types of accounting regulations:

1. ***International Financial Reporting Standards*** *(IFRS)*,

2. ***International financial reporting standard for small and medium-sized legal entities*** *(IFRS for SMEs)* and

3. ***Rulebook on the manner of recognition, valuation, presentation and disclosure of positions in individual financial reports of micro and other legal entities*** (“Official Gazette of RS”, number 89/2020 - hereinafter: *Rulebook for micro and other legal entities*).

According to the ***Law on Corporate Income Tax*** (“Official Gazette of RS”, no. 25/2001, 80/2002, 80/2002 (other laws), 43/2003, 84/2004, 18/2010, 101/2011, 119 /2012, 47/2013, 108/2013, 68/2014 (other law), 142/2014, 91/2015 (authentic interpretation), 112/2015, 113/2017, 95/2018, 86/2019, 153/ 2020 and 118/2021) stipulates that the basis of corporate income tax is taxable profit. Taxable profit is determined in the tax balance sheet by adjusting the taxpayer’s profit shown in the income statement, which is written in accordance with international accounting standards, i.e. international financial reporting standards, i.e. international financial reporting standards for small and medium-sized legal entities and by regulations governing accounting in the manner established by this law.

The taxable profit of a taxpayer who, according to the regulations governing accounting, does not apply IAS, i.e. IFRS and IFRS for SMEs, is determined in the tax balance by adjusting the taxpayer's profit, expressed in accordance with the method of recognition, measurement and assessment of income and expenses prescribed by the Minister of Finance, in the manner determined by this law.

The aforementioned three regulations do not prescribe in a uniform manner the rules for the recognition and valuation of perennial plantings. This significantly affects the different recognition and valuation of the corresponding items in the balance sheet and income statement of economic entities that have perennial plantings.

In this paper, we prove the following hypotheses:

H1 - the accounting regulations applied in the Republic of Serbia do not prescribe uniform rules for the recognition and valuation of perennial plantings.;

H2- different rules for recognizing and valuing perennial crops have an impact on the amount of the subject's tax obligations; and

H3 - part of the entities in the Republic of Serbia that are engaged in the cultivation of perennial crops can, by voluntarily changing the accounting regulations, influence the time schedule of reporting income, and thus influence the amount of profit tax throughout the tax periods.

Rules for the recognition and valuation of perennial plantings

Investment in perennial plantations has the treatment of investments in progress until the plantations will have started to be used. It is considered that the use of the plantation has started when the plantation starts to give regular and stable yields.

Facilities which serve for the use of perennial plantings are reported as construction objects (irrigation canals, drainage, fences, etc.), while facilities that are an inseparable part of the plantings, such as poles and wires, are an integral part of the plantings.

When it comes to the recognition and valuation of perennial plantings., there are different rules, on the one hand, contained in *the IFRS for SMEs* and *the Rulebook for micro and other legal entities* and, on the other hand, in *the IFRS*.

Recognition and valuation of perennial plantings in accordance with IFRS for SMEs and the Rulebook for micro and other legal entities

The IFRS for SMEs (Section 34 Specialized Activities) and *the Rulebook for Micro and Other Legal Entities* (Article 21) stipulate that all types of perennial crops are recognized and valued in a unique way. Namely, in these two regulations there is no further division of perennial crops, ie. regardless of the type of plant, all perennial plants are valued in the same way.

The entity values multi-year plantings at initial recognition and at each balance sheet date at fair value reduced for sell costs (net fair value). Annual depreciation is not calculated for these assets. Changes in fair value reduced for sell costs of these assets are recognized immediately in the income statement, as income or expense.

Perennial plantings for which the fair value cannot be determined, without excessive efforts and costs (*for example, if it is a large plantation in a territory where there is no turnover of such plantations*), the subject is valued at the purchase value/cost price reduced for calculated depreciation and any eventual losses based on their impairment.

Recognition and valuation of perennial plantings in accordance with IFRS

In contrast to two cited regulations, we must differentiate between **fruit-bearing perennial plantings** and those that are not. Namely, fruit-bearing perennial crops are regulated in *IAS 16 Real Estate, Facilities and Equipment*, and perennial crops that are not fruit-bearing in *IAS 41 Agriculture*. The valuation of perennial crops that are within the scope of *IAS 41 Agriculture* is, in essence, the same as the valuation of perennial crops using *IFRS for SMEs* and *the Rulebook for micro and other legal entities*. But the **valuation of fruit-bearing perennial plantings** in *IAS 16* is completely different.

According to *IAS 16*, a fruit-bearing perennial crops planting is a set of living plants that have the following characteristics:

- which are used in production or for the provision of agricultural products;
- which are expected to produce (yield) products during more than one (vegetation) period; and
- for which there is a probability that they will be sold as an agricultural product only in a longer period of time, except for sporadic sales in the form of waste.

The plants listed below are not fruit-bearing plants:

1/ plants that are grown for their harvesting (harvesting, cutting) as agricultural products (*for example, trees that are grown on plantations for use as timber or timber mass/for example, fast-growing poplars planting/*

- this type of agricultural production remains within the scope of *MRS 41*);

2/ plants that are grown for the production of agricultural products, but also for the sale of the plant itself at the end of their productive life - it is therefore not a question of sporadic (waste) sales (*an example of such plantings can be walnuts: they are grown for picking walnut products, but also because of the valuable timber obtained at the end of the productive life of the trees. If obtaining valuable timber at the end of the productive life of the trees is part of the goal of their cultivation, it is unlikely that the asset is classified as a fruit-bearing (basic) plant and therefore in this case walnut wood would be within the scope of IAS 41*);

3/ annual crops (*for example, corn and wheat*).

When a fruit-bearing plant due to its age (or for some other reason) can no longer be used to obtain agricultural products, it is discarded (its biological life ends) and sold (*for example, plum trees are sold as firewood*). Such sales of those plant species do not affect the termination of their classification as fruit-bearing plants.

Agricultural products that grow on fruit-bearing plants are biological assets.

The accounting inclusion of fruit-bearing perennial plantings in accordance with *IAS 16* is identical to the inclusion of facilities and equipment:

1. initial valuation is at purchase value/cost price;

2. subsequent evaluation is done by choosing one of the following two models:

1) *purchase value model* and
2) *revaluation model*.

The impact of the application of different accounting regulations on the amount of taxable profit

In relation to the accounting inclusion of such perennial plantings by the application of *IFRS for SMEs* and *the Rulebook for micro and other legal entities* or by the earlier application of *IAS 41 Agriculture*, the similarities and differences are as follows:

1. the application of the purchase value model can be applied even if the net fair value can be determined without excessive efforts and costs;

2. when applying the revaluation model, the increase in fair value is not recorded as income, but as an increase in the revaluation reserve and depreciation is calculated.

In order to understand these differences, it is necessary to point out that *the Board for International Accounting Standards* amended *IAS 16 Real Estate, Facilities and Equipment* and *IAS 41 Agriculture* with the beginning of application on January 1, 2016. The most important change was that fruit-bearing plants (orchards, vineyards) are no longer within the scope of *IAS 41*, but that they are accounted for by applying the provisions of *IAS 16*. This change makes it possible to apply either *the acquisition cost model* or *the revaluation model* for the subsequent valuation of such biological assets. If *the revaluation model* (valuation at fair value) is chosen, the increase in fair value would no longer be recorded as income (which was the requirement of *IAS 41*), but as an increase in the revaluation reserve. This was the main reason for changing these two standards. Namely, many obligees of the application of *IFRS* in the world who were engaged in the cultivation of fruit-bearing perennial plantings complained that the method of valuing these assets prescribed by *IAS 41* represents a problem in their business. When raising these plantations, their growth leads to an increase in their fair value, which is immediately recognized as income and increases their taxable profit, and these plantations are not in full crops and their cultivation does not generate income on the market sufficient to generate cash to settle also increased income tax liabilities. With the amendment of these two standards, the mentioned problem of entities engaged in the cultivation of fruit-bearing perennial crops has been solved.

However, entities that apply *IFRS for SMEs* and *the Rulebook for micro and other legal entities* are still facing this problem in our country. These entities can solve this problem by voluntarily choosing *IFRS* as the regulation they will apply for keeping business books and compiling financial statements. Namely, Art. 25 and 26 of *the Accounting Law*, obligees of the application of this law are given the possibility to voluntary use *IFRS*, with the condition that they apply them continuously for at least five years from the beginning of the application of their voluntary use, except in cases of opening bankruptcy or liquidation proceedings.

It is implied that the accountant's knowledge of the mentioned aspects of the accounting coverage of perennial plantings is a prerequisite for the entities to decide on the voluntary application of *IFRS*.

Conclusion

In this paper, we proved that depending on which regulation for the recognition and valuation of perennial plantings is used by the corporate income tax payer, it can affect the amount of taxable profit and thus the amount of tax liability. Obligees who apply IFRS for SMEs and the Rulebook for micro and other legal entities by valuing perennial plants according to the fair value model, report income in the initial phase of growth of perennial plantings that increases taxable profit, as well as tax liability for which they do not acomplish a real inflow of funds, because they have not yet gained income from the turnover of crops of perennial plants, hence the liability for income tax must be financed from other cash flows. On the other hand, obligees who apply IFRS for the valuation of perennial plantings, value perennial plantings according to the purchase value model, i.e. the revaluation model, which means that they do not report income from the increase in the value of perennial plantings, but revaluation reserves and thus do not have a greater burden on the basis of tax liability at a profit until there is a turnover of the crop of perennial crops. In this way, an obligee is able to periodically distribute income tax obligations and consequently affect cash flows during tax periods.

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INVESTMENT IN CREATING THE VALUE ADDED IN LIVESTOCK PRODUCTION[1]

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Abstract

Livestock production is one of the most important sectors that generally increases overall profitability gained in agriculture. It could be a good alternative to farms that have available large areas under the crop production. Special segment of livestock growing is milk production and further gaining of value added through the milk processing. Locally, within the dairy production traditionally appears full-fat cow cheese. In performed research was tested the economic justification of initial investment in cow milk production and later milk processing into the full-fat cheese that will enable the sustainability and increase in gained profits at observed farm located in northern part of Montenegro. Investment analysis involves appliance of usual set of indicators, mainly NPV, IRR and DPBP. Gained results have been showed that the investment decision could be considered as fully justified for the farmer.

Key words: *investment, livestock production, value added, full-fat cow cheese production.*

Introduction

Within the structure of agriculture, the livestock production has great importance (Sere et al., 1996). Generally, it provides highly valuable products, as essential source of, above all, proteins and fats in human nutrition (Smith et al., 2013; MacRae et al., 2005). Gained primary livestock products serves as precious raw material in food processing industry, enabling increase in employ-

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ment and obtained profitability in rural space and overall agriculture (Devendra, Thomas, 2002; Negassa et al., 2012). So, regardless the observed economic system, the processing of livestock products and by products (such are milk, meat, eggs, honey, animal fat, feather, leather, bones, etc.) in several industries (food, feed and textile industry, pharmacy and cosmetology, light chemical industry, etc.), (Shen et al., 2019; Jayathilakan et al., 2012) empowers food security, industrial progress, level of gained GDP, employment, export or touristic offer, etc., at the macro level (Wilkinson, 2012; Rais et al., 2013), as well as it provides the creation of value added, increase in use of disposed production capacities, higher profits and overall sustainability at the farm level (Sharma et al., 2014; Gill et al., 2009).

Globally, the main segments of livestock production are milk and meat production (Salter, 2017; Smith et al., 2013). Despite their large presence in human nutrition as raw, or fresh products, generally due to expressed perishability they are usually processing into the valuable dairy and meat products (Prakash et al., 2017).

From the farmer's side, processing activity could be equalized with value added creation and increase in farm incomes and sustainability (Cucagna, Goldsmith, 2018; Clark, 2020). Basically, mentioned comes from the one of definitions that considers the value added as the change in product features into more desirable, or more attractive for the final consumers (Kogut, 1985; Coltrain et al., 2000). Through the processing, farm is capturing the larger segment of the value-added created in previously formed value chain in certain line of production, i.e. it is cutting the larger part of the final price of certain product at the local market (Jeločnik et al., 2020).

In general, milk processing at the farm level (establish in cows, sheep, goats, etc. growing) usually involves production of one or few dairy products such are cheese (differing from soft to hard full-fat cheese), sour cream, yogurt, kaymak, butter, ice cream, etc. (Singh, Bennett, 2002), and by-products, such is a whey (Arsic et al., 2018). Contrary to fact that initiates the increase in farm incomes or better use of available farm capacities, establishment of processing at the farm requires certain level of investment (Subic et al., 2014).

Technologically, milk processing is quite a complex activity (Babyna, Babyn, 2022), as it requires advanced organization and logistic, perfect hygiene, as well as smooth linkage of engaged labor, animal bio-cycles and capacities of equipment. Investing in milk processing usually involves investment in basic herd (milking cows), stables, milk production and processing facilities and equipment, storing capacities, etc. (Subić et al., 2020b).

No matter to final dairy product, in essence, milk production depends on to farm available natural conditions, or availability and price of feed and other used inputs, grown animal species and kinds, price of final products, used financial incentives, etc. (Nastić et al., 2012; Ivanović et al., 2020). Observed globally, cow milk production dominates (Britt et al., 2021). Cow milk production is dominantly organized at the small family farms that have limited herds, while the milk processing involves both the small farms and large processors (Lyson, Gillespie, 1995; Gogić et al., 2012).

Investment in such an activity, depending to primary dairy product, volume of processed milk, size of batch, level of professionalism in processing approach, involved technology, etc., could be very expensive business venture for a farm or agricultural enterprise. It could be financed by own, external (e.g. credit lines or donations) or common (e.g. cooperative) financial assets.

The main goal of the paper is to assess the economic justification of one investment alternative suitable for the farm involved in hard cheese production.

Methodology

In line to research focus, in paper was done the analysis of investment in completing the required elements for full-fat cow cheese production, i.e. purchasing the herd of heifers, building and equipping the facilities for heifers growing, as well as building and equipping the facilities for milk production and processing (production of full-fat cow cheese). Observed livestock farm is located in the northern part of Montenegro, while it has available all preconditions for producing and storing adequate volume of hi-quality feed for cattle growing, along with mostly skillful internal labor.

Like in some previous author's researches, investment analysis implies appliance of usually used package of economic indicators for economic assessment of investment effectiveness, i.e. calculation of static (Total output-total input ratio, Net profit margin, Accounting rate of return, and Simple payback period), as well as dynamic indicators (Net present value (NPV), Internal rate of return (IRR), and Dynamic payback period (DPBP)), (Ivanović et al., 2015; Subić et al., 2017; Jeločnik, Subić, 2020; Subić et al., 2020a; Jeločnik et al., 2022).

Analysis involves more conservative approach, as the used discount rate (7%) is in some extent higher that the current one, striving to adequately covers more pronounced risks in animal production. Although in one part, investment implies purchasing the production and processing facilities and equipment, observed investment period is 5 years, what is linked to usual period of utilization of heifers in milk production. All values are presented in EUR, by adequate tables, and explained by proper comments.

Results with Discussion

Farm, mainly oriented to crop production and partly to livestock production, is planning to go deeper into the milk production and further milk processing in the full-fat cheese under the traditional receipt, assuming that the regional recognizability and increase in demand for cheese produced from this location, will secure cheese realization and additionally strengthen the farm profitability and sustainability. In line to mentioned farm will invest in purchasing the basic herd (70 high quality heifers), as well as in building and equipping the stable for their growing, and facilities that will be used in milk, and later full-fat cow cheese production (Table 1.). Used facilities and equipment will technologically traced the step forwards in cheese production, harmonizing the tradition and technological achievements.

Table 1. Initially planned investment (in EUR)

No.	Description	Total
I	**Facilities**	**191,888.83**
1.	Stables for heifers / cows	
2.	Trench silo	
3.	Facility for dry-feed storing	
4.	Storage for solid manure and slurry pit for liquid manure	
5.	Facilities for milk production and processing	
6.	Facility for cheese production and storing	
II	**Equipment and cold storage**	**114,202.12**
1.	Milking system	
2.	Binding frames	
3.	Watering system	
4.	Equipment for feed preparation	
5.	Lacto-freeze (milk tank)	
6.	Centrifugal pump	
7.	Filters for pump	
8.	Duplicator tank	
9.	Prepress for cheese	

No.	Description	Total
10.	Cold storage with compressor	**114,202.12**
11.	Manure scraper system	
III	**Basic herd**	**161,000.00**
1.	Pregnant heifers (70 heads)	
Total (I+II+III)		**467,090.95**

Source: IAE, 2023.

There are planned investment in fixed assets and permanent working capital (PWC). All invested values are presented without VAT. Total investment values 560,509.14 EUR. In its structure (Table 2.) dominates fixed assets.

Table 2. Composition of the initially planned investment (in EUR)

No.	Description	Total investment	Share in total investment (in %)
I	**Fixed assets**	**467,090.95**	**83.33**
1.	Facilities	191,888.83	34.23
2.	Equipment	114,202.12	20.37
3.	Basic herd	161,000.00	28.72
II	**PWC**	**93,418.19**	**16.67**
Total (I+II)		**560,509.14**	**100.00**

Source: IAE, 2023.

The most of investment (entire fixed assets) will be financed by farm own sources, while PWC will be financed from short term credit line (Table 3.).

Table 3. Source of financing (in EUR)

No.	Description	Total investment	Share in total sources (in %)
I	**Own sources**	**467,090.95**	**83.33**
1.	Fixed assets	467,090.95	83.33
II	**Other sources**	**93,418.19**	**16.67**
1.	PWC	93,418.19	16.67
Total (I+II)		**560,509.14**	**100.00**

Source: IAE, 2023.

Forming of total income (Table 4.) assumes at market realized full-fat cheese and whey, sold calves, value of unused heifers and excluded cows, sold manure and used subsidies.

Table 4. Forming of total income (in EUR)

Description	Years				
	I	II	III	IV	V
Sale incomes	286,629.00	299,009.00	299,009.00	293,507.21	303,086.21
Total	**286,629.00**	**299,009.00**	**299,009.00**	**293,507.21**	**303,086.21**

Source: IAE, 2023.

In next table (Table 5.) are presented overall costs (material and intangible) that follow the investment exploitation, separately for each observed year and in total.

Table 5. Overall costs (in EUR)

No.	Description	Years				
		I	II	III	IV	V
I	**Material costs**	**67,857.87**	**69,908.06**	**69,908.06**	**68,996.94**	**70,583.27**
1.	Direct material	47,467.17	49,517.35	49,517.35	48,606.23	50,192.56
2.	Energy	8,295.40	8,295.40	8,295.40	8,295.40	8,295.40
3.	Other material costs	12,095.31	12,095.31	12,095.31	12,095.31	12,095.31
II	**Intangible costs**	**129,051.76**	**126,560.58**	**126,560.58**	**126,560.58**	**126,560.58**
1.	Depreciation	48,417.43	48,417.43	48,417.43	48,417.43	48,417.43
2.	Insurance	3,711.47	3,711.47	3,711.47	3,711.47	3,711.47
3.	Labor	73,811.11	73,811.11	73,811.11	73,811.11	73,811.11
4.	Interest	2,491.18	0.00	0.00	0.00	0.00
5.	Other intangible costs	620.57	620.57	620.57	620.57	620.57
Total (I+II)		**196,909.63**	**196,468.64**	**196,468.64**	**195,557.51**	**197,143.84**

Source: IAE, 2023.

After determining overall costs and income derived by exploitation of investment, there could be calculated farm financial success of implemented business activity (Table 6.).

Table 6. Profit-loss statement (in EUR)

No.	Description	Years				
		I	II	III	IV	V
I	**Total revenues**	**286,629.00**	**299,009.00**	**299,009.00**	**293,507.21**	**303,086.21**
1.	Sale incomes	286,629.00	299,009.00	299,009.00	293,507.21	303,086.21
II	**Total expenditures**	**196,909.63**	**196,468.64**	**196,468.64**	**195,557.51**	**197,143.84**
1.	Business expenditures	194,418.45	196,468.64	196,468.64	195,557.51	197,143.84
1.1.	Material costs	67,857.87	69,908.06	69,908.06	68,996.94	70,583.27

No.	Description	Years				
		I	II	III	IV	V
1.2.	Intangible costs without depreciation and interest	78,143.14	78,143.14	78,143.14	78,143.14	78,143.14
1.3.	Depreciation	48,417.43	48,417.43	48,417.43	48,417.43	48,417.43
2.	Financial expenditures	2,491.18	0.00	0.00	0.00	0.00
2.1.	Interest	2,491.18	0.00	0.00	0.00	0.00
III	**Gross profit (I-II)**	**89,719.37**	**102,540.36**	**102,540.36**	**97,949.70**	**105,942.37**
IV	**Income tax**	7,766.32	9,304.84	9,304.84	8,753.96	9,713.08
V	**Net profit (III-IV)**	**81,953.0**	**93,235.5**	**93,235.5**	**89,195.7**	**96,229.28**

Source: IAE, 2023.

Then was established the economic flow for planed investment (Table 7.). It is positive in each observed year.

Table 7. Economic flow (in EUR)

No.	Description	Zero moment	Year				
			I	II	III	IV	V
I	**Total revenues (1+2)**	**0.0**	**286,629.0**	**299,009.0**	**299,009.0**	**293,507.0**	**621,508.0**
1.	Total incomes	0.0	286,629.0	299,009.0	299,009.0	293,507.0	303,086.0
2.	Salvage value	0.0	0.0	0.0	0.0	0.0	318,422.0
	2.1. Fixed assets	0.0					225,004.0
	2.2. PWC	0.0					93,418.0
II	**Total expenditures (3+4)**	**560,509.0**	**146,001.0**	**148,051.0**	**148,051.0**	**147,140.0**	**148,726.0**
3.	Value of investment	560,509.0					
	3.1. In fixed assets	467,091.0					
	3.2. In PWC	93,418.0					
4.	Costs without depreciation and interest	0.0	146,001.0	148,051.0	148,051.0	147,140.0	148,726.0
5.	Income tax	0.0	7,766.0	9,305.0	9,305.0	8,754.0	9,713.0
III	**Net income (I-II)**	**-560,509.0**	**140,628.0**	**150,958.0**	**150,958.0**	**146,367.0**	**472,782.0**

Source: IAE, 2023.

Currently there are all preconditions for determining and assessing the selected static indicators for each year of analyzed period. As was previously mentioned, selected indicators involve: Total output-total input ratio, Net profit margin, Accounting rate of return, and Simple payback period.

a) Total output-total input ratio

Investment exploitation could be considered economically justified as the ratio between the total incomes and total costs derived from its use is above 1 (Table 8.) in each observed year.

Table 8. Total output-total input ration (in EUR)

Year	Total incomes	Total expenditures	Value of indicator
I	286,629.00	196,909.63	1.46
II	299,009.00	196,468.64	1.52
III	299,009.00	196,468.64	1.52
IV	293,507.21	195,557.51	1.50
V	303,086.21	197,143.84	1.54

Source: IAE, 2023.

b) Net profit margin,

Established investment is considered economically justified in case when the value for Net profit margin (the share of profit within the overall income derived from the use of planned investment) is higher than the presumed discount (interest) rate (7%) in each observed year (Table 9.).

Table 9. Net profit margin (in EUR, %)

Year	Profit	Total incomes	Value of indicator
I	81,953.05	286,629.00	28.59
II	93,235.52	299,009.00	31.18
III	93,235.52	299,009.00	31.18
IV	89,195.74	293,507.21	30.39
V	96,229.28	303,086.21	31.75

Source: IAE, 2023.

c) Accounting rate of return

Like with previous indicator, established investment is considered economically justified if the value for Accounting rate of return (the ratio between the gained profit and totally invested assets) is higher than the presumed discount (interest) rate (7%) in each observed year (Table 10.).

Table 10. Accounting rate of return (in EUR, %)

Year	Profit	Overall investment	Value of indicator
I	81,953.05	560,509.14	14.62
II	93,235.52	560,509.14	16.63

Year	Profit	Overall investment	Value of indicator
III	93,235.52	560,509.14	16.63
IV	89,195.74	560,509.14	15.91
V	96,229.28	560,509.14	17.17

Source: IAE, 2023.

d) Simple payback period

According to calculated value for the Simple payback period (Table 11.), investment could be considered economically justified as the initial investment will be paid off in 3.81 years, or 3 years and 9.67 months, what is shorter than the period of possible investment utilization, or the usual period of credit line expiration.

Table 11. Simple payback period (in EUR)

Years	Net incomes from economic flow	Cumulative net incomes
0	-560,509.14	-560,509.14
I	140,627.99	-419,881.16
II	150,957.79	-268,923.36
III	150,957.79	-117,965.57
IV	146,367.13	28,401.57
V	472,781.78	501,183.34

Source: IAE, 2023.

As to farm available financial assets currently have a higher value than in upcoming future, investment analysis implies calculation of dynamic assessment indicators, such are Net present value (NPV), Internal rate of return (IRR) and Dynamic payback period (DPBP).

a) Net present value and Internal rate of return

According to gained results (Table 12.), there are strong belief that the farm will initiate the growth (NPV) in its production base (summarized to zero moment by assumed discount rate of 7%) for 274,747 EUR with the exploitation of planed investment in next five years. In same manner, based on the obtained value for the IRR (20.63%), the investment is considered economically justified, as the value of indicator is higher than assumed discount rate (7%).

Table 12. NPV and IRR

No	Description	Zero moment	Year					Cumulat.
			I	II	III	IV	V	
0	1	2	3	4	5	6	7	8
1.	Net income from economic flow	-560,509.0	140,628.0	150,958.0	150,958.0	146,367.0	472,782.0	1,061,692.0
2.	Discount rate (%)	7.0	7.0	7.0	7.0	7.0	7.0	
3.	Discount factor $(1+i)^{-n}$ while i = discount rate; n = years	1.0	0.935	0.873	0.816	0.763	0.713	
4.	Current value of the net income	-560,509.0	131,428.0	131,852.0	123,227.0	111,663.0	337,087.0	835,257.0
5.	NPV	274,747.0						
6.	Relative NPV	0.49						
7.	IRR	20.63%						

Source: IAE, 2023.

b) Dynamic payback period

According to calculated value for the Dynamic payback period (Table 13.), investment could be considered economically justified as the initial investment will be paid off in 4.18 years, or 4 years and 2.22 months, what is shorter than the utilization period of the investment, or the usual period of credit line expiration.

Table 13. Dynamic payback period (in EUR)

Years	Current net incomes from economic flow	Cumulative net incomes
0	-560,509.00	-560,509.00
I	131,428.00	-429,081.00
II	131,852.00	-297,229.00
III	123,227.00	-174,002.00
IV	111,663.00	-62,339.00
V	337,087.00	274,747.00

Source: IAE, 2023.

Conclusion

At the current global scene, where the agriculture is among the economy sectors which are particularly under the strong pressure of economic and climate trends, sustainability of small farmers is especially endangered. In these circumstances, creating the value added and additional incomes is highly important for them, while the food processing could occur as very welcomed alternative. In livestock growing, in line to increased demand, one of processing possibilities could be the production of cheese, in this case specifically full-fat cow cheese.

Right decision towards the investment in milk processing into the full-fat cow cheese (purchasing the basic herd of heifers, as well as the building and equipling the production and processing facilities) requires adequate investment analysis. According to gained values for the static and dynamic evaluation indicators, there is strong belief that the planned investment is considered economically justified. Specifically, making the positive investment decision could be based on:

a) Values of static indicators, i.e. Total output-total input ratio (1.54, gained in fifth year of project implementation), Net profit margin (31.75%, gained in fifth year of project implementation), Accounting rate of return (17.17%, gained in fifth year of project implementation) and Simple payback period (3 years and 9.67 months).

b) Values of dynamic indicators, i.e. Net present value (274,747 EUR), Internal rate of return (20.63%), and Dynamic payback period (4 years and 2.22 months).

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SELECTION OF SUSTAINABLE SUPPLIERS IN AGRICULTURAL ENTERPRISES[1]

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Abstract

The aim of the work was to select sustainable suppliers for the agricultural enterprise according to predetermined criteria. The subject of choice was mineral fertilizer, given that the company is registered for the production and sale of grain wholesale and retail. For the purpose of selection, we used multi-criteria decision-making, that is, the MABAC method of multi-criteria decision-making. The decision makers were employed engineers in the company in question. The work focused on five suppliers and ten criteria, and the criteria "pollution control" and "quality" received the highest value when evaluating the criteria. The results showed that the fifth selected supplier best met the set criteria. Future research should be based on the development of new decision-making methods in order to make rational decisions that are particularly important for this sector of the economy.

Key words: *Suppliers, multi-criteria decision-making, MABAC method, agricultural enterprise, sustainability*

Introduction

Organizational sustainability plays an important role in every company and has attracted a lot of attention in the last thirty years. This certainly includes a rational and sustainable choice of suppliers that would satisfy environmental interests in addition to economic interests. The choice of a sustainable supplier plays a special role in agribusiness, i.e. with economic entities from agriculture, due to the very specificity of the final products, as well as its supply and sales channels.

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With the development of higher stages of processing as well as the use of conventional methods of processing and protection, concern for the environment grows, and the social responsibility of the holders of the organization in production and trade increases. On this occasion, as Puška and Maksimović (2016) point out, among the choice of suppliers, environmental protection is increasingly emphasized. That choice implies the inclusion of quantitative and qualitative criteria, which by their nature can be limited by various restrictions, and very often contradict each other. For this purpose, multi-criteria decision-making methods have a logical use.

The choice of suppliers, i.e. the acquisition of a certain necessary means of production, represents the primary function of every organization, so choosing the best supplier is one of the most important issues in a competitive environment (Kannan et al., 2013).

Considering the previous statement, the goal of the work would be the selection of a sustainable supplier for an agricultural company. The company, which is the subject of the work in this case, is located in the wider area of the city of Novi Sad and is engaged in primary agricultural production and trade in agricultural products. The goal of the work is to choose a supplier of seed goods for the upcoming sowing with an emphasis on environmental protection and a higher degree of sustainability in the phase of supplying the necessary goods.

In recent research, we have found numerous examples of domestic and foreign authors of supplier selection in agriculture and agribusiness, precisely using multi-criteria decision-making methods. (Qureschi et al., 2018; Alaoui et al., 2019; Balezentis et al., 2020; Maksimović et al., 2021; Kieu et al., 2021; Nedeljković et al., 2021; Nedeljković et al., 2022; Nedeljković et al., 2023; Puška et al., 2022; Puška et al., 2022a) When it comes to the sustainability of suppliers in agribusiness, some authors also apply multi-criteria decision-making methods. (Miranda-Ackerman, 2019; Ramakrishnan and Chakraborty, 2020; Kazemitash et al., 2021; Tirkolaee et al., 2021; Puška et al., 2021; Ecer, 2022) Thus Nedeljković (2022a) by applying fuzzy logic of multi-criteria decision making in one agricultural company in the area of the municipality of Bijeljina selects the supplier that best meets 13 set criteria, some of which related exclusively to sustainability and environmental protection (Safety and health, Pollution control, Waste management, Recycling, Green product). Also, the same author, in his work (Nedeljković, 2022b), using the DEMATEL method of multi-criteria decision-making, ranks the criteria important for choosing the most favorable supplier. For this purpose, it considers criteria related to environmental management system, green product, pollution control, recycling, eco design. Puška et al. (2023) in their study on the example of agribusiness companies choose a sustainable supplier and for this purpose use the new fuzzy multi-criteria decision-making method TRUST CRADIS. Choosing the most favorable supplier strengthened the sustainable strategy of the company in question, as well as demonstrated the successful application of the multi-criteria decision-making method used.

Certainly, increasing sustainability in procurement must be accompanied by legal regulations at the state level, that is, encouraged within its formal framework. As concluded by Vasiljević et al. (2015), in the period after 2000 until today, agriculture has not been characterized by a clear strategy for development, so it would be necessary to do more in that field as well.

Research methodology

We used the MABAC (Multi-Attributive Border Approximation area Comparison) method of multi-criteria decision-making as a working method. The method was developed by Pamučar and Ćirović (2015) and actually defines the distance of the criterion function of each of the observed alternatives from the marginal fair value. The reason for using this method lies in the fact that it is relatively new, easy to use and currently less popular in this subject area in our country. Its authors define the following steps of this method:

Step 1: Formation of the initial decision matrix (X)

$$
= \begin{array}{c} \\ A_1 \\ A_2 \\ \dots \\ A_m \end{array}
\begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \dots & C_n \end{array} \\
\begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \dots & \dots & \dots & \dots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \end{array}
$$

Step 2: Normalization of the element of the initial decision matrix (X)

$$
N = \begin{array}{c} \\ A_1 \\ A_2 \\ \dots \\ A_m \end{array}
\begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \dots & C_n \end{array} \\
\begin{bmatrix} n_{11} & n_{12} & \cdots & n_{1n} \\ n_{21} & n_{22} & \cdots & n_{2n} \\ \dots & \dots & \dots & \dots \\ n_{m1} & n_{m2} & \cdots & n_{mn} \end{bmatrix} \end{array}
$$

a) For benefits type criteria

$$n_{ij} = \frac{x_{ij}-x_i^-}{x_i^+-x_i^-}$$

b) For cost type criteria

$$n_{ij} = \frac{x_{ij}-x_i^+}{x_i^--x_i^+}$$

Step 3: Calculation of the weight matrix element (V)

$$V_{ij} = w_i g(n_{ij}+1)$$

Step 4: Determination of the matrix of boundary approximate surfaces (G)

$$g_i = \left(\prod_{j=1}^{m} v_{ij}\right)^{\frac{1}{m}}$$

Step 5: Calculation of elements of alternative distance matrices from the limit approximate domain (Q)

$$Q = \begin{bmatrix} q_{11} & q_{12} & \cdots & q_{1n} \\ q_{21} & q_{22} & \cdots & q_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ q_{m1} & q_{m2} & \cdots & q_{mn} \end{bmatrix}$$

Step 6: Ranking of alternatives

$$S_i = \sum_{j=1}^{n} q_{ij} \quad j = 1,2,\ldots,n \quad i = 1,2,\ldots,m$$

In this case, the joint decision-makers were five employed engineers in the company, which normally has around 60 employees of various profiles. The weights of the given criteria in the paper were determined by the popular AHP method of multi-criteria decision making.

Results

Table 1 provides an overview of the criteria used (assigned) in the work. The criteria were obtained using a review of the relevant literature that was discussed in the previous chapters of the paper, and were informally divided into criteria related to the economic-technical aspect of business, as well as criteria related to their sustainability. Each of these criteria should meet its maximum or minimum.

Table 1. Research Criteria

Criterion label (C)	Criterion	Criteria Type
C1	Price	Minimum
C2	Quality	Maximum
C3	Costs of transport	Minimum
C4	Delivery time	Minimum
C5	Techological capacities	Maximum
C6	Sustainable management standards	Maximum
C7	Pollution control	Maximum
C8	Ecological production design	Maximum
C9	Environmentally acceptable materials	Maximum
C10	Reducing resource consump-tion	Maximum

Source: Authors

To evaluate the linguistic statements of the decision makers, we used the values shown in the following table 2. Based on the linguistic scale, the decision makers in this case, experts (engineers) from the subject area gave a summary assessment of the given criteria.

Table 2. Linguistic scale of values

Evaluation of criteria	Linguistic scale
1	VP-Very Poor
2	P-Poor
3	M-Medium
4	G-Good
5	VG-Very Good

Source: Đalić et al., 2020

After calculating the weights of the criteria, we notice that the greatest importance is given to the criteria "quality" as "pollution control". Immediately afterwards, "price" and "delivery time" were evaluated as important criteria. The weighting coefficients ranged from 0.03 to 0.22. The next steps in the work concerned the normalization of the decision-making matrix (table 4), as well as the weighting of the normalized decision-making matrix (table 5).

Table 3. Decision Matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
A1	2	4	3	5	4	3	2	2	5	4
A2	3	2	4	4	3	3	3	2	4	3
A3	4	3	3	2	3	3	3	4	4	4
A4	3	3	4	3	3	2	3	3	3	2
A5	5	4	5	4	4	4	4	4	5	5
Weight	**0,12**	**0,22**	**0,09**	**0,12**	**0,07**	**0,09**	**0,18**	**0,05**	**0,03**	**0,03**
Max.	5	4	5	5	4	4	4	4	5	5
Min.	2	2	3	2	3	2	2	2	3	2

Source: Authors

Table 4. Normalized Decision Matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
A1	1	1	1	0	1	0,5	0	0	1	0,66
A2	0,66	0	0,5	0,33	0	0,5	0,5	0	0,5	0,5
A3	0,33	0,5	1	1	0	0,5	0,5	1	0,5	0,66
A4	0,66	0,5	0,5	0,66	0	0	0,5	0,5	0	0
A5	0	1	0	0,33	1	1	1	1	1	1

Source: Authors

Table 5. Weighted Normalized Decision Matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
A1	0,24	0,44	0,18	0,12	0,14	0,135	0,18	0,05	0,06	0,0498
A2	0,1992	0,22	0,135	0,1596	0,07	0,135	0,27	0,05	0,045	0,045
A3	0,1596	0,33	0,18	0,24	0,07	0,135	0,27	0,1	0,045	0,0498
A4	0,1992	0,33	0,135	0,1992	0,07	0,09	0,27	0,075	0,03	0,03
A5	0,12	0,44	0,09	0,1596	0,14	0,18	0,36	0,1	0,06	0,06
Gi	0,1787	0,3414	0,1396	0,1709	0,092	0,1318	0,2637	0,0715	0,0465	0,0457

Source: Authors

In the following, the distance of the alternatives from the approximate range of limit values was calculated (table 6), and finally the suppliers (alternatives) were ranked (table 7). As we can see, the fifth supplier performed best, that is, it is the supplier that best meets the set criteria and was therefore selected.

Table 6. Distance of the Alternatives from the BBA

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
A1	0,0613	0,0986	0,0404	-0,0509	0,0477	0,0032	-0,0837	-0,0215	0,0135	0,0041
A2	0,0205	-0,1214	-0,0046	-0,0113	-0,0223	0,0032	0,0063	-0,0215	-0,0015	-0,0007
A3	-0,0191	-0,0114	0,0404	0,0691	-0,0223	0,0032	0,0063	0,0285	-0,0015	0,0041
A4	0,0205	-0,0114	-0,0046	0,0283	-0,0223	-0,0418	0,0063	0,0035	-0,0165	-0,0157
A5	-0,0587	0,0986	-0,0496	-0,0113	0,0477	0,0482	0,0963	0,0285	0,0135	0,0143

Source: Authors

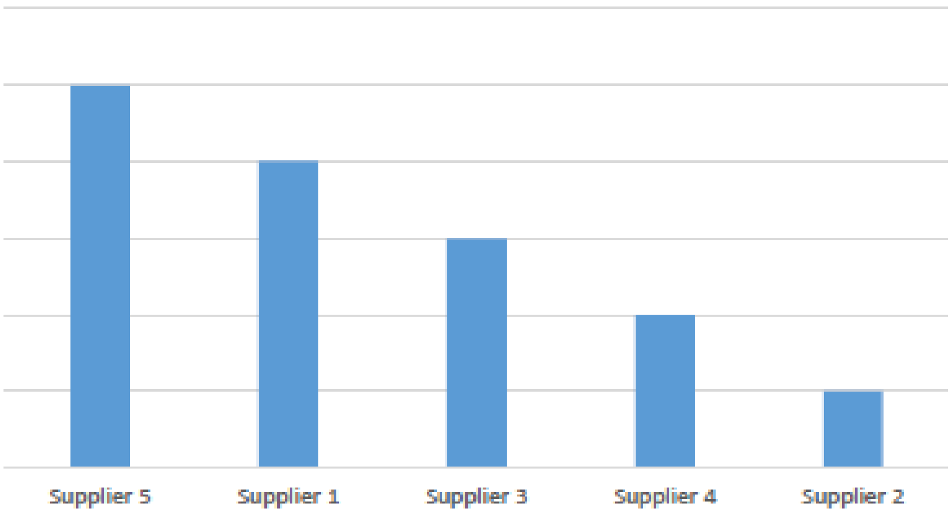
Table 7. Ranking alternatives (Suppliers)

Si	**Rank**
0,1127	**2**
-0,1533	**5**
0,0973	**3**
-0,0537	**4**
0,2275	**1**

Source: Authors

A visual representation of the order (ranking) of suppliers after the necessary calculations is given in the following chart 1.

Graph 1. Supplier ranking



Conclusion

The choice of suppliers, that is, the supply chain, represents a complex process for every company in today's market economy. For this reason, and according to pre-defined standards, it is necessary to satisfy certain criteria of an economic and technical nature, as well as recently increasingly authentic standards of sustainability. In the previous example, the selection of the most favorable supplier for seed goods in an agricultural company was made in the paper, and the fifth supplier proved to be the best supplier. For the purpose of selection, the multi-criteria decision-making method (MABAC) was used, which proved to be a real solution for such situations, given that certain criteria are in conflict with each other. The most highly rated criterion was the quality of the goods, and the fact that the pollution control criterion was recognized as one of the most important criteria is also pleasing. The work represents a realistic basis for future research in this area, as well as an opportunity to improve existing and introduce new multi-criteria research methods, especially when it comes to the procurement sector in agriculture and agribusiness.

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STUDY ABOUT EVOLUTION OF THE ROMANIAN OILSEED MARKET AND ROMANIAN PLACE IN THE INTERNATIONAL TRADE WITH OILSEED

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Abstract

This paper is focused on the analyse of the Romanian oilseed market evolution during recent years and its contribution in the international trade with oilseed. The research method is related with the quantitative methods, based on official available time data series about oilseed production and trade. The results indicated that Romania became a top producer and exporter on EU oilseed market, and many Romanian farmers focused in the last years on oilseed production, due the high imports demand on worlds markets and attractive national production and trade context.

Key words: *trade, oilseed market, Romania.*

Introduction

This paper is focused on the analyse of the Romanian oilseed market evolution during recent years and its contribution in the international trade with oilseed.

Due its key place in the Romanian crop production, the trends of oilseeds production were at the centre of several researchers. While Soare E. (2014, 2023) underlined that in Romania oilseed crops are covering large areas from the total cultivated areas, Popescu A. (2012, 2020) focused on Romanian farmers necessity to adapt the oilseed production to the climate change effects, and Chiurciu I. (2023) focused on the Romanian trade with sunflower and rapeseeds and mentioned the impact of increase of the Ukrainian exports' oilseeds in region.

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Sunflower seed production was for some decades the main oilseed production in Romania who reached a production of over 3.5 million to in 2019 but, also the rapeseed is a very good option for the Romanian farmers, who reached over 1.6 million to in 2017 and 2018. Soybean is the third target for the Romanian farmers who reached a production of over 0.4 million to in 2018 and 2019.

In this paper we analysed the entire Romanian oilseed production and market, considering not only the Romanian ranking in the EU and World oilseeds exports, but also the main destinations of the Romanian oilseeds exports and how they changed during the recent period.

Material and methods

The research method is related with the quantitative methods, based on official available time data series about oilseed production and trade. Data used in this study were mainly provided by the National Institute of Statistic and International Trade Center, which acts under WTO and United Nations.

Beside statistic indicators that were considered for the evolution of oilseeds areas and production in Romania, in the last decades, we used specific trade indicators as: volume of trade exports, or Balassa index with which we measured the degree of specialisation of Romanian oilseed exports.

Results and discussions

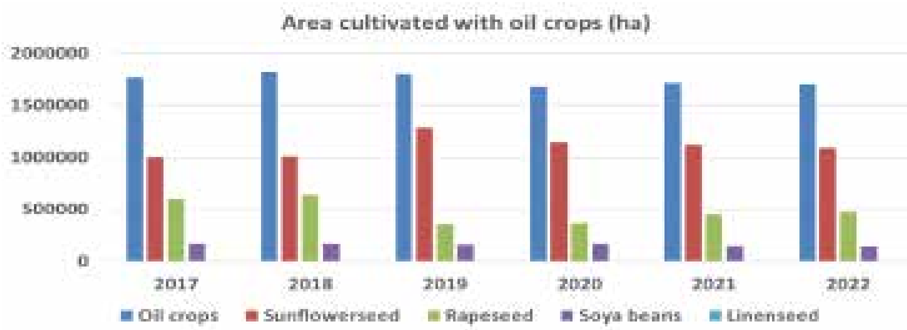
Areas cultivated with oilseeds in Romania

In the last decade, the surfaces cultivated with oil crops in Romania increased by 19.2 %, while the entire areas cultivated with main crops decreased by 2 %. In 2022, Romania cultivated: 1.09 million ha with sunflower, which is above average, of 1.07 million cultivated in this period. From 2012 to 2022 the sunflower cultivated area didn't fall bellow1 million ha.

In 2022 Romania cultivated also 0.46 million ha with rapeseed, which was below average of 0.43 million ha cultivated in the last decade. In 2018 the areas cultivated with rapeseed reached a peak of 0.63 million ha, 6 times more than was cultivated in 2012 (approximative 0.1 million ha).

Only 0.13 million ha with soyabean were cultivated in 2022, which was closed to the average area cultivated with soyabean in this last decade. Is to mention here that the cultivated areas with soybeans varies greatly from one year to another.

Fig 1. Evolution of Areas cultivated with oil crops in Romania

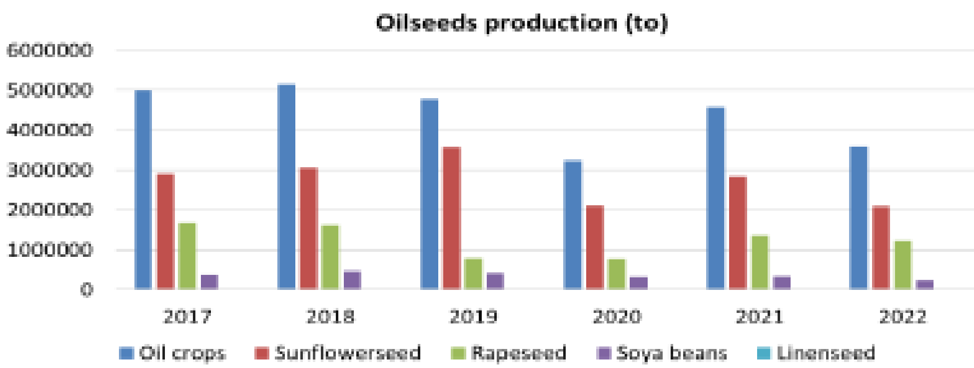


Data source: INSSE Romania, 2023

Oilseed Production in Romania

Oilseed production in Romania increased by 20.8% in the last decade. In 2022 the oilseed production was about 3.5 million to, which was below average of 3.9 million to recorded in the last decade. The sunflower seed production was about 2.1 million to (2.4 million to in average for the last decade), while the rapeseed production was 1.22 million to (1.1 million in average), and soyabean production recorded 0.24 million to (0.30 million to in average).

Fig 2. Evolution of oilseed production in Romania

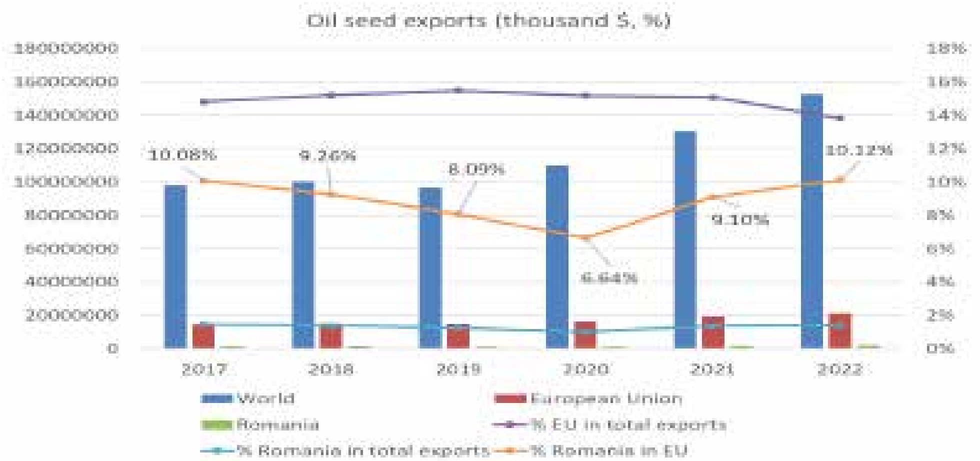


Data source: INSSE Romania, 2023

Oilseed exports of Romania

Romanian exports of oilseeds increased from 97 million $ in 2003 to 2,136 million $ in 2022. In the same period of time the EU oilseeds exports increased from 4,664 million $ in 2003 to 21,104 million $ in 2022. In 2017 and 2022 over 10% from the total EU oilseeds exports were from Romania.

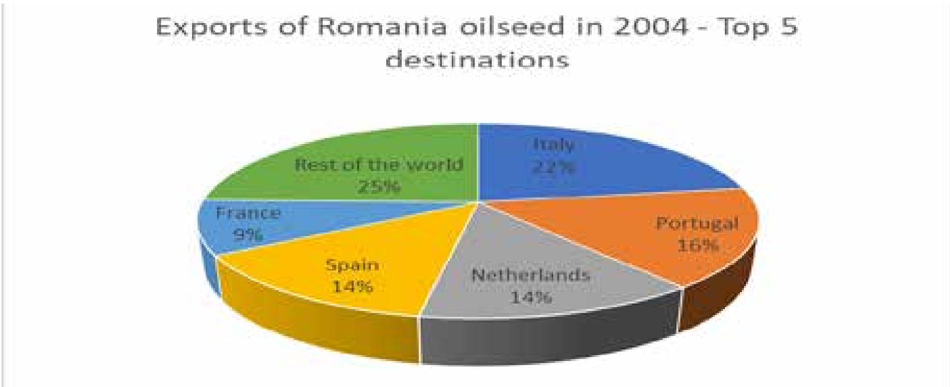
Fig 3. Evolution of Romanian oilseed exports: share in EU and World oilseed exports



Data source: Intracen, 2023

To understand the evolution of the exports of oilseed from Romania, we selected the years 2004, 2010, 2016 and 2022, for which we determined the main countries destinations.

Fig 4. Top 5 destinations of oilseed exports from Romania in 2004



Data source: Intracen, 2023

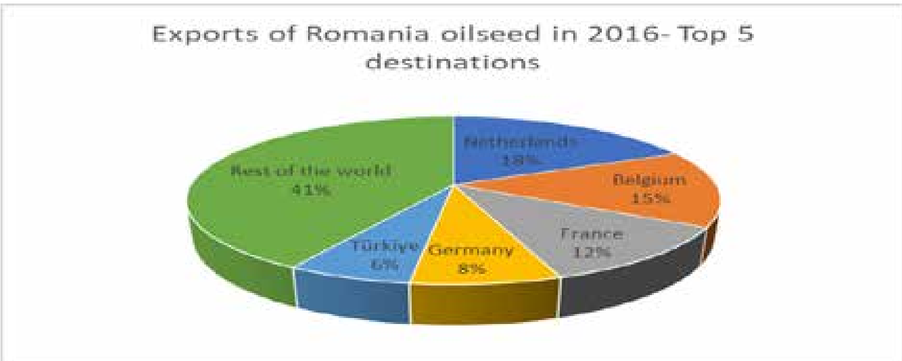
In 2004 Italy was the main destination of Romanian`s oilseed exports, with a value of 22,188 thousand $, representing 22% from the total Romanian`s oilseed exports from that year followed by Portugal, with a value of 16,347 thousand $ (16%), Netherlands with a value of 13,530 thousand $ (14%) and Spain with a value of 13,474 thousand $ (14%). Over 25% of Romanian`s oilseed exports in 2004 were delivered in other world countries.

Fig 5. Top 5 destinations of oilseed exports from Romania in 2010

Data source: Intracen, 2023

In 2010 Netherlands replaced Italy as the main destination of Romanian`s oilseed exports, with a value of 159,468 thousand $, representing 21% from the total Romanian`s oilseed exports from that year followed by France, with a value of 107,528 thousand $ (14%), and Belgium with a value of 82,898 thousand $ (11%). Over 37 % of Romanian`s oilseed exports in 2010 were delivered in other world countries. The increase of exports value was significant between 2004 and 2010.

Fig 6. Top 5 destinations of oilseed exports from Romania in 2016



Data source: Intracen, 2023

In 2016 Netherlands remained the main destination of Romanian`s oilseed exports, with an increased value of 230,238 thousand $, representing only 18% from the total Romanian`s oilseed exports from that year, followed by Belgium, with a value of 186,487 thousand $ (15%), and France with a value of 145,668 thousand $ (12%).

Over 41% of Romanian`s oilseed exports in 2016 were delivered in other world countries.

Fig 7. Top 5 destinations of oilseed exports from Romania in 2022

Data source: Intracen, 2023

In 2022, the last year for which we compared the oilseed export destinations, Netherlands remained the main destination of Romanian`s oilseed exports, with a value of 358,935 thousand $, representing about 17% from the total Romanian`s oilseed exports from that year, followed by Hungary, with a value of 285,736 thousand $ (13%), and Bulgaria with a value of 202,818 thousand $ (10%).

More than 43% of Romanian`s oilseed exports in 2022 were delivered in other world countries.

The degree of specialization of Romanian oilseed exports within EU oilseeds exports, in relation with the entire Romanian` exports, and entire EU exports, using Balassa index, the results indicated for the year 2022 the next situation:

H 12 Romanian exports of oilseeds in 2022: 2,136,739 thousand $

Total Romanian exports in 2022: 96,829,602 thousand $

Share of Romanian oilseeds exports in the total of Romanian exports in 2022: 2.20%

H12 Total (other) EU exports of oilseeds in 2022: 18,968,235 thousand $

Total (other) EU exports in 2022: 6,868,741,879 thousand $

Share of (other) EU oilseeds exports in the total of (other) EU exports in 2022: 0.27%

Balassa Index: 2.20/0.27 = 7.99, which mean that Romania has an export specialization for the oilseed exports compared with the other EU-27 member states.

Conclusions

The results indicated that Romania became a top producer and exporter on EU oilseed market, and many Romanian farmers focused in the last years on oilseed production, due the high imports demand on worlds markets and attractive national production and trade context. Only in 2022 Romania exported oilseeds that valued 2,136,739 thousand $. While the sunflower seeds are the main oilseeds exported by Romania, the rapeseeds exports increased their share in total oilseeds exports, in the last years. The main destination of Romanian exports in the analyzed period became Netherlands, which is the main terminal of the oilseeds exports outsides EU. The Romanian degree of specialization in the oilseed exports is high but Romania exports only raw oilseeds and the added value is not comparable with the one that is related with oilseeds processed products.

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ANALYSIS OF CEREAL FOREIGN TRADE IN EUROPEAN UNION

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Abstract

Given the fact that worldwide, cereal grains are considered a major component of the diet (Awika, 2011), and in 2022 the area harvested with cereals in European Union was 54.480 thousand ha, this market deserve to be investigated. We consider that the subject of this paper is an unresearched one, given the fact that querying Web of Science database, only 10 articles were found on the subject of "cereal foreign trade in EU" between 2017 and 2022. In brief, this paper will provide a snapshot of the current situation on cereal market, the more so as the economic context (the war between Ukraine and Russia) changed the dynamics of this market in the last years. The research involves also a bibliographic analysis on the subject of „cereal market" which was made using VOSviewer software, based on Web of Science database query that revealed 3.571 scientific documents that contains the term "cereal market". In this context, we consider that the paper brings an important and an up-to-date status regarding the situation of cereal foreign trade in European Union and candidate countries.

Key words: *foreign trade, bibliometric analysis, cereal market, European Union.*

Introduction

Cereals play a very important role in the world economy, due to several reasons, including their use as food and as raw material for numerous products. [4]

Foreign trade subject is composed from indicators like: imports, exports, trade balance, being in a close connection with production and consumption among every country. [5]

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The purpose of the paper is to identify the related research directions of the studied subject, and to provide a picture with the main characteristics, the dynamics and the degree of concentration of indicators among cereals' foreign trade from European Union and candidate countries between 2003 and 2022.

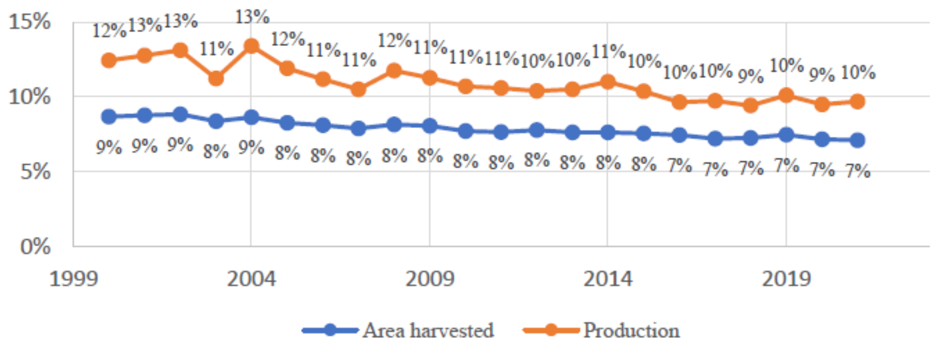
The motivation for writing this paper came from several sides, such as:

- the subject of cereals foreign trade in European Union and candidate countries is unresearched one, given the fact that querying Web of Science database, only 10 articles were found on the subject of "cereal foreign trade in European Union" all of them being written 2017 and 2022;

-it is a field in focus in the present geopolitical situation (the war between Ukraine and Russia);

- the European Union cereal's production represented in 2021 7% from the total area harvested with cereals, and 10 from the whole production of this indicator (Figure 1).

Figure 1. The share of EU area harvest and EU production of cereals in the total at the World level



Source: Edited by the authors based on FAO data

Conform with FAO, among EU and candidate countries, in case of the production, the countries with the highest quantity of cereals are: Ukraine (85,338,631 tones), France (66,880,910 tones) and Germany (42,359,400 tones). On the other hand, the countries with the largest area harvest with cereals are: Ukraine (15,649,490 tones), Turkey (10,917,931 tones) and France (9,326,650 tones).

In a brief, we can say that the importance of cereal field can be summed, to the fact that international trade increases connections and dependencies between countries, weaving a network of global supply chains.[1]

Methodology

In this paper, a bibliometric analysis has been carried out in the first instance, by determining maps of the connections and their intensity between keywords searched in bibliometric databases. Thus, the Web of Science bibliometric database was used to search for indexed articles containing the phrase "cereal market". For this query, 3571 scientific documents were identified and 2940 of them being articles. Maps will also be made of the connections between the countries in which those scientific papers have been published. All these bibliometric analyses will be carried out with VOSviewer software. VOSviewer program, version 1.6.15, allows the survey of bibliometric and sociometric networks regarding the performance of articles or specialized works, of authors, organizations, the impact factor, etc. and which allows to identify those networks that are located close to each other, the approach of distance and the strength of association can be used.

In the second part of the research, quantitative research will be carried out on the analysis of external trade in cereals for the European Union and candidate countries. The dynamics of exports, imports and trade balances of cereals will also be analysed. When we analyzed data for cereal's category, conform Intracen.org, we make reference to: wheat and meslin, rye, barley, oats, maize or corn, rice, grain sorghum, buckwheat, millet, canary seed and other cereals (excl. wheat and meslin, rye, barley, oats, maize, rice and grain sorghum). The analyzed period of cereal foreign trade was from 2003 to 2022, using the statistical database of the International Trade Center (ITC), extracting data expressed in thousand euros.

Finally, according to these data, the degree of concentration of these indicators will be calculated using the GINI coefficient, with the following formula:

$$\text{Gini Coefficient} = \sqrt{\frac{n * \sum_{i=1}^{n} p_i^2 - 1}{n-1}}, \text{ where}$$

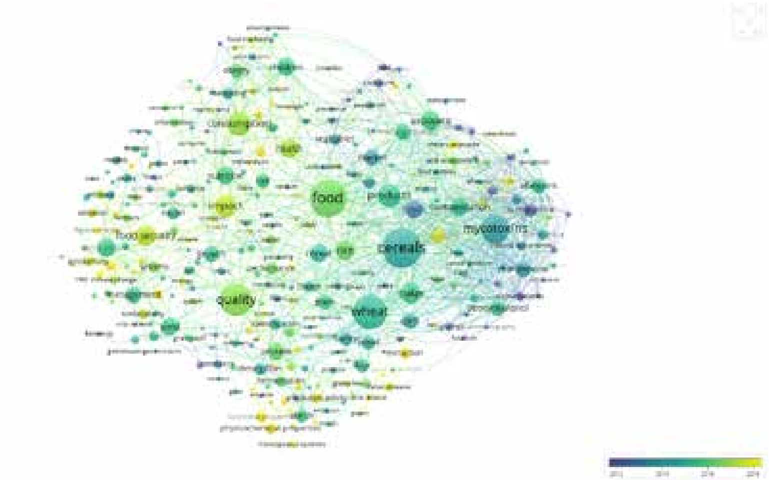
, where:

pi – share of each indicator observation in the total;
n – number of observable units.[3]

Results and Discussions

In this chapter, the bibliometric analysis will be presented, as well as the snapshot of imports, exports and trade balance of cereals.

Figure 2. Link between short food chains and other related terms



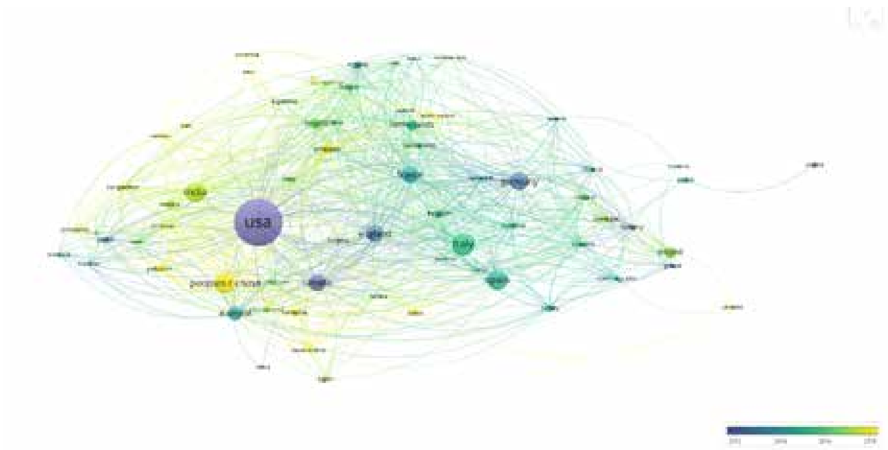
Source: Own processing using VOSviewer of information extracted from WoS

The map presented in Figure 2 were made with the following specifications:

- Unit of analysis: All keywords
- Counting method: Full counting.
- Minimum number of scientific documents required for a country to appear on the map: fifteen.

In the analysis of the identified keywords, according to the criteria described above, important clusters can be observed in terms of theme and time period according to the authors' research. Thus, in the past, it is possible to identify a cluster (with darker fonts) about cereal production characteristics, i.e. this cluster contains words such as cereals (mentioning the main cereals), mycotoxins, contamination and other toxins that can affect crops and production. Then a more recent cluster has been identified, which relates to the food – quality – nutrition – consumption – health interconnection. And the latest keywords identified in current research refer to food security, productivity, physico-chemical properties, which leads us to think about nutritional security. These most recent keywords have been researched in the period 2020-present, so they can be justified in view of the multitude of crises in this period that may have provoked these research themes with reference to ensuring food security and sufficient productivity and yields; crises such as the Covid-19 pandemic, the Russia-Ukraine military conflict, the energy crisis, all of them interspersed over time, putting pressure on agricultural resources.

Figure 3. Link between coauthor countries



Source: Own processing using VOSviewer of information extracted from WoS

The map from the Figure 3 were made with the following specifications:

- Unit of analysis: Co-authors.
- Counting method: Full counting.
- Scientific documents with authors from more than 25 countries have been ignored when generating the map.
- Minimum number of scientific documents required for a country to appear on the map: ten.

Regarding the interconnections between the frequency of co-authors developed according to countries, the countries for which there is interest in the topics researched were identified. Since the beginning of the last decade, this subject has been studied in countries such as the United States of America, Canada, Germany, where the largest number of scientific results have been obtained, and there are also countries where these subjects have been researched, to a lesser extent, such as Hungary, Croatia and Greece. Subsequently, an average proportion studied topics related to the grain trade in France, Italy, Spain, the Netherlands and even Brazil. More recently, there has been an increase in research in Asia, countries such as China, India, Pakistan, and Sri Lanka. However, it is noted that among the countries with the most recent research in the field are Romania and Russia, with a small but existing volume, given the Russia-Ukraine military conflict, the topic of trade in cereals being of high topicality, Romania being the first destination of Ukraine's exports, following the conflict, and the topic is of particular interest, given the implications of this situation.

Imports

In the table from below, the value of imports with cereals, expressed in euro thousand, in each European Union and candidate countries was presented, in the last column being calculated the increasing percent of the indicator from 2003 to 2022.

Table 1. List importers countries of cereal among UE and candidate countries (euro thousand)

Importers	**2003**	**2008**	**2013**	**2018**	**2022**	**2022/ 2003**
World	38,678,680	82,021,059	97,303,892	102,860,071	189,428,254	490%
Total UE& candidate countries	9,051,538	18,124,275	19,043,518	20,982,629	40,071,996	443%
Spain	1,293,105	2,577,614	2,319,500	3,159,075	6,261,176	484%
Italy	1,499,580	2,508,167	2,746,751	2,863,445	5,936,723	396%
Turkey	615,394	1,452,643	1,524,435	1,714,888	5,129,069	833%
Germany	738,136	2,073,461	2,492,917	2,679,879	4,246,413	575%
Netherlands	929,586	2,444,850	2,745,977	2,855,564	4,214,199	453%
Belgium	891,540	1,724,806	1,950,041	1,828,551	3,100,002	348%
Portugal	453,513	803,242	746,628	916,810	1,443,159	318%
France	422,882	765,119	773,246	818,316	1,162,737	275%
Poland	105,102	585,192	327,670	394,751	1,132,447	1077%
Austria	101,712	204,222	460,787	449,644	982,035	966%
Romania	310,160	298,135	327,398	322,269	967,895	312%
Hungary	35,068	117,739	143,494	159,868	806,304	2299%
Ireland	127,053	199,916	304,886	478,274	702,541	553%
Greece	299,837	442,368	357,169	400,247	679,908	227%
Switzerland	134,234	242,952	265,314	250,431	493,653	368%
Denmark	152,383	435,633	240,417	263,770	318,290	209%
Latvia	5,096	60,843	68,443	201,952	290,567	5702%
Czech Republic	37,166	98,804	127,059	150,731	245,383	660%

Importers	2003	2008	2013	2018	2022	2022/ 2003
Slovakia	24,961	137,207	95,942	97,648	232,249	930%
Bulgaria	30,539	77,784	60,558	67,122	191,524	627%
Lithuania	19,742	78,179	67,746	80,698	188,580	955%
Cyprus	78,173	131,845	108,929	106,426	182,752	234%
Bosnia and Herzegovina	30,006	122,081	109,416	111,422	177,834	593%
Ukraine	461,774	99,583	230,773	161,818	146,153	32%
Finland	37,218	52,825	38,807	50,400	142,132	382%
Slovenia	52,659	75,223	85,685	84,610	136,561	259%
Croatia	24,525	56,661	40,878	70,946	125,919	513%
Albania	41,075	92,455	90,759	85,970	101,196	246%
Luxembourg	14,713	24,264	42,320	44,307	72,851	495%
Serbia	-	19,344	30,901	18,533	63,000	326%
Republic of Moldova	24,991	15,265	9,546	18,375	61,535	246%
North Mace-donia	21,180	27,680	26,040	27,547	47,063	222%
Malta	23,845	49,009	44,251	19,917	46,074	193%
Estonia	14,590	19,813	28,513	20,594	31,017	213%
Montenegro	-	9,351	10,322	7,831	13,055	140%

Source: Edited by the authors based on ITC data

Among all EU and candidate countries, the countries that imported the highest value of cereals were: Italy in: 2003 (1,5 billion euro) and in 2013 (2,747 billion euro); Spain in: 2008 (2,578 billion euro), 2018 (3,159 billion euro) and 2022 (6,261 billion euro).

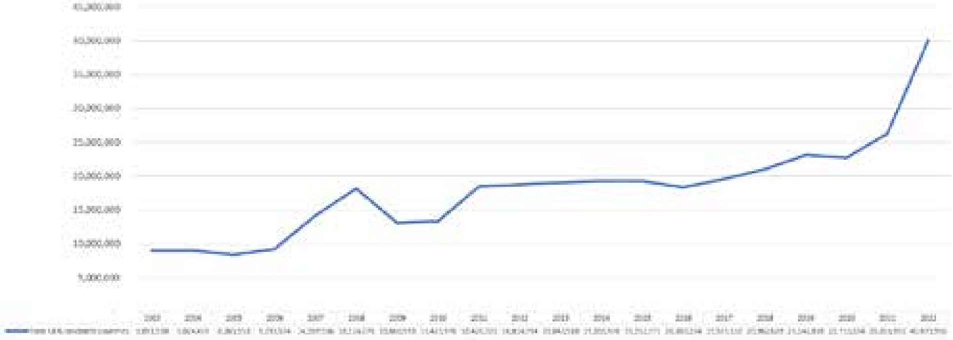
The largest increase in the value of exports is observed in Latvia, which increased the value of cereals imports from 5,096 euro thousand in 2003 to 290,567 euro thousand in 2022.

Being a country with an important percent of cereal production, Ukraine is situated among the countries with the lowest value of import of cereals, its value increased among 2003-2022 period only with 32%.

Serbia's cereal imports are also relatively low, ranking 30th in the countries analyzed.

Romania can be noted that is a country with an important value of cereals imported, being "the main door for European Union cereal trade to East".[2]

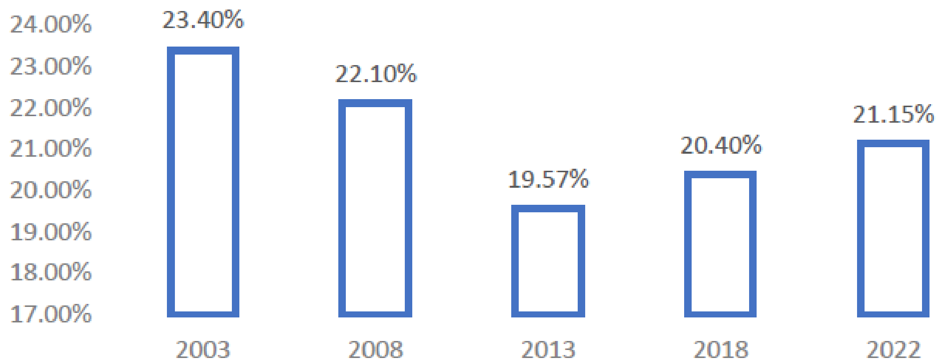
Figure 4. The evolution of value of import among EU and EU candidate countries (Euro thousand)



Source: Edited by the authors based on ITC data

The value of imports among European Union candidate countries increased with 443% from 2003 to 2022, but the biggest increase it was identified in 2022, a fact that can be attributed to the war between Russia and Ukraine.

Figure 5. The share of EU and EU candidate countries value of import with cereals in the total value of imports with cereals among the whole world between 2003-2022



Source: Edited by the authors based on ITC data

The share of European Union and candidate countries' cereal imports in the world total has decreased, thus, there has been a significant global increase in the growth of cereal imports. Thus, in addition to crisis situations, reasons such as population growth or the transition of the agri-food sector towards high value-added products can be identified.

Exports

In the table from below, the value of export with cereals, expressed in euro thousand, in each European Union and candidate countries was presented, in the last column being calculated the increasing percent of the indicator from 2003 to 2022.

Table 2. List exporters countries of cereal among UE or candidate countries (euro thousand)

Exporters	2003	2008	2013	2018	2022	2022 /2003
World	34,669,774	71,342,827	93,219,467	94,915,469	171,939,014	496%
Total UE& candidate countries	8,258,382	18,765,467	27,433,059	24,928,227	46,323,848	561%
France	3,991,661	6,550,956	8,177,840	6,172,343	11,333,749	284%
Ukraine	355,364	2,517,292	4,796,771	6,130,993	8,761,665	2466%
Romania	17,359	621,927	1,995,884	2,158,052	4,383,578	25252%
Germany	1,262,974	2,577,717	3,256,141	1,668,279	3,573,666	283%
Poland	61,544	124,502	838,563	813,554	3,133,864	5092%
Bulgaria	58,992	454,805	1,189,249	1,038,477	1,890,748	3205%
Hungary	351,933	1,272,277	1,308,368	1,162,486	1,759,923	500%
Italy	352,922	813,876	608,711	626,636	1,135,015	322%
Lithuania	78,474	319,218	566,439	418,041	1,114,854	1421%
Czech Republic	107,996	299,099	503,626	487,470	1,043,502	966%
Latvia	19,305	183,954	301,882	362,275	1,002,610	5194%
Slovakia	34,892	141,499	259,092	279,402	796,276	2282%
Belgium	293,165	684,527	567,897	564,154	736,786	251%
Serbia		102,982	366,488	391,771	690,809	671%
Austria	179,589	308,770	385,976	366,746	678,252	378%
Netherlands	171,956	504,363	560,828	598,598	663,109	386%
Turkey	49,611	26,107	241,617	87,123	657,953	1326%
Spain	401,481	491,078	450,052	407,730	589,982	147%
Croatia	36,241	38,129	111,366	188,840	546,701	1509%
Moldova of Republic	16,338	34,161	90,919	188,552	391,213	2394%
Denmark	247,729	246,731	382,803	263,062	371,050	150%
Greece	50,086	168,311	116,380	132,687	298,976	597%
Estonia	2,552	44,674	92,734	105,411	289,150	11330%
Portugal	24,368	40,245	27,690	116,263	178,488	732%
Slovenia	1,807	10,972	33,823	51,875	100,065	5538%
Finland	60,532	124,384	131,046	80,167	83,401	138%
Ireland	19,695	32,281	26,389	18,820	63,879	324%

Exporters	2003	2008	2013	2018	2022	2022 /2003
North Macedonia	366	2,190	4,726	9,295	19,434	5310%
Luxembourg	8,297	9,373	12,370	19,210	18,093	218%
Bosnia and Herzegovina	122	992	10,376	12,053	8,718	7146%
Switzerland	996	2,106	2,271	6,634	6,206	623%
Albania	19	26	73	70	1,946	10242%
Cyprus	8	1,386	1,759	79	171	2138%
Montenegro		133	22	4	16	12%
Malta	8	14,424	12,888	1,075	-	13438%

Source: Edited by the authors based on ITC data

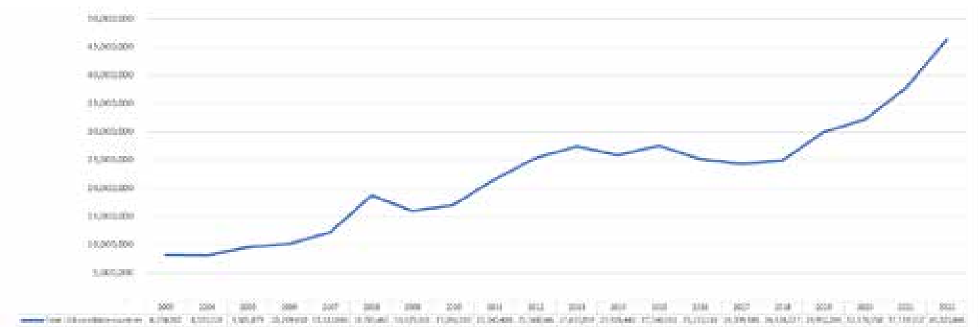
Among all EU and candidate countries, France it was the country that exported the highest value of cereals among all analyzed years, increasing its exported value with 284% from 2003 and 2022.

The largest increase in the value of exports is observed in Romania, which increased the value of cereals imports from 17,3 million euro in 2003 to 4,3 billion euro in 2022. This is because Ukraine's post-conflict exports passed through Romania.

Being a country with an important percent of cereal production, Ukraine is situated among the countries with the highest value of export of cereals.

Serbia's cereal exports are at the medium level, ranking 15th place in the countries analyzed.

Figure 6. The evolution of value of export among EU and EU candidate countries (Euro thousand)



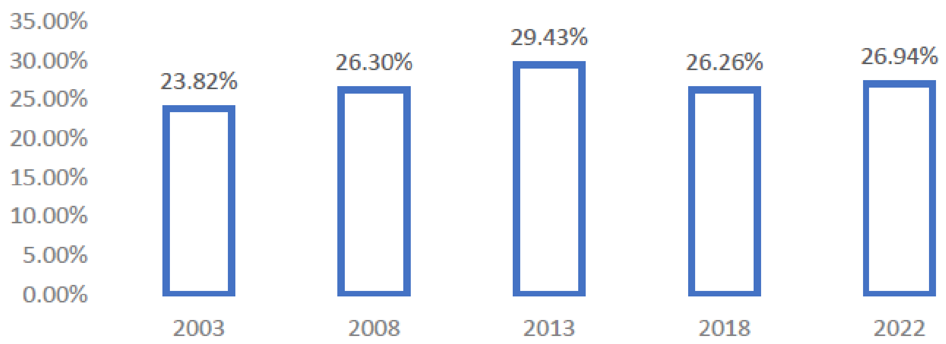
Source: edited by the authors based on ITC data

The value of exports among European Union and candidate countries increased with 496% from 2003 to 2022, but the biggest increase it was identified in 2022, a fact that can be attributed to the war between Russia and Ukraine.

In this situation, the share of cereal exports from the European Union and candidate countries in the world total is increasing, so it can be estimated that Ukraine (candidate country) contributes to this contribution.

Global exports should also match imports. Even though exports increased more during the period under review, the value of exports was lower than imports for the year 2022, so stocks can also be considered to have been affected.

Figure 7. The share of EU and EU candidate countries value of exports with cereals in the total value of exports with cereals among the whole world between 2003-2022



Source: edited by the authors based on ITC data

The share of European Union and candidate countries' cereal exports in the world total has increased with 3.1% from 2003 to 2022.

Trade balance

In the table from below, trade balance, expressed in euro thousand, in each European Union and candidate countries was presented 2003 to 2022. Trade balance is calculated as the difference between exports and imports.

Table 3. Trade balance among 2003-2022 period, euro thousand

Countries	2003	2008	2013	2018	2022
World	-4,008,906	-10,678,233	-4,084,426	-7,944,602	-17,489,240
France	3,568,779	5,785,837	7,404,594	5,354,027	10,171,012
Ukraine	-106,410	2,417,709	4,565,998	5,969,175	8,615,511
Romania	-292,800	323,792	1,668,486	1,835,784	3,415,683
Poland	-43,558	-460,690	510,893	418,803	2,001,417
Bulgaria	28,454	377,022	1,128,691	971,355	1,699,223
Hungary	316,865	1,154,538	1,164,873	1,002,618	953,619
Lithuania	58,733	241,040	498,693	337,343	926,274
Czech Republic	70,830	200,295	376,567	336,738	798,119
Latvia	14,209	123,112	233,439	160,323	712,043
Serbia	-	83,637	335,586	373,238	627,809
Slovakia	9,930	4,292	163,149	181,754	564,027
Croatia	11,717	-18,533	70,487	117,895	420,782
Moldova, Republic of	-8,653	18,896	81,372	170,177	329,678
Estonia	-12,038	24,860	64,220	84,817	258,133
Denmark	95,347	-188,902	142,386	-708	52,760
Montenegro	-	-9,219	-103,00	-7,827	-13,039
Macedonia, North	-20,814	-25,490	-21,314	-18,252	-27,629
Slovenia	-50,852	-64,251	-51,861	-32,736	-36,496
Malta	-23,837	-34,586	-31,362	-18,842	-46,074
Luxembourg	-6,416	-14,891	-29,951	-25,096	-54,758
Finland	23,314	71,559	92,239	29,767	-58,730
Albania	-41,055	-92,429	-90,686	-85,899	-99,249
Bosnia and Herzegovina	-29,884	-121,089	-99,040	-99,369	-169,116
Cyprus	-78,165	-130,459	-107,169	-106,348	-182,581
Austria	77,877	104,548	-74,811	-82,898	-303,782
Greece	-249,751	-274,057	-240,790	-267,560	-380,932
Switzerland	-133,238	-240,846	-263,043	-243,797	-487,447
Ireland	-107,358	-167,635	-278,497	-459,454	-638,662
Germany	524,838	504,255	763,225	-1,011,600	-672,747
Portugal	-429,145	-762,997	-718,939	-800,547	-1,264,670
Belgium	-598,375	-1,040,279	-1,382,144	-1,264,396	-2,363,216
Netherlands	-757,630	-1,940,487	-2,185,150	-2,256,966	-3,551,090
Turkey	-565,782	-1,426,537	-1,282,818	-1,627,765	-4,471,116
Italy	-1,146,658	-1,694,291	-2,138,040	-2,236,809	-4,801,708
Spain	-891,624	-2,086,537	-1,869,447	-2,751,345	-5,671,194

Source: Edited by the authors based on ITC data

Among 2003-2021, France, is the country with the higher values of positive trade balance, followed distantly by Bulgaria and Hungary.

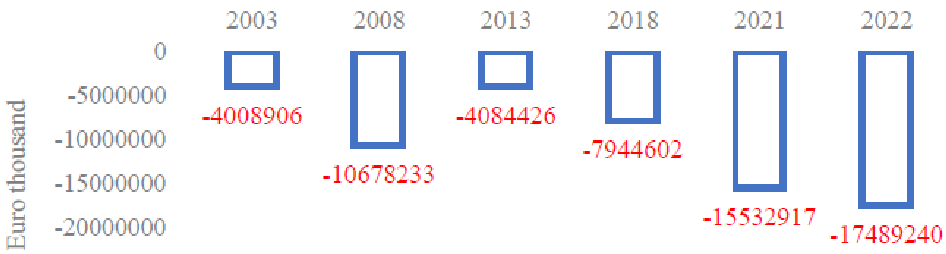
Regarding the deficits, Spain presents the highest deficit value (-5,672 billion euro in 2022), closely followed by Italy and Turkey.

From 2008 to 2022 Serbia increased its positive cereal's trade with 751%, exporting cereals more than importing.

In 2022, almost 50% of European Union and candidate countries presented a positive cereal's trade balance.

Having the biggest value of imports, Spain is the country with the biggest negative trade balance. Compared with 2003, in 2022 Romania it was in a much better position.

Figure 8. Dynamics of the total trade balance for cereals among the whole world (euro thousands)



Source: Edited by the authors based on ITC data

At the whole world level, it is visible that the deficit of cereals it is ranging in the last 10 from -4.08 billion euros in 2013 to -17.5 billion euros in 2022.

In 2022 the deficit it was the biggest from last 20 years (-17.5 billion euros), being the worst year in the last 20 years, from this point of view.

Compared with 2003, in 2022, the deficit it was the biggest (-17.5 billion euros), being the worst year in the last 20 years, from this point of view.

GINI coefficient

As a final analysis, we determined the degree of concentration of imports and exports for European Union and candidate country using Gini coefficient.

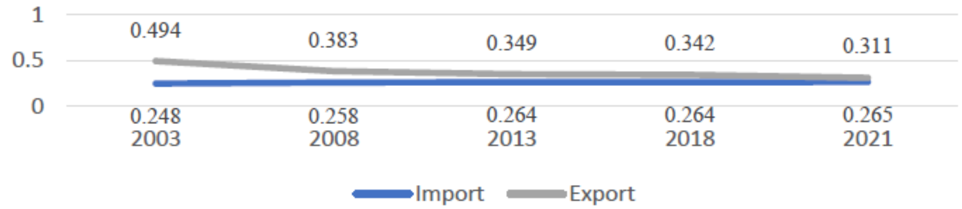
GINI coefficient represents the degree of concentration of imports and exports.

Table 4. Determination of the GINI coefficient on import and export values

GINI	2003	2008	2013	2018	2021	Average
Import	0.248	0.258	0.264	0.264	0.265	0.260
Export	0.494	0.383	0.349	0.342	0.311	0.376

Source: authors' calculations

Figure 9. Dynamics of GINI coefficient



Source: Edited by the authors

For imports there do not present high degree of concentration (GINI) imports are somewhat evenly distributed.

For exports, GINI coefficient shows us that among the 20 years analyzed, the concentration degree is getting smaller, in 2022 being under the average. This represents that the exports are more evenly distributed than the imports.

Conclusions

The bibliometric analysis revealed that very recently the attention of researchers being focused on food security, productivity, physico-chemical properties lead us to think about nutritional security; in a direct connection with the last events from the cereal market. The subject has been studied in countries like: United States of America, Canada, Germany, and also the countries with the most recent research in the field are Romania and Russia (in a lower extend).

Among a picture with the main characteristics and the dynamics of the cereals' foreign trade from European Union and candidate countries between 2003 and 2022 stand out:

- Spain imported the biggest value of cereals in 2022 (6.261 billion euro; +424 vs. the value from 2003). The largest increase in the value of exports is observed in Latvia, which increased the value of cereals imports from 5,096 euro thousand in 2003 to 290,567 euro thousand in 2022.

- France exported the biggest value of cereals in 2022 (11.333 billion euro; +284 vs.2003). The largest increase in the value of exports is observed in Romania, which increased the value of cereals imports from 17,3 million euro in 2003 to 4,3 billion euro in 2022.
- In 2022, almost 50% of European Union and candidate countries presented a positive cereal's trade balance. France, is the country with the higher values of positive trade balance, followed distantly by Bulgaria and Hungary, while, in terms of deficits, Turkey presents the highest deficit value (-3,239 billion euro in 2022), closely followed by Netherlands and Spain.
- Regarding the degree of concentration, imports did not show a high degree of concentration by country, while exports are more evenly distributed than the imports.

We consider that the goal given up at the beginning of the work has been fulfilled.

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THE GLOBALG.A.P. CERTIFICATION SCHEME IN SERBIAN AGRICULTURE: CONSULTANTS' ATTITUDES [1]

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Abstract

The authors examine the progress of Serbia in the implementation of the GLOBALG.A.P IFA standard, as well as the quality of the business environment for its implementation. Data on the number of certified producers were obtained from the GLOBALG.A.P. organisation which is the standard's owner. The business environment was assessed based on the results of the interviews with six representatives of domestic consulting companies which provide support to farmers in certification processes. The results show that although Serbia is making progress in this field (considering the number of GLOBALG.A.P. certified producers according to indicators), the percentage share of certified farmers in the total number of farmers is extremely low and can be expressed by parts per thousand. The authors identified numerous systemic problems in the process of the standard implementation, as well as the limitations related to high implementation and certification costs.

Key words: *sustainable agriculture, farm certification scheme, Serbia, business environment.*

Introduction

Throughout the literature authors strongly agree that it is required to monitor the environmental sustainability of agriculture, invest in new (cleaner and greener) agricultural technologies, while promoting more environmentally friendly and energy-efficient sector policies and applying environmental regulations in a stricter manner (Latruffe et al., 2016; Pasko et al., 2020; Uddin, 2020; Rad, Ray & Barghi, 2022; Mitić, Fedajev & Kojić, 2023). The response

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of public policies, traders and processors to the demands of consumers and society regarding a more intensive transformation of agriculture in terms of sustainability can be seen in numerous standards for food safety and quality, plant health, and animal health and welfare. This response is also reflected in food quality schemes which combine public regulations with private and voluntary agricultural product certification schemes in an increasing number of countries (de Raymond & Bonnaud, 2014; Popović & Paraušić, 2016; FAO, 2016; EC, 2020; Flachsbarth, Grassnick & Brümmer, 2020; EU, 2022).

The private scheme and the standards of GLOBALG.A.P. (Good Agricultural Practices for primary production and the supply chain) represent one of the leading international farm certification schemes for sustainable agriculture (EU, 2022). As stated by a group of authors (Laosutsan, Shivakoti & Soni, 2019, p. 878), "*good agricultural practices are important for the most important thing - that is human health followed by the economic value of the products*". GLOBALG.A.P. standards focus on sustainable agricultural practices, supply chain traceability, food security and safety, workers' well-being, and animal welfare (FAO, 2016; EU, 2022; GLOBALG.A.P. organisation website). They are requested as a trading requirement in the EU from farmers and exporters by retailers, supermarkets and processors (EU, 2022; GLOBALG.A.P. organisation website). The most significant GLOBALG.A.P. standard (resulting in the largest number of certificates) refers to the Integrated Farm Assurance (abbr. IFA) standard for fruit and vegetables (abbr. F&V) (GLOBALG.A.P. organisation website; GLOBALG.A.P. database). This is a standard for "*responsible farming practices at primary production level. It is built on a holistic approach that covers the key topics of food safety, environmental sustainability, workers' well-being, production processes, and traceability*" (GLOBALG.A.P. organisation website).

The compliance with the GLOBALG.A.P. IFA standard is increasingly becoming a prerequisite for exporting F&V to the EU market (and other high-income markets). Therefore, there is a clear impact of this standard on the international trade flows, global food supply chains, as well as on the competitiveness and export performances of companies and national economies in all countries worldwide, particularly in developing countries (Masood & Brümmer, 2014; FAO, 2016; Andersson, 2019; Fiankor et al., 2020; Flachsbarth, Grassnick & Brümmer, 2020; Amekawa et al., 2021; Rao, Bast & De Boer, 2021).

In the paper, the authors consider the progress of Serbia in the implementation and certification of the GLOBAL G.A.P. IFA standard in agricultural production, and they examine the factors of the business environment which affect this process, either by encouraging it or limiting and hindering it. The main objective of this paper is to provide recommendations to the relevant ministry for eliminating potential problems in the process of the standard implementation and creating a stimulating business environment for the more intensive implementation of this standard in the future.

Material and method

For the needs of the research, the authors used data on the number of GLOBALG.A.P. certified producers and certified area (crops base) in Serbia during the period from 2013 to 2022. Upon the authors' request, the data were provided by the GLOBALG.A.P. organisation based in Germany (GLOBALG.A.P. c/o FoodPLUS GmbH), which owns the standard. The interview method was applied to examine the factor of the business environment which influences (either positively or negatively) the processs of the standard implementation. In September and October 2023, the authors conducted 30-minute to one-hour long phone interviews with six consultants (from different consulting companies) whose knowledge and competences made them competent for the research topic. Comprehensive local and foreign literature was analysed, while descriptive statistics and inductive and deductive methods were applied to reach suitable conclusions.

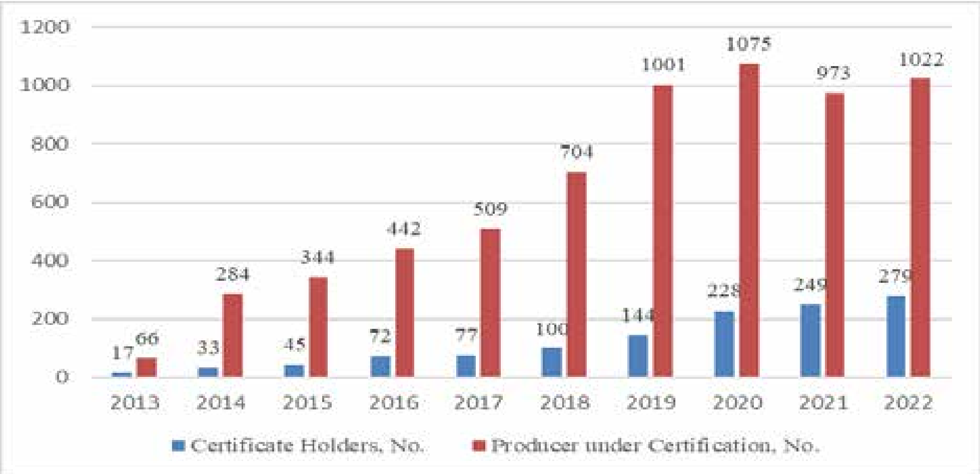
Achievements of Serbia in the implemetation of the GLOBALG.A.P. standard

Different quality schemes and food safety and quality standards are part of the national policy on the quality of agri-food products. This policy is under the jurisdiction of the Ministry of Agriculture, Forestry and Water Management (abbr. MAFWA), and the Sector for Rural Development (The Government of the Republic of Serbia, 2014).

For many years, MAFWA has provided support to agricultural producers who implement and certify primary production in accordance with the GLOBALG.A.P. farm certification schemes (co-financing the certification costs). However, the relevant ministry does not have the data on the number of GLOBALG.A.P. certified producers yet. In 2024, it is planned to establish an indicator

(GLOBAL G.A.P. certified producers as the % of the total number of farms) through its baseline and target values (The Government of the Republic of Serbia, 2022).

Graph 1. Certificate holders (group certification) and producers under GLOBALG.A.P. IFA certification in Serbia, crops base, 2013-2022, No.



Source: GLOBALG.A.P. database. Data obtained on the authors' request.
Note. For 2022, the period until June 30, 2022 is included.

According to the data obtained by the authors from the GLOBALG.A.P. organisation (the standard's owner), the certified area in plant production in Serbia increased by 38 times during the period from 2013 to 2022. Starting from 893 ha in 2013, it reached the area of 33,973 ha in 2022. The number of producers under certification rose from 66 in 2013 to 1,022 in 2022, while the number of certificate holders (group certification) rose from 17 (2013) to 279 (2022) (Graph 1). Although the number of producers under certification increased by more than 15 times during the analysed period, the percentage share of GLOBALG.A.P. IFA certified farmers in the total number of farms in Serbia is still extremely low and can be expressed parts per thousand.

Since the GLOBALG.A.P. standard is private (and voluntary), it is still not widely present in Serbia. The reasons for this are reflected in the following circumstances: (a) the domestic market of agricultural products does not set standards as a prerequisite for marketing products (except in the case of several large retail chains, such as Lidl or Delhaize); (b) a large number of small-scale farmers participate only in local markets and are insufficiently integrated into global food supply chains; (c) due to production, financial and many other limitations, a large number of small-scale farmers are unable to access the EU market or fulfil the strict EU standards regarding food quality and safety as well as the requirements of domestic retail chains (The Government of the Republic of Serbia, 2014; Bešić et al., 2015; Paraušić & Roljević Nikolić, 2020; The Government of the Republic of Serbia, 2022; Paraušić, Bekić Šarić & Babić, 2023).

Experiences in the implementation of the GLOBALG.A.P. standard in Serbia: the consultants' attitudes

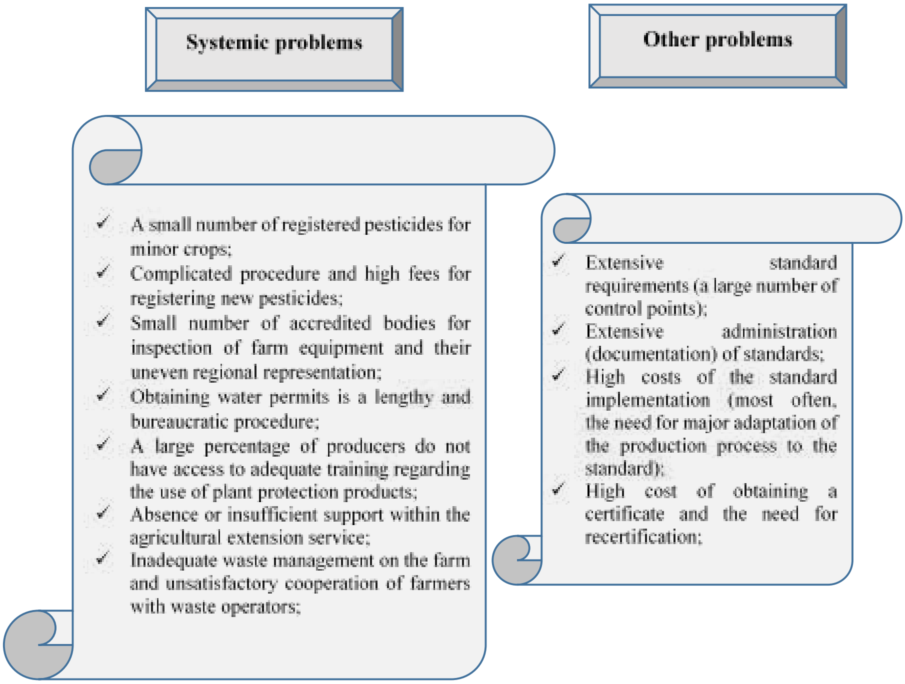
According to the information obtained in the interviews with the consultants providing services to producers in the implementation of the GLOBALG.A.P. standard, berries are most frequently certified in Serbia, followed by other fruits (apples, cherries, plums, sour cherries). When it comes to vegetables, the most commonly certified types are lettuce, tomatoes, peppers, cucumbers, peas, green beans, sweet corn, carrots and potatoes. In general, certification of vegetables is more prevalent in the region of Vojvodina, while fruit certification is more common in other regions of Serbia.

The interviewed consultants receive the largest number of requests for support in the standard implementation when it comes to individual certification (where the standard's holder is a cooperative, company and less frequently a family farm). These producers establish their production on large areas, and their production capacities can meet the demands of large buyers (in terms of the quantity and quality of deliveries). The holders of group certification are legal entities. These are most frequently refrigerated storerooms (which are often exporters of fresh and/or frozen F&V), and suppliers of fresh and chilled F&V that deliver to domestic and/or export markets.

The implementation of the GLOBALG.A.P. standard is most frequently demanded by buyers from the EU. Most certified producers have decided to use this standard because it increases their export possibilities. The standard implementation is additionally stimulated by the standard possession requirements (as a precondition for cooperation and entry into the supplier database) imposed by F&V processors (for example, by the company Frikom Ltd, Belgrade) and several large retail chains in the country.

Scheme 1. shows some of the most frequent limitations for greater GLOBALG.A.P. IFA certification, based on the perceptions of the interviewed consultants. In addition to these limitations, another obstacle to more extensive certification is the fact that agricultural producers frequently do not achieve higher (or significantly higher) selling prices on the market (domestic and/or foreign market) for certified F&V compared to uncertified ones.

Scheme 1. Limitations of GLOBALG.A.P. certification in Serbia, perceptions of the interviewed consultants



Source: Paraušić, Bekić Šarić & Babić (2023).

The relevant ministry provides the support to agricultural producers through the measure Introduction and certification of food quality systems, organic producers and products with the geographical indication of origin (50-65% certification cost reimbursement). However, the consultants highlight that this support is useful but not as crucial as the possibilities for marketing products, particularly to the EU market, which are offered by the standard.

Conclusion and recommendations

The IFA standard for F&V is an internationally acknowledged standard, as well as and the most significant and prevalent GLOBALG.A.P. standard. It is based on a holistic approach and focuses on the compliance with the principles of sustainable and responsible farm production. Since this is a private (voluntary) standard, it is still not widely represented in Serbia. However, the increasing demands of the EU retailers, supermarkets and processors towards farmers and exporters of F&V, and demands of a number of domestic retail chains lead to the rise of the number of GLOBALG.A.P. certified farmers in Serbia. Consequently, during the period from 2013 to 2022 (until June 30, 2022), the certified area in plant production in Serbia rose by 38 times (from 893 ha in 2013 to 33,973 ha in 2022). The number of producers under the IFA certification increased by more than 15 times, i.e. from 66 in 2013 to 1,002 in 2022. Nevertheless, the percentage share of GLOBALG.A.P. IFA certified farmers in the total number of farms in Serbia is still low and can be expressed by parts per thousand.

The interviews with the consultants who provide support to farmers in the implementation of this standard revealed numerous systemic problems which significantly impede and hinder the process of the GLOBALG.A.P. standard implementation. Several other limitations were also identified – extensive standard requirements, extensive administration requirements, high costs of implementation and certification. Another important obstacle lies in the fact that agricultural producers do not often obtain higher (or significantly higher) selling prices for certified F&V compared to the producers who sell uncertified F&V.

In the future period the increase in the number of agricultural producers within the GLOBALG.A.P. certification scheme will greatly depend on the financial strength of family farms, cooperatives and export companies implementing this standard. In addition, the systemic problems in this field must be solved. Being under the jurisdiction of the Government of the Republic of Serbia, this process involves institutional adjustments, i.e. amending/passing of appropriate laws and applying the existing regulations more efficiently.

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AN OVERVIEW OF THE EUROPEAN UNION WINE SECTOR DYNAMICS: AN EMPIRICAL ANALYSIS FROM THE ROMANIAN PERSPECTIVE

Violeta Sima[1], Ileana Georgiana Gheorghe[2]

Abstract

The European Union is the world's largest producer and exporter of wine, the wine sector being the export leader among the EU's agri-food sectors. Climate challenges, along with the increase in the price of electricity and the decrease in purchasing power, have challenged the world of wine. This paper aims to evaluate the general aspects of the evolution of the wine sector in Romania compared to the European Union. For the analysis, we used the following indicators: the area cultivated with grapes, wine production, in total and by owner, wine export and consumption, the average surface area of the vineyard. The main results of the analysis could serve as input for decision-makers in developing agricultural guidelines in terms of functionality and application in understanding developments in the wine sector.

Key words: *wine sector, wine production, vineyard surface area, wine consumption*

Introduction

Wine production in recent years has been a good one worldwide. But, against the background of the decrease in consumption in the period 2019-2022, to keep prices at an optimal level, the big producers had to destroy huge quantities. The main danger is that prices fall below production costs, which would create serious economic problems.

The countries at the top of the world wine market have taken radical measures to rebalance the overproduction situation. France has allocated 200 million euros to destroy surplus wine reserves to support producers. Initially, at the

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EU level, a budget of 160 million euros was established to eliminate the extra amount of wine. Still, the French government allocated 200 million euros to support this measure; it is necessary to stop prices from collapsing and producers becoming bankrupt.

The most affected producers in France are in the Bordeaux region, where some of the most expensive wines come from. One producer in three in the Bordeaux region has already been affected. French analysts say that the changes in consumption habits that led to the current crisis are mainly based on the increase in the cost of living and the effects of the pandemic, to which were added the new crises caused by the war in Ukraine.

For its part, the Spanish government has decided to allocate 2.7 million euros of European funds to destroy the surplus production of wine - measures to distil the overproduction to support Catalonia and Extremadura producers. The money was allocated both for the process of distilling the wine and for compensating the losses. Initially, Spain had allocated 15 million euros from European funds to offset the costs of destroying unripe grapes from vineyards - "green harvesting" measures. In this way, Spain has proposed to give up 40 million liters of wine in 2023.

Romania is less affected and could even take advantage of this context to achieve a better positioning on the world market. Romania took these measures during the pandemic - crisis distillation, green cutting and storage at the source; during 2020-2021, 42.9 million euros were allocated only for distillation.

Romania produced, in 2023, more wine than in 2022. From the data collected by the International Office of Vine and Wine (OIV) and analyzed by Wines of Romania, a platform promoting Romanian wine, Romania is among the first four countries with increasing wine production this year. Globally, wine production in 2023 is estimated to average 244 million hectoliters, 7% less than last year, representing a decline in output to a level not seen in the previous 60 years. But 4.4 million hectoliters of wine were produced in Romania this year, 15% more than in 2022 and 4% more than the average of the last five years. Specialists in this market say that the current situation could be a good opportunity for Romania, which we could take advantage of, to join the ranks of the big players at the international level.

Data and methodology

The main goal of the research is to perform a study regarding the general aspects of the evolution of the wine sector in Romania vis-à-vis the European Union. To achieve this objective, we have analyzed representative indices, such as the area cultivated with vines, wine production, the export and consumption of wine, the number of vineyards, the average surface area of the vineyard, and the ratio between the area dedicated to the production of high-quality wines and the one devoted to the production of table wine. The data sets were extracted from the Romanian National Institute of Statistics databases and Eurostat. Regarding the methodology, we used descriptive analysis of variables and augmentation to identify the main trends, limits and future developments.

Results and Discussions

Trends in the wine sector

In the last decade, the dimensions of vineyards in the European Union (EU) have not changed significantly; they have stabilized at an area of 3.3 million ha. This situation can be considered to be due to EU regulations. These regulations, imposed starting in 2016, allow the member states to authorize new plantings with an annual increase of up to 1% of the areas already planted by each member state (European Parliament, 2013).

Among the EU member states, Spain is the most important wine producer. Thus, the wine-growing area of Spain was 964 thousand ha in 2021, with an increase of 0.4% compared to 2020. However, it decreased by almost 1% in 2022, up to 955 thousand ha. In contrast, France, the country ranked second in wine-growing area, continuously increased by 0.2% in 2021 compared to 2020 and by 0.8% the following year, reaching 812 thousand ha in 2022 (Roca, 2022). After five years of continuous growth, Italy has maintained the same level of 718 thousand ha of surface cultivated with vines as of 2020 (Khan, Fahad, Naushad, & Faisal, 2020).

Most of the other EU countries important in the wine sector recorded decreases in 2021 compared to 2020: Portugal (-0.2%), Romania (-0.7%) and Hungary -1.2%). Portugal and Romania also decreased in 2022 by 0.5% each, reaching 193 thousand ha and, respectively, 188 thousand ha. Germany kept the wine-growing area constant at 103 thousand ha, a figure by the average of the last twenty years.

Wine production in the EU has been affected in recent years by weather conditions. Thus, in 2021, this was 153.7 million hl, representing an 8% decrease compared to 2020, 5% below the average of the last five years. Instead, in 2022, it registered an increase of 4%, reaching 161.1 million hl. Italy, France and Spain contributed approximately half of the world's wine production. Thus, in 2021, Italy, with 50.2 million hl, France, with 37.6 million hl and Spain, with 35.3 million hl, represented 47% of the world's wine production. In 2022, although Italy's wine production dropped to 49.8 mil hl and Spain's to 35.7 mil hl due to France's production increasing to 45.6 mil hl, they gave 51% of worldwide output (WWTG, 2017).

In the rest of the EU member states, only Germany and Hungary recorded decreases in wine production in 2021. Thus, Germany's production decreased by 5% compared to 2020 due to unfavorable weather conditions that affected certain parts of the country. Hungary's production (2.6 million hl) in 2021 is 12% lower than in 2020 (Roca, 2022).

All other important EU wine-producing countries saw positive changes in production levels. Thus, in 2021, wine production reached 7.3 million hl in Portugal (14% increase), 4.5 million hl in Romania (+16%), 2.5 million hl in Austria (+3%) and 2.4 million hl in Greece (+ 6%). It is noteworthy that Portugal's 2021 wine production has been at its highest since 2006. In 2022, Germany's wine production increased by 6%, reaching 8.9 million hl. On the other hand, wine production decreased in Romania (-19%), Greece (-14%), Portugal (-8%), Hungary (-6%) and Austria (-5%) (Roca, 2022).

Italy is the largest producer of grapes in the EU, with 8.15 million tons of grapes in 2021, followed by Spain (6 million tons) and France (4.5 million tons), according to Eurostat.

Trends in wine consumption

In 2022, the EU, with an estimated wine consumption of 111 million hl, represents almost half of the world's consumption (48%). This value is 3% above the level of 2020, affected by the Covid crisis (110.5 million hl, one of the lowest volumes ever recorded), but 2% below 2021 (114 million hl) (Pirvutoiu & Popescu, 2013). In terms of importance in world wine consumption, the share of the EU has decreased significantly compared to 2000, when it was estimated at 59% of world consumption. This is the result of the effect generated, on the one hand, by the growth of new markets and, on the other hand, by the decrease of traditional consumption in the EU wine-producing countries by about 15%, meaning about 20 million hl, compared to the year 2000 (Roca, 2022).

Among the EU countries, France remained the most significant consumer (Alonso Ugaglia, Cardebat, & Jiao, 2019) in 2022 (and the second largest in the world), with a consumption of 25.3 million hl, slightly above the volume of 2021 (25.2 million hl). In 2022, Italy, occupying the second position among the EU markets and the third position worldwide, had an estimated level of wine consumption of 23 million hl, being 5% below that of 2021, when the highest level of wine consumption in this country was recorded since the 2008 global financial crisis.

Although wine consumption continues to decline in Germany, it maintains its position as the third largest consumer within the EU (and fourth worldwide), registering a level of 19.4 million hl in 2022 3% lower than in 2021). Recovering from the restrictions of the health crisis, Spain increased its wine consumption in 2021 compared to 2020 by 9.9%, reaching 10.5 million hl, and registered a slight decrease in 2022, reaching 10.3 million hl (Roca, 2022).

Similarly, in 2021, countries such as Romania (4.0 mil hl, +4.6% compared to 2020), the Netherlands (3.8 mil hl, +3.4% compared to 2020), Austria (2.4 mil hl, +2.3% compared to 2020) and the Czech Republic (2.3 mil hl, +11.9% compared to 2020), saw increased wine consumption levels in 2021. While wine consumption levels decreased in 2021 in Portugal (4.6 mil hl, -0.6% compared to 2020), Belgium (2.5 mil hl, -4.1% compared to 2020), Greece (2.2 mil hl, -0 .4% compared to 2020), and Sweden (2.1 mil hl, -0.3% compared to 2020), the decreases being not only compared to 2020, but also to the averages of the last five years (Roca, 2022).

In 2022, increases in wine consumption were recorded only in the Czech Republic (+0.3%), while decreases were recorded in the other countries; thus, we should mention Belgium with -15%, Sweden with -6%, the Netherlands with -3.6%, Austria with -0.4% and Romania with 0.2%.

Trends in Romania

Romania had a total production of grapes of 990,000 tons in 2021, thus ranking fourth in the list of the largest producers in the European Union, according to data from Eurostat, the European statistical office. However, in 2022, due to the drought, the total production of fruit vineyards in Romania (covering an area of 160,000 hectares) decreased to 808,000 tons, according to INS data.

The production of grapes in 2023 is promising and could exceed that of 2022, with 808,000 tons. Romania thus remains among the top five largest producers of grapes in the European Union.

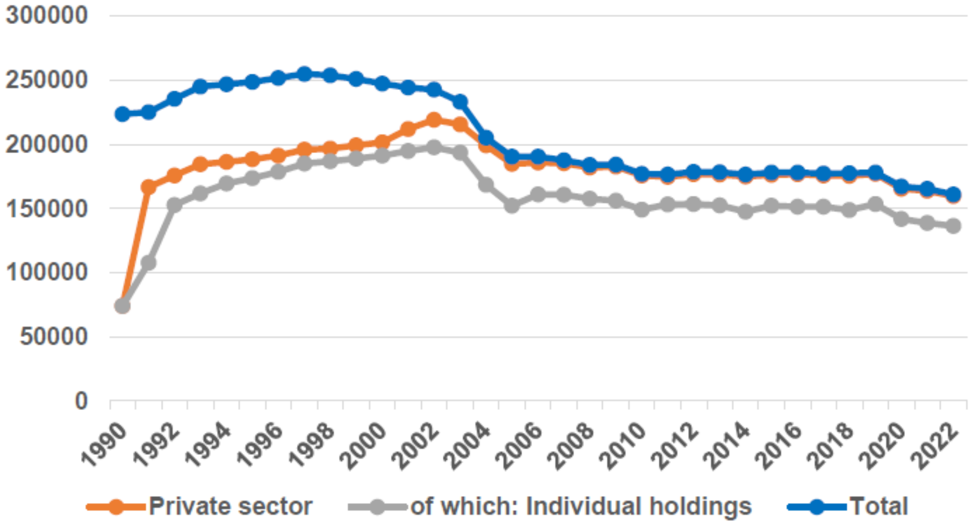
Developments in the production of grapes and wine and the specialization of farms

Chart 1 presents an overview of the evolution of the *areas of the vineyards in bearing,* for thirty-three years in Romania between 1990 and 2022. During 1990-1998, a slight increase in the total area is observed. Also, the substantial increase in the share of the private sector in the first year is worth mentioning. It continues to grow, but at a slower pace until 2002, as does the share of individual holdings. This increasing evolution is due to the state of emulation of the farmers after the re-entry into private ownership of the majority of vineyards in Romania (Popescu, 2013). A period of decreasing surfaces follows until 2005, an effect of the economic crisis (Pirvutoiu & Popescu, 2013). Areas under vines remain relatively flat until 2019, indicating stable conditions. After 2019, the decline starts again. This decrease may represent the effect of factors such as the COVID-19 crisis, changes in agricultural policies in the EU, the evolution of inflation or other changes in the economic-social environment.

In 2021, Romania owned 2.6% of all the area cultivated with vines worldwide. This value places the Romanian market in the top ten worldwide. Spain, France, China and Italy are at the top of this ranking, each with over 700,000 hectares. Turkey and the USA follow, with areas around 400,000 hectares, and Argentina, Chile, Portugal and Romania, with areas around 200,000 hectares.

Romania has not expanded its area planted with vines for more than five years, and even, as we have shown, after 2019, there is a slight decrease, below one per cent per year, but it continues. Italy, China and France are the only countries among the top ten ranked worldwide, with an increase from 2016 to 2020. Also, in the same countries, the cultivated area increased in 2020 - the first year of the pandemic - compared to 2019. As for Romania, the money invested in the field in the last decade - primarily European funds - were used for the conversion of existing vines, not for planting new areas.

Chart 1. Evolution of the areas of the vineyards in bearing by ownership form in Romania (ha)



Source: National Institute of Statistics of Romania (online data code: AGR111A)

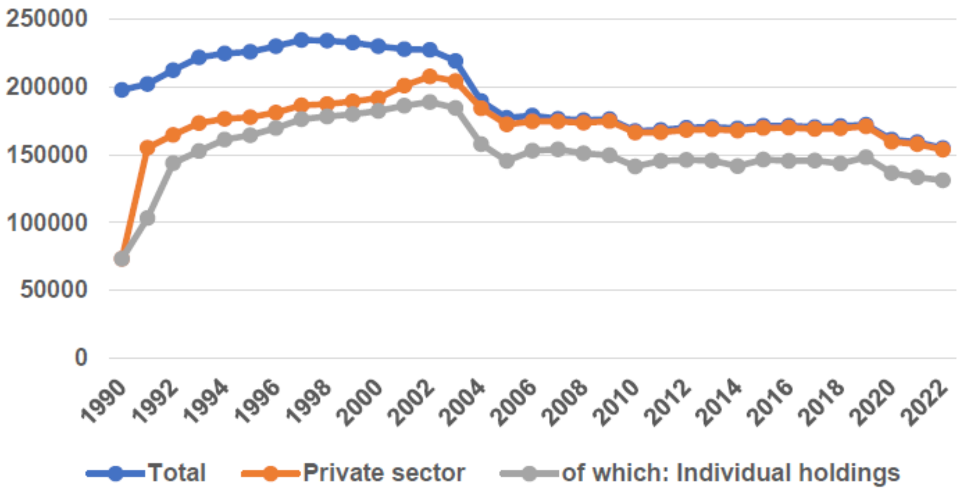
Chart 2 shows the evolution of *the areas of the wine grape vineyards in bearing by ownership form in Romania*. They increased during 1990-2002, the growth being more robust in the first three years. A steeper decline occurred in 2003-2005, followed by a period of relative stability until 2019, after which the decline resumed, an effect of the health crisis and the decrease in wine consumption worldwide.

The last few years have brought changes in the profile market, starting with the programs for the reconversion of vine crops and those carried out through the National Rural Development Program. Massive investments in winemaking capacities also had a positive impact, developing new wine production units.

Another interesting aspect regarding the vine plantations in Romania is that approximately 66% of them are over 30 years old, our country being outranked from this point of view only by Bulgaria, where the percentage reaches almost 69%.

At the same time, according to Eurostat, 27.9% of the total area occupied by local vineyards is dedicated to producing high-quality wines; the remaining 72.1% of the entire local area goes to producing table wine.

Chart 2. Evolution of the areas of the wine grape vineyards in bearing by ownership form in Romania (ha)

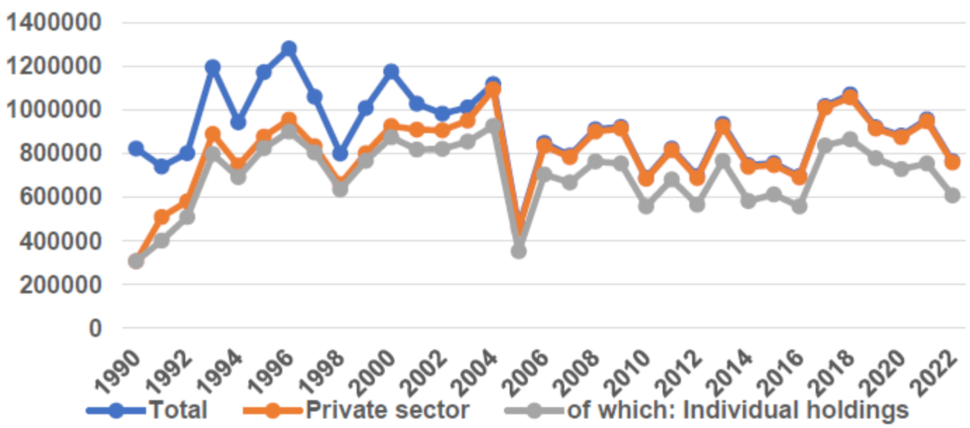


Source: National Institute of Statistics of Romania (online data code: AGR111A)

Regarding wine grapes production (Chart 3), 2021 stands out. After over seven years of losses, 2021 represented a revival of the Romanian grape and wine market. Growers recorded massive productions due to favorable weather conditions. These results placed Romania in sixth place among the top European grape producers. Despite the decrease in wine production worldwide from 2021, the wine market in Romania recorded the most significant percentage advance among European states.

Looking at the evolutions presented in Chart 3, it can be seen that they are not totally consistent with those in Chart 2. These differences could result from factors influencing grape production that differ from one country to another. Among these, the most frequently cited are climate and local conditions, access to agricultural solutions and, last but not least, cultural traditions, which can affect the quantity and quality of grapes that a given country produces from year to year.

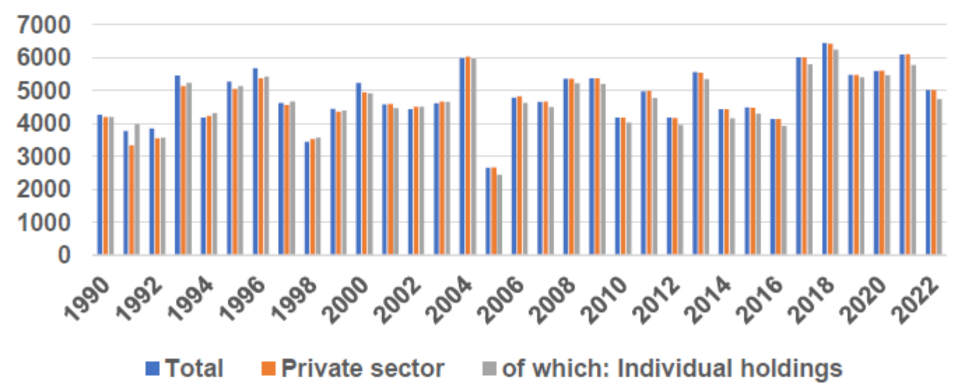
Chart 3. Evolution of the production of wine grapes by ownership form in Romania (to)



Source: National Institute of Statistics of Romania (online data code: AGR112A)

Chart 4 shows that the average production of grapes per hectare fluctuated throughout the analyzed period. There are also significant differences in grape production from one wine-growing area to another. Another aspect worth mentioning is that production is higher in the private sector.

Chart 4. Evolution of the average production of grapes per hectare, by ownership form in Romania (kg/ha)



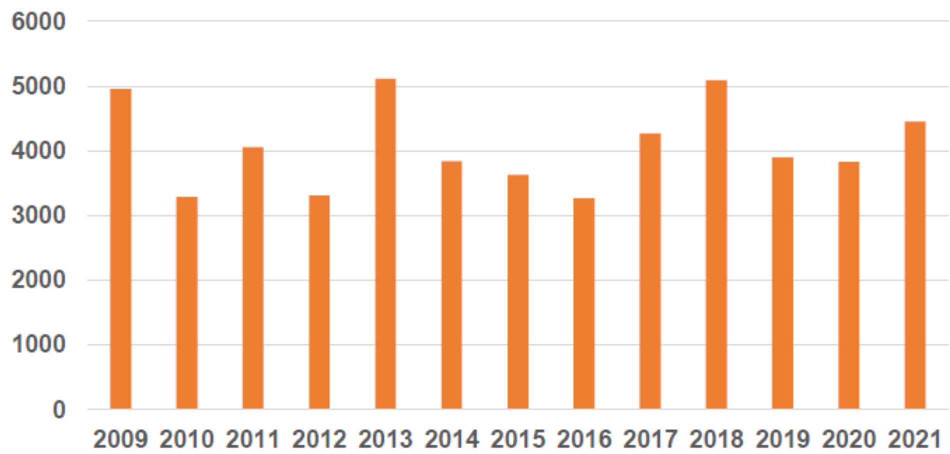
Source: National Institute of Statistics of Romania (online data code: AGR113A)

Chart 5 shows that wine production in Romania fluctuated between 2009-2021. Romania is among the top ten wine producers in Europe and the top 20 world producers regarding the amount of wine produced.

2021 was excellent for Romanian wine producers, primarily due to the weather favoring production. Romania climbed up to 6th place in Europe.

However, less than 10% of the wine produced in Romania ends up being exported after not even passing the 5% threshold in recent years. The value of the wine sold abroad was 30-35 million euros last year.

Chart 5. Evolution of the wine production in Romania (thousands hl)



Source: Eurostat

In 2021, Romanian wine exports reached 174.0 thousand hl, worth 34.2 million euros, increasing by 10.7% in value terms compared to the previous year. Despite good production, exports do not exceed 7% of the annual output. Romania ranks 32nd worldwide.

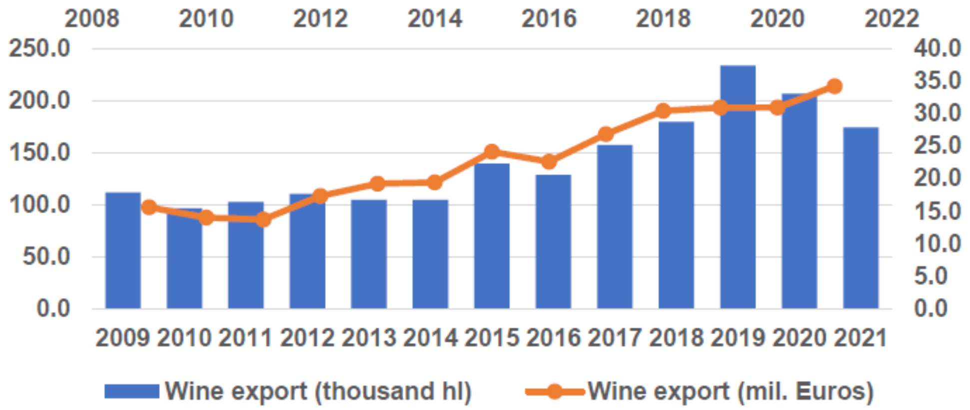
Until 2018, Romania did not exceed more than 3-4% of production for export.

Romania is a country that imports more than it exports in the field of wine. The desire to reach foreign markets is small because most of the production in Romania is consumed by the domestic market, and the production cannot be easily increased to satisfy the export as well, according to an analysis by Cory Lipoff, an expert in the field. It shows that one in ten Romanians chooses to drink wine approximately once a week, with young people and women being more active in this regard. According to European statistics, every Romanian consumes an average of 27 liters of wine per year.

Although Romania exports little wine, it also sells it cheaply. According to the producers' data, the value of exported wine is 1.5-2 euros per liter.

The preferred destinations for Romanian wines are the USA, Canada, Switzerland, and Japan.

Chart 6. Evolution of the wine export for Romania



Source: Eurostat

With an average annual consumption per capita of approx. 25 liters and a production of around 4.5 million hectoliters in 2021, Romania ranks 13th in the world in terms of consumption. According to data from the International Organization of Vine and Wine, Romania is the sixth largest producer in Europe. There are over 250 active wineries at the local level, and most of the Romanian wine production, in a proportion of over 90%, remains on the domestic market, the Romanian consumer preferring domestic productions to the detriment of imported ones.

Conclusions and Explanations

Productivity per hectare, rising energy, labor and transport costs, solid domestic demand and consumer nationalism define the operating framework of the Romanian wine industry. One explanation is that, of the 188,000 hectares, only about 110,000 are modernized, economically efficient plantations.

Apart from the previously mentioned factors, the main forces that will influence the evolution of the domestic profile industry seem to be the decrease in purchasing power and the intensification of the medical discourse in the direction of reducing the consumption of alcohol of any kind, as well as an increase in competition from neighbor's across the Prut (Romania is the main export market - and the fastest growing - for wines from the Republic of Moldova, often perceived by consumers as "Romanian wines") and from other categories of alcoholic beverages with very dynamic international marketing.

Externally, the Romanian wine market will be influenced by the evolution of domestic demand, as well as the productivity of the industry as a whole, in the global climate context - it should be remembered that the production of the European Union in 2023 is estimated at the lowest level in the last 60 years, in while that of Romania increased. Last but not least, the desire and ability of the industry to build a "country image" for Romanian wine will also matter.

Despite the difficult climatic conditions and significant decreases in production in other European countries, such as Greece, Croatia, and Spain, Romania is establishing itself as a key player in the European wine landscape. Although significant reductions in global wine production from 2023 can be seen, Romania is consolidating its position on the world map of wine producers.

Although challenges continue to exist, the increase in production in Romania is considered good news, reflecting the maturation of the domestic wine market. With the continued promise of the quality of Romanian wines and the diversification of the offer, the Romanian wine industry seems ready to establish itself internationally in the coming years.

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ANALYSIS OF AGRICULTURAL POLICY DEVELOPMENTS IN SERBIA[1]

Vlado Kovacevic[2]

Abstract

The aim of the paper is to analyze the measures of agricultural policy and provide recommendations for its improvement. The Republic of Serbia implements agricultural policy measures at the national level, at the level of the Autonomous Province of Vojvodina, local self-governments and within the framework of the IPARD program. In addition to the above, the arrector also has other measures of support from various donors. In the work, the research method of literature review of legal regulations, the scope and measure of subsidies and the effects of the mentioned measures was supported. The most significant results that have been evidenced are the dominance of directly coupled subsidies, while the share of rural development measures has decreased. Furthermore, the legal framework was analysed and the existence of numerous systemic limitations are evidenced, negatively affect the Serbian agriculture competitiveness, protection of the environment and human health. The need to improve the legal framework is particularly significant in the sector of farmers' interest associations, regulation of GMO, control of pesticide traffic, etc.

Key words: *Agricultural support, IPARD, Rural development.*

Introduction

Main aim of this research is to analyze budgetary support to agriculture as well as legal framework. As sufficient support for the agricultural sector is crucial for increase for competitiveness in this sector, but supportive legal framework for doing business must not to be overlooked.

Serbia agricultural sector it characterized with low productivity (Kljajić et al., 2023), lack of risk management tools, farmers literacy (Radović, 2020). This deficiency is often compensated for by the lower costs of labor, energy, and land.

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on agricultural production in Serbia is the chronic lack of financing. Agricultural producers frequently struggle to get loans (Popović et al., 2018). Rural tourism activities as a complementary activity to rural households' budget are emerging (Nedeljković, 2022; Vuković and Kljajić, 2023).

Another critical limitation to Serbian agriculture lies in the unfavorable farm structure, dominantly with small and fragmented land parcels. This farm structure often hinders the attainment of competitiveness through economies of scale. Instead, the potential lies in the production of value-added products such as organic and geographical indications production (SWG, 2020; Nedeljkovič et al., 2022).

Another challenge in the development of agriculture in Serbia is the limited activity of cooperatives. The cooperative sector in Serbia significantly lags behind that of the European Union in terms of business activity, assets, and the number of cooperative members. As a consequence, small farms facing high input costs, challenges in marketing their products, and absence of storage and processing capacities, which are readily available to their counterparts in the EU (Milovanović and Kovačević, 2017). According to same authors, reasons for limitation in cooperative activities is found in inadequate legal framework and total absence of support measures toward cooperatives.

Serbian agricultural policy is strongly influenced by the EU accession process. The EU accession and alignment of national legislative with EU acquis as well as the EU pre-accession support play pivotal roles in compelling Western Balkan nations to align their agricultural policies with the Common Agricultural Policy of the EU (Erjavec et al, 2021).

The national policy framework relies on financial support through subsidies. These subsidies are predominantly implemented as direct coupled payments. Rural development measures are executed as a low percentage of the total investment value. The beneficiaries of national support encompass both individual and legal entities registered in the Farm Register (Radović, 2014.; Zubović and Jovanović, 2021). The rest of the paper is organized as follow: the methodology of the work and the analyzed incentive measures as well as the overall legal framework. Based on the conducted research, it is summarized.

Material and methods

The methodology employed in this research is:

Literature Review:

- In-depth exploration of existing scholarly literature in the agricultural sector.
- Comprehensive examination of relevant legal framework, studies, theories, and best practices to establish a strong knowledge base.

Stakeholder Consultations:

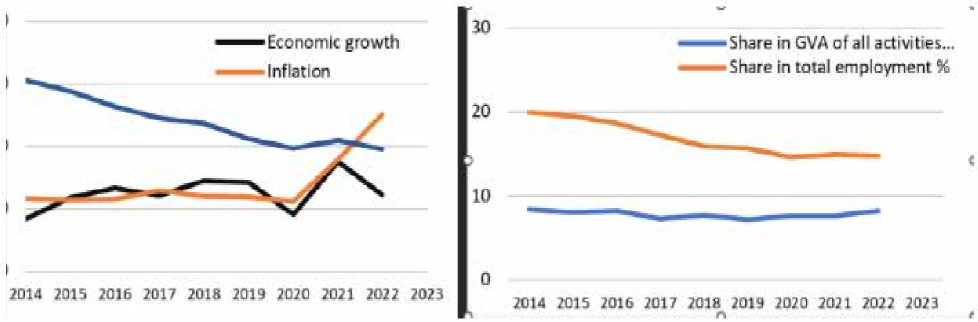
- Key stakeholders in agriculture.
- Capturing valuable insights and perspectives from experts, practitioners, and decision-makers.

The main data sources are SORS and SWG.

Discussion

Agriculture is one of the most important sectors in Serbian economy (Figure 1).

Figure 1: Economic growth (real change in GDP), inflation rate, unemployment rate (left) and share of AgGVA in all activities, share of Ag employment in total employment (right) (%); 2013-2022



Source: SORS

Agriculture is rare sector of Serbian economy with constant foreign trade surplus (Table 1).

Table 1. Foreign trade balance in agricultural products 2014-2022

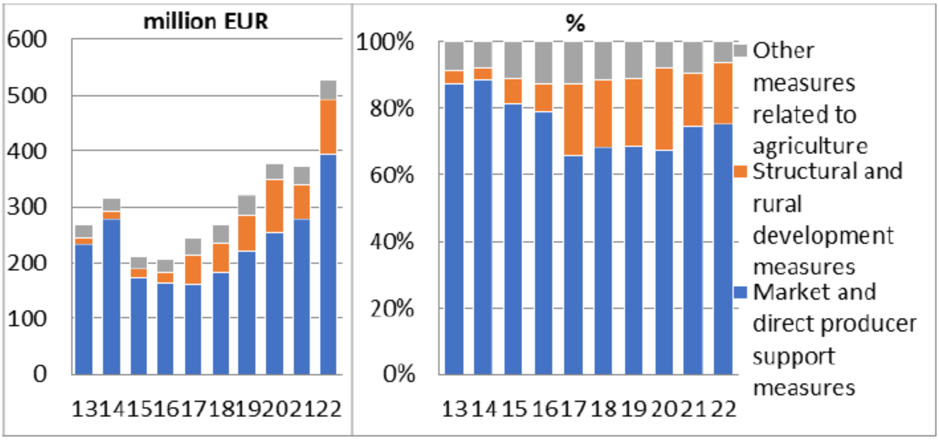
	2014	2015	2016	2017	2018	2019	2020	2021	2022
Exports	2.294,7	2.560,2	2.889,6	2.817,1	2.851,5	3.246,2	3.643,4	4.210,4	4.790,6
Imports	1.255,4	1.359,8	1.392,9	1.609,8	1.705,0	1.866,8	2.047,8	2.377,6	3.145,3
Trade balance	1.039,3	1.200,4	1.496,7	1.207,3	1.146,5	1.379,4	1.595,7	1.832,8	1.645,3

Source: SORS

It should be noted that structure of foreign trade is not favorable as Serbia is exporting low value mostly raw products, while on import side added value products are prevailing.

The foundation of Serbian agriculture is defined by the Strategy for Agriculture and Rural Development of the Republic of Serbia 2014 to 2024. While support measures are delineated by the Law on Agriculture and Rural Development and Law on Subsidies in Agriculture and Rural Development. Budgetary expenditure for agriculture is increasing (Figure 2).

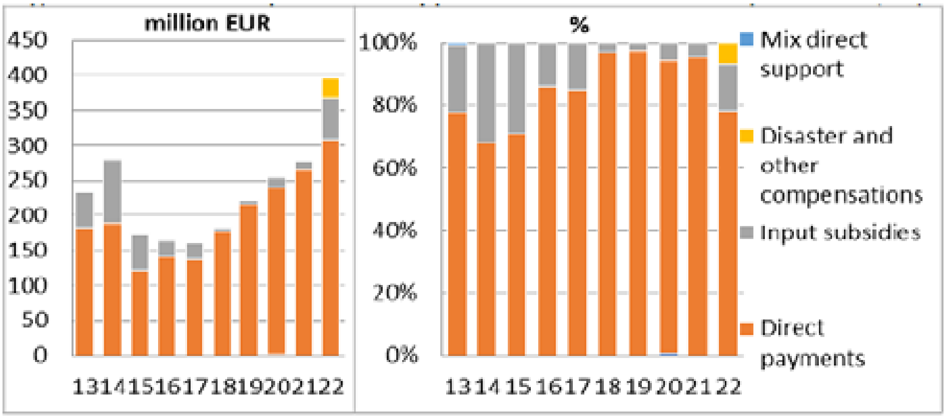
Figure 2. Agrarian budget 2013-2022 (million EUR; %)



Source: SWG, 2022

Most of subsidies are direct payments, through area-based and per-animal payment schemes. Moreover, significant financial support is channeled through supplementary mechanisms such as the milk premium, which is linked to production levels. When looking at specific product categories, the dairy industry stands out as receiving the most substantial support, especially for raw milk.

Figure 3. Market and producers support measures 2012-2021 (mill. EUR; %)

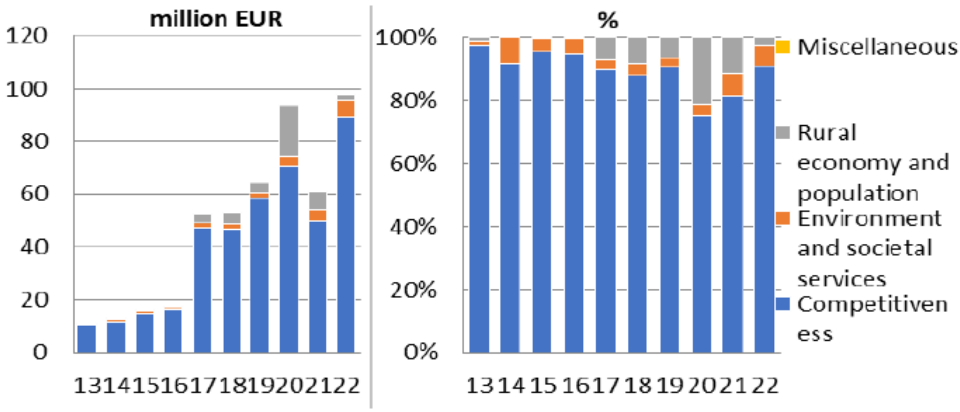


Source: SWG, 2022

Serbian coupled direct subsidies are not allowed by the EU regulations.

It can be stated that the stabilization of livestock production is attempted with little success by increasing subsidies. The basic systemic problem of Serbian livestock sector lies in the fact that the production and use of GMO animal feed is prohibited, while the import of animal products produced with cheaper GMO feed is allowed. In this way, Serbian livestock farmers are put in an unfair position, and the systemic problem is being solved with increased direct subsidies. At the scheme 4 rural development measures composition are presented.

Figure 4. Rural development measures 2012-2021 (mill. EUR; %)



Source: SWG, 2022

Beside national envelope Serbian Regarding the IPARD is available for Serbian agriculture. The IPARD II Programme will be succeeded by the commencement of the IPARD III Programme by the end of 2023. Total EU budgetary support in IPARD III totaling 288 million EUR. New measures are introduced within the IPARD III: agro-ecological-climate measures and organic production measures (Measure 4), local rural development strategy implementation via the LEADER approach (Measure 5), and investments in public rural infrastructure (Measure 6).

Regarding the institutional and regulatory framework, Serbia has a long way to go in establishing the institutional and regulatory framework. The need for further improvement in this area of analysis within this research is defined in the most important areas:

- IACS and LPIS systems need to be established;
- CMO regulation is adopted in Serbia and detailed regulations on producers' organizations and market interventions are awaiting;
- Serbia is rear Western Balkan country without full control of pesticide trade. Aldo the Law on pesticides prescribe that only registered users can purchase pesticides and introduction of central evidence on pesticide trade, this system is not in place.
- Insurance as a most important risk management tool is not fully developed in Serbia. Some approximation is that insurance coverage is around 5% of agricultural land. Structure of insurance is another problem dominating single peril insurance and lacking yield insurance.
- Legal framework on cooperatives is limiting further development of cooperatives in Serbia, while support measures are not in place.
- There is no guarantee institution in Central Serbia to support farmers in access to loans.
- Further progress in agricultural statistics as a main driving force toward evidence based agrarian policy is needed. The definition of rural areas is in accordance with OECD scheme instead of EU Degurba regulation.
- Initial success with public warehouse system allowing farmers to lend against stored products are limited with lack of inspection control on public warehouses.

Conclusion

The main conclusions drawn from this research are as follows:

- Shifting from coupled subsidies to rural development is necessary.
- Absence of the Integrated Administration and Control System (IACS), which hampers the full adoption and control of subsidies.
- The identification of Areas Facing Natural or Other Specific Constraints (ANCs) and public awareness regarding "green" policies remain areas in need of improvement. The definition of rural areas is in accordance with OECD scheme instead of EU Degurba regulation.
- Ongoing efforts to align policies, enhance awareness, and establish the necessary systems will be crucial for Serbia's agricultural sector as it progresses towards EU integration.
- In terms of institutional and legal frameworks, there is substantial room for further improvement in enhancing the competitiveness of the Serbian agricultural sector and ensuring environmental and health protection. Key areas for improvement include the enhancement of the cooperative legal framework, the introduction of producer organizations, and structural support for farmers' associations. Additionally, addressing the regulation of GMO issues, market interventions, and the regulation and control of pesticide use, as well as the introduction of agricultural insurance tools, are vital steps to promote the development of comprehensive insurance and increase insurance coverage.

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COMPLEX BUSINESS SYSTEM MANAGEMENT IN AN AGRO-INDUSTRIAL COMPLEX[1]

Zoran Simonović [2], Biljana Ilić[3]

Abstract

Management of business functions in the business system also includes management in agricultural production. It indicates that the production process, other company operations (procurement, sales, and finance), and the work, means of production, products of production, and technology are all harmonized. Production management's primary objective is to maximize the economic benefits; all other secondary goals (technological, social, and production) must serve this primary objective. When achieving goals, it should also take care of ecology. The management model of a complex business system connected to the agro-industrial complex, which will comprise independent variables and constraint matrices, will be the main topic of the study.

Key words: *Agricultural management, business system, economic objective, independent variables, constraint matrices.*

Introduction

Specificity in the sphere of production management manifests itself in all phases, as well as at all levels. The complexity and specificity of agricultural management are conditions by the existence of production dependence by the need to make the most of the potential synergy hidden in them. (Novković & Šomođi, 1999). The skill of agricultural production management lies precisely in the fact that the potential production synergy is maximally used and valorized through the economic efficiency and effectiveness of the business system as a whole (enterprise, cooperative, or peasant farm. Based on the above, the requirement arises that the integrity and hierarchy of management are the char-

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acteristics of management business systems in agriculture and agro-industry. Integrality, management, as a feature implies that the subject is the business system as a whole (with respect and use of the specificities of individual subsystems) to achieve maximum overall economic effectiveness at defined (satisfactory) levels of efficiency. (Šomođi et al., 2006) The integrality of agricultural production management implies the maximum synchronization of production factors and the achievement of the optimal synergy of horizontal and vertical production structure, i.e., the integration of the optimal level of intensity of individual production lines and the optimal production structure to achieve maximum economic effectiveness (Novković et al., 2015). Integrality implies the complete management of functional and development production processes to realize the economic effects of the production process in a rather short period, for which it is necessary to ensure continuous growth of production capacity and production results through development processes. Hierarchy, as a characteristic of production management, implies that individual management decisions are not equally significant or equally inclusive. In other words, the hierarchy of agricultural production management means the necessity of the division of decision-making (Novković & Šomođi, 2016) In the case of large business systems in the agro-industry, all strategic share of tactical decisions at the headquarters levels and the other part of tactical and operational management decisions are brought at the level of individual subsystems, i.e., organizational units. Production management implies the temporal and essential synchronization of strategic, tactical, and operational management decisions and activities at each of the mentioned management levels which is necessary to harmonize the four head phases of the management process - planning, organization, management, and control. (Drinić & Ceranić, 2018). An essential element of successful management, i.e., achieving maximum economic results under certain conditions for production, is the choice of adequate management methods for solving specific problems. Methods are a tool used to solve a problem. Therefore, it is necessary to adapt the method to solve every problem with the same method. (Simonović, 2014). Operational management means direct management of work operations that make up the production process. That deals with the formation of operational production plans, their specific organization, and the management of their realization and control as a basis for the upcoming operation plane. The specificity of this management level of production in agriculture (especially in plant production) is in the planning, organization, management, and control of campaign works. Campaigns in agriculture differed from each other, in terms of duration, implementation time, size of engagement of production workers and means of mechanization, necessary materials, etc. (for example, autumn and spring sowing campaigns, harvesting, pruning...). Network planning is an effective method for this level of production process management.

Traits of sophisticated business systems

The characteristics of complex business systems in the agro-industry are (Novković, 2018): very high value of engaged capital, the volume of production and number of employees, diversified production program and business activity (from primary agricultural production through primary and secondary processing of agricultural products, to traffic and other services (tertiary) activities), a large number of owners (shareholders), the development of all business functions, a complex and developed organizational structure and a complex and developed hierarchy of leadership and control. Complex business systems in the agro-industrial complex consist of a large number, of organizational units. Those units characterize a relatively large scope of independent business decision-making. Most often, a complex business system is composed of a large number of economic entities- businesses that have a special legal and economic status (giro account). (Djukic & Ilic, 2021). What connects these companies in a complex business system is the ownership, i.e., the interests of the majority shareholders in these companies, by establishing new organizational entities - companies (Simonović et al., 2017). Complex business systems in the agro-industry were also created by the integration of separate companies, or by the purchase of company shares on the capital market. Individual companies, within the framework of complex business systems in agro-industry with common majority owners (shareholders), are most often connected and production-technologically. That means that some companies within the business system produce raw materials and semi-finished products for the needs of other companies within the same business system, which market their products and services. If there is this type of production-technological dependence within complex business systems, then they are usually organized according to the principle of strategic business units, i.e., profit centers (Simonović et al., 2011). At the same time, due to the unique capital at the level of the complex business system as a whole, the profits of individual companies do not represent a priority goal. The priority goal is the maximum total profit at the level of the complex business system. Profit, as a rule, does not represent a simple sum of the maximized profits of individual companies due to the synergistic connections that pass between them and based on production-technological dependencies. Owners of complex business systems in agribusiness invest excess free financial resources (according to the principle of maximum effectiveness) in companies that are not technologically compatible with the existing production program, that are not even in the same industry, but are attractive because they potentially bring high profits. (Ilic, 2023). There are two underlying forms of organizing complex business systems in the sense of organization, management, and leadership. These are corporation and holding. In the corporate organization of complex business systems, there is a higher degree of integration of the management functions. At the corporate level, there is one board of directors, which, appoints managers and decides on all strategic issues in subsidiaries (subsidiary companies). This means that with the corporate form of organizing complex business systems, the majority of owners are the same in all subsidiary companies and that the degree of their business decision-making is limited (dependent) by the framework set by the parent company. (Stojanović et al., 2017). Board of directors managed corporation appointed by the shareholders' meeting. The chairman of the board of directors is usually the majority shareholder. The board of directors appoints the general director (manager) by the corporation's functional directors of individual business functions and directors of subsidiaries. Shared business functions of the corporation (financial, development, marketing, personnel, legal, etc.) are united within the parent company. (Ilić & Nikolić 2019). They coordinate the work of analogous business functions in subsidiaries. With the organization of complex business systems according to the holding principle, the degree of integration of management at the level of the whole system is lower. It means that at the level of subsidiary companies, there are opportunities for them to make business decisions independently. The basis for establishing a holding is also the interests of capital owners and the establishment of production and technological dependencies between individual companies. However, in the case of holdings, in companies - companies that join the holding, there are different dominant capital owners. (Ilić et al., 2019). In this case, the organizational connection in the holding is not based on the unity of the capital but on the economic interests of several different owners of companies. The organization system of a holding is similar to that of a corporation, with the difference that management boards are formed in individual companies by the ownership structure of the capital and that a smaller number of management responsibilities from the delegates at the level whole of the holding. (Ceranić et. al, 2013) The primary goal of managing a complex business system in an agro-industrial complex is to ensure integral optimal functioning and development. The business system combines primarily agricultural productions as a raw material base (cost business unit) and the processing industry as a strategic business unit, i.e., profit center. (Đekić & Jovanović, 2010). In development management, the primary economic goal is maximizing effectiveness, i.e., the need of the business system in the agro complex to deal with the actual productions in the future, i.e., products that bring maximum profit. In the management of functioning, the primary economic goal is maximizing efficiency, that is, the need of the business system in the agro complex to produce what it produces in the right way, whereby the maximum value of the relations of economic effects and economic efforts (income and costs) by achieved. (Praća et al., 2017). In both cases, the linear programming method can be implemented to the needs of production management, more precisely, at the planning of the production structure. In planning the overall development of a complex system, a development policy and long-term and medium-term development plans are adopted, based on which individual investment programs and projects are further elaborated (Ilić et. al., 2017). The plan, the functioning of the complex system as a whole, and a business policy for a specific year be adopted, as complex production and financial.

Management of an agro-industrial complex's growth of a complex business system

Considering that in the business systems in the agro-industrial complex production is much diversified, the independent variables in the linear programming model for optimizing production development can be grouped, according to the authors Novković and Vukelic to independents variables in plant production, independent variables in animal husbandry, and independent variables in primary processing. (Novković & Vukelić, 2020). Secondary goals of development, which lead to the realization of the primary goal determined by planning: effective production technology, the optimal level of production intensity, the optimal structure of crop production, the optimal livestock production, the optimal primary processing, and the optimal relationship between crop production, livestock, and primarily processing. These maximum goals must be realized under the conditions of several limiting factors and available conditions for production. The most important groups of constraints in the linear programming model can be defined, as land constraints, biotechnical and zoo-technical constraints, productive labor force constraints, mechanization resource constraints, stable capacity constraints, processing capacity constraints, constraints connecting crop production, animal husbandry and primary processing, constraints investment funds, and market restrictions. Maximizing the total net income of the business system is taken as an optimality criterion. (Šomođi et al., 2004). Based on the above, the general linear model programming for planning the development of the agro-industrial business system can be formulated as follows. (Novković & Vukelić, 2020)

- Independent variables in crop production (condition a)

$$Babcd \geq 0 \qquad \text{a)}$$

Babcd is the area (in hectares) of the crop "a", produced by technology "b", on the land of type "c", in the sowing structure "d",

where:
a = 1(1) m; m = the number of crops taken into the model
b = 1(1) n; n = the number of technologies for the production of certain crops
c = 1(1) o; o = the number of types of land
d = 1(1)2; 2 = number of sowings per year (1 = regular sowing; 2 = subsequent sowing)

- Independent variables in livestock farming (condition b)

$$Sef \geq 0 \qquad \text{b)}$$

where:
Sef is the average annual number of "structural" heads of livestock "e", which are bred according to the production technology (keeping method)
"F" e=1(1) p; p = the number of majors produced in livestock
f=1(1) q, q = the number of production technologies of individual lines of production in livestock farming

- Independent variables in the primary treatment (condition c)

$$Pgh \geq 0 \qquad \text{c)}$$

where:
Pgh - annual volume of production of food product "g", produced according to production technology "h", in appropriate units of measurement (t, hl,)
g=1(1) r; r = number of food products
h=1(1) s, s = number of processing technologies of certain products

Constraint matrix

- Land restrictions
- Regular sowing (formula d)

$$\sum_{a=1}^{m} * \sum_{b=1}^{n} B_{abc1} = A_c \qquad \text{d)}$$

A_c = land area type "c"

- Subsequent sowing (formula e)

$$\sum_{a=1}^{m} * \sum_{b=1}^{n} * B_{abc1} - \sum_{a=1}^{m} * \sum_{b=1}^{n} B_{abc2} \geq 0 \qquad \text{e)}$$

1. Agro technical restrictions (formula f)

$$\sum_{b=1}^{n} B_{abcd} \leq k_a \, A_c \qquad \text{f)}$$

ka = coefficient of maximum participation of crop "a" in the sowing structure

2. Manpower limitations (formula g)

$$\sum_{a=1}^{m} * \sum_{b=1}^{n} * \sum_{c=1}^{0} * \sum_{d=1}^{z} R^{i}{}_{abcd} B_{abcd} + \sum_{e=1}^{p} * \sum_{f=1}^{q} * R^{i}_{ef} S_{ef} \ \sum_{g=1}^{r} * \sum_{h=1}^{s} * R^{i}_{gh} P_{gh} \leq R^{i}_{u} \qquad \text{g)}$$

where:
– technical coefficient, which represents the required number of working hours of production workers per unit of activity in period "I"
– total available food of working hours of production workers in the period "*u*".

In addition to the mentioned limitations, according to the same author, the following stand out:

- Limitations of mechanization
- Stall capacity limitations
- Limitations of processing capacity
- Self-sufficiency in fodder needs
- Raw material security for processing

Considering the limitation of the research on these factors, we only mentioned them in the paper and did not process the formulas that show their limitedness.

Conclusion

By solving the linear programming model of the optimal development of the business system in the agro-industry, a series of information has been obtained that make up the essential elements of the development program. These are the optimal structure of the total production of the business system, the optimal sowing structure, the production technologies that are the most effective in cattle production, the optimal structure of livestock production, the directions and technologies of livestock production that are the most effective, the optimal of processing, the most effective processing technologies, the balance of animal feed needs by types, degree of provision of own raw materials for processing needs, total needs of the production workforce and their distribution by activities, total needs for mechanical work by types, production bottlenecks (minimum factors), real restrictions on product placement, we need and distribution of investment funds by activities and total planned net income (profit) of the business system.

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ECONOMIC EFFECTIVENESS OF APPLICATION OF BIOSTIMULATORS IN SPRING OATS[1]

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Abstract

The use of biostimulants in agriculture is a key approach to organic production in the context of fulfilling the EU Green Deal. The aim of the present study is to determine the economic effect of applying foliar organic fertilizers to spring oats. Biostimulants are developed based on chitosan, vermicompost extract, and a naturally identical growth regulator. An economic-mathematical analysis model is applied, for which a system of inequalities and constraints is used. The analyzes of the scientific team are based on the hypothesis that it is possible to apply biostimulants to significantly increase the yield of spring oats per unit area, but not to increase the profit of the agricultural holding as a whole. The research team accepts that those biostimulants that increase the economic efficiency of the farm are considered beneficial. It was derived conclusions.

Key words: *economic effectiveness, biostimulants, spring oats.*

Introduction

The assessment of the economic efficiency of the application of biostimulants in agriculture refers to those complex and hard-to-solve challenges not only in the world, but also in Bulgaria (Belcheva, S., 1989; Brown P. and Saa S., 2015; Looney, N. & Jackson, D., 2011; Rademacher, W., 2018; Rademacher, W. J., 2015; Izumi, K. et al., 1984). When solving them, many interdependent factors are taken into account, related not only to purely technological, experimental and legal constraints, but also to the diversity of social and behavioural aspects. It is currently known that the use of biostimulants may pro-

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vide benefits in the cultivation of agricultural crops, but the economic results are not fully understood. The researchers limit themselves to presenting the increase in yield. Nowadays, it is even more important to consider whether the use of biostimulants is economically effective for farmers and whether they will contribute to an increase in profit in general. All of these challenges have many possible solutions that differ depending on the goals set. The application of biostimulants has a positive effect on bulk density, porosity soil structure, and crop yields (Findura et al., 2022). Studies have shown that biostimulators have a beneficial effect on the weight of the root, the number of grains of grade, weight, and seed yield (Szczepanek et al., 2018).

Oats are rich in fat, the amount of which can reach up to 18% (Mihalkova et al. 2017). In 2021, global production of oats is over 22 million tonnes - Russia with 17% of the total and Canada with 12%. The spring oats (*Avena sativa*) are a unique species typically ready for grazing after 50 days or for hay in 70 days. An additional benefit of growing spring oats is weed suppression and moisture conservation. However, excessive fertility can encourage laying. Oats have numerous uses in foods - crushed into oatmeal, a variety of baked goods, milk substitute, several different drinks, etc.

Numerous publications on the subject are available in the scientific literature. For example: Observations on the phytosanitary status of crops in organic and conventional agriculture, the degree of weeding of winter oats (Atanasova and Maneva, 2019); in organic, biodynamic and conventional oat cultivation (Maneva, V. et al. (2023); evaluation of yield potential of different oat varieties (Duda, M. et al., 2021); the effect of growth biostimulators on the formation of oat grain yield and evaluation of the economic efficiency of its use (Batalova and Budina, 2008); evaluation of four biostimulants at different concentrations on forage oats (Zulfiqar Ali Gurmani et al. 2021), etc.

The aim of the present study is to propose an optimization model for evaluating the economic efficiency when using biostimulators on spring oats.

Material and methods

For primary data, the results obtained from the Agricultural Experiment Station (AZS) are used, in a test (experimental) field at the Institute of Agriculture and Seed Science (IZS) "OBRAZTSOV CHIFLIK" – Ruse region at the Agricultural Academy. In the two-year period 2021-2022, 19 plots of 10 square meters each were prepared, in which spring oat seeds (variety Alexa 1

(IZS selection)) were planted. The selection of 19 plots is consistent with the condition of having 1 control plot for both crops and 18 plots on which three repetitions of three biostimulants (BS) will be made (table 1). The spring oats were treated with biostimulants developed at the Institute of Cryobiology and Food Technologies (ICHT) at the Agricultural Academy at different concentrations of the active substance.

Table 1. Applied biostimulants and their concentration

Biostimulants	Description
BS1_CH	(GA) chitosan 500 ml/ha
BS2_2CH	(GA+GA) chitosan 2*500 ml/ha
BS3_V	(HA) vermicompost extract 500 ml/ha
BS4_2V	(HA + HA) vermicompost extract 2*500 ml/ha
BS5_VR	(HA_IA) vermicompost + nature-identical growth regulator 500 ml/ha
BS6_2VR	((HA_IA+ HA_IA) vermicompost + nature-identical growth regulator 2*500 ml/ha

Source: Institute of Cryobiology and Food Technology, Agricultural Academy, Sofia

The spring oats were treated twice (treating the crops in the branching phase with a different solution of the biostimulator in two stages of growth - branching and booting). Harvesting of the crops was done mechanized. Before sowing, all necessary agrotechnical measures have been observed. After obtaining the experimental results of the application of the different BS on spring oats in the experimental fields, they were automatically equated to 1 Dca. After that, a specific agricultural holding in the region is selected, which will serve as a model on which to construct the optimization model for evaluating the economic efficiency. In this farm, along with the intended crops in the production structure, spring oats are added - controls and treated with BS. Based on experimental results obtained from 2021-2022 and the complex of additional factors, such as existing (available) resources: land, labor resources, mechanization, etc.; as well as the development of technical and economic standards (TES), the optimization model was developed.

Optimization is a method of finding the optimal value (max or min) of a certain function under given constraints. The function f is called the objective function. Setting a system of inequalities and/or equations is called a system of constraints. The most frequently used in practice are linear optimization, nonlinear (quadratic, hyperbolic) optimization, integer optimization, convex optimization, matrix games, etc. If the objective function and the constraints are linear, then we have a case of linear programming – one of the most important branches of mathematical optimization.

Modeling is a categorical approach to studying complex problems that involve replacing the object with another similar to the original. We can construct this problem in a system of linear dependencies. They should reflect the conditions that must be taken into account when solving the task (Nikolov, N., et al., 1994). The objective function expresses the optimality criteria (min, max):

$$A_{11}X_1 + A_{12}X_2 + \cdots + A_{1n}X_n \leq B_1$$
$$A_{21}X_1 + A_{22}X_2 + \cdots + A_{2n}X_n \geq B_2$$
$$.$$
$$.$$
$$.$$
$$A_{m1}X_1 + A_{m2}X_2 + \cdots + A_{mn}X_n = B_1$$

$$F = C_1X_1 + C_2X_2 + \cdots + C_nX_n \rightarrow \max\ (min), \tag{1}$$

Where:

- Xj - shows the size (magnitude) of activities or metrics,
- Aij и Cj - indicates the activities to be performed,
- Bi - means the amount of resources available or the amount of activities (constraints)
- The objective function ***F*** gives the optimality criteria.

The economic-mathematical model (EMM) makes it possible to compare many possible solutions, from which to choose the most optimal one. In reality, however, it is quite difficult, and often even impossible, to account for the influence of the complex of factors. Solving the present economic problem with the help of mathematical methods means to compose an economic-mathematical problem. In a broader sense, modeling is a certain approach to studying complex problems that involve replacing the object with another that is similar to the original. The economic-mathematical model is a mathematical task that reflects with satisfactory accuracy the most important, essential connections and dependencies characterizing the economic problem.

Results

1. Results from an experimental field of the Institute of Agriculture and Seed Science „Obratzov Chiflik“ – Ruse

The primary data were collected from an experimental field of the Institute of Agriculture and Seed Science “Model Farm” - Ruse, Agricultural Academy. Table 2 presents the yields of spring oats in three repetitions of the biostimulants at different concentrations of dry matter and the control - 8(K). Tables 3 and 4 presents the biometric indicators after treatment with biostimulants.

Table 2. Spring oats yield, harvest 2021-2022

Bio stimulant	1 rep (kg)	2 reps (kg)	3 reps (kg)	Total (kg)	Average (kg)	kg/dca	Index	% humidity
Chitosan 500 ml/ dca	2,62	2,21	2,32	7,15	2,38	238,47	1,14	13,35
Chitosan-2*500 ml/ dca	2,21	2,47	2,51	7,19	2,40	239,70	1,15	13,50
Vermi compost extract 500 ml/ dca	2,57	2,15	2,38	7,09	2,36	236,42	1,13	13,55
Vermicomposting + nature-identical growth regulator 2*500 ml/ dca	2,09	2,06	2,22	6,37	2,12	212,38	1,02	14,45
Vermicomposting extract 2*500 ml/ dca	2,59	2,12	2,51	7,21	2,40	217,80	1,04	14,00
Vermicomposting + nature-identical stretch regulator 500 ml/ dca	2,33	2,04	2,31	6,67	2,22	222,42	1,06	13,40
Control	**1,94**	**2,03**	**2,31**	**6,28**	**2,09**	**209,17**	**100,0**	**13,50**

Source: The primary data from The Agricultural Experimental Station (AES) in a test (experimental) field at the Institute of Agriculture and Seed Science “Obraztzov Chiflik” – Ruse, Agricultural Academy, 2021-2022

Table. 3. Biometrics – spring oats, 2021

Bio stimulant	Plant height cm.	Number of spike-bearing stems per 1 plant	Panicle length, cm	Number of spikelets in 1 panicle	Number of grains in 1 panicle	Weight of grain from 1 panicle
BS1_CH	88,30	3,80	15,50	33,90	52,50	1,42
BS2_2CH	89,20	5,40	16,50	34,00	62,00	1,75
BS3_V	83,10	4,40	16,30	34,60	53,60	1,70
BS4_2V	87,70	5,50	15,60	30,90	42,40	1,33
BS5_VR	90,90	5,50	16,30	38,50	63,40	1,69
BS6_2VR	86,10	5,50	15,90	35,50	55,50	1,49
Control	**87,50**	**5,40**	**16,70**	**40,90**	**63,10**	**1,72**

Source: The primary data from The Agricultural Experimental Station (AES) in a test (experimental) field at the Institute of Agriculture and Seed Science "Obraztzov Chiflik" – Ruse, Agricultural Academy, 2021

Table. 4. Biometrics – spring oats, 2022

Bio stimulant	plant height cm.	Number of spike-bearing stems per 1 plant	Panicle length, cm	Number of spikelets in 1 panicle	Number of grains in 1 panicle	Weight of grain from 1 panicle
BS1_CH	75.10	3.30	14.60	36.10	74.10	2.65
BS2_2CH	78.90	3.80	15.20	35.40	68.30	2.29
BS3_V	79.30	3.50	15.30	41.80	87.60	2.81
BS4_2V	78.80	3.50	15.30	36.60	73.30	2.42
BS5_VR	80.00	3.70	13.10	35.70	73.90	2.60
BS6_2VR	79.90	3.40	14.50	35.90	78.00	2.52
Control	**79.10**	**3.60**	**15.40**	**42.10**	**83.50**	**2.47**

Source: The primary data from The Agricultural Experimental Station (AES) in a test (experimental) field at the Institute of Agriculture and Seed Science "Obraztzov Chiflik" – Ruse, Agricultural Academy, 2022

The construction of the model uses two criteria - max gross margin and max profit. There were build two economic-mathematical tasks based on these criteria:

First task. A task with optimized production structure of a farm, considering the agrotechnical requirements for crop rotation. The solution gives the most optimal production structure under both criteria of *max gross margin and max profit*. It will allow obtaining a decision on how to optimally combine available resources (land, labor force, size of arable land) and farm constraints; what crops to produce; agrotechnical requirements; which biostimulants to apply; on which cultures and in what concentration to be applied BS; in which phase to treat them to achieve the highest economic effect.

Second task. There were set bounds for the minimal and maximum size of the arable land, including crops treated with biostimulants. The aim is to find an optimal solution, achieving *max gross margin* and *max profit*. The solution gives the optimal combination of the most economically effective productions. The result is the best combination of the available resources (land, labor resources, and various biostimulants), giving specific constraints. Also, what crop to produce and what agrotechnical requirements? All this achieves the highest economic effect.

It was worked on the following hypothesis: Biostimulants, applied in the critical phases of vegetation in the appropriate dose, stimulate the productivity of crops to an extent dependent on the species and variety belonging and increase the economic efficiency of agricultural holdings.

Defined variables and constrains

The subjective restrictions shrink the possible solutions. This is because including more and more different group criteria in the model (e.g., land, crops, BS, land constraints, labor force, etc.) searches for a balance between the defined constraints and often leads to compromise solutions to the task.

The variables used to evaluate the BS effect on economic efficiency are presented in Tables 5 and 6. In addition, it was used other factors such as other crops, resources (land, labor force), and financial indicators (gross margin, costs, profit), (table 9).

Table. 5. Variables with biostimulants treatment

Crop	Biostimulants (ha)						
	Control	BS1_CH	BS2_2CH	BS3_V	BS4_2V	BS5_VR	BS6_2VR
spring oats	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}

Source: Authors' calculations

Table. 6. Other variables

Other crops (ha)		Resources		Finance (BGN)	
x_1	Wheat	x_{18}	Own arable land (ha)	x_{22}	Income
x_2	Corn	x_{19}	Rented arable land (ha)	x_{23}	Material costs
x_3	Sunflower	x_{20}	Permanently employed mechanics (number)	x_{24}	Labor costs
		x_{21}	Permanent employees (number)	x_{25}	Margin
				x_{26}	Gross margin
				x_{27}	Fixed costs
				x_{28}	Profit
				x_{29}	Profit with subsidies

Source: Authors' calculations

Constrains

The constraints of the optimal plan are divided into three groups: land usage (table 7); labor (table 8); and supporting constrains (table 9).

Table 7. First group of constrains related to the land usage (ha)

Constrains	**Formula**	
	Optimal production structure task (first)	**Max and min area bounds task (second)**
Area constrains (acres)	$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 + x_9 + x_{10} = x_{18} + x_{19}$	$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8 + x_9 + x_{10} \leq x_{18} + x_{19}$
Constrain on rented area (ha)	$x_{19} = 11000$	$x_{19} \leq 11000$
Constrain on owned area (ha)	$x_{18} = 1000$	

Constrains	Formula	
	Optimal production structure task (first)	Max and min area bounds task (second)
Autumn cereal crops, minimum 45% of the sowing area (ha)	$x_{19} \geq 5400$	
Autumn cereal crops, minimum 55% of the sowing area (ha)	$x_1 \leq 6600$	
Sunflower, maximum 17% (1/6) of the sowing area (ha)	$x_3 \leq 2040$	
Constrains on the land, using BS, minimum (ha)		$x_4+x_5+x_6+x_7+x_8+x_9+x_{10} \geq 3360$
Constrains on the land, using BS, maximum (ha)		$x_4+x_5+x_6+x_7+x_8+x_9+x_{10} \leq 4560$

Source: Authors' calculations

Table 8. Second group of constrains related to the labor (number)

Constrains	Formula
Permanently employed mechanics (number)	$x_{20} = 4$
Permanent employees (number)	$x_{21} = 2$

Source: Authors' calculations

Table 9. Third group of constrains, supporting (BGN)

Constrains	Formula
Income	$116x_1 + 136x_2 + 190x_3 + 133{,}52x_4 + 135{,}48x_5 + 120{,}08x_6 + 118{,}63x_7 + 115{,}79x_8 + 127{,}12x_9 + 115{,}95x_{10} = x_{22}$
Variable material costs	$27x_1 + 27x_2 + 26x_3 + 24{,}5x_4 + 39{,}5x_5 + 39{,}5x_6 + 39{,}5x_7 + 39{,}5x_8 + 39{,}5x_9 + 39{,}5x_{10} = x_{23}$
Labor costs	$x_{24} = 18000x_{20} + 18000x_{21}$
Fixed costs	$x_{27} = 55x_{19}$

Constrains	Formula
Margin	$x_{25} = x_{22} - x_{23}$
Gross margin	$x_{26} = x_{22} - x_{23} - x_{24}$
Profit	$x_{28} = x_{22} - x_{23} - x_{24} - x_{27}$

Source: Authors' calculations

Objective function

The objective function and the constrained values were added in the following linear programming model, using two optimal criteria – max gross margin and max profit.

$$F = 80x_1 + 102x_2 + 155x_3 + 100{,}02x_4 + 86{,}98x_5 + 71{,}58x_6 + 70{,}13x_7 + 67{,}29x_8 + 78{,}62x_9 + 71{,}05x_{10} - 18000x_{20} - 18000x_{21} \rightarrow \textbf{Max gross margin,} \qquad (2)$$

$$F = 80x_1 + 102x_2 + 155x_3 + 100{,}02x_4 + 86{,}98x_5 + 71{,}58x_6 + 70{,}13x_7 + 67{,}29x_8 + 78{,}62x_9 + 71{,}05x_{10} - 18000x_{20} - 18000x_{21} - 55x_{19} + 31x_{18} + 31x_{19} \rightarrow \textbf{Max profit} \ (3)$$

Conclusion

Based on the results of the empirical test collected from AES in the experimental field at the Institute of Agriculture and Seed Science "Obratzov Chiflik" – Ruse, Agricultural Academy, there was collected and analyzed primary data related to the impact of experimentally developed biostimulants at the Institute of Cryobiology and Food Technology, Agricultural Academy, Sofia, on spring oat. On this basis and additionally collected information, it was developed production optimization model.

The construction of the model uses two criteria - max gross margin and max profit. There were build two economic-mathematical models based on these criteria. The first model allows obtaining a decision on how to optimally combine available resources (land, labor force, size of arable land) and farm constraints; what crops to produce; agrotechnical requirements; which biostimulants to apply; on which cultures and in what concentration to be applied BS; in which phase to treat them to achieve the highest economic effect. The second model gives the optimal combination of the most economically effective productions. The result is the best combination of the available resources.

The applied approach is widely used in solving optimization problems. The next step will be to verify constructed methodology in other farms in Bulgaria. Also, to derive conclusions related to the biostimulants' effect on the economic efficiency of the farm.

Acknowledgements

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STUDY OF THE INFLUENCE OF FOLIAR HUMAT ROST FERTILIZER ON GROWTH IN OILY SUNFLOWER

Georgi Georgiev[1]

Abstract

According (Škorić et al., 2007) to the oilseed sunflower is the most widespread crop worldwide and its oil is one of the best quality oils compared to other oils obtained from different crops. The requirements of agricultural producers (Miklič et al., 2010) for higher indicators - seed yield kg/ha in the case of oil-bearing sunflowers require the replacement of less productive hybrids with more productive ones in certain regions. In order to achieve a high yield of seeds in the oil sunflower, it is necessary to study the quantitative signs - number of seeds per pit, mass of seeds per plant, mass of 1000 seeds when treated with foliar organic fertilizers. The following authors: (Encheva et al., 2014, Encheva et al., 2015, Kaya et al., 2004, Kaya, 2015, Hladni et al., 2005) found that with strong weeding of the fields and with a high spread of the parasite Orobanche cumana it is necessary to use tolerant sunflower hybrids. Environmental conditions and the duration of the growing season significantly affect this trait and less than the genetic factor and parental lines involved in hybridization. In order to realize an optimal yield with this crop, it is necessary to study the signs that have a direct influence on it - number of seeds per plant, mass of seeds per plant, mass of 1000 seeds. For this reason, it is necessary to investigate the interrelationship between climatic factors, the studied characters and the genotype of the crop. The selection of sunflower is aimed at increasing the quantitative characteristics - number of seeds per planth, mass of seeds per plant and mass of 1000 seeds.

Key words: *vegetation, sunflower, sowing, yeld, plant height, head diameter.*

Introduction

HumateRost is an organic fertilizer based on peat and trace elements that stimulate plant growth. It is designed for crop production and organic production. It has a wide range of applications: foliar and root treatment of plants, agrotechnical treatment of seeds and seedlings, soil restoration and enrichment.

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HumatRost. HumateRost increases yields, strengthens the root system of plants, increases their immunity and resistance to disease and weather, supports the process of photosynthesis. Plants are better adapted to adverse climatic conditions and herbicide treatments, are resistant to disease, stress and pests.Especially useful for weak and depleted soils.Timely and correct use of HumateRost leads to: healthier and more fertile soil. Faster germination, emergence and maturation of plants. Stronger and healthier root system and foliage.Healthier and more resistant to disease and climate change plants, higher yields.

Results and Discussion

A study of the influence of the leaf organic fertilizer Humat Rost was conducted in 2023 in the Dobrudja Agricultural Institute, General Toshevo. The soil type is Haplic Chernozems. The predecessor is wheat. Sowing was carried out at the optimal time - 20.05.2023. Sowing was carried out manually with an inter-row distance of 0.70 cm. The experiment was sown with a plot size of 30 m2. The experiments were set up according to the block method in 2 randomized repetitions. The observations were carried out according to the accepted UPOV methodologies. Measurements were taken from all variants, the aim of which was to analyze the yield structure. During the sunflower growing season, the following phenological indicators were recorded: sowing, germination, phase 2-3 leaf, budding, beginning of flowering, flowering, end of flowering, flowering period, technical maturity and vegetation period number of days. The following structural characteristics were also investigated: plant height (cm), seed diameter (cm), 1000 seeds (g), full seeds, empty seeds, seeds per plant, yield kg/ dka, % oil, oil in absolute dry matter %, moisture %, oleic acid.

EXPERIMENT SCHEME

1	1	1	2	2	2	3	3	3	4	4	4
3	3	3	1	1	1	4	4	4	2	2	2

I rep.
II rep.

Treatment of oilseed sunflower hybrids with HumatRost foliar fertilizer

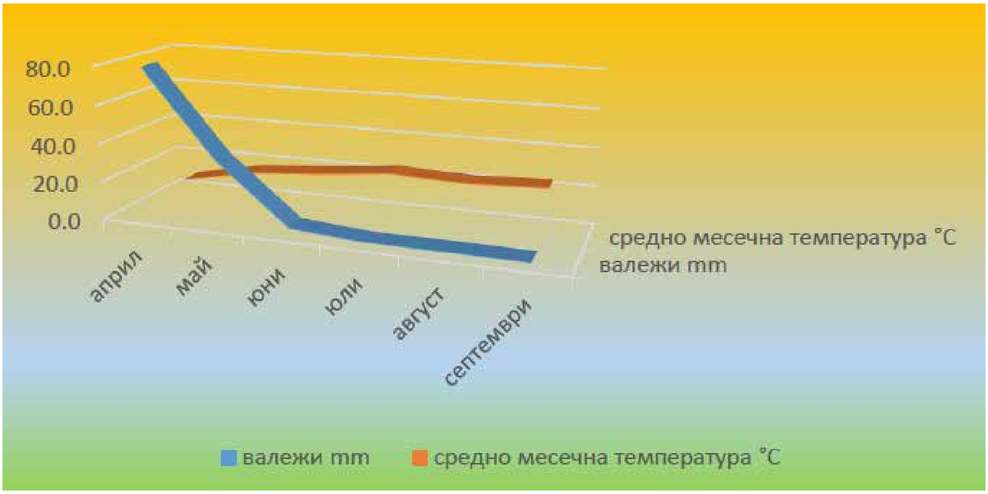
Control without spraying

Control by spraying with the preparation Humat Rost with a dose of 3 ml/30m2 (100 ml/dka)

Control by spraying with the preparation Humat Rost with a dose of 9ml/30m2 (300ml/ha)

Treatment of oilseed sunflower hybrids with foliar fertilizer HumaterRost
Control without spraying
Control by spraying with Humate Rost at a rate of 3ml/30m2 (100ml/ha)
Control by spraying with Humate Rost at a rate of 9ml/30m2 (300ml/ha)
1. Hybrid Enigma CLP CLP-Clearfield technology
2. Hybrid Deveda SU- Sulfo-technology
3. Hybrid Krasi CLP
4. Hybrid Prometey SU

Figure 1. Average monthly temperature and precipitation



The main climatic factors that determine the growth, development and productivity of the sunflower are temperature, precipitation, their combination and distribution during the growing season, as well as the relative humidity of the air.

Data on average monthly values of temperature and precipitation during the study period are presented in figure 1.The influence of temperatures and precipitation are of particular importance in the formation of yield.

The highest temperature amplitude was recorded in the months of July, August and September respectively (24.1 C, 22.8 C and 24.6C). High temperatures combined with dry winds in the second half of the sunflower vegetation led to a reduction in yield. The rains that fell at the beginning of the sunflower's vegetation period favored the friendly germination of the seeds, the crops were garnished well, but subsequently the lack of precipitation after June until the end of the crop's vegetation period had a effect in the structural characteristics (plant, diameter, number seeds from one plant, mass of 1000 seeds, etc.) and yield.

The main factors that influenced phenological development and the formation of productivity are:

Germination started on 20.05. The plants sprouted in unison and the experience was very well garnished.Phase 2-3 leaf was recorded on 30-31.05. The rainfall at the beginning sunflower vegetation had good effect on the rapid of the culture. In this phase of the culture, foliar treatment with HumatRost was carried out with a dose of 5ml/30m2 with a working solution of 700-800ml. The plants entered the budding phase on 4-6.07.2023. During this phase, the second treatment with the preparation HumatRost was carried out with a dose of 9ml/30m2 with a working solution of 700-800ml.

Phenofase 2-3 leaf

Phenofase budding

Hybrid Enigma CLP treatment with 5ml/30m2

Hybrid Enigma CLP treatment with 9ml/30m2

Hybrid Deveda treatment with 5ml/30m2

Hybrid Deveda treatment with 9ml/30m2

Hybrid Krasi CLP treatment with 5ml/30m2

Hybrid Krasi CLP treatment with 9ml/30m2

Hybrid Promethey SU treatment with 5ml/30m2

Hybrid Promethey SU treatment with 9ml/30m2

The beginning of flowering began on 8.07-11.07 for individual sunflower hybrids, depending on whether they were treated with the HumatRost preparation. A prolonged period of flowering was reported for the hybrids treated foliarly with the preparation HumatRost with a dose of 5ml and 9ml/30m2 from 10 to 14 days, respectively.

Hybrid Enigma CLP treatment with 5ml/30m2

Hybrid Enigma CLP treatment with 9ml/30m2

Hybrid Deveda treatment with 5ml/30m2

Hybrid Deveda treatment with 9ml/30m2

Hybrid Krasi CLP treatment with 5ml/30m2

Hybrid Krasi CLP treatment with 9ml/30m2

Hybrid Promethey SU treatment with 5ml/30m2

Hybrid Promethey SU treatment with 9ml/30m2

The technical maturity of the sunflower hybrids began on September 8, and the hybrids treated with HumatRost entered this phase earlier. In them, the vegetation period is shorter compared to the hybrids included in the control (without treatment), respectively 110-111 days.

Hybrid Enigma CLP treatment with 5ml/30m2

Hybrid Enigma CLP treatment with 9ml/30m2

Hybrid Deveda treatment with 5ml/30m2

Hybrid Deveda treatment with 9ml/30m2

Hybrid Krasi CLP treatment with 5ml/30m2

Hybrid Krasi CLP treatment with 9ml/30m2

Hybrid Promethey SU treatment with 5ml/30m2

Hybrid Promethey SU treatment with 9ml/30m2

Table 1. Structural features related to seed yield

hybrid	treat-ment/ml 30m2	Stem Height cm	Head cm	1000 seeds	full seeds	number empty seeds	Number seeds from 1 plant
Enigma	**I**	145	20	68,2	1424	135	1559
Enigma	**I 5ml.**	140	25	56,8	1400	80	1480
Enigma	**I 9ml.**	140	22	54,5	1445	88	1533
Deveda	**I**	135	21	54,5	1667	208	1875
Deveda	**I 5ml.**	140	18	58,8	1525	175	1700
Deveda	**I 9ml.**	135	22	48,2	1700	118	1818
Krasi	**I**	160	21	66	1440	166	1606
Krasi	**I 5ml.**	155	20	54,4	1334	109	1443
Krasi	**I 9ml.**	160	20	68,1	1247	94	1341
Promothey	**I**	145	17	72,4	1257	104	1361
Promethey	**I 5ml.**	140	16	55,7	1380	198	1578
Promethey	**I 9ml.**	155	20	65,2	1237	142	1379
Enigma	**II**	145	20	62	1042	248	1290
Enigma	**II 5ml.**	130	19	44	1426	175	1421
Enigma	**II 9ml.**	130	17	46,8	1624	82	1706
Deveda	**II**	140	21	56,4	1522	130	1652
Deveda	**II 5ml.**	135	19	49,2	1356	303	1658
Deveda	**II 9ml.**	140	18	44,3	1270	372	1642
Krasi	**II**	160	22	59,6	1366	77	1443
Krasi	**II 5ml.**	165	21	61,5	1253	188	1441

hybrid	treat-ment/ml 30m2	Stem Height cm	Head cm	1000 seeds	full seeds	number empty seeds	Number seeds from 1 plant
Krasi	**II 9ml.**	150	19	71,7	1345	61	1406
Promethey	**II**	150	18	57,4	1229	152	1381
Promethey	**II 5ml.**	145	18	61,4	1545	88	1633
Promethey	**II 9ml.**	145	19	71,6	1305	80	1385

Table 1 presents the results of the structural features related to seed yield. Due to the prolonged long-term drought during the test of the sunflower hybrids, no significant difference in plant height and seed diameter was found. The obtained results show from the experiment with treatment (5ml/9ml) with the preparation HumatRost a significant increase in the values of the number of full seeds in the pit, compared to control numbers without treatment. Spraying with HumatRost preparation during the growing season resulted in significantly very good pollination of the hybrids and obtaining a very low number of empty seeds. The boron content in the preparation increases the vitality of the pollen, which in turn leads to the production of more full seeds and fewer empty seeds in the comb. HumatRost organic fertilizer increases the resistance of plants to adverse conditions - drought, etc. plants have very good architecture, with larger leaves, with greater height compared to the control without treatment. During testing of the hybrids, attack by enemies and diseases was not detected. This shows the very good efficiency of this organic fertilizer.

Table 2. Structural features related to seed yield

hybrid	treat-ment	Num-ber of planth	Yield Kg/da	average of 2 repetitions/ yield kg/da	% oil	oil in absolute dry matter %	moisture %	oleic acid %
Enigma	**I**	168	218,5	**195,2**	38,2	40,3	5,3	42,5
Enigma	**I 5ml.**	133	248,9	**215,4**	39,7	41,9	5,3	41,4
Enigma	**I 9ml.**	100	308	**252,7**	39,2	41,3	5,1	41,9
Deveda	**I**	156	247,6	**245,1**	40,5	42,8	5,3	40,3
Deveda	**I 5ml.**	129	314,1	**287,3**	39,8	42	5,3	41,0
Deveda	**I 9ml.**	138	299,5	**302,4**	41,6	44	5,6	37,8
Krasi	**I**	141	227,9	**270**	40,2	42,8	6,1	66,9
Krasi	**I 5ml.**	164	262,8	**297,3**	41,1	43,6	5,8	68,9

hybrid	treat-ment	Num-ber of planth	Yield Kg/da	average of 2 repetitions/ yield kg/da	% oil	oil in absolute dry matter %	moisture %	oleic acid %
Krasi	**I 9ml.**	180	270,5	**302,7**	38,9	41,3	5,7	69,4
Pro-methey	**I**	150	260,7	**254,7**	41,9	44,3	5,3	41,0
Pro-methey	**I 5ml.**	148	273,6	**274**	41	43,3	5,2	41,5
Pro-methey	**I 9ml.**	133	357,2	**351,6**	40,6	42,8	5,1	42,6
Enigma	**II**	152	172,9		39,8	41	5,2	41,6
Enigma	**II 5ml.**	143	182		39,7	41,9	5,3	40,0
Enigma	**II 9ml.**	180	197,5		39,9	42,2	5,5	38,7
Deveda	**II**	114	242,6		39,6	41,8	5,4	41,6
Deveda	**II 5ml.**	168	260,6		39,1	41,3	5,2	39,7
Deveda	**II 9ml.**	171	305,3		40,2	42,7	5,8	37,1
Krasi	**II**	125	312,2		40,5	43	5,9	67,7
Krasi	**II 5ml.**	128	331,8		42,3	44,8	5,7	63,2
Krasi	**II 9ml.**	120	334,9		37,8	40	5,7	64,3
Pro-methey	**II**	168	248,8		40,6	42,8	50,8	40,0
Pro-methey	**II 5ml.**	142	274,4		39,3	41,5	5,4	43,8
Pro-methey	**II 9ml.**	125	346		38,1	40,2	5,3	43,2

Table 2 presents the results of testing the influence of organic fertilizer HumatRost on seed yield, % oil. The optimal yield kg/ha was obtained in hybrids treated with organic fertilizer HumatRost, while the yield varied in the controls without treatment from 172.9 kg in the Enigma hybrid to 312 kg in the Krasi hybrid. When treated with a dose of 5ml/30m^2 in the 2-3 leaf phase, the yield of variara in the Enigma hybrid is 182 kg to 331.8 kg in the Krasi hybrid.

With foliar treatment at a dose of 9ml/30m2 in the budding phase, the increase in yield was significantly stopped compared to treatment with 5ml and control-no treatment. Here the yield varies from 197.5 kg for the Enigma hybrid to 357.2 kg for the Prometheus hybrid.

In the Average yield of the two repetitions, in the individual hybrids, an increase in good yield compared (without treatment) and with treatment 5 ml/30 ml2 was found, respectively: In the Enigma hybrid - an increase compared to the control - 57.5 kg/ha, compared to treatment with 5ml/30m2 – 37.3kg. Hybrid Camels - control - 57.3 kg, compared to treatment with 5 ml/30 m2 - 15.1 kg. In hybrid Krasi, the excess compared to the control is: 32.7kg, compared to treatment with 5ml/30m2 -5.4kg, In hybrid Prometheus, the excess in seed yield compared to the control is: 96.9kg, compared to treatment with 5ml/30m2 -77.6kg .

Regarding oil, a slight increase in %oil was found compared to the control. As the oil varies in individual hybrids from 37.8% in hybrid Krasi to 41.1% in hybrid Deveda.

Conclusions

The final results show that when treated with the HumatRost preparation, the structural signs increase significantly (mass per 1000 seeds, full seeds). Optimal effect with HumatRost preparation evaluated on main biological characteristics of the selected oilseed sunflower hybrids. It should be taken into account that during the second half of the sunflower growing season, weather conditions were not favorable during the time after flowering and seeding. This determined the further development and formation of the final yield. In general, the universal organic fertilizer HumatRost led to a very good physiological condition of the plants during the individual phenophases of development, the structural elements having a direct effect on the yield compared to the untreated plots. The study found a significant increase in seed yield per unit area for individual hybrids (5ml/30m 2, 9ml/30m 2) from 32.7kg to 96.9kg/ha compared to the untreated sunflower hybrids in the control trials. Treatment with the organic fertilizer HumatRost significantly leads to an increase in pollination and obtaining good yield, 1000 seeds, % oil.

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IMPACT OF INTENSIVE AGRICULTURAL PRODUCTION ON THE ENVIRONMENT[1]

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Abstract

Today, intensive agricultural production is presented as a key production system for maintaining global food security, but at the same time it brings with it numerous challenges that affect the environment. This paper will analyze the impact of intensive agriculture on the environment, investigating how these processes can have different effects on ecosystems. The positive and negative impacts of technological progress will be analyzed. In which aspects of water and air pollution, loss of biodiversity and climate change will be included. Also, aspects of enabling increased productivity and food security for the world's population, more efficient use of resources, as well as the possibility of producing higher yields on smaller areas. This paper will also present a set of measures that directly affect the reduction of the negative impact of intensive agriculture, enabling the sustainability of agricultural production.

Key words: *intensive agriculture, environment, climate change.*

Introduction

Agriculture, as one of the most important branches of the global economic system, faces the challenges of balancing between the increase in food production, which is necessary for the growing world population, and the preservation of the environment. Improvement in agriculture and food production technology are critical for increasing yields and efficiency to meet food security requirements.

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Intensive agricultural production, with its ability to increase yields and use resources efficiently, simultaneously brings with it a number of negative impacts on the environment (Kughur, et al., 2015). Therefore, the field of intensive agriculture is a topic of discussion at different levels, although it is considered crucial in securing food for the global population, its effects on the environment are considered very questionable.

Positive aspects such as increased productivity (Janković et al. 2020), more efficient use of resources and maintenance of food security for the future, represent fundamental support for intensive

Agriculture. On the other hand, air and water pollution, loss of biodiversity and finally climate change are just some of the negative aspects that must be considered.

Based on the mentioned aspects of intensive agriculture, this analysis investigates the impacts of intensive agriculture on the environment, analyzes negative and positive aspects and looks at potential trends and measures for sustainable food production in the future. This approach aims to achieve a balance between growing food needs and preserving the environment for future generations.

Negative impact

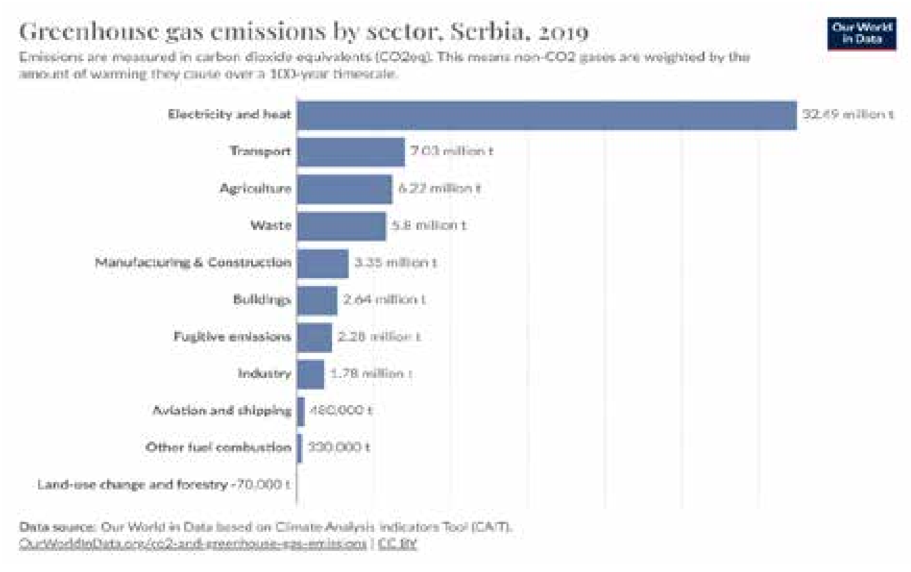
Air pollution

Daily use of agricultural machinery in intensive agricultural production plays a significant role in air pollution. The use of tractors, harvesters and other agricultural machinery during all agricultural operations consumes large amounts of fossil fuels. Burning these fossil fuels releases various chemical compounds (oxides as well as organic compounds). Further evaporation of organic compounds leads to the appearance of the greenhouse effect. Greenhouse gas (GHG) emissions are largely associated with agricultural production. Carbon dioxide (CO_2) is one of the most common greenhouse gases (Yoro & Daramola, 2020). This group of gases also includes nitrogen suboxide (N_2O) and methane (CH_4) (Pao et al., 2015).

CO_2 is known as the base of various environmental problems such as global warming, the occurrence of extreme weather conditions and the rise of sea levels. (Lin & Xu, 2018; Chamberlain et al., 2016). The reason why the emission of CO_2 is the subject of various scientific research is the fact that the concentration of CO_2 has increased by 40% since 1750. IPCC, I. (2014). At the global level in recent years, China has been presented as a country that needs a quick reaction to reduce CO_2 emissions because there has been a rapid increase in CO_2 concentration. In this country, the agricultural sector has for some time been shown to be the main sector that has led to an increase in CO_2 emissions (Dogan et al., 2016). The increase within this sector was largely contributed by the mechanization of the agricultural industry (Xu, & Lin, 2017).

What represents a serious threat to the Republic of Serbia is that, based on the analysis of CO_2 emissions by sector, agriculture is in the third position in terms of CO_2 emissions (33.49 million t), after the production of electricity and heat (7.03 million t) and transport (6.22 million t)(Fig. 1).

Figures 1. *CO_2 emissions in 2019 by sector, Republic of Serbia.*



Source: https://ourworldindata.org/co2/country/serbia

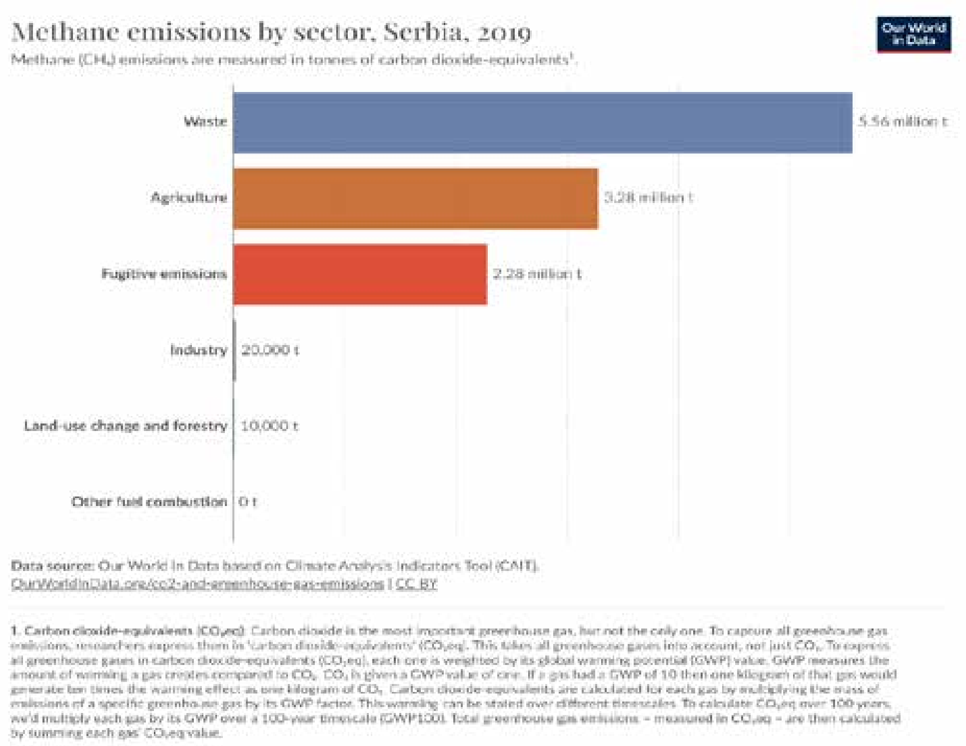
If this dramatic increase in CO_2 emissions continues, without adequate measures, it is predicted that the consequences will result in global warming as well as serious climate changes.

Emission of CH_4 methane from the agricultural sector is often associated with various processes and activities, and the largest amounts of methane are produced as a product during the process of manure manipulation and storage.

(De Corato, 2020; Čustović et al. 2015). Today's farms often do not have adequate conditions for waste management. According to the methane emission, the agriculture sector (3.28 million t) at the end of 2019 was in second place according to the methane emission based on the sector of the Republic of Serbia (Fig. 2).

What can also contribute to methane emissions are various activities during tillage. The use of tractors and other machinery for soil cultivation can create specific anaerobic conditions (without the presence of oxygen). Such conditions make the work of microorganisms easier in the decomposition of organic matter. This causes the emission of metals from the soil.

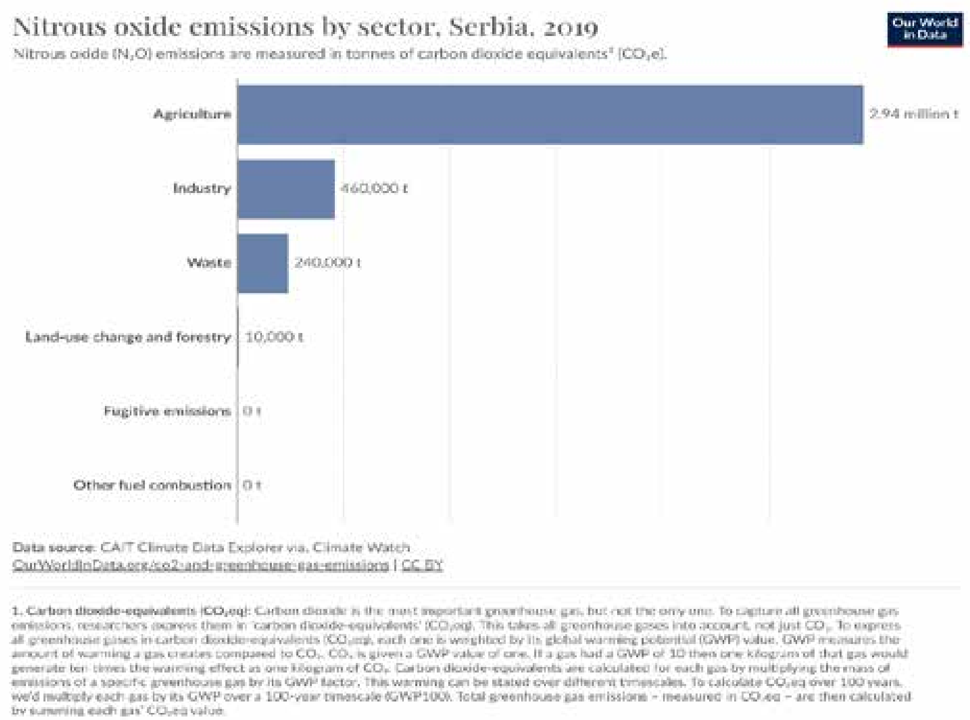
Figure 2. Methane emissions by sector for 2019 in the Republic of Serbia



Source:[*https://ourworldindata.org/grapher/methane-emissions-by-sector?time=latest&country=~SRB*](https://ourworldindata.org/grapher/methane-emissions-by-sector?time=latest&country=~SRB)

Agricultural production increasingly requires monitoring of the effects that remain after the finished production processes. As already mentioned, intensive agricultural production requires the use of large amounts of fertilizers and chemicals in order to achieve high yields (Kovačević, et al., 2011). Therefore, intensive agricultural production can leave a serious environmental problem by increasing another greenhouse gas emission, i.e. by increasing N2O (nitrogen suboxide) emissions. In the Republic of Serbia, according to data from 2019, the agricultural sector (2.9 million t) is in first place in terms of nitrogen oxide emissions (Fig. 3).

Figure 3. Emission of N2O by sectors of the Republic of Serbia, 2019



Source:[*https://ourworldindata.org/co2/country/serbia#nitrous-oxide-how-much-does-the-average-person-emit-where-do-emissions-come-from*](https://ourworldindata.org/co2/country/serbia#nitrous-oxide-how-much-does-the-average-person-emit-where-do-emissions-come-from)

Water pollution

Water pollution from agriculture is a serious environmental problem worldwide (Evans et al., 2019), including the Republic of Serbia. The main sources of water pollution are industrial and municipal waters, which are largely untreated. Agriculture also has a big impact on pollution. Water is also polluted by intensive agricultural production, which in today's conditions requires the application of high doses of mineral fertilizers and pesticides. Excessive amounts of these substances seep into the underground water and thus can end up in lakes, streams or rivers, which causes water pollution. Water pollution is most often caused by fertilizers that contain nitrogen and phosphorus. This process can lead to a decrease in water quality, endangering aquatic life and reducing biodiversity.

The negative effect of intensive agricultural production for the environment are particularly visible in rural areas. The reason for this is the fact that these areas are the main places for food production. The use of agrotechnical measures - pesticides, fertilizers and salt - puts water conservation at risk. Only 10-15% of applied pesticides (Đorđević, 2018) reach the target pests, and the rest end up in environmental elements (air, water and soil) (Roljević Nikolić & Paraušić 2019) and never reach the target surface (Sedlar et al., 2018).

Loss of biodiversity

Biodiversity loss due to agricultural production is present to a large extent. Therefore, one of the most important problems we face in the 21st century is the loss of biological diversity, especially in conditions of intensive agricultural production (Šeremešić at el., 2017). Agricultural production in the Republic of Serbia is distinguished by large monoculture areas, which are focused on the cultivation of certain crops (corn, wheat or sunflower). This is the reason for the change in diversity in the plant world. This practice can have a negative impact on local biodiversity (Hendershot et al., 2020). Also, the use of agrochemical substances can cause poisoning and death of many beneficial organisms, such as bees, other insects and birds, which directly affects biodiversity. Intensive land cultivation can lead to soil erosion (Chamizo, 2017), which has the effect of reducing soil fertility and destroying habitats for various organisms, including microorganisms, plants and animals.

Climate changes

All previously mentioned negative impacts lead to global climate change. The phenomenon of climate change today represents one of the most important and very complex problems faced by the growing human population. Climate change is a constant process on earth, but in recent times, roughly the last 100 years, the pace of these changes has increased dramatically. (Arora, 2019).

For the most part, the impact on climate change is reflected through the emission of gases with the greenhouse effect, the deformation and change of land use, the intensive use of pesticides and fertilizers.

The consequences of these activities, if there are no changes in production, will result in an increase in extreme weather conditions, such as droughts, floods and unpredictable changes during different seasons of the year (Nikolić Popadić, 2023). Which will affect both the yields of agricultural production and livestock production

Positive effects

Intensive agriculture, despite all the criticism related to negative impacts, can have several positive aspects regarding resource efficiency and sustainable agriculture (Mkonda, 2021). The main advantage of intensive agriculture is the increase in yield per unit area. The introduction of modern systems such as vertical farms, hydroponic systems or buildings with protected space (greenhouses or greenhouses) (Marina & Grujić Vučkovski, 2022) enables adequate optimization of land use.

Today's modern systems used in agriculture require large sums of money. Therefore, their application in systems of intensive agriculture is the most profitable and most frequently applied. Through the use of precision technology (like sensors for detecting various changes) irrigation system, more precise dosing of all resources is possible (fertilizer, pesticides and water) which can affect losses and unnecessary consumption of these resources (Oparnica et al, 2019).

An intensive production system with proper management and strict adherence to appropriate practices can ensure food safety. Given that intensive agriculture provides adequate means for food production, which would satisfy the needs of an ever-growing population.

Incorporating sustainable methods into the framework of intensive agriculture creates an opportunity to achieve a balance between increased productivity and conservation of natural resources. Sustainable practices within intensive agriculture can be key in meeting global food demands while ensuring long-term sustainability for future generations.

Recommended measures for the improvement of intensive agriculture

Intensive agricultural production has achieved certain goals, but several key measures can be found that could improve existing systems:

- Use of Precision Technologies: The application of sensors, UAV technology, GPS signals, certain software varies depending on many factors. In many developed countries, the application of precision agriculture is quite high, while in other parts of the world, especially in smaller farms or in less developed areas, this application can be limited.

- Vertical production and hydroponic systems: The development of innovative systems such as vertical farms, hydroponic systems and aeroponics helps to intensify production in a smaller space, reducing the impact on the environment and increasing efficiency.

- Robotics and Automation: The use of robots and automated systems in agriculture can significantly improve efficiency, reduce the need for manual labor and precisely manage processes such as sowing, mowing and harvesting.

- Sustainable Water Management: This primarily refers to the processing of waste water, but in combination with the use of modern irrigation systems. This combination reduces the total water consumption in agriculture. (Rosa et al., 2020). Also, the implementation of sensors for measuring moisture levels enables continuous monitoring of soil conditions and dosing of water according to the individual needs of the plant.

- Use of alternative pesticides: The development of environmentally friendly chemical agents and alternative methods for pest control can reduce the use of harmful pesticides, reducing the harmful impact on the environment (Bonanomi et al., 2020).

These recommended measures cover various fields, from precision agriculture, agrochemistry, water management to robotics. Which promotes sustainable practice and better use of resources in the system of intensive agriculture. Also, the application of these technological strategies is crucial for preserving the environment, increasing productivity and reducing the negative impacts of intensive agriculture.

Conclusion

Intensive agriculture has a complex range of impacts on the environment. Negative aspects, such as pollution and loss of biodiversity as well as climate change, require urgent changes and regulations in order to slow down and reduce their harmful effects as soon as possible.

The future of intensive agriculture will be reflected in the application of sustainable practices and technological innovations aimed at producing a sufficient amount of food, but at the same time preserving the environment. This will include the implementation of precision agriculture systems, the introduction of sustainable strategies to reduce negative impacts on the environment, and regulations that encourage environmentally friendly practices.

Through this approach, we can expect to achieve a balance between food production and environmental protection, ensuring the sustainability of agriculture and meeting the needs of future generations. Sustainable food production will be a major issue in solving the challenge of global food security.

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SPANISH CANE PRODUCTION IN THE FUNCTION OF CIRCULAR ECONOMY AND RENEWABLE ENERGY SOURCES

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Abstract

In recent years many countries direct their researches to finding the best way for getting energy and reasonable using of renewable energy as part of circular economy. In research it was analyzed a significant source of all forms of energy, the Spanish cane. Spanish cane can be used on many ways: as biogas, vegetable coal, and as an alternative source of plant fibers. Its cellulose fiber is used for production of paper as well as in the textile industry (substitute for cotton, flax, and kenaf fibers). The Spanish cane can be established as perennial grass areas at degraded and unused land due to its ability to be cultivated in marginal agro-ecological conditions. By development of new technologies for the biological waste processing into energy, within the circular economy, there is increase in the alternative fuel use and, thanks to its low requirements for water and warmth Spanish cane is a desirable energy crop. Speaking of erosion, it has to be mentioned that Spanish cane is one of the best crops for soil protection against all types of erosion. It is also very good in phytoremediation and absorption of harmful gases from the atmosphere, valued in as an ornamental plant and in the construction industry.

Key words: *renewable energy sources, circular economy, Spanish cane as energy crop, biofuel and biogas, phytoremediation.*

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Introduction

Throughout its long history, European, African, and Asian peoples have used Spanish cane for various purposes. The growing interest of producers and processors was also influenced by the fact that above-ground biomass is an excellent source for obtaining biofuels. Spanish reed belongs to the group of plants of the C3 pathway of photosynthesis. Recently it is used as a raw material in numerous industrial branches, it is interesting for processing in small businesses and home crafts. Spanish reed is used for phytoremediation, and absorption of harmful gases from the atmosphere. It is among the best crops for soil protection against all types of erosion and valued as an ornamental plant Ahmed et al. (2011). Spanish cane is grown for above-ground biomass, which is used in further processing as fresh or dried trees. According to the method of use, the method and time of product collection are determined. When for the production of bio-ethanol is use above-ground biomass it is mowed in the phenological stage with silo harvesters. The mowed biomass, which was cut by the forage harvesters to a length of about 10 cm, is inserted by conveyor belts into the means of transport and taken directly to further industrial processing. Two swaths can be obtained during the year, only if the conditions of the external environment are very favorable (long growing season) Hardion et al. (2016).

In our agroecological conditions, Spanish cane for obtaining biofuel from fresh biomass would be cut once a year, in the second half of August. After mowing, the plants regenerate and, through photosynthetic activity, provide assimilates necessary for the life functions of underground trees and roots Janković et al. (2017).

In our agroecological conditions, Spanish cane for obtaining biofuel from fresh biomass would be cut once a year, in the second half of August. After mowing, plants regenerate and, through photosynthetic activity, provide assimilatives necessary for the vital functions of underground trees and roots. If the goal of production is dry above-ground trees, they are cut during the winter, usually in February. Mowing is done with rotary tractor mowers or machine aggregates that tie the mowed biomass into bundles. Winter mowing is the most favorable because the leaves have already fallen and the water content in the trees is about 30%. After a short drying in the field, the bundles are transported and stacked in covered rooms, canopies protected from precipitation. Further drying processes continue in dry rooms. Dry trees are used as solid biofuels in large boiler plants, for example in thermal power plants, then to obtain cellulose, as well as in other industrial branches Ball et al. (2006).

Finally, it should be noted that this is not a new and little-known plant species. Developing for centuries throughout the American continent, the Spanish reed showed an efficient way to synthesize a large amount of useful and usable organic substances from the available water and mineral salts from the soil through its metabolic C3 pathway.

A more modern way of using Spanish cane in construction is the use of woody mass, as an adhesive material for the production of chipboards and plywood, which are used for the production of numerous household appliances, and more recently, furniture. The world-famous company IKEA plans to reorient itself to "green technology" by 2030 and to replace wood with alternative building materials originating from annual cultivated plants Lambert et.al. (2010); Glamočlija et al. (2022).

Aim of this research was analyzing of the possibilities of using Spanish cane, which is grown for biomass, which is a raw material in numerous industrial branches and is interesting for processing in the small economy and at home. It is rich in carbohydrates, which can be used in many ways, including for obtaining biofuel. Due to these properties, as well as the fact that it has negligible nutritional value, today it is predominantly used to obtain biofuels and is considered one of the most important energy crops of the third generation. Of biomass are produced solid, liquid, and gaseous fuels in a realistic, efficient and clean way, and as such it presume a renewable source of energy. The term "biomass energy" means energy products obtained from organic matter (plant, animal, or microbial origin). Gao et al. (2012) said that for insurance of necessary energy sources supply, most countries in the world are, in their research, tried to find the most rational way of using renewable energy sources Gao et al. (2012).

Material and Method

The research analyzed the use of Spanish cane as a significant source of renewable energy, in the function of the circular economy: biofuel production; construction and pulp industry; home industry and soil remediation.

Results and discussion

The above-ground biomass of Spanish cane is of low nutritional value. The content of useful nutrients depends on the age of the plants. Determining the chemical composition of Spanish cane stems and leaves, it can be concluded that it has a low nutritional value Ahmed et al. (2011). According to the data of a number of authors, the nutritional value of above-ground biomass as fodder is not significant, except for the higher content of phosphorus salts (table 1).

Table 1. Nutritional value of Spanish cane (%)

Nutritious substance	Young plants	Wandering	Ripe plants	
	Stem	The leaves	Stem	The leaves
Total proteins	8.13	12.25	5.94	8.88
Digestible proteins	1.50	1.96	0.63	1.10
Oil	2.2	1.9	3.0	2.2
Carbohydrates	20.0	20.7	23.2	21.7
Alpha-cellulose	54	52	54	53
Hemicellulose	32	28	36	35
Lignin	5.8	3.5	8.2	7.1
Mineral salts	3.80	4.55	3.30	3.82
Potasium	3.09	3.19	2.04	2.42
Calcium	0.30	0.43	0.52	0,67
Magnesium	0.12	0.19	0.25	0.32
Phosphorus	0.11	0.16	0.08	0.11

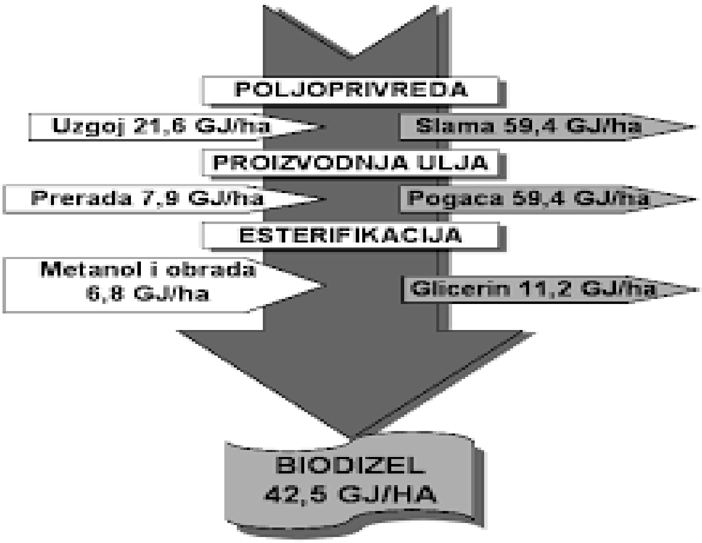
Source data: *Ahmed et al*. (2011)

Fuel consumption in the past decades is constantly increasing, as is the number of inhabitants on the planet. As sources of energy, we use solar energy, which manifests itself in the following ways: hydropower, electric and thermal energy, then energy from the biosphere. The fourth form of energy is called bioenergy. It is created in the processes of photosynthesis in plants and is released by burning biological material. Today, bioenergy is a very important source of energy, which according to its origin can be non-renewable (solid, liquid, and gaseous fossil fuels) and renewable (biomass of agricultural and forest species, their remains, as well as all agricultural and municipal waste (Ikanović et al. 2022; 2023). Thanks to the very high annual yields of above-ground biomass rich in cellulose and without a significant share of undesirable compounds, Spanish cane is today among the most important energy crops. The annual increase in biomass can be used for heating in the household, as well as for industrial energy needs because it can be used in several ways to convert into heat and electricity. Spanish reed achieves a dry weight yield of 50-80 tons per hectare. To these facts should be added the possibility of cultivation in a wide geographical area, in different agroecological conditions, and with minimal investment in production technology

(Janković et al. 2017). The simplest way of using biomass as an energy source is the burning of previously baled dry trees in large boiler plants of thermal power plants. For this method of use, dry biomass is cut with silo harvesters and pressed into round bales weighing 600-800 kg, which are stored next to the point of consumption Schmer et al. (2008). The fact that the Spanish reed, with minimal agrotechnical investments during the annual cycle, forms the highest yield of above-ground biomass attracted the special interest of scientists. It is rich in carbohydrates, which can be used in many ways, including for obtaining biofuel, Pictures 1-2. Due to these properties, as well as the fact that it has negligible nutritional value, today it is predominantly used to obtain biofuels and is considered one of the most important energy crops of the third generation.

Biodiesel is an alternative fuel available today which is prepared from vegetable oils and used in diesel engines. Diesel is clean, and efficient and is generated from renewable sources (Figure 1, Krstić et al. 2007).

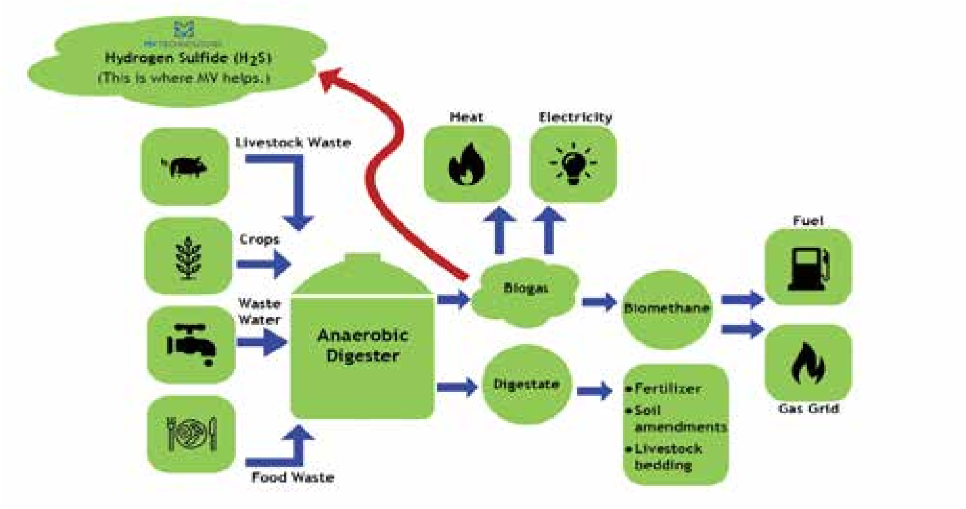
Picture 1. Energy balance of biodiesel production (Krstić et al. 2007)



Picture 2. Spanish cane for biofuels,

Source: https://www.facebook.com/photo/?fbid=440819259323489&set=trska-presovana-plocanad-preselt-tablavelicinameret-150m-x-080m

Picture 3. The Environmental & Economic Benefits of Anaerobic Digestion - MV Technologies



One of important natural process is anaerobic respiration. Primitive organisms, including the oldest surviving bacteria use that process. Organic matter, by the anaerobic metabolism of bacteria release large amount of nitrogen, biogas methane, some of hydrogen-sulphide and organic solid and liquid residues. Hydrogen sulfide is toxic to humans and most other animals by inhibiting cellular respiration. (https://en.wikipedia.org/wiki/Hydrogen_sulfide). MV Technologies' systems help to remove the H2S gas from the methane. Following this process, both the biogas and the remaining organic solids and liquids can be used in multiple ways, presenting both environmental and economic benefits (Picture 3, Dražić et al. 2019; Rakaščan et al. 2021; Popović et al. 2020;

2023; Rakić et al. 2023). Although this function is useful in microbiology and the oil industry, excessive production of methane is a problem because it is as large a greenhouse gas as carbon dioxide, linked to climate change.

Anaerobic digestion is a naturally occurring process. In the absence of oxygen, bacteria break down organic materials and produce biogas. The process reduces - or digests - the amount of material, producing biogas as a byproduct. This biogas can then be used as an energy source. The anaerobic digestion process occurs in three steps. First, plant or animal matter is decomposed by bacteria into molecules, such as sugar. The decomposed matter is then converted to organic acids, which are then converted to methane gas (biogas). The by-products of the process include methane gas and organic solids and liquids and small amounts of hydrogen sulfide (H_2S) gas. MV Technologies' systems help to remove the H_2S gas from the methane. Following this process, both the biogas and the remaining organic solids and liquids can be used in multiple ways, presenting both environmental and economic benefits (Picture 3, Dražić et al. 2019; Rakaščan et al. 2021; Popović et al. 2020; 2023; Rakić et al. 2023).

If the wood mass is used for combustion in smaller plants (boilers for floor heating of residential and commercial spaces), it is first chopped and then briquettes are made from it, for larger boilers or pellets. The thermal power of these energy sources is similar to the same wood products. Pellets have a high absorbent power and can be used as a mat in barns and boxes for pets.

A more modern way of using Spanish cane in construction is the use of woody mass, as an adhesive material for the production of chipboards and plywood, which are used for the production of numerous household appliances, and more recently, furniture. The world-famous company IKEA plans to reorient itself to "green technology" by 2030 and to replace wood with alternative building materials originating from annual cultivated plants Lambert et al. (2010), Picture 4.

Picture 4. Spanish cane furniture

Source: https://indizajn.rtl.hr/inspiracija/noviteti/povratak-trske-ali-spanjolske-imamo-ideje-koje-ce-vas-osvojiti/

In the modern industry of musical instruments such as bass, clarinet, oboe, saxophone, bassoon, bagpipes, flute and other instruments with wooden parts, Spanish reed trees are used for their manufacture today. The best raw material is obtained from plants from the area of Attica.

The Romans used trees to make writing pens. In addition, it was used to make fishing rods, then as a support for annual and perennial climbing plants (legumes, decorative plants, vines and the like).

The plantings (crops) based on the sloping sides of watercourses form a strong stand with powerful roots and rhizomes, which provide a solid ice, preventing soil particles from being washed away during periods of bank flooding. In areas with pronounced periodic air currents during the summer and autumn, the density of Spanish reeds softens wind blows and prevents fine soil particles from being carried away. After studying vertical wind gusts in the plant's natural habitat in southern France, Speck et al. (2003) concluded that Spanish reed can withstand strong wind gusts without major mechanical damage.

According to soil conditions, it is very tolerant, it also succeeds in conditions of increased concentration of arsenic, cadmium and lead. By absorbing these elements and depositing them in the underground organs of the rhizome, the Spanish reed exhibits a significant potential for phytoremediation and is recommended for cultivation in conditions of increased soil and groundwater contamination. This method of remediation is recommended on forbidden surfaces, in canals with waste water, as well as in hydroponic production if the water is contaminated with heavy metals Spencer et al. (2006).

Conclusion

Spanish cane as an autochthonous species in the wide Mediterranean and hinterland, is one of the most promising crops for the production of bio-fuels of this area, where it has already shown its production values. Based on the fact that growing Spanish cane yields much higher raw material yields per hectare than corn, it provides 1.5 times more of this energy source and excludes the use of this important food grain for energy purposes. It should also be noted that the production costs of Spanish cane are about 50% lower than maize.

Spanish cane provides opportunities that, on degraded and unused lands establish perennial grass areas, thanks to its low need in water and warmth. Therefore, it is recommended to establish grass areas next to roads, industrial and livestock buildings, i.e. areas that are major polluters of the atmosphere.

Beside its important role in erosion protection, Spanish cane is one of the best crops for phytoremediation, absorption of harmful gases from the atmosphere, and valued as an ornamental plant. It is rich in carbohydrates, which can be used in many ways, including for obtaining biofuel. Due to these properties, as well as the fact that it has negligible nutritional value, today it is predominantly used to obtain biofuels and is considered one of the most important energy crops of the third generation. Biomass is a renewable source of energy that is used to produce solid, liquid and gaseous fuels in a realistic, efficient and clean way.

In our agro-ecological conditions, the production of Spanish cane can be profitable because it can be grown on lands that are less fertile. Serbia is at the very top of European countries as per amount of available and unused biomass which represents largest renewable source of energy. Technologies for its use are available and environmentally acceptable. This fact could possibly serve as a practical recommendation for the cultivation of Spanish cane for energy production and phytoremediation on poor soils.

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NATURAL CHARACTERISTICS AS A BASE FOR THE SUSTAINABLE AGRICULTURAL PRODUCTION – THE MUNICIPALITY OF TEMERIN EXAMPLE[1]

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Abstract

The climate, pedological and hydrological characteristics as a base for planning agricultural production in the region of Vojvodina (the Municipality of Temerin area, the South-Backa administrative district) were represented in this paperwork. This research goal was to show the summarized data on the climate parameters, the representation of soil types, hydrological resources, number of agricultural husbandries and the utilised agricultural land in this research area. The data were collected from the relevant strategic and statistical documents, as well as the scientific paper works in which a similar topic has been studied. According to the results obtained from the research and discussions has concluded that this area of the South-Backa administrative district has been very favourable for the diverse agricultural production. These results are also significantly important for further planning of agricultural production and its intensification by the farmers in the Temerin Municipality.

Key words: *climate indicators, pedological characteristics, hydrological characteristics, the utilised agricultural area.*

Introduction

One of the crucial challenges of the Century we live in are the climate changes. These changes have seized the whole planet Earth, and thereby our coun-

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try. Changes reflect in a marked change and variability in air temperature, especially in summer months, and more marked precipitation variability. The precipitation deficiency in Serbia has been particularly present since ‘80s of 20th Century (Popović et al., 2009). In parallel, there was also present concern about influence of the global climate changes on agriculture, which have been traditionally one of the most important sectors of Serbian economy, and thereby factors that affect agriculture have simultaneously affected the entire Serbian economy (Lalić et al, 2011).

In the sector of agriculture, the climate changes show their presence through the meteorological droughts frequency as a result of the increased air temperatures and reduced amounts of precipitations during summer time. This is what reflects in the reduction of agricultural species’ yield and has a chain transmission to a price of agricultural products. On the other hand, agricultural land as well as a basic factor of agricultural production are one of the most important factors and basic resource for the food production requires a responsible management both for the agricultural land and environmental preservation (Zubović et al, 2017). Due to increasing climate changes and their significant effect on the agricultural production, for planning and initiating the agricultural production or its intensification where possible, it is important to study land and climate indicators as well as the presence and opportunity of water resources use in the specific region for the irrigation apply during the vegetation period of a cultivated plant.

The rational use of natural resources through financial support can enable good long-term positioning of agricultural products from our country, as on domestic as well as on the international market (Đurić and Prodanović, 2017).

Agriculture is a supporting column of the Republic of Serbia economic development. However, besides a huge potential which the agricultural production has thanks to the favourable natural conditions (favourable climate conditions, availability of a great production capacity land and availability of water resources), it hasn’t been sufficiently developed (Subić et al., 2022). Owing to the importance of agricultural sector for the development of the Temerin municipality, this research’s goal is to perceive natural factors that have an effect on the agricultural production success and its improvement.

Materials and Methods

The approach to a descriptive statistic (DESK) was used for the analysis of climate and pedological indicators in the municipality of Temerin. There were used empirical data taken over from the electronic database of the Statistical Office of the Republic of Serbia, as well as the Republic Hydrometeorological Service of Serbia. Strategic documents of the municipality and the Republic of Serbia, such as the Local Waste Management Plan of Temerin Municipality, the Spatial Plan of Temerin Municipality, the Development Strategy of Temerin Municipality, the Strategy of Agriculture and Rural Development of the Republic of Serbia supported the research on a given topic. These documents helped finding data related to the climate, pedological and other relevant parameters. Besides, there were used also the related scientific paper works, which had studied the same or similar problem, and provided additional information on the given topic in this paper work.

Research results and discussion of the results

Within the research results were shown natural characteristics of the Temerin municipality region, one of the municipalities that represented a part of the South-Backa District. Those characteristics comprised studying climate through its basic indicators, and furthermore studying different pedological types represented in this territory, number of registered agricultural husbandries, areas (in ha) under crops in the field of vegetable growing, fruit growing and viticulture, areas under industrial and fodder, as well as areas for livestock production.

Climate characteristics

Climate, as one of the crucial natural factors, has an important effect on the development of economy and society of the related area, and especially on agriculture. Climate of Vojvodina is moderately-continental with certain particularities. It is characterised by hot summers and cold winters, while springs and autumns last shortly. Summer temperatures range from 21°C to 23°C, and winter temperatures range in average -2°C. However, there are great extremes in temperatures, and therefore differences between the lowest and the highest values can amount up to 70°C (Popović et al, 2005.)

For in-detail perception of the climate specificities of the Temerin municpality area, there were analysed the mid-month values of the climate parameters for the period 2012-2022, as well as the mid-annual values derived from its parameters' monthly values in the meteorological station „*Rimski Šančevi/Novi Sad*[5]". The parameters comprised by the analyses are: *Maximum, minimum and middle temperature of air (T, ºC); Air pressure (mb); Relative air humidity (RH, %); Numer of days with strong (>6Bft) and torrential wind (>8Bft), (V, day); Insolation (n, hour); Cloudiness (tens); Precipitation (P,mm).* These parameters values are shown in the table 1 and chart 1.

Table 1. Value of the climate parameters from the Meteorological Station Rimski Sancevi (Novi Sad) for the period 2012-2022

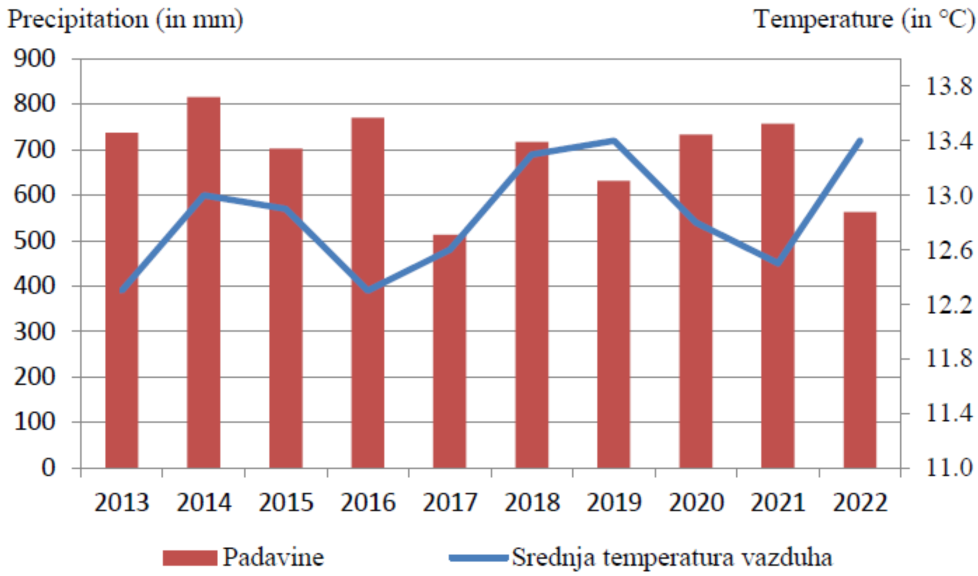
Year	**Air pressure (mb)**	**Air temperature (ºC)**			**Relative air humidity (%)**	**Wind speed m/s)**	**Insolation (n)**	**Cloudiness (number of days)**	**Precipitation (mm)**
		max	**min**	**Average**					
2013	1,005.6	17.8	7.4	12.3	77	2.4	2,113.1	5.5	737.4
2014	1,005.5	18.4	8.4	13.0	78	2.6	2,059.5	5.7	816.0
2015	1,008.5	18.3	7.9	12.9	76	2.2	2,288.5	5.1	702.7
2016	1,007.1	17.7	7.5	12.3	78	2.6	2,155.6	5.5	770.7
2017	1,007.4	18.4	7.2	12.6	72	-	2,415.2	5.1	513.1
2018	1,006.1	18.8	8.4	13.3	75	-	2,260.1	5.5	717.1
2019	1,005.9	19.3	8.2	13.4	73	-	2,336.3	5.1	632.1
2020	1,007.4	18.4	7.8	12.8	73	2.7	2,275.1	5.2	733.2
2021	1,006.7	18.2	7.4	12.5	73	2.8	2,338.3	5.0	757.6
2022	1,00.,8	19.3	7.9	13.4	70	2.6	2,443.5	4.9	563.6
Average	**1,006.8**	**18.5**	**7.8**	**12.9**	**74.5**	**-**	**2,268.5**	**5.3**	**694.4**

Source: Calculation according to data from the meteorological yearbooks (climate data) of the Republic Hydrometeorological Service of Serbia, Belgrade, 2012-2022

The average value of air pressure is 1006.8 mb. Maximum air temperatures range from 17.7 ºC (2016) to 19.3 ºC (2019 and 2022), while minimum air temperatures range from 7.2 ºC (2017) to 8.4 ºC (2014 and 2018). Middle temperatures of air were shown in the chart 1, together with precipitation, and were in average 12.9 ºC.

5 Elevation 86 m, latitude 45°19'N, longitude 19°50'E

Chart 1. Review of precipitation and air temperatures' middle values



Source: Authors'presentation according to the database of the Republic Hydrometeorological Srvis of Serbia

The precipitation regime of Vojvodina has partly characteristics of the Danube regime. This implies unevenness by months during a hydrological year and during a vegetation period of plant species, and therefore often due to the insufficient quantities of available water to plants in the zone of a root system, the lack of water must be replaced by irrigation. There can be singled out the particularly rainy periods in the beginning of summer (especially in June), as well as periods without or with negligible quantity of precipitation (October and March). Short summer storms with hail and heavy rainfall are possible during summer time.

The average values of total precipitation for the period 2012-2022 were 694.4 mm per year.

The data on wind speed are incomplete, because some monthly measurements in the specific years are missing, and therefore there cannot be presented an average value of wind speed. Winds that mostly blow in Vojvodina are: „košava"cold and strong wind, with great energy potential as a drive for the wind power plants in Banat; „severac", also cold wind; „south"warm wind; and „west" wind that brings precipitation through rainfall or snow (Wind Atlas of AP Vojvodina, 2008). For the Temerin area are characteristic strong winds, which blow from the southeast direction mainly in the colder half of the year, primarily koshava (košava), while winds from the northwest direction blow during spring and summer (Local Waste Management Plan for the Temerin Municipality, 2011).

A total number of sunny hours (in average) for the Temerin Municipality is 2,268.5 hours, and the average cloudiness is 5.3.

Soil

The most represented types of soil in the region of Temerin Municipality are *chernozem, humogley*, *eugley*, *humofluvisol*, *solanchak* and *solodj*. The spatial presence of these soil types is expressed in ha and shown in the table 2, as well as a percentage share in relation to a total area of these soil types.

Table 2. Types of soil in the Temerin municipality

	Temerin	
	Areas (ha)	***Share (%)***
Chernozem	14,244.06	84.01
Humogley and Eugley	475.37	2.80
Humofluvisol	1,139.01	6.72
Solonchak and Solonetz	1,096.84	6.47
Total	**16,955.27**	**100.00**

Source: Report „Possibilities for cultivation of fast-growing energy crops from the agricultural land availability in RS point of view Republic of Serbia. Ministry of Mining and Energy, Ministry of Agriculture and Environmental Protection. UNDP Serbia. Belgrade, 2017

Since the production of food is related mostly to soil, the care about land is inevitable, and therefore is necessary to overtake all adequate measures of soil protection and implement a predetermined goal for its sustainable use (Kljajić et al, 2012).

Water wealth

The water wealth is constituted of the surface and ground water, which are connected to the surface and therefore makes an inseparable part of water resources when considering the water balance. The largest part of the Republic of Serbia territory, and therefore the AP Vojvodina, belongs to the Black Sea basin, i.e., the Danube basin. Hydrological network of regional station Novi Sad is shown in the Image 1.

On the territory of the Temerin Municipality all water flows have been turned into canals and included in the Danube-Tisa-Danube hydro system, which has been used in agriculture (for irrigation) and drainage of the excess waters.

The river Jegricka is the longest water flow in the south part of Backa loess plain and the territory of Temerin Municipality. Jegricka is 64.5 km long and flows into the river Tisa on the right side. *Kisac Canal* flows through Sirig (flow length is 16 km), and it flows into the Jegricka river east of the settlement. The other water flow is *Beli Canal* or *Bela Bara*, which starts south from Backi Jarak, slightly turns to the north in west part of Temerin and flows into Jegricka. The flow is channelled from Temerin to the confluence. In east part of the Temerin Municipality there are minor channelized water flows, such as *Ciganka* and *Mala Bara.* There are no natural lakes here.

Image 1. Network of surface water stations – Hydrological regional station Novi Sad

Source: https://www.hidmet.gov.rs/ciril/hidrologija/povrsinske/hrs_novi_sad.php

Groundwater on the territory of Temerin Municipality is present as the *artesian and phreatic water*. The artesian water, which use for exploitation, appears in greater depths of 100 m, even up to 300 m. The abundance of these layers is small and amounts 5 l/s, and in optimal conditions up to 10 l/s.

The phreatic water appears in the water permeable layers of soil at a shallow depth. The upper level of the phreatic aquifer moves freely depending on inflow of water and soil evaporation.

Thermo-mineral waters were located in Temerin in 1914. This water is beneficial and is used for swimming in pools, and also for bathing in tubs.

The utilised agricultural area

The South Backa District, where the Temerin Municipality is located, has 26,297 agricultural husbandries, or 20.7% of a total number of AH in the region of Vojvodina, and 4.7% of a total number of AH in the Republic of Serbia (table 3).

Table 3. General data on the agricultural husbandries and the utilised agricultural area

	Republic of Serbia	**Vojvodina Region**	**South Backa District**	**Temerin Municipality**
Number of husbandries	564,541	127,070	26,297	1,367
Utilised agricultural area (ha)[6]	3,475.894	1,574.366	273,729	14,480
Ploughland and gardens (ha)	2,571.580	1,433.130	262,394	13,984
Orchards (ha)	182,923	19,494	3,626	146
Vineyards (ha)	20,466	4,614	730	21
Meadows and pastures (ha)	676,724	112,742	6,086	305

Source: Census of Agriculture, Survey on the agricultural husbandries' structure, 2018

The utilised agricultural area in the South Backa area is located on 273,729 ha, or 7.9% of the utilised agricultural area in the Republic of Serbia, and 17.4% of the utilised agricultural area in the region of Vojvodina. There are 1,367 registered agricultural husbandries on the territory of the Temerin Mu-

6 *The utilised agricultural area is composed of: agricultural area in garden plots, ploughland and gardens (including fallow land), permanent plantations – orchards, vineyards, nursery gardens, basket willow plantations, areas under female rushes, carob plants, areas where truffles grow, as well as plantations of fir trees for sale (Christmas trees), and meadows and pastures that are regularly cultivated – ut*ilised.

nicipality, and 14,480 ha of the utilised agricultural area, or 0.4% of the totally utilised agricultural area at the republic level, and 0.9% of the utilised agricultural area at the South Backa area level.

Cereals are mainly represented on the territory of the Temerin Municipality on area of 8,334 ha, and then industrial crops on area of 4,392 ha, vegetable, melon plantations and strawberries, on area of 137 ha, and legumes on the total area of 12 ha (table 4).

Table 4. Number of husbandries and areas under arable and vegetable crops

	Republic of Serbia	**Vojvodina Region**	**South Backa District**	**Temerin Municipality**
Cereals (total) in ha	1,702.829	879,312	133.873	8,334
Legumes (total) in ha	7,834	2,635	350	12
Industrial crops (total) in ha	493,570	426.158	97,920	4,392
Fodder (total) in ha	230,323	50.172	7,796	74
Vegetables, melon plantations and strawberries (total) in ha	50,107	20.665	6,662	137
Flowers and decoration plants (total)	440	196	26	7
Seed and planting material for sale (total)	3,806	3,506	1,211	71

Source: https://data.stat.gov.rs/Home/Result/1300020201?languageCode=sr-Cyrl&displayMode=table&guid=18db8167-285a-4665-b02e-e118ffb57e99(na dan 12.10.2023.)

Orchards are widespread on totally 146 ha. There are mostly apricots on 52 ha and apples on 51 ha. Raspberries are grown on 18 ha, plums on 13 ha, and pears on 11 ha, while according to the Census of Agriculture there are no other fruit species (table 5), maybe in smaller areas, i.e. garden plots.

Table 5. Number of husbandries and areas under fruits

	Republic of Serbia	Vojvodina Region	South Backa District	Temerin Municipality
Number of husbandries (total)	270,847	18,505	3,170	218
Orchards (total)	182,874	19,493	3,626	146
Apples	26,680	7,440	1,471	51
Pears	4,977	1,114	236	11
Peaches	5,178	1,024	140	0
Nectarines	1,129	124	22	0
Apricots	6,039	1,030	256	52
Cherries	4,330	485	137	0
Sour cherries	19,613	1,705	253	0
Plums	72,983	2,582	342	13
Quinces	1,950	228	57	0
Nuts	2,796	418	69	0
Hazelnuts	4,564	2,335	369	1
Almonds	9	5	2	0
Other fruit species	534	37	12	0
Raspberries	24,899	739	248	18
Blackberries	6,055	23	3	0
Blueberries	644	134	0	0
Other berry fruits	495	69	8	0

Source: *https://data.stat.gov.rs/Home/Result/1300020204?languageCode=sr-Cyrl&displayMode=table&guid=ca2116fd-7557-4777-a41d-72a5799704e5(na dan 12.10.2023.)*

In the Backa Region 76 husbandries have vineyards, which makes only 1.3% of the total number of agricultural husbandries in this area. Viticulturists are mainly settled in the Municipality of Odzaci, although the largest area under vineyards has the Temerin Municipality (Viticulture Atlas, 2015). Vineyards in the Temerin Municipality are located on 21 ha, while the most represented are grape varieties for the production of red wine, or 71% (table 6).

Table 6. Number of husbandries and areas under vineyards

	Republic of Serbia	Region of Vojvodina	South Backa Region	Temerin Municipality
Number of husbandries (total)	602.228	4.684	762	48
Vineyards (ha)	20.466	4.614	730	21
Grape varieties for the production of wine with a geographical indication	2.065	793	42	1
Varieties for production of red/rose wine	9.028	2.453	290	15
Varieties for the production of white wine	3.303	808	250	2
Table grape varieties for eating	6.070	560	149	3

Source: https://data.stat.gov.rs/Home/Result/1300020206?languageCode=sr-Cyrl&displayMode=table&guid=ae16d462-2e26-4824-b0b9-ad2d12007811 (na dan 12.10.2023.)

Wines from this area have an important place in the wine supply of Vojvodina, and contribute significantly to the development of rural tourism. The most important varieties of wine are: *Chardonnay, Cabernet sauvignon, Rose, etc.*

Livestock breeding

As we can notice from the table, there prevails the breeding of pigs and poultry on the territory of the Temerin Municipality. The Temerin Municipality is not abundant with pastures and meadows, and the breeding of sheep isn't developed. The number of pigs is 197 on 100 ha of ploughland, while at the South Backa District level 121 pigs, at the Vojvodina level 95 pigs, and at the republic level 136 pigs.

Table 7. Livestock concentration in Temerin Municipality in comparison to the regions in the Republic of Serbia, 2012

Livestock concentration per an area unit	Republic of Serbia	Vojvodina Region	South Backa Region	Temerin Municipality
Number of cattle on 100 ha of arable land	33	17	17	15
Number of pigs on 100 ha of arable land	136	95	121	197
Number of sheep on 100 ha of agricultural land	51	17	18	11
Number of poultry on 100 ha of arable land	1,063	817	1,096	1,615

Source: Development Strategy of Temerin Municipality 2016-2020

Like related to pig breeding, in the Temerin Municipality prevails the poultry breeding, which can be concluded according to an indicator of poultry concentration of 1,615 on 100 ha of ploughland, or much more than at the district (1,096), provincial (817) and republican level (1,063).

Conclusion

In accordance to the collected data analysis, there can be noticed the favourable conditions for different forms of agricultural production in this area. The climate and pedological factors result in suitability for the intensification of almost every branch of agricultural production:

- Good qualities of soil types, high production capacity, favourable climatic conditions and tradition in production make this area suitable for ***fruit production;***
- Temerin area is abundant with a large number of sunny days and favourable climatic conditions for the growing of ***vine***. This area is famous by the production of wine and every year organizes the international wine evaluation as one of the biggest wines' competitions in Serbia;
- Favourable climatic conditions, sufficient amount of precipitation and arable land make this area very favourable for growing various types of ***vegetables***. Mainly grown vegetables are: bean and potato, etc;
- This area has a developed ***livestock*** tradition, especially in pigs and poultry. Pastures provide excellent conditions for sheep grazing, and there are also good conditions for cattle breeding;

- ***Cereals, industrial and fodder crops*** are widespread, which proves the fact that Temerin is favourable area for this type of agricultural production.

The area of the Temerin Municipality still has developed production capacities and tradition in these agricultural branches. It is necessary to include the application of modern technologies and innovations, which will provide high, stable and economically justified yields in perspective that will lead to the development of a local economy. Besides, the adequate infrastructure in form of good and high-quality roads to rural areas, good water supply network and inevitable application of irrigation in production are also necessary factors for the development of agricultural sector of the Temerin Municipality. Rural tourism, together with agriculture, is an inevitable factor for improvement of rural life through the creation of a market for the local agricultural products.

One of the basic problems related to Serbian agriculture is the lack of agricultural production financing, as well as for the improvement of life and work in rural areas, i.e. in the countryside (Vasiljević et al., 2015). Consequently, there recognizes a need for subsidies in agriculture that should be directed to raising the high-quality products' yield. The current models of agricultural and rural development financing must become efficient for the users of agrarian policy measures, along with the introduction of adequate systematic changes. The agrarian policy should contribute to a growth of agricultural sector competitiveness and the reduction of a producer's/processor's income risk (Strategy of Agriculture and Rural Development of the Republic of Serbia for the period 2014-2024).

The possibility of using the pre-accession EU funds for rural development (IPARD II program) that implies a pre-accession assistance program to farmers is very important. Its main contribution should be increasing productivity and competitiveness, as well as the improvement of life quality in rural areas. This program is oriented to the development of the entire Republic of Serbia territory, including the belonging municipalities and towns.

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MAIZE GRAIN YIELD IN ANIMAL-POWERED FARMING AS AFFECTED BY SOIL FERTILIZATION VARIANT: RESULTS FROM THE 2023 SEASON IN NORTH-EAST CROATIA

Ranko Gantner[1], Igor DelVechio[2], Zvonimir Steiner[3], Bishal K. Sitaula[4], Krešimir Bošnjak[5], Vesna Gantner[6]

Abstract

The objective of this study was to investigate maize grain productivity in a low-input farming system as affected by the variant of soil fertilization. All the agrotechnical operations in this field research were powered solely by draft horses and by the use of traditional horse-drawn implements (plow, tine-harrow, seeding machine and inter-row cultivator), except the modern horse-drawn roller-cutter made for green-manures and cover crops management prior to establishment of cash crops, and a small reconstructed (halved) disc-harrow (initally made for a small tractor). Tested soil fertilization variants were: Zero fertilization, horse farmyard manure application (FYM), green manuring with crimson clover (Trifolium incarnatum L.) (GMC), FYM + GMC, and full dose mineral NPK fertilization. Maize grain yields in this research were lower than in previous field trials in the north-east Croatia, most likely because of later seeding term, but not due to source of powering. The highest yielding was NPK variant (7.60 t/ha) which was significantly higher than the lowest Zero variant (2.01 t/ha). FYM (6.67 t/ha), FYM+GMC (6.24 t/ha) and GMC (4.60 t/ha) were intermedium but not significantly different from the NPK.

Key words: *maize, yield, soil fertilization, animal power, sustainability.*

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Introduction

Modern crop farming is characterized by using powerful diesel-powered tractors with implements that have raised the human work efficiency to the levels never seen before. Slow but continuous growth of crops yields is achieved thanks to the broad use of agrochemicals (mineral fertilizers and pesticides). Though, the sustainability of current intensive practices is questionable due to several major issues: excessive soil compaction induced by heavy machinery (Hamza and Anderson, 2005), soil structure and microbiome degradation due to excessive use of mineral fertilizers and lack of organic fertilizers (Singh et al., 2020), reliance on exhaustive fossil energy resources for powering the farm operations (Gantner et al., 2014) and fertilizers production (Lal, 2004) associated with adverse effect to climate, and excessive emissions of toxic compounds from the pesticides applications and consequential loss of biodiversity (Demeneix, 2020) in broad areas of arable countryside, as well as negative impacts to human health. With aim to mitigate these negative consequences of modern intensive farming there advented some more sustainable options in last few decades, like ecological farming, organic farming, integrated farming, conservation farming, precision farming, regenerative farming and low-input farming. Currently the low-input farming option appears to receives the least attention and is mainly unknown to the general public and even to the majority of farmers. According to Poux (2007), low input farming systems should be considered as a core option for Europe. Low input farming systems seek to optimize the management and use of on-farm resources and to minimize the use of production inputs as off-farm resources, such as purchased fossil fuels, chemical fertilizers, and pesticides (Parr et al., 1990; cit. Poux, 2007). Thereafter low-input farming systems have the potential to fit into organic farming regulations. The main advantages of low input farming systems over the high input ones are the potentially higher efficiency at the farm level, reduction of pollution risks and beneficial effects to biodiversity and landscape (Poux, 2007). According to Garré (2022), the inclusion of work horses in sustainable transitions, can help increase the farm autonomy and sustainability of European smallholdings. Since the animal-drawn agronomy relies on the on-farm produced fodder as a source of clean and carbon-neutral bioenergy (Gantner et al., 2014), it perfectly fits into concepts of low-input farming and circular economy as well.

Aim of this research is to test the maize grain productivity in a low-input farming system as affected by the variant of soil fertilization. Maize crop is chosen for the study since maize is the most important crop in Croatia (about third of Croatian arable area is occupied by it).

Material and Methods

The field trial was set up near Požega town in the Slavonia province, the north-east part of Croatia. At the trial site the terrain was slightly sloped and generally well drained. Forecrop was spring oats harvested in July 2022. After the oats harvest, the soil was plowed shallowly (about 10 cm in depth) by traditional single-bottom horse plow with bottom width of 0.25 m. Before commencing the operations for the trial, the soil was levelled by tine harrowing with a traditional horse-drawn tine-harrow.

Basic parcel area was 42 m^2 (= 4.2 m × 10 m) and consisted of 6 maize rows with interrow distance of 0.7 m and length of 10 m. In the trial there were tested 5 variants of soil fertilization, each with specific sequence of agrotechnical operations (Table 1). All variants were repeated in two replications (in two basic parcels), spatially randomized in a complete random block arrangement.

Table 1. Tested variants of soil fertilization with specific sequences of agrotechnical measures

Trial variant	Soil fertilization	Agrotechnical operations
# 1	No fertilization (ZERO)	Autumn plowing (2022), spring plowing (2023), discing, tine-harrowing, seeding, inter-row cultivation, hand harvesting
# 2	Farmyard manure (FYM)	Everything like in #1, but horse farmyard manure was added by broadcasting before autumn plowing, 24 t/ha (170 kg/ha of N, 53 kg/ha P_2O_5, 119 kg/ha K_2O)
# 3	Green manuring with crimson clover (GMC)	Crimson clover wass hand-seeded in August 26th 2022 (20 kg/ha), covered by soil by tine-harrowing, and plowed-under in spring 2023. Than followed operations like in #1
# 4	Farmyard manure + crimson-clover cover crop (FYM+GMC)	Everything like in #2, but after plowing-under the FYM, the soil was harrowed and crimson clover seeded in September 24th 2022 (20 kg/ha), and covered with soil by tine-harrowing. Than followed operations like in #1
# 5	Mineral fertilization (NPK)	Everything like in #1, but 567 kg/ha of PK 20:30 + 369 kg/ha of urea 46%N were spread before spring discing (170 kg/ha of N, 113 kg/ha P_2O_5, 170 kg/ha K_2O)

Soil quality (texture and chemical properties) was analysed upon sampling the layer of top 30 cm before commencing the trial. Soil was appraised as a silty loam (Table 2), whilst the chemical traits indicated medium acidic soil with good levels of plant available P and K, and medium humus content.

Table 2. Soil texture and chemical parameters of soil fertility at the trial site before commencing the trial (average sample of the top 30 cm layer)

Particle class (and dimension)	Coarse sand (2 to 0.2 mm)	Fine sand (0.2 to 0.063 mm)	Coarse silt (0.063 to 0.02 mm)	Fine silt (0.02 to 0.002 mm)	Clay (< 0.002 mm)
Fraction (weight %)	1.82	7.37	43.96	30.18	16.67
Soil texture appraisal based on weight fractions of particle classes is silty loam.					
Chemical parameter	pH (H_2O)	pH (KCl)	Humus (%)	AL-P_2O_5 (mg/100 g of soil)	AL-K_2O (mg/100 g of soil)
Value	5.30	4.15	2.48	21.21	22.12

Nitrogen fertilization was limited to 170 kg/ha of N, according to the Nitrate directive by the Croatian authority. In the NPK variant, nitrogen was given in the form of granulated urea (369 kg/ha of urea 46 %), together with 113 kg/ha of P_2O_5 plus 170 kg of K_2O in the form of granulated PK 20:30 (567 kg/ha PK 20:30). Mineral fertilizers were hand-spread before discing operation. In the variants with FYM there were added 24 t/ha (2.4 kg/m^2) of FYM, also to adhere to the Nitrate directive. FYM was about 6 months old and content of plant nutrition minerals (Table 3) was analysed at the agrochemical laboratory of the Faculty of agrobiotechnical sciences Osijek. Nutrients content was similar to average of Croatian farming operations (Cvjetković et al., 2014). FYM was broadcasted by hand fork prior to the autumnal plowing with traditional front-wheeled single-bottom horse-drawn plow with furrow width of 25 cm. Plowing depth in autumn was about 15 cm.

Table 2. Characteristics of the farmyard manure (FYM) collected from horses and used after about 6 months of deposition (fermentation)

pH (1:5 v/v)	Dry matter content (%)	Total carbon in fresh-weight (%)	Total nitrogen in fresh-weight (%)	Total P (P_2O_5) in freshweight (%)	Total K (K_2O) in freshweight (%)
8.39	48.5	8.821	0.721	0.221	0.497

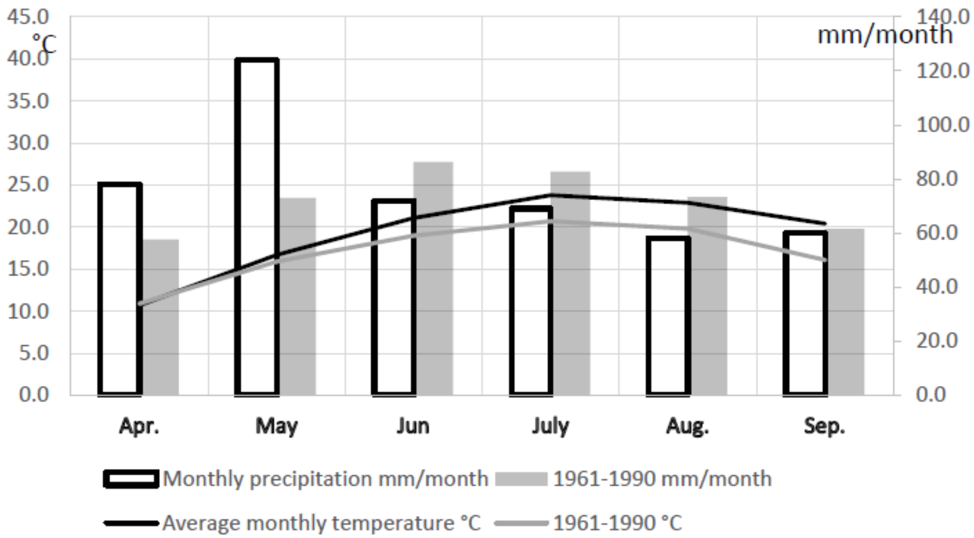
Despite the seeding term was intended for the beginning of May 2023, seedbed preparation and seeding were postponed to mid of June due to extraordinary excessive and frequent rains during the spring 2023. Previous winter was extraordinary mild so the volunteering spring oats survived the winter and produced a considerable oats herbage growth, thus acting as a cover crop on every trial variant. In order to enable the required operations, the oats herbage was chopped by a modern horse-drawn roller-cutter (“Rolcut V” of the Italian manufacturer Equi Idea of Verona) few days before plowing. Plowing with traditional front-wheeled single-bottom horse-drawn plow to depth of about 10 cm was done on June 14th 2023. Subsequent discing was done the next day by using small disc-harrow containing two gangs, each with five discs, of total working width of 1.5 m. Tine-harrowing was done immediately after disc-harrowing with the traditional tine-harrow composed of three wings, with total working width of 1.8 m. Seeding was done also on June 15th 2023, with traditional mechanical two-row seeding machine at the interrow distance of 0.7 m. The established crop stand was denser than recommended for the seeded maize hybrid (8/m^2) because there was no feature to adjust the seeding machine. Seeded hybrid was Bc-344 (FAO 300 of the Bc-Institute, Croatian plant breeding and seed company). When maize plants were about 20 cm tall inter-row cultivation was performed with a traditional horse-drawn single-row inter-row cultivator. There was no additional weeding done. Harvest was done on October 16th 2023 by hand-picking of maize ears from the two inner rows of each basic parcel, and solely from the mid two meters, thus the harvested area per each plot was 2 m × 1.4 m = 2.8 m^2. Ears were weighed and separated into kernels and cobs which were weighed again to get the freshweights. Subsamples of harvested kernels and cobs were air-dried for two weeks and then oven-dried at 70°C for 4 hours in order to get the dry-weights. Based on the ratio of dryweight/freshweight there were calculated dry matter content and moisture at harvest for each variant and replication. Dry kernel yields were recalculated to yields of standard quality kernel (14 % of moisture) in tons per hectare (t/ha). Statistics were calculated by using MS-Excel (arithmetic averages, analysis of variance and LSD for comparison of means).

All the draft power for doing the agrotechnical operations in this research was from two mares of the Croatian heavy draft horse breed. They were harnessed with traditional leather harnesses and hitched to the traditional implements (plow, disc-harrow, tine-harrow, seeding machine and inter-row cultivator).

Results and discussion

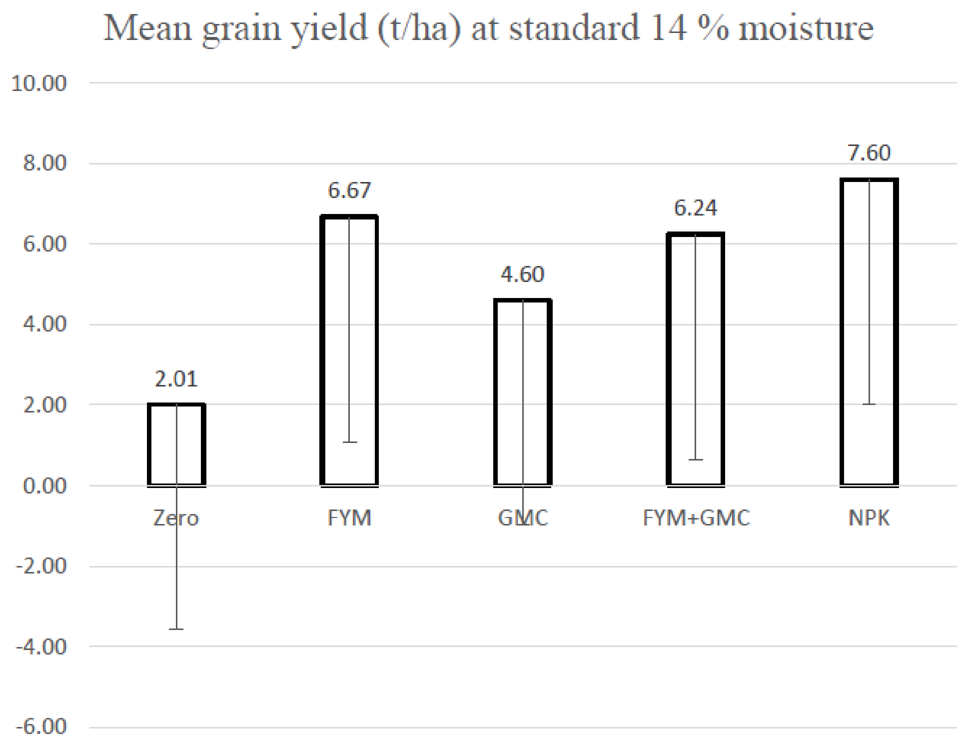
Considering the weather during the maize vegetation in north-east Croatia (DHMZ, 2023), it was about 3°C warmer than in the reference 30-year period (1961-1990) recorded at the nearest meteorological station in Slavonski Brod (Figure 1), with excessive precipitation in April and May and lack of rainfall from July till the September indicating droughty conditions.

Figure 1. Weather conditions during the spring and summer 2023, period that was critical for maize crop development, along with the 30-year reference period average.



Results of the field experiment showed that only NPK variant significantly (α=0.95) outyielded the Zero control variant (Figure 2). However, grain yields of organic fertilization variants didn't differ significantly from the NPK variant which was the highest yielding. Average yields of tested variants varied between 2.01 (Zero fertilization) and 7.60 t/ha (NPK fertilization), and were much lower than yields in the previous research of Ambrušec et al. (2021) in north-east Croatia, who also obtained the lowest yield in zero fertilization (about 5 t/ha) and highest yields in NPK fertilization (11 and 14 t/ha on lower- and higher-quality soil). Generally lower yields in this trial can be attributed to the much later seeding term in this research (mid-June 2023) than in Ambrušec et al. (2021) research (May 2019). Among the organic fertilization variants in this trial, green manuring (GMC) appeared inferior to NPK as well as to the farmyard manure (FYM) variant. Similarly, in the previous research in north-east Croatia (Ambrušec et al., 2021), maize grain yield on lower-quality soil was significantly lower upon green manuring with crimson clover than upon full NPK variant (8 vs. 11 t/ha), but only slightly lower at higher-quality soil (13 vs. 14 t/ha). Yields in this research were also lower than in previous Marković et al. (2017) research in north-east Croatia, probably also because of late seeding term in this trial. Poor performance of GMC variant in this trial was the consequence of poor overwintering of crimson clover. Namely, crimson clover plants were overdeveloped (too tall and too lush) due to unusually long, warm and moist autumn, and they come to rotting at arrival of cooler winter temperatures. Better overwintering was at the FYM + GMC variant due to later seeding term of crimson clover.

Figure 2. Average grain yields of each tested variant (columns), recalculated to the standard moisture content of 14 %. LSD(α=0.95) is presented as vertical bar, and equals to 5.58 t/ha.



Average maize grain moisture varied among tested variants (Table 3) and the respective cob yield associated to the grain yield. Cob/grain ratio of about 0.16 was similar to the ration in previous research of Marković et al. (2017) near Osijek in their Zero fertilization variant where they obtained average maize grain yield of only 5.7 t/ha despite the maize was seeded much earlier, in beginning of May 2010 and 2013. Cob/grain ratio in their NPK variants was about 0.11 thus indicating the high share of grain in the total ears yield.

Table 3. Average maize grain moisture content (%) and ratio of cobb/grain dry matter yield

Fertilization variant	Zero	FYM	GMC	FYM+GMC	NPK
Grain moisture content (%)	32.9	24.3	22.8	31.2	25.7
Ratio cob/grain yield	0.18	0.16	0.19	0.16	0.16

Obtained maize grain yields in this solely animal-powered agronomy were quite satisfactory (NPK variant 7.6 t/ha) when the very late seeding term (mid-June) is regarded, thus supporting the thesis that considering the yield, this way of powering the farming operations is not inferior to tractorized one. Completely low-input farming variants FYM and FYM + GMC (with no chemical inputs) have shown about 16 % lower yields (6.67 and 6.24 t/ha) than the NPK variant thus indicating either slight inferiority of organic soil fertilization when compared to NPK, or the need for greater doses of FYM, or the need for application of FYM timely closer to the maize crop establishment (prior to the spring plowing). However, expected losses of plant nutrients from autumn applied FYM are minimal due to very quick establishment of volunteering oats that acted as a winter cover/catch crop. There might be beneficially to rethink the annual nitrogen limit of 170 kg/ha from the farmyard manures since not all nutrients comprised in FYM are readily available, i.e. there is always a fraction of organically-bound nutrients that require time to be released for plant nutrition (Eghball et al., 2002), unless the FYM is applied every year in the rate of 170 kg/ha, thus forming the stock of organic nitrogen in soil for the sufficient crop nutrition in a long run. The inter-row cultivation, efficiently controlled the weeds in the inter-row space in this trial since there was no perennial weeds in the field and almost no weed emergence after the operation. The most abundant weed was annual grass *Setaria viridis* L. which virtually did no harm to the maize crop.

Animal-powered and human-handled operations in this trial required a lot of physical effort. Human operators were much more tyred than when driving a tractor. Work efficiency was much smaller than it would be if the operations were done by tractor with implements. These realizations could lead to the reluctance of completely animal-powered farming despite the many advantages it offers (as mentioned in the Introduction chapter). If the low-input farming is to be a significant contributor to the sustainable development of agriculture and societies, along with other more sustainable farming options, there would be needed personal inner transformation of farmers and potential new farmers to accept such labor-intensive farming (Gantner et al., 2023). In line with this are the findings of Woiwode et al. (2021) who stated that, besides the technological solutions, inner transformation would be required for system change towards sustainability. In this context, the inner transformation relates to consciousness, mindsets, values, worldviews, beliefs, spirituality and human–nature connectedness. Research should be continued with addition of tractorized agronomy as a control variant, and the economics should be investigated too.

Conclusion

Maize grain yields in this research were lower than in previous field trials in the north-east Croatia, most likely because of later seeding term, but not due to source of powering. There sims that completely animal-powered agronomy can give maize grain yields competitive to the fully tractorized agronomy. However, FYM and FYM + GMC organic soil fertilization variants have given slightly (insignificantly) lower yields than the NPK variant thus indicating the need for improvement of their application (either application of FYM timely closer to the maize crop establishment or increase of FYM rate since not all nutrients from the FYM are readily available, i.e. there is always a fraction of organically-bound nutrients). Solely animal-powered operations were associated with extraordinary physical efforts of human operators and low work efficiency, which could cause the reluctance to this way of farming. Personal inner transformation might improve the acceptance of such the way.

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THE PRODUCTS OBTAINED BY MILK PROCESSING WITH A SPECIAL REFERENCE TO OBTAINING WHEY IN THE PRODUCTION OF CHEESE[1]

Slavica Arsić[2], Ivan Bošnjak[3], Anton Puškarić[4]

Abstract

For the economy of every country, milk represents one of the strategic products, therefore the aspiration is to ensure sufficient quantities to meet the needs of the population with the development of primary milk production. Analyzes have established that of the total milk produced in Serbia, about 1.5 billion liters of milk per year, almost half (50%) is purchased by the processing industry, which is focused on the production of products that do not require a lot of time and for which the technological processes are not complex and long-lasting. These products are the most used in the market, even though they have a short shelf life.

The paper will show that in the process of cheese production, whey is created as a side product, which is one of the insufficiently used side products of the dairy industry. Also, the production of cow's milk as well as the products obtained in dairies for realization on the market for the period from 2015 to 2021 will be processed, with special reference to the use of whey in the food industry, where it is most often used as concentrated or whey powder.

Key words: *Milk, cheese, whey and its use in production.*

Introduction

The cow's milk represents the most complete and most balanced foodstuff from the nutritious point of view. Due to its nutritional composition, it is also the most represented by its quantity, and is used for the production of all dairy products. In regard to the cow's milk, as the most represented, with

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around 1.5 million litres, there are as well increased number of goat and sheep milk origin production on the market, although with small quantities. When it comes to a total quantity of produced milk, the production of this kind of milk in husbandries is only 3%, which points out to an increase in regard to previous years, when it was only 2% (Kljajić et al., 2009; Arsić et al., 2011., Arsić et al., 2015).

According to the Statistical Office of the Republic of Serbia data, a share of milk that is delivered to dairies from the husbandries is 60%. The significant amount of milk (35%) is used for personal consumption in husbandries, feeding calves, as well as for the processing of dairy products meant for the market, it is usually cheese, kaymak (cream), paprika in sour cream, curd cheese (whey cheese) that sell on the market. Milk delivered to dairies is used as a raw material with a great potential, since many products are obtained by it: cultured buttermilk, yoghurt, various kinds of cheeses, sour creams, butters as well as numerous fermented dairy products (Kljajić et al., 2009; Arsić et al., 2011.).

The annual production and use of milk in dairies for the year 2022 is shown in the table 1, where there can be noticed the movement of all kinds of milk quantities in dairies.

Table 1. Annual production and use of milk (total) in husbandries for the year 2022

Availability of milk	**Quantities (1000 t)**
Cow's milk in husbandries	1468,037
Milk from dairy cows	1436,146
Sheep's milk	9,300
Goat's milk	34,771
Total	1512,108

Source: Statistical Office of the Republic of Serbia, Belgrade. 2022

The cheese used to be a privileged class food, however since the Middle Ages it has become everyday food of all classes of the population (Siso, 1996). The production of cheese has been developed from a homemade cheese to the industrial mass production, and it has been the product of a certain nation and country. In accordance to a method of production, each country can have their specificities, which depends on region, climate, as well as the market requirements. The cheese can be fresh or mature that is obtained by thickening of egg whites in milk with separation of whey, and is one of the basic foodstuffs. During the production of cheese, the quantity of an obtained whey is almost equal to the quantity of milk necessary for making cheese. Depending on a cheese sort that is produced, there gets from 8 to 12 l of whey from the production of 1 kg of cheese. (Savant et al., 2000.)

In this paper was also given the table of all kinds of cheeses production, as well as of whey, which was left after their production (Table 2).

Table 2. Annual use of milk in dairies for cheese production

Cheese by firmness	Quantity (1000 t)
Soft cheese	23,519
Semi-soft cheese	-
Semi-hard cheese	13,068
Hard cheese	2,103
Extra hard cheese	0,016
Fresh cheese	11,385
Processed cheese	1,798
Whey total	6,753
Delivered liquid whey	2,632
Delivered concentrated whey	0,031
Whey powder or in blocks	0,014

Source: Statistical Office of the Republic of Serbia, Belgrade, 2022

Fifty percent of the globally obtained quantities of whey transform in various food products. The liquid whey is used 45%, as powder 30%, as well as lactose 15%, and the rest as the protein concentrates (OECD, 2010; Börgardts et al., 1998). According to the predictions about the cheese production, the scientists consider that the production of whey will increase for at least 2% with the production of cheese (Arsić et al., 2018; Siso, 1996.). In dairy and fermentation industry uses around 50% of the obtained whey, however, the remaining quantity discharges in waterways without any previous processing. Such rejected whey represents a loss of nutritionally valuable raw material, and also causes big environmental problems regarding high values of the chemical consumption of oxygen (CCO) and the biological consumption of oxygen (BCO), because it affects the physical and chemical structure of soil, and therefore the reduction of yield. On the other hand, discharging into waterways leads to the high consumption of oxygen and the death of flora and fauna. (Savant et al., 2000; Klasnja et al., 2000; Peters, 2005; makroekonomija.org)

Different ways of whey exploitation in various technological processes were shown in this paper.

The production of milk and cheese in Serbia

The total production of milk in Serbia origins from the family husbandries (92%), while only 8% comes from the social enterprises and cooperatives. Fifty percent of the total milk production delivers to dairies, while the rest uses for own needs and sale on markets as fresh or processed. In the period 2015-2017 the production of milk has stabilized to 1.5 billion litres, which has resulted thanks to the increased production of milk per cow. Since the beginning of reducing number of cows and heifers in 2019, on which the entire COVID-19 situation has affected, there had come to the production of milk and dairy products, as well as the production of various kinds of cheeses. Investing in this production is very profitable, because in cheese making the profit is 2-3 times higher than a raw milk sale. Except the profit in this production, there is also obtained a by-product whey, with nowadays numerous commercial uses (Arsić et. al., 2011).

In accordance to the Statistical Office of the Republic of Serbia, there can be noticed that the production of milk has reduced since there was noticeable a number of cattle decrease, and therefore in 2021 was reduced for 100 million litres. Decreasing trend of cattle was continued in 2022. That is the reason why there was 3.3% less milk in regard to the year 2021. The reason of decreasing number of cows and heifers, as well as milk, is abandoning production by many farmers, due to a low purchase price of milk and expensive forage. Big milk producers stimulate more, while smaller producers produce small quantities, and due to numerous criteria, they cannot fulfil the conditions. Decreasing the production of cheese comes parallel with the reduction of milk, and for now it is 60,000 tons of all kinds of cheeses. Annually, 10 kg per capita has been eaten, and 15,600 tons of the total cheese production has been exported, mostly in the Russian Federation and the surrounding countries. However, Serbia imports 12,000 tons mainly from Germany, Poland and Croatia (Vlahović et al., 2018; SEEDEV, 2020).

The production of milk and dairy products are one of the most important agricultural branches in Serbia, and on an annual basis 180 to 200 kg per capita is spent; in some other countries like Finland it is more than 300 kg or in Denmark up to 900 kg (Gulan, 2018).

According to the amount of milk collected in 2021, there are 104 dairies per collection interval of 5.000 liters and less; from 5.001 to 20.000 liters there are 24 larger dairies and from 20.001 to 50.000 liters there are 8 dairies that are among the largest milk collectors. When it comes to purchasing centers up to 1.000 liters, there are 9 centers and over 1.001 to 5.000 liters there are 3. According to the amount of processed milk (t/year) of 5.000 and less, there are 129 dairies (149.25 t/year), from 5.001 to 20.000 there are 20 dairies (184.18 t/year) and from 20.001 to 50.000 there are 8 dairies (with 279.53 t/year) (RZS, 2022).

When it comes to the amount of production of all types of cheese in 2021, the interval of the amount of cheese tons per year, there is a smaller number of dairies engaged in this production, so there are 75 dairies with a production of up to 100 (t/year) whose annual production is 2.56 thousand tons, then from 101 to 1000 tons per year, there are 67 dairies with an annual production of 18.37 thousand tons and from 1001 to 4000 t/year. 9 dairies whose production is 18.1 thousand tons. There are also larger quantities of production, but they are unavailable, from the Statistical Office of republic of Serbia, whose source was used (stat.gov.rs).

Utilization of whey in production

Whey is the liquid phase obtained during the production of protein milk (cheese, casein). Casein is the liquid that separates from curds after coagulation of milk by enzymes, acids or heat. The largest quantities of produced whey are obtained from milk processors, who in their production processes, by processing milk, especially various types of cheese, obtain whey as a by-product.

The largest quantities of produced whey are obtained from milk processors, who in their production processes, by processing milk, especially various types of cheese, obtain whey as a by-product. By using whey in further production processes, processors have a direct economic benefit because it has multiple uses as a high protein product. In industry, it is used as an ingredient in baby food, supplements, protein nutrition, production of cheese spreads and butter. Also, whey is very important for the pharmaceutical industry through lactose, which as a pure preparation is used in the production of tablets, most often as an inert carrier for medicinal substances (Marshal, 2004).

According to its composition of whey, which depends on the basic composition of milk as well as on the technological processes of making various types of cheese, i.e. casein, in which whey is produced, it contains 93% water and over 50% dry matter that passes from milk. The largest part of the dry matter of 70% is lactose, which is a very important source of the energy value of whey, 1% are proteins and in a smaller amount there are minerals and water-soluble vitamins.

Whey is one of the underutilized by-products of the food industry in Serbia. In the dairy industry, the main problem is that only 10 to 20% of the milk is used to make cheese and/or casein, while 80 to 90% goes to whey, which is not used. Due to insufficient utilization, whey becomes a serious environmental problem because it is a very big polluter, which is inconsistent with the possibilities it has as a raw material.

The most important reason why whey is less used as a raw material in industry is its easy perishability and low content of dry matter. Therefore, it must be processed in the shortest possible time, because its composition favors the development of harmful bacteria. Bearing this in mind, whey must, if not used immediately after cheese production, be cooled to 5 degrees C to reduce the growth of harmful bacteria (Arsić, 2018).

Of the total amount of whey produced, 50% is waste, bearing in mind the development of modern industry tends towards more efficient use of whey in order to better preserve the environment. In processing processes, products with added value can be created by using whey, which at least partially reduces the costs of not using it.

The production of functional fermented beverages based on whey is a simple solution related to its full utilization. The process of lactic acid fermentation utilizes all the nutritional potential of whey as a raw material, which removes from the environment a material that is a biologically very dangerous pollutant, and creates a product that is cheap, healthy and completely natural (Bulatović, 2015).

Whey can be used in different ways in the food industry, most often as whey powder or concentrates and isolates of whey protein or lactose are produced. Whey is widely used in the bread and pastry industry, in confectionery, in the meat industry and in the production of various creams, soups, sauces and toppings, where it is most often used as concentrated whey or whey powder.

Conclusion

For the economy of every country, including Serbia, milk is one of the strategic products, so the development of primary milk production is always aimed at ensuring sufficient quantities for the needs of the population as well as for milk processing, i.e. dairy industry. According to the analyzed period, we can see that the number of dairy cows stagnated and that milk production remained at 1.5 billion liters, thanks to the increase in milk production per cow. When it comes to the production of all types of cheese, production remained at 60.000 tons. Given that in the very process of obtaining cheese, whey is obtained as a by-product, which has multiple uses as a high protein product. Due to its composition, it is used in various biotechnological processes that include the production of lactose, protein concentrates, enzymes, as well as the production of functional and nutritious foods.

That is why certain support measures should be used to influence the development of livestock, as well as to maintain or increase the number of quality cows, because a large number of milk products and various processed products have a commercial character.

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EVALUATING OF ECOSYSTEM SERVICES: CARBON STORAGE IN THE FOREST ECOSYSTEMS OF BELGRADE

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Abstract

The amount of carbon stored in Belgrade's urban forests is detailed as follows: 1,143,686 t/ha in above-ground biomass, 185,094 t/ha in underground biomass, 57,184 t/ha in dead wood biomass, 391,816 t/ha in forest floor, and 2,537,519 t/ha in soil, totaling 4,315,299 t/ha (Ratknić T et al., 2022). Satellite imagery was employed for measurements, facilitating automation and daily change monitoring. Wood has varying prints depending on its use, such as paper production, building materials, furniture, fuel, or biomass (pellets). It is necessary to develop a circular economy-based certification concept. Projected net-zero greenhouse gas emissions by 2050 underscore the need for incentivizing private forest involvement in carbon sequestration through storage or afforestation. This calls for a new management system ensuring the permanent fixation of carbon within the forest.

Key words: *ecosystem services, bound carbon, urban forests, City of Belgrade.*

Introduction

Forest ecosystems play a significant role in the global carbon cycle. This component modifies climate characteristics in the context of global warming. Concentrations of carbon dioxide, methane, and nitrous oxide are currently at an all-time high in the last 800,000 years. According to the latest IPCC Report (2023), the average global surface temperature was 1.09 [0.95 to 1.20]°C

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higher in 2011–2020 than in 1850–1900, with larger increases over land (1.59 [1.34 to 1.83]°C) than oceans (0.88 [0.68 to 1.01]°C). Global surface temperature in the first two decades of the 21st century (2001–2020) was 0.99 [0.84 to 1.10]°C higher than 1850–1900. Global surface temperature has risen faster since 1970 than in any other 50-year period over at least the last 2000 years (high confidence) (IPCC AR6 SYR, 2023). The concentration of carbon dioxide, the most important greenhouse gas, has increased by 50% compared to the pre-industrial period and is now at 415.7 parts per million (ppb). The concentration of methane has increased more than 2.5 times (1908 ppb), and the concentration of nitrogen compounds by 25% (334.5 ppb). According to the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol, and the Paris Agreement, the Republic of Serbia is obligated to reduce greenhouse gas emissions by 9.8% by 2030 compared to the reference year of 1990. This reduction represents the National Determined Contribution (NDC) to mitigating greenhouse gas emissions. Each Party to the Paris Agreement is required to establish the NDC and update it periodically.

Forestry (alongside agriculture) plays a crucial role in climate change mitigation. Vegetation accounts for nearly 30% of bound carbon globally (IPCC, 2014), contributing significantly to climate change mitigation. This sector proves cost-effective compared to other sectors and aligns with sustainable development goals. The carbon bound in forest ecosystems serves as a vital economic parameter within the concept of ecosystem services. The carbon market should function as an incentive for agriculture and forestry to reduce greenhouse gas (GHG) emissions. This market operates through "carbon credits, a standard amount of GHG reduced or sequestrated, that can be bought and sold" (USDA, October 2023). They are one of the crucial ecosystem services enabling farmers and forest landowners to generate additional income.

While carbon markets have already been established in some countries, they are in their infancy in our region, largely due to the lack of relevant information about actual quantities present on agricultural and forest land, as well as in forest ecosystems. This study aims to determine the actual stocks of bound carbon in the urban forests of the City of Belgrade.

Material and methods

The quantity of sequestered carbon was determined based on data from forest management plans of all forest managers in the Belgrade area, along with information on areas covered by private forests. The forest growing stock data was processed based on landscape types using data from forest management units. In cases where forest management units spanned two or more landscape types, appropriate recalculations were performed to allocate the data to the corresponding type.

The research area was divided into the following 11 types based on the "Landscape Typology of Belgrade developed for the application of the European Landscape Convention" (Cvejić et al., 2008). The spatial database included information on area, tree species, canopy, tree mixture, developmental stages, age classes, volume, and volume increment. A Geographic Information System (GIS), enabling spatial analysis and spatial representation of biomass, was used to estimate the quantity of bound carbon. Carbon reserves were calculated for living biomass (encompassing aboveground and belowground biomass), dead organic matter (including dead wood and litter), and soil (soil organic matter) (Dimitijević et al., 2022). The estimation of carbon reserves followed the guidelines provided by the Intergovernmental Panel on Climate Change (IPCC) (2003, 2015). The results of carbon production are presented for the years 2030 and 2050, considering three scenarios: no increment increase, a 10% increment increase, and a 30% increment increase.

Results and discussion

Carbon reserves in the forests of the City of Belgrade for the period 1990-2050 are presented in Tables 1-7. The total carbon reserve in the forests of the City of Belgrade amounts to 4,315,301 tons, distributed as follows: above-ground biomass: 1,143,687 tons, below-ground biomass: 185,094 tons, dead wood biomass: 57,185 tons, forest litter: 391,816 tons, soil: 2,537,519 tons.

In the "Strategy for Addressing the Impact of Climate Change on the Interaction of Ecosystem Services in the Use and Management of Forest Resources in Belgrade", carbon storage is included in the "Regulation and Maintenance" section, under the "Mediation of Waste, Toxins, and Other Disturbances" sector. Carbon storage has a strong impact on the "Maintenance of Physical, Chemical, and Biological Conditions" sector.

Table 1. Carbon Reserves in Aboveground Biomass (tons)

Landscape type	1990	2020	2030			2050		
			Scenario			Scenario		
			0%	+10%	+30%	0%	+10%	+30%
Type 1/1		107109	115135	123963	125569	183356	192185	193790
Type 1/2		43100	44976	47039	47415	60923	62987	63362
Type 2		62263	64425	66803	67236	82801	85179	85612
Type 3		76777	79268	82008	82507	100443	103184	103682
Type 4		16374	16899	17475	17580	21355	21931	22036
Type 5		39477	41468	43658	44056	58391	60581	60979
Type 6		29813	31060	32433	32683	41667	43040	43290
Type 7		113772	119045	124845	125900	163866	169666	170721
Type 8		45375	47813	50495	50983	68538	71220	71708
Type 9		441105	460981	482846	486821	629932	651796	655771
Type 10		144613	151998	160122	161599	214772	222895	224372
Type 11		23909	24868	25924	26116	33025	34080	34272
Total	550507	1143687	1197936	1257611	1268465	1659069	1718744	1729595

Table 2. Carbon Reserves in Belowground Biomass (tons)

Landscape type	1990	2020	2030			2050		
			Scenario			Scenario		
			0%	+10%	+30%	0%	+10%	+30%
Type 1/1		17334	18633	20062	20322	29674	31103	31363
Type 1/2		6975	7279	7613	7674	9860	10194	10255
Type 2		10077	10427	10811	10881	13401	13785	13855
Type 3		12426	12829	13272	13353	16256	16699	16780
Type 4		2650	2735	2828	2845	3456	3549	3566
Type 5		6389	6711	7066	7130	9450	9804	9869
Type 6		4825	5027	5249	5289	6743	6966	7006
Type 7		18413	19266	20205	20376	26520	27459	27629
Type 8		7344	7738	8172	8251	11092	11526	11605
Type 9		71388	74605	78144	78787	101948	105487	106130
Type 10		23404	24599	25914	26153	34759	36073	36312
Type 11		3869	4025	4195	4227	5345	5516	5547
Total	89094	185094	193874	203531	205288	268504	278161	279917

Given the increasing establishment of the carbon market, this ecosystem service could potentially be included in the "Provision" section, under the "Materials" sector in the near future. Carbon offsets are sold through various exchanges, online markets, and directly through carbon projects that reduce or eliminate emissions. The carbon prices as of November 17, 2023, in specific countries are provided in Table 7.

Table 3. Carbon Reserves in Dead Wood (tons)

Landscape type	1990	2020	2030			2050		
			Scenario			Scenario		
			0%	+10%	+30%	0%	+10%	+30%
Type 1/1		5355	5757	6198	6278	9168	9609	9689
Type 1/2		2155	2249	2352	2371	3046	3149	3168
Type 2		3113	3221	3340	3362	4140	4259	4281
Type 3		3839	3963	4100	4125	5022	5159	5184
Type 4		819	845	874	879	1068	1097	1102
Type 5		1974	2073	2183	2203	2920	3029	3049
Type 6		1491	1553	1622	1634	2083	2152	2164
Type 7		5689	5952	6242	6295	8193	8483	8536
Type 8		2269	2391	2525	2549	3427	3561	3585
Type 9		22055	23049	24142	24341	31497	32590	32789
Type 10		7231	7600	8006	8080	10739	11145	11219
Type 11		1195	1243	1296	1306	1651	1704	1714
Total	27525	57185	59896	62880	63423	82954	85937	86480

Manulife Investment Management, the world's largest manager of natural capital with nearly \$15 billion in assets under management in timberland and agriculture combined has established the Forest Climate Fund (FCF). Launched in 2022, this fund is a strategy involving the generation of carbon credits through natural carbon sequestration. It is designed to provide American investors with an opportunity to contribute to climate change mitigation through sustainable forest management. Approximately 70% of the fund will be invested in carbon projects, aiming to prioritize carbon sequestration over timber harvesting. To date, the fund has raised around \$224.5 million, with a target of reaching \$500 million (https://carboncredits.com/manulifes-forest-carbon-credit-fund-closes-224-million/).

The Strategy for Addressing the Impact of Climate Change on the Interaction of Ecosystem Services in the Use and Management of Forest Resources in Belgrade includes, among other things, increasing carbon storage to mitigate climate change. The strategy also envisions the establishment of new forests through afforestation. The utilization of carbon credits in the future will also contribute to the restriction of forest logging.

Table 4. Carbon in Forest Litter (tons)

Landscape type	1990	2020	2030			2050		
			Scenario			Scenario		
			0%	+10%	+30%	0%	+10%	+30%
Type 1/1		33119	33119	36431	43055	33119	40074	55972
Type 1/2		22489	22489	24737	29235	22489	27211	38006
Type 2		12324	12324	13556	16021	12324	14912	20828
Type 3		13882	13882	15271	18047	13882	16798	23461
Type 4		4761	4761	5237	6189	4761	5761	8046
Type 5		16123	16123	17735	20960	16123	19509	27248
Type 6		8844	8844	9729	11498	8844	10702	14947
Type 7		42799	42799	47078	55638	42799	51786	72330
Type 8		12493	12493	13742	16241	12493	15117	21113
Type 9		146475	146475	161123	190418	146475	177235	247543
Топ 10		67579	67579	74337	87853	67579	81771	114209
Type 11		10928	10928	12021	14206	10928	13223	18468
Total	300672	391816	391816	430997	509361	391816	474099	662171

The following activities related to carbon storage are planned through the strategy:

1. Specific Goal: Conservation of existing forest areas and their expansion through preservation of biodiversity as a crucial component of ecosystem services.
   a) Valorization of private forests to determine the scope and methods of afforestation and land acquisition.

Table 5. Soil Organic Carbon (tons)

Landscape type	1990	2020	2030			2050		
			Scenario			Scenario		
			0%	+10%	+30%	0%	+10%	+30%
Type 1/1		214490	214490	235939	278837	214490	259533	362488
Type 1/2		145643	145643	160207	189336	145643	176228	246137
Type 2		79814	79814	87795	103758	79814	96575	134886
Type 3		89907	89907	98898	116879	89907	108787	151943
Type 4		30833	30833	33916	40083	30833	37308	52108
Type 5		104417	104417	114859	135742	104417	126345	176465
Type 6		57278	57278	63006	74461	57278	69306	96800
Type 7		277176	277176	304894	360329	277176	335383	468427
Type 8		80909	80909	89000	105182	80909	97900	136736
Type 9		948617	948617	1043479	1233202	948617	1147827	1603163
Type 10		437662	437662	481428	568961	437662	529571	739649
Type 11		70773	70773	77850	92005	70773	85635	119606
Total	1947240	2537519	2537519	2791271	3298775	2537519	3070398	4288408

Table 6. Total Carbon Reserves in Forest Ecosystems in the Belgrade Area in 2020 (tons)

Landscape type	Carbon in					
	aboveground biomass	belowground biomass	deadwood biomass	forest litter	soil	Total
Type 1/1	107109	17334	5355	33119	214490	377407
Type 1/2	43100	6975	2155	22489	145643	220362
Type 2	62263	10077	3113	12324	79814	167591
Type 3	76777	12426	3839	13882	89907	196831
Type 4	16374	2650	819	4761	30833	55437
Type 5	39477	6389	1974	16123	104417	168380
Type 6	29813	4825	1491	8844	57278	102251
Type 7	113772	18413	5689	42799	277176	457849
Type 8	45375	7344	2269	12493	80909	148390
Type 9	441105	71388	22055	146475	948617	1629640
Type 10	144613	23404	7231	67579	437662	680489
Type 11	23909	3869	1195	10928	70773	110674
Total	1143687	185094	57185	391816	2537519	4315301

2. Specific Goal: Integration of ecosystem services into forest management standards.

a) Development of methods to demonstrate the impact of forest management practices on the provision of ecosystem services and the introduction of the concept of the “Ecosystem Services Zone” as part of forest ecosystem protection.
b) Development of partnerships (public and private) for the utilization of ecosystem services in forest ecosystems.
c) Introduction of ecosystem services certification.
d) Creation of favorable market conditions for owners of forest ecosystem services certificates and the implementation of mechanisms for efficient payment for certified ecosystem services.
e) Development of market opportunities for ecosystem services.

3. Specific Goal: Adaptation and mitigation of the consequences of climate change on ecosystem services.

a) Development of a project on potential areas for the establishment of intensive plantations of forest tree species.
b) Promotion of the use of renewable energy sources.
c) Afforestation with tree species resilient to new climate conditions.

d) Strengthening the capacity of nursery production for the cultivation of species resilient to climate change.
e) Production of planting material for afforestation in areas of natural goods.

Table 7. Carbon Prices in Various Countries on November 17, 2023

Carbon Prices	**Last**	**Change**	**YTD**
Compliance Markets			
European Union	€78.05	−3.28%	−2.44%
UK	£42.53	+0.07%	−41.94%
California	$29.45	-	+1.31%
Australia (AUD)	$31.40	+1.29%	−7.10%
New Zealand (NZD)	$70.05	−0.07%	−8.34%
South Korea	$7.38	−3.54%	−40.31%
China	$10.05	−1.15%	+25.38%

Source: https://carboncredits.com/carbon-prices-today/

4. Specific Goal: Conservation, improvement, and sustainable use of the population of indigenous species and communities of hunting and fishing resources, as well as the protection of the biodiversity of bees, birds, wildlife, and fish.

a) Creating conditions to prevent degradation and fragmentation of habitats suitable for wildlife.
b) Developing a project on the formation of a coastal vegetation belt that contributes to creating favourable microclimatic conditions around fish hatcheries.
c) Developing a study on the UN REDD+ Program (Reducing Emissions from Deforestation and Forest Degradation) and biodiversity.

The financial success of carbon storage projects depends on predicting future carbon prices. Currently, 64 carbon pricing initiatives have been implemented across one supranational jurisdiction, 45 national, and 35 subnational jurisdictions covering over a fifth of global greenhouse gas emissions. The largest of these is the European Union Emissions Trading Scheme (EU ETS), which covers emissions from factories, power plants, and other installations in 30 countries (EU countries, Iceland, Liechtenstein, and Norway) and accounts for 40% of greenhouse gas emissions in the EU. Other national initiatives include ETS in Kazakhstan, New Zealand, Mexico, and China, as well as carbon taxes in South Africa, Chile, Argentina, and Canada.

California enacted carbon pricing systems in 2013, and Washington State introduced its own carbon pricing system in 2021. Eleven northeastern U.S. states participate in the Regional Greenhouse Gas Initiative, covering 18% of emissions in participating states (https://carboncredits.com/manulifes-forest-carbon-credit-fund-closes-224-million/).

Carbon prices are widely variable, ranging from $0.30 per ton in Ukraine to $75 per ton in the EU. In Sweden, companies pay $200 per ton of carbon emissions. Outside the European Union, prices are significantly lower, ranging from $20 to $5 per ton. The projected carbon price in 2030 is expected to be in the range of 56 to 152 EUR per ton (MBIE, 2016; IEA World Energy Outlook, 2015). This implies a potential value of carbon storage in forest ecosystems ranging from 21,997,809.00 to 59,648,322.00 EUR.

Funding for projects to increase carbon storage in the forests of the City of Belgrade will come from European Union funds, including: Instrument for Pre-accession Assistance (IPA); IPARD - Instrument for Pre-Accession in Rural Development; Western Balkan Investment Framework (WBIF); European Social Fund; Cohesion Fund; European Regional Development Fund; Horizon 2020; LIFE - Environment and Climate Action Program; Invest EU; Connecting Europe Facility; Modernization and Innovation Fund (within EU-ETS); EU Territorial Cooperation Programs (INTERREG); Action Plan: Financing Sustainable Development (COM (2018) 97).

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THE CURRENT STATE OF ORGANIC PRODUCTION IN US AND THE WORLD

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Abstract

Stability and quality of agricultural production can be ensured by sustainable resource management. Health-safe products, economic benefit, preserving the environment and health can be achieved by organic production. Organic production in the World, Serbia, Montenegro, Croatia, Bosnia and Herzegovina, Slovenia and North Macedonia was analyzed in this research. Agricultural land covers 76 mill. ha which is 1.6% of world land. It is noted a growth trend of the organic agricultural area in 2021 by 1.7% according data collected from 191 countries. The largest organic agricultural land areas are in Oceania (36 mill. ha or 47%) and Europe (17.8 mill. ha - 23%) followed by Latin America (9.9 mill. ha - 13%), Asia (6.5 mill. ha, 8.5 percent), Northern America (3.5 mill. ha - 4.6%) and Africa (2.7 mill. ha - 3.5%). A trend of area growth in 2021compared to 2020 was noted Serbia, Croatia, Slovenia, B&H and North Macedonia. The largest increase had North Macedonia (7794 ha, 109.1%), then B&H (2495 ha, 47.5%), Serbia (23527 ha, 21.8%) and Croatia (121924 ha, 12.3%). Great export opportunity of Serbia is in that it has excellent conditions for the growth of organic production, because of its excellent geographical position and good quality land.

Key words: *Organic production, trend of growth, health-safe products*.

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Introduction

Conservation of soil and water, protection of plant, animal, and human health, biodiversity, and agro-biodiversity can made easy by growth of organic farming. It, with the application of ecological principles, emphasizes the control, quality, and safety of the product. Popovic et al. (2012) states that, for customers to obtain a high-quality, controlled product, organic production is required. Maintain and improving of soil fertility in the long run can be achieved by organic farming. A production system - crop rotation harmonized with proper soil cultivation, fertilization based on soil fertility level (organic and other permitted fertilizers), and other cultural practices (Bavec & Bavec,2006) maintain soil fertility. Using of biological fertilizers (derived largely from animal and plant wastes and nitrogen-fixing cover crops) in organic farming makes it a sustainable agricultural system. Products made on organic way have lower yields (for 5- 25%) and a slightly larger price for consumers. Soil well-provided with organic matter and possessing good structure and water-air properties iz the main for organic farming to be successful and, in connection with that, main point of organic production is soil tillage. In the development of integrated systems very important are Field-rotation and crop- rotation. Weed control measures which are: proper treatment of crop residues and by-products of primary agricultural production; crop rotation; intercropping; companion cropping; exploitation of allelopathic relations etc. are important for organic production. Malesevic et al. (2008), Popovic et al. (2012) recommend that for weed control, disease, and pest control, it has to use plants that contain natural chemical toxins or possess allelopathic properties should be used in. Conventional agriculture, by use of chemical pesticides and synthetic fertilizers made the environmental damage, but organic farming could be the solution to it because it uses fewer pesticides, reduces soil erosion, decreases nitrate leaching into groundwater and surface water, and recycles animal wastes back into the farm (Popovic et al., 2019; 2022; Buric et al., 2023).

In 191 countries, on more than 76 million hectares of agricultural land cultivated by at least 3.7 million farmers, organic production is practiced. A growth trend of global sales of organic food and drink recorded and, in 2021, it reached almost 125 billion euro. Organic agriculture, farmland and sales of organic product, worldwide, according to the latest FiBL survey, reached another all-time high in 2021. This study aimed to determine the agricultural state production in our country and the world.

Materials and Methods

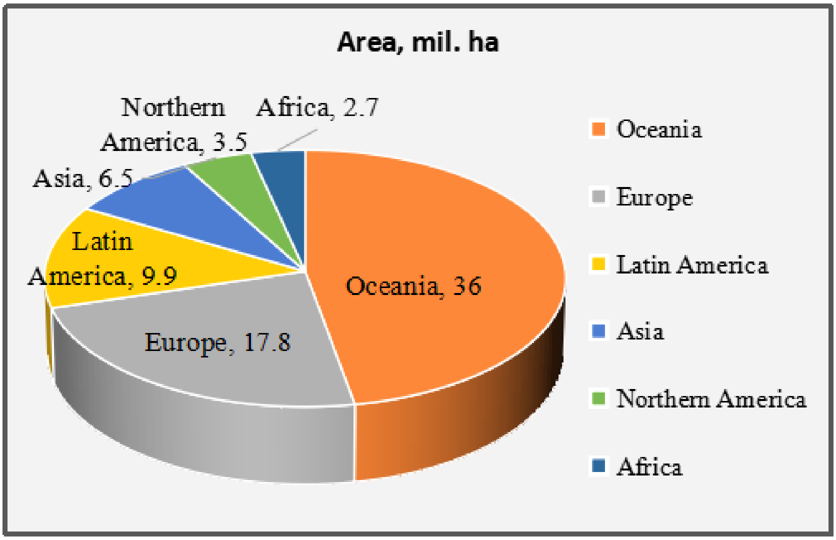
Organic production in Serbia, Montenegro, Croatia, Bosnia and Herzegovina, Slovenia and North Macedonia was analyzed in this research (FiBL, 2023; Willer et al., 2023) and possibilities for improving organic production were indicated. The survey results were processed descriptively and shown in tables and graphics.

Results and Discussion

World production of agricultural organic products

In 2021(FiBL, 2023), in the world, more than 76.4 million hectares was belonged to organic farmland which was 1.6 percent of the total farmland and represented increasing of 1.7 percent compared to 2020. The largest organic agricultural land has Oceania (36.0 mill. ha or 47%), then Europe (17.8 mill. ha or 23%), Latin America (9.9 mil. ha or13%), followed by Asia (6.5 mil. ha or 8.5%), Northern America (3.5 mil. ha or 4.6%), and Africa (2.7 mil. ha or3.5 %). Oceania (9.7%) and in Europe (3.6%; European Union: 9.6 %) are regions that have higher organic shares of the total agricultural land. The biggest organic agricultural land by area among countries have Australia (35.7 mil. ha), Argentina (4.1 mil. ha), and France (2.8 mil. ha), Picture 1.

Picture 1. Organic agricultural land in 2021 in million ha, by regions.



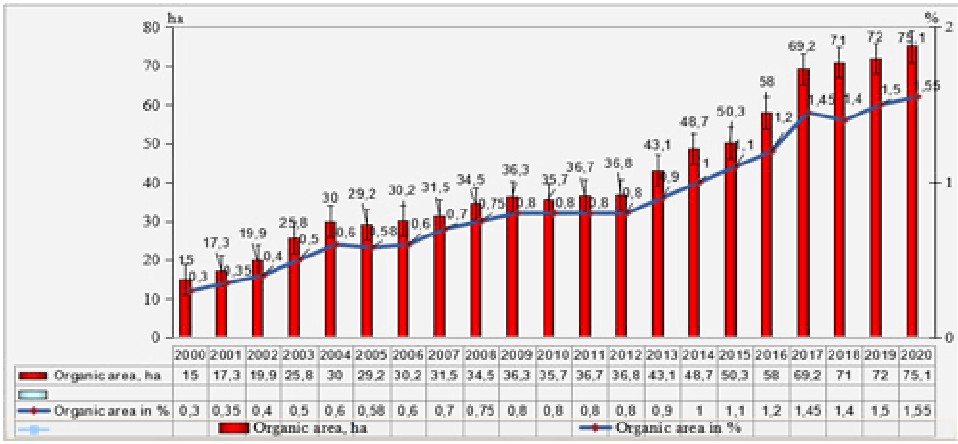
Rising of area of organic land was noted in Africa, Asia, Europe, and Oceania in 2021. (Table 1, Figures 1 and 2) while in North- and Latin- America it decreased.

Table 1. The World organic agricultural land in 2021 and the share of regions in it

Region	Organic agricultural land, ha	Shares of the total agricultural land, %	Shares	Increased
			of global organic agricultural land, %	
Oceania	35985809	9.7	47.1	+23.0
Europe	17844853	3.6	23.4	+4.4
Latin America	9870887	1.4	12.9	-1.55
Asia	6504211	0.4	8.5	+5.8
Northern America	3542140	0.8	4.6	-1.35
Africa	2663983	0.2	3.5	+17.3
World*	76403777	1.6	100	+1.7

Source: FiBL survey 2023. Note: Agricultural land includes in-conversion areas and excludes wild collection, aquaculture, forest, and non-agricultural grazing areas.

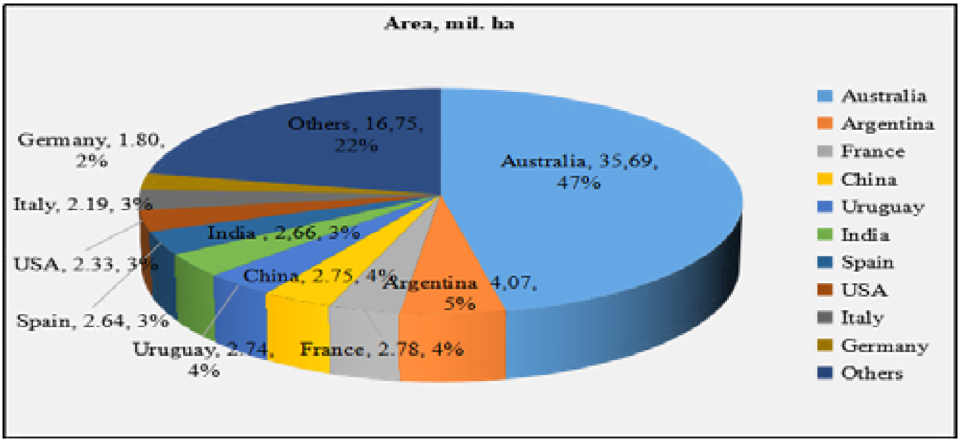
Picture 2. World`s agricultural land for organic production (2000-2020). Area and share



Source: FiBL-IFOAM-SOEL surveys 2001-2023

The biggest of a growth trend were in China (320000 ha or13.1%), France (228000 ha or 8.9 %), and Spain (198000 ha or 8.1%), some countries decreases was recorded (in Argentina, 0.38 mil. ha less). The highest organic share has Liechtenstein (40.2%), Samoa (29.1 %), and Austria (26.5 %). Demand for organic products of consumers all around is showing a growing trend because COVID-19 has raised consumer interest in health. Country with the most organic agricultural land was Australia (35.69 mil. ha) followed by Argentina (4.07 mil. ha), (2.78 mil. ha), China (2.75 mil. ha), Uruguay (2.74 mil. ha), India (2.66 mil. ha), Spain (2.64 mil. ha), USA (2.33 mil. ha), Italy (2.19 mil. ha), Germany (1.80 mil. ha), (Picture 3). Almost 80% of the world's organic agricultural land is in ten countries - total of 59.6 million hectares.

Picture 3. 10 countries with the largest areas of organic land in 2021 (mil. ha).



In 2021. there were 3,699 million of organic producers worldwide and, compared to the year before, their number increased by 4.9 % . More than 91% of them were in Asia (48.6 %), Africa (30.6 %), and Europe (12 %). The absolute highest numbers are in India 1.6 million farmers, then Uganda (400,000) and Ethiopia (218,000) (Table 2). The number of producers (in 2021) increased in Africa, Oceania, Europe, North and Latin America, while in Asia slightly decrease (Table 2).

Table 2. World: The producers number changes by region

Region	2020, no.	2021, no.	1 year growth, no.	1 year growth, %	10 years growth, no.	10 years growth, %
Africa	968'233	1'123'255	155'022	16.0%	595'342	112.8%
Asia	1'811'209	1'782'134	-29'075	-1.6%	1'171'012	191.6%
Europe	417'987	442'274	24'287	5.8%	152'646	52.7%
Latin America	262'115	280'436	18'321	7.0%	-27'111	-8.8%
NorthernAmerica	22'448	23'392	944	4.2%	6'794	40.9%
Oceania	15'930	18'479	2'549	16.0%	4'293	30.3%
World	3'496'898	3'669'201	172'303	4.9%	1'902'412	107.7%

Source: FiBL survey 2023.

Total of organic products retail sales in 2021

The World sales of organic food and drink, in 2021, according to the FiBL survey, it reached almost 125 billion euro which is 3 % higher than in 2020. Leading markets in 2021were the United States (48.6 billion euro), Germany (15.9 billion euro), France (12.7 billion euro) and China (11.3 billion euro). The largest single market was the United States, followed by the European Union (46.7. billion euro) and China. By region, Europe had the lead (54.5 billion euro), followed by North America (53.9 billion euro) and Asia (13.7 billion euro). Estonia registered the biggest percentage market growth (21 %). Denmark with 13% had highest shares of organic market of the total market, then Austria (11.6 %), Luxembourg (11 %), and Switzerland (10.9 %), (The World of Organic Agriculture, 2023). Speaking of the countries of the former Yugoslavia, the largest area and share in organic production in 2021 was Croatia (121924 ha; 8.1%), followed by Slovenia (52078 ha; 10.8%), Serbia (23527 ha; 0.7%), North Macedonia (7794 ha; 0.6%), Montenegro (4404 ha; 0.57%), Bosnia & Herzegovina (2495 ha; 0.14%), (Table 3).

The most of former Yugoslav republic of (Serbia, Croatia, Slovenia, B&H, and North Macedonia) recorded a trend of area growth in 2021 compared to 2020. The largest area increases recorded Macedonia (7794 ha), of 109.1%, then B&H (2495 ha, 47.5%), Serbia (23527 ha, 21.8%), Croatia (121924 ha, 12.3%). Slovenia recorded stagnation (52078 ha), while Montenegro recorded a decrease in surface area in 2021 (4404 ha) compared to 2020 (4823 ha), by 418.8 ha ie. 8.7%.

Table 3. Organic agricultural land by ex-Yugoslavia countries , 2020-2021,

Country/ Territory	Organic agricil-tu. land 2020, ha	Organic agricult. land 2021, ha	1 year growth, ha	1 year growth, %	10 years growth, ha	10 years growth %	Share in word, %
Slovenia	52078	52078	0.0	0.0	16977.0	48.4	10.8
Croatia	108610	121924	13314.0	12.3	90020.5	282.2	8.1
Serbia	19317	23527	4210.4	21.8	17187.3	271.1	0.7
North Macedo-nia	3727	7794	4067.0	109.1	-4937.2	-38.8	0.6
Montene-gro	4823	4404	-418.8	-8.7	1335.9	43.5	0.57
Bosnia & Herzeg.	1692	2495	803.3	47.5	2152.5	627.8	0.14

Source: statistics.fibl.org, FiBL survey 2023

The largest number of organic production producers, processors and importers in 2021 had Croatia (6024; 378; 12), then Slovenia (3685; 139; 28), Serbia (458; 152; 74), North Macedonia (887; 17; 8), Montenegro (422; 25), while smallest Bosnia & Herzegovina (90; 51), (Table 4).

Table 4. Organic producers, processors, importers and exporters of ex-Yugoslavia countries in 2021

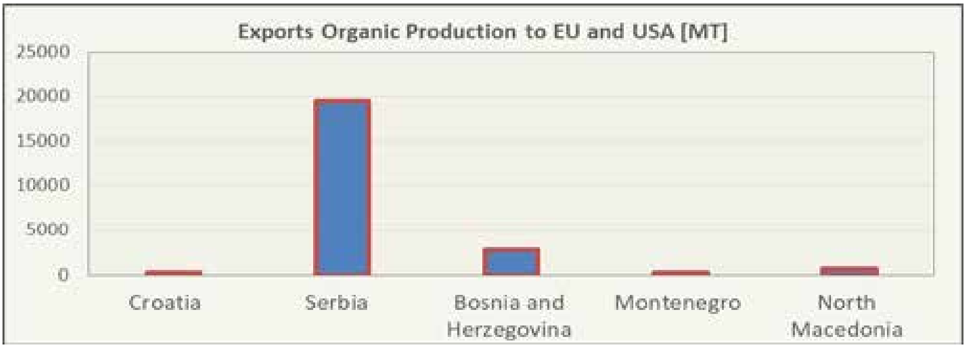
Country/Territory	Producers1	Processors	Importers	Exporters
Slovenia	3685	139	28	0
Croatia	6024	378	12	-
Serbia	458	152	74	82
North Macedonia	887	17	8	1
Montenegro	422	25	-	0
Bosnia& Herzegovina	90	51	-	20

The organic products largest exporter to the EU and USA in 2021 was Serbia (199468 MT), then Bosnia and Herzegovina (2788 MT), North Macedonia (662 MT), Croatia (27 MT), and Montenegro (17 MT), while Slovenia did not export organic products or did not submit export data (Table 5, Picture 4).

Table 5. Ex-Yugoslavia countries exports of organic products to the EU and USA in 2021

Country/Territory	Exports to EU [MT]	Exports to USA [MT]	Exports to EU and USA [MT]
Croatia		27	27
Serbia	19373	95	19468
Bosnia and Herzegovina	2762	26	2788
Montenegro	17		17
North Macedonia	654	8	662

Picture 4. Export of organic products to the EU and USA from ex Yu countries, 2021



Important Methods of Organic Farming

Governments defined organic agriculture. Farmers must be certified for their producing and products, to become labeled "organic". In the European Union (EU), organic standards ban the use of genetically engineered plants or products, synthetic pesticides, fertilizers, ionizing radiation, sewage sludge. Organic certification and inspection in the EU (according to EU standards), are carried out by approved organic control bodies. The National Organic Standards of the Department of Agriculture defined organic farming, and many accredited organic certifiers are across the country.

Agriculture, organic production and the environment have been closely linked in the past years. Organic farming employs a variety of methods to cultivate crops and raise animals in a sustainable and eco-friendly manner. Each method is designed to work in harmony with nature and minimize the use of synthetic inputs: crop Rotation, composting, green manure cover crops, mulching, biological pest control, integrated pest management, natural weed control, non-GMO seeds - non-genetically modified seeds to maintain biodiversity and preserve traditional crop varieties, animal husbandry practices, and water conservation, Picture 4.

Picture 4. Important Methods of Organic

Farming https://geopard.tech/blog/why-is-organic-farming-better-for-the-environment/

These methods of organic farming prioritize environmental sustainability, soil health, and natural resource conservation. By adopting these practices, organic farmers contribute to healthier ecosystems, reduced environmental impact, and the production of nutritious and safe food (Bavec & Bavec, 2006; Malesevic et al., 2012; Ikanović & Popović, 2020; Zejak et al., 2012; Popović et al., 2012; 2019; 2022; Burić et al., 2023).

Organic farming holds the key to a sustainable future. Its myriad benefits, from preserving soil health and conserving water to providing healthier and safer food options, highlight its importance. By choosing organic products, consumers can support farmers, protect the environment, and contribute to a more resilient and balanced ecosystem.

Health, Ecology, Fairness, and Care are principles of organic agriculture which is answer to industrialization paradigm.

These principles and their interactions make a positive impact on economic, environmental, social, cultural, and health contexts. Popović et al. (2022), Burić et al., (2023) said that enhances of the immune system, reduces the presence of pesticides, boosts cardiovascular protection, prevents cancer and premature aging represent only a few of benefit of organic food.

Conclusion

Just 1.6% of the world's agricultural land is farmed organically. Oceania has the largest organic agricultural land areas (36 mill. ha or 47%), then Europe (17.8 mill. ha, 23%), Latin America (9.9 mill. ha, 13%), Asia (6.5 mill. ha, 8.5 percent), Northern America (3.5 mill. ha, 4.6%) and Africa (2.7 mill. ha, 3.5%). 80 percent of the total world's organic agricultural land (59.6 million hectares) are in the next ten countries: Australia, 35.69 mill. ha, Argentina, 4.07 mill. ha, France, 2.78 mill. ha, China, 2.75 mill. ha, Uruguay, 2.74 mill. ha, India, 2.66 mill. ha, Spain, 2.64 mil. ha, USA, 2.33 mil. ha, Italy, 2.19 mil.ha, Germany, 1.8 mil. ha.

In 2021. there were 20 countries with 10% or more of all agricultural land under organic management which is more compared with 2020 (18 countries). Countries with the largest share of organic land were Liechtenstein (40.2 %), Samoa (29.1 %), Austria (26.5%), Sao Tome and Principe (21.1 %) and Sweden (20.2 %).

An increase in the area of organic agricultural land experienced in 86 countries, while 37 countries reported decrease. Many countries kept up or initiated support activities for organic agriculture, including new action plans or policies aiming to foster growth.

A trend of area growth in 2021 compared to 2020 was recorded in Serbia, Croatia, Slovenia, B&H, and North Macedonia. The largest increase recorded Macedonia (7794 ha), of 109.1%, then B&H (2495 ha, 47.5%), Serbia (23527 ha, 21.8%), Croatia (121924 ha, 12.3%). Slovenia had a stagnation of surface area (52078 ha) was recorded, while Montenegro decreases in surface area in 2021 (4404 ha) compared to 2020 (4823 ha), by 418.8 ha i.e., 8.7%. Serbia`s great export opportunity is excellent conditions for the growth of organic production thanks to our excellent geographical position and good quality land.

The challenge for future organic agriculture will be increase area and yields, maintain of environmental benefits, and while meeting the challenges of climate change and an increasing number of world's population.

Acknowledgments

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THE DIFFERENCES IN SUBCLINICAL MASTITIS PREVALENCE AND EFFECT ON MILK PRODUCTION DUE TO COWS' BREED AND BREEDING REGION

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Ranko Gantner[4], *Klemen Potočnik*[5]

Abstract

The purpose of this study was to look into how the breed (Holstein or Simmental) and breeding region (Central, Eastern, and Mediterranean) influence the occurrence of subclinical mastitis and its impact on milk production. In order to do this, the study examined 3,953,637 test-day records of Holstein cows and 4,922,751 test-day records of Simmental cows. The daily lactose content was utilized to diagnose subclinical mastitis. The study's findings showed that subclinical mastitis rates varied significantly depending on the breed and breeding location. The Eastern region's Holstein cows were the least common. On the test-day, when subclinical mastitis was found in all regions and breeds, the lowest daily milk output was also noted. Subsequent milk records, however, revealed an increase in milk output that differed according to breed and breeding location. The Holstein cows from the Eastern region showed the largest overall increase in milk production. According to these results, healing potential differs greatly depending on the breed and breeding area. Eastern region farms raised Holstein cows, who had the lowest rate of mastitis-related problems and the best likelihood of recuperating and reaching their genetic output potential. As a result, this study implies that dairy cows that are reared at the large, specialized dairy farms that are common in the Eastern region recover more quickly.

Key words: *milking cows, subclinical mastitis, occurence, milk production.*

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Introduction

Undoubtedly one of the most common and expensive diseases affecting dairy cows, mastitis is characterized by inflammation of the udder. The condition causes a range of symptoms in the udder, including swelling, increased warmth, redness, pain, and in severe cases, necrosis. These symptoms lead to a reduction in milk production and overall weakening of the animals. Mastitis can be induced by a variety of factors, including bacterial infections (such as *Escherichia coli, Staphylococcus aureus,* and *Streptococcus species*), non-infectious factors (such as mechanical injury, irritation, or hormonal imbalances), and environmental factors (such as inadequate hygiene, dirty or wet bedding, and inadequate milking).

Mastitis can occur in clinical or subclinical states, and both states cause substantial losses in revenue for dairy farmers as a result of a decline in milk quality and reduced milk yield. Furthermore, the incidence of mastitis may have detrimental effects on the environment; however, by identifying, treating, and preventing subclinical mastitis early on, a dairy farm can lower its greenhouse gas emissions per kilogram of milk produced. Ebrahimi et al. (2019) have reported that increased use of antibiotics in response to mastitis can lead to possible resistance of the causative agent. Therefore, it is essential to develop efficient ways of monitoring dairy herds and preventing mastitis prevalence to enable economically and environmentally efficient dairy farming. Pyorala (2003) states that daily lactose content is a good measure of the prevalence of mastitis. According to Silanikove et al. (2014), inflammation in the mammary gland results in cell damage and reduced lactose production, which lowers the amount of lactose in milk. According to Babnik et al. (2004), milk with a daily lactose concentration of less than 4.5% implies a substantial risk of mastitis prevalence.

Given that mastitis is one of the most common issues on dairy cattle farms, this study attempted to assess the effect of cow breed (Holstein or Simmental) and breeding area (Central, Eastern, and Mediterranean) on subclinical mastitis occurrence and its impact on the production of milk. This study will provide a more comprehensive understanding of the factors that contribute to mastitis prevalence, which will help in the development of effective strategies to prevent and control the condition, leading to more efficient and sustainable dairy farming practices.

Material and Methods

The research used test-day records of dairy cattle (Simmental and Holstein breed) collected during regular milk recording in Republic of Croatia between 01 / 2005 and 12 / 2022. Milk recording was conducted every four weeks using the alternative milk recording method (AT4/BT4). Milk samples were tested at the Croatian Agency for Agriculture and Food's Central Laboratory for Milk Quality Control using the Milcoscan FT6000, which uses an infrared spectrophotometry method to determine milk components. The dataset underwent logical control in accordance with ICAR guidelines and nonlogical variable values were rectified (ICAR, 2017). 3,953,637 test-day records for the Holstein breed and 4,922,751 test-day records for the Simmental breed made up the corrected dataset.

To determine the *subclinical mastitis prevalence*, the daily lactose content (DLC) was used as an indicator. A DLC of 4.5% or higher meant the animals were healthy, while a DLC lower than 4.5% indicated a subclinical mastitis prevalence. The subclinical mastitis prevalence was expressed as a percentage of cows at subclinical mastitis from the total dairy cattle population and was analysed separately for each breed and breeding region.

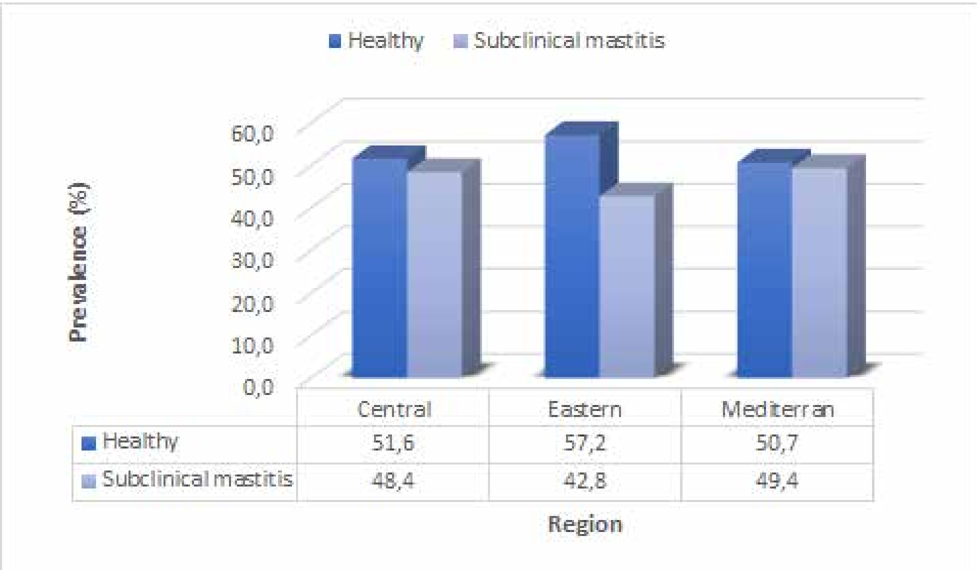
The study also looked at the *effect of subclinical mastitis* on daily milk production at successive milk recordings. The analysis included only cows with a determined subclinical mastitis (DLC < 4.5%), and the daily milk yield on the day when subclinical mastitis was determined was used as the reference value. The mastitis index was created based on the number of days after subclinical mastitis was confirmed. The index includes five categories: D-0 (which is the day when subclinical mastitis was detected), A-1 (within 35 days), A-2 (from 36 to 70 days), A-3 (from 71 to 105 days), and A-4 (more than 105 days). To evaluate the effect of subclinical mastitis on daily milk production, a statistical model was used. This model considered various factors, including lactation stage, age at first calving, milk recording season, herd size, and mastitis index. The statistical analysis was done separately for each breed (Holstein and Simmental) and breeding region (Central, Eastern, and Mediterranean). To test the significance of differences between the estimated LSmeans, the MIXED procedure of SAS (SAS Institute Inc., 2019) was used, along with Scheffe's method of multiple comparisons.

The *estimated differences in daily milk production* between the analysed milk recordings (D-0, A-1, A-2, A-3, A-4) were presented separately by breed and breeding region. Based on the estimated daily differences and intervals between successive recordings, the *total difference in milk production* over four successive milk recordings (from D-0 to A-4) after subclinical mastitis was calculated. Finally, the total difference in milk production in kg of milk in the analysed period was presented separately by breed and breeding region.

Results and discussion

The present study aimed to investigate the prevalence of subclinical mastitis in dairy cows and to identify potential factors that contribute to its occurrence. Results showed that there were significant differences in the health status of dairy cows based on their breeding region (figures 1 and 2). Holstein cows exhibited a prevalence rate ranging from 42.8% to 49.4%, with the Mediterranean region having the highest prevalence rate, and the Eastern region having the lowest. Similar trends were observed in Simmental cows, with a slightly higher prevalence rate ranging from 45.7% in the Eastern region to 52.5% in the Mediterranean region.

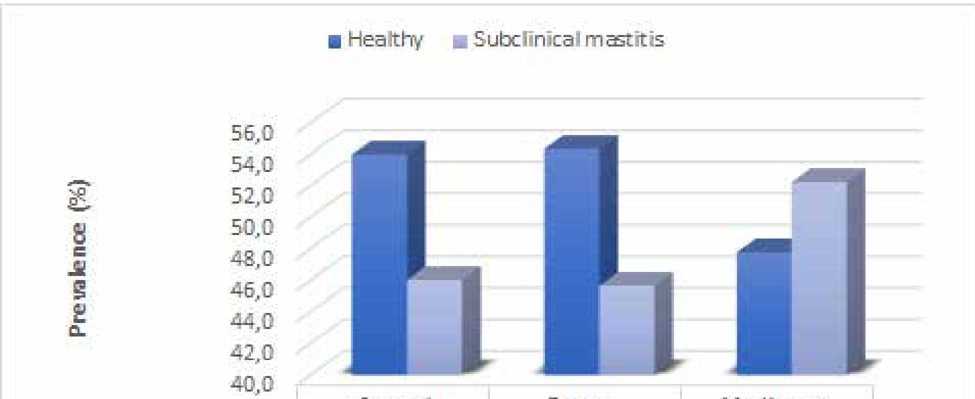
Figure 1. The occurrence of subclinical mastitis in Holstein cows in three breeding regions (Central, Eastern, and Mediterranean)



According to Tomazi et al. (2018), a variety of parameters, including season, herd size, level of production, and production system, can influence the occurrence of mastitis-causing bacteria and the incidence rate of mastitis cases in dairy herds. Furthermore, high temperatures and humidity promote heat stress in dairy cows, increasing the likelihood of intramammary infections caused by environmental pathogens. According to Antanaitis et al. (2021), the causal agent of subclinical mastitis in milk appears more frequently during the summer. However, the occurrence of mastitis can be linked to seasonal fluctuations in management systems, diet, and housing. Gantner et al. (2011) and Weber et al. (2020) have also noted that season, herd size, husbandry system, and average production may all be connected with the occurrence of mastitis in dairy cattle.

The observed differences in subclinical mastitis occurrence regarding breed and breeding region could be explained by the differences in animals' genetics (Holstein and Simmental breed), as well as by the difference in management practices, average herd size, and environmental conditions in different breeding regions (with the highest frequency of heat stress days in the Mediterranean region). Overall, these data indicate that focused treatments aimed at minimizing the impact of environmental factors and enhancing herd management methods could help lower the occurrence of subclinical mastitis in dairy cows.

Figure 2. The occurrence of subclinical mastitis in Simmental cows in three breeding regions (Central, Eastern, and Mediterranean)



	Central	Eastern	Mediterran
Healthy	54,0	54,3	47,8
Subclinical mastitis	46,0	45,7	52,2

Statistical analysis showed that daily milk production, in both breeds (Holstein and Simmental) and all regions (Central, Eastern, and Mediterranean), was significantly (< 0.0001) affected by mastitis index (D-0, A-1, A-2, A-3, A-4). LsMeans of daily milk yield in Holstein cows varied from 23.71 kg/day at D-0 to 24.19 kg/day at A-3 in the Central region; from 23.32 kg/day at D-0 to 24.48 kg/day at A-4 in Eastern; and from 23.07 kg/day at D-0 to 23.59 kg/day at A-2 and A-4 (Table 1). The highest daily milk production was observed in Holsteins bred in the Central region. In the Simmental breed, significantly lower daily milk yield in comparison to Holstein was determined with the highest production observed in the Eastern region.

In all breeds and regions, the lowest daily milk production was determined at D-0 (the test-day record when subclinical mastitis was determined), followed by an increase at subsequent milk recordings that varied depending on the breed and region of breeding.

Table 1. LsMeans of daily milk yield at evaluated milk recordings (D-0, A-1, A-2, A-3, A-4) concerning the breeding region and breed.

Milk recording	Parameter	Holstein			Simmental		
		CE	ES	ME	CE	ES	ME
D-0	Estimate	23.71	23.32	23.07	17.26	17.73	17.55
D-0	StdErr	0.05	0.03	0.09	0.06	0.03	0.09
A-1	Estimate	24.19	24.12	23.50	17.47	18.03	17.94
A-1	StdErr	0.05	0.03	0.09	0.06	0.03	0.09
A-2	Estimate	24.15	24.23	23.59	17.37	17.98	18.05
A-2	StdErr	0.05	0.03	0.09	0.06	0.03	0.09
A-3	Estimate	24.08	24.25	23.48	17.28	17.91	18.15
A-3	StdErr	0.05	0.03	0.09	0.06	0.03	0.09
A-4	Estimate	24.09	24.48	23.59	17.16	17.87	18.26
A-4	StdErr	0.05	0.03	0.08	0.06	0.02	0.07

* CE – Central, ES – Eastern, ME – Mediterranean

Table 2 presents the total difference in milk production (kg) in the analysed period from D-0 to A-4 milk recordings, considering the breeding region and breed. Among all breeds and regions, Holsteins in the Eastern region showed the highest increase in daily milk yield (24.03 kg) at first successive milk recordings after detecting subclinical mastitis (A-1), with a total increase in milk production of 35.05 kg. In contrast, Simmental cows bred in the Central region showed the lowest increase in milk production (6.12 kg), with a decrease of 3.07 kg at the end of the analysed period.

The highest total increase in milk production was observed in Holstein cows in the Eastern and Simmental cows in the Mediterranean region. The amount of increase in milk production following the prevalence of subclinical mastitis represents the animal's recovery potential. The findings of this study show that this potential varies greatly depending on the breed and breeding region. Holstein cows situated in farms in the Eastern region showed the highest possibility of recovery aa well as restoration of production following their genetic potential.

Table 2. Total difference in milk yield in the analysed period of four successive milk recordings (from D-0 to A-4) regarding the breeding region and breed

Holstein					
Region	A-1	A-2	A-3	A-4	Total difference
CE	14.28	-1.26	-2.12	0.29	11.19
ES	24.03	3.28	0.63	7.10	35.05
ME	12.80	2.67	-3.34	3.51	15.63
Simmental					
Region	A-1	A-2	A-3	A-4	Total difference
CE	6.12	-3.03	-2.47	-3.69	-3.07
ES	9.01	-1.50	-2.25	-1.15	4.11
ME	11.47	3.36	3.16	3.26	21.25

* CE – Central, ES – Eastern, ME – Mediterranean

The differences in milk production increase after detecting subclinical mastitis depended on the breed and the breeding region. These differences can be explained by varying feeding management and microclimatic conditions in different regions, as well as the genetic potential of different breeds. Holsteins bred in the Eastern region showed the greatest rise in daily milk yield, showing that they recuperate more efficiently when bred on big, specialized dairy farms common in that region. Chen et al. (2023) also observed differences in mastitis occurrence across regions, which they attributed to diverse climate conditions. According to Antanaitis et al. (2021), variances in systems for management, feeding approaches, and animal care contribute to discrepancies in milk yield.

Conclusion

The purpose of this study was to evaluate at the impact of breed (Holstein or Simmental) and breeding region (Central, Eastern, and Mediterranean) on the occurrence of subclinical mastitis and its effect on milk production. The findings revealed considerable disparities in subclinical mastitis frequency among breeding regions and breeds, with Holstein cows from the Eastern region having the lowest incidence. Furthermore, the lowest daily milk yield was recorded on the test day, when subclinical mastitis occurred in all breeds and all regions, followed by an increase in subsequent milk recordings that fluctuated depending on the breed and region of origin. Holstein cows from the Eastern region experienced the greatest overall increase in milk production.

These findings show that recovery potential varies greatly depending on the breed and breeding region. Holstein cows from farms in the Eastern region had the lowest prevalence of mastitis-related disorders and the best chance of recovering and restoring output due to their genetic potential. Therefore, these data show that dairy cows recuperate more quickly when they are reared on big, highly specialized dairy farms, which are widespread in the Eastern region.

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POSSIBILITY OF BIOLOGICAL RECLAMATION OF DEGRADED SOIL IN THE DUMPS OF THE PLJEVLJA MINE[1]

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Abstract

The aim of this work is to carry out biological remediation on the reclaimed land of The Pljevlja Coal Mine, primarily focusing on the process in which soil suitable for the development and cultivation of medicinal plants is applied to the rocky material. Lavender, sage, and balm were planted in the experimental fields. During the two-year study, the mechanical and chemical properties of degraded soil, soil with the addition of shale and humus, as well as the chemical properties of the control soil, were monitored. An analysis of the content of microelements and heavy metals in the soil, shale, and humus was conducted, as well as an analysis of the content of microelements and heavy metals in the dry plant mass. The soil undergoing reclamation had a alkaline reaction. The analysis of shale, soil, and humus samples revealed an increased content of nickel (Ni) as the only heavy metal. The results of the analysis of medicinal plants from the experimental fields did not show an increased quantity of heavy metals. Bacteriological analysis detected the presence of common saprophytic microflora (fungi from the genus Mucor). Reclamation with plant crops is possible on deposited materials from surface mines.

Key words: *reclamation, biological remediation, heavy metal*

Introduction

Surface exploitation most often results in significantly altered landscapes compared to those before the start of exploitation, or after the exploitation

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period. This area experiences a considerable reduction in aesthetic value, and negative ecological impacts on the broader environment occur. This necessitates integrated planning, revitalization, reclamation, and the arrangement of the disturbed space for its renewed humane use in the post-exploitation period (Pavlović, 2000).

The reclamation of surface mines and dumps involves a series of mining, engineering, and agricultural measures aimed at restoring the terrain and ecosystem disrupted by surface exploitation ("Sl. list CG" No. 75/18). The area covered by reclamation fits into the existing ecosystem or changes its purpose entirely or partially for new needs. The implementation of biological reclamation requires a prior analysis of the existing conditions on-site, phased execution, as well as subsequent monitoring of the process and constant adjustments (Golubović et al., 2015).

Before initiating any activity, it is necessary to conduct mechanical and chemical analyses, as well as assess the heavy metal content in the soil. High concentrations of heavy metals reduce soil quality, disrupt the biological balance, and damage other ecosystem functions (Kožul, 2018).

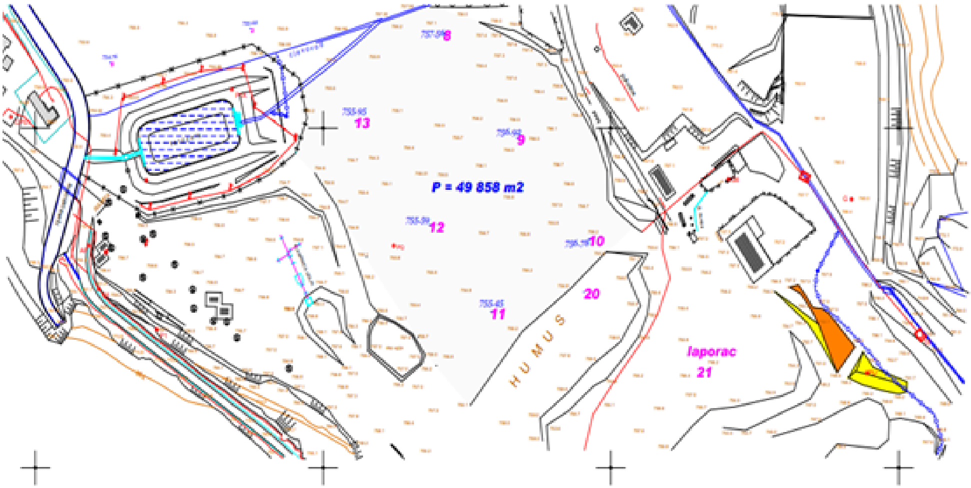
The goal of this work is to perform biological remediation on the reclaimed soil of the Pljevlja Coal Mine, primarily focusing on the process of applying soil suitable for the development and planting of medicinal plants on damaged land surfaces. Lavender, sage, and sweet woodruff have been planted in experimental fields.

Materials and Methods

The research was conducted on mining-degraded soil at the Pljevlja Mine site. For the purposes of the study, and with the aim of assessing soil quality for the planting of specific plant species, soil sampling was performed according to a defined sampling map as follows: analysis of the surface layer 0–30 cm across the entire planned area; two samples were taken at the location where a layer of humus was applied and on the layer of shale; soil analysis to a depth of 100 cm from the experimental fields.

Samples were collected using a soil auger, and pedological profiles were opened to a depth of 100 cm, as needed for undisturbed sampling for the physical properties of the soil. Before sampling on the map or topographic plan, the location to be investigated was selected and marked. Point sampling was applied. For each measurement profile, two samples were taken. Figure 1 shows the sampling map with corresponding coordinates.

Figure 1. Soil Sampling Map



Source: Authors.

Soil samples taken at a depth of 0–30 cm are marked according to the location points: location point 8 (I), location point 9 (II), location point 10 (III), location point 11 (IV), location point 12 (V), location point 13 (VI), at the location of shale application (VII), humus application (VIII). Lavender, sage, and sweet woodruff were planted in experimental fields, and soil samples were taken at a depth of 0-30 cm. Soil samples were analyzed using standard analytical methods at the Institute of Mining and Metallurgy in Bor. Mechanical soil analysis was conducted at the Institute of Pomology in Čačak, while the Institute of Fodder Plants in Kruševac performed chemical analysis of plant samples.

Results and Discussion

Mechanical Characteristics of the Soil

For assessing soil quality for the planting of specific plant species and in the context of quality monitoring, understanding the mechanical composition of the soil is crucial (e.g., clay content, skeletal structure, coarse and fine sand, silt, and clay). The results of the soil's mechanical parameters, analyzed at the Institute of Mining and Metallurgy in Bor, are presented in Table 1.

Table 1. Mechanical Fractions of Soil

Samples	Clay, (%)	Alevrit, (%)	Sand, (%)	Gravel, (%)
I	2,14	38,06	11,35	48,45
II	5,47	79,63	7,40	7,50
III	0,00	31,50	8,25	60,25
IV	3,11	49,94	7,80	39,55
V	4,88	75,42	6,30	13,40
VI	5,67	62,15	7,90	24,30
VII	2,97	39,88	20,90	36,25
VIII	3,33	53,22	14,35	29,10

Source: Authors.

The mechanical characteristics of the soil in these plots indicate that it belongs to the category of light loams. These are generally medium-deep and deep soils, with a silty and silty-clayey composition. They have a surface, A-horizon, that is quite structured and loose, extending to a depth of 15-30 cm. Deeper variations of these soils are good agricultural soils.

Many medicinal herbs thrive on very sandy and rocky soils. Thus, this composition suits the planned plant cultures well (Radanović et al., 2003). In our karst regions, it can successfully be cultivated even on skeletal soils, provided they are suitable for cultivation and the depth allows for satisfactory rooting. However, all research indicates that it thrives best on well-drained soils, which are of lighter texture and well-supplied with calcium (Ca), which aligns with the investigated location.

With certain corrections, it can be used for the production of selected medicinal plant species. For these purposes, soil improvement measures, such as humanization (introduction of organic material), are necessary. In these plots, it is advisable to introduce 15 to 20 t/ha of well-composted manure (cow, sheep) from animals raised on organic principles. This measure improves the water-air characteristics of the soil in the upper profile, stimulating root development and, consequently, the growth of the entire plants. In the nutrition program, it is desirable to use foliar fertilizers several times during the vegetation period.

Chemical Soil Analysis

The need for nutrients in the soil in medicinal plant plantations depends on various factors, primarily the type of substrate, planting density, yield height, and others. For the normal life of plants, biogenic elements are essential: C, O, H, N, P, S, K, and others. Before introducing them, their presence in the soil needs to be determined through analysis. Adding larger quantities than the plants actually need unnecessarily increases production costs and can lead to a decrease in crop quality, the occurrence of toxicity, and deficiencies in other elements (Vučetić et al., 2000).

Basic chemical properties of the soil were analyzed through active and substitutional soil acidity (pH in H_2O; pH in 1M KCl), carbonate content, humus, total nitrogen, as well as the content of easily accessible forms of phosphorus and potassium. The results of chemical analyses of samples taken at a depth of 0-30 cm are presented in Table 2.

Table 2. Results of analysis of soil samples

Parameter	Samples					
	I	II	III	IV	V	VI
pH u H_2O	7.88	7.97	8.00	8.10	7.99	7.83
pH u KCl	7.60	7.62	7.72	7.86	7.58	7.71
clay content	2.14	5.47	0.00	3.11	4.88	4.95
organic matter, %	4.86	5.06	3.30	2.77	5.24	5.47
Al, %	1.69	1.78	1.45	1.16	2.19	1.75
Fe, %	3.01	2.83	2.65	2.59	3.17	2.13
Na, %	0.0091	0.0023	0.0083	0.015	0.0032	0.0067
Mg, %	0.35	0.29	0.39	0.40	0.31	0.40
Mn, %	0.10	0.11	0.089	0.097	0.13	0.065
K, %	0.15	0.16	0.13	0.12	0.18	0.23
$CaCO_{3\ \%}$	25.44	23.36	23.30	24.51	23.12	22.26
P_2O_5 [mg/100 g]	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
K_2O,[mg/100 g]	15.9	18.9	20.0	14.6	14.2	16.4

Source: Authors.

The agrochemical analysis results indicate that the soils in the studied area predominantly belong to the group of neutral to slightly alkaline soils, with an average pH value (in KCl) of 7.8. Such soils, during agricultural use, are stable with a low potential for significant chemical transformation processes. The total magnesium content in the soil ranges from 0.29% to 0.4%, with the lower limit typical of sandy soils and the upper limit of clayey soils (Mengel i Kirby, 2001; Maguire i Cowan, 2002; Kastori et al., 2016). The average humus content in the examined samples is 3.45%, classifying these soils as humic. Based on its content in the organic layer, the soil falls into the group of moderately clayey soils with 2.0-5.0% humus. Humic soils with over 4% humus characterize only 10% of the sampled area. The humus content decreases with soil depth.

Results show that the examined soil contains 22-24% $CaCO_3$, classifying it as highly calcareous. This aligns with the literature and makes the soil suitable for the intended plant cultures. Limestone samples exhibit high carbonate content, over 60% Ca, with a neutral pH, indicating compatibility with the chemical characteristics and purpose of the soil. In comparison, Belić et al. (2011) recorded a wide range of $CaCO_3$ content (0% to 38.3%) and humus content (1.5% to 5.23%) in the Hetin soil, with a pH ranging from 5.57 to 8.75. The phosphorus content in the examined soil is less than 0.2 mg/kg, indicating a very low level. Adequate phosphorus supplementation is necessary. Concerning potassium, most sampled soils fall into the category of well-supplied, with 83% of samples showing a high level of this element (>25 mg/100 g).

The examined plots exhibit favorable characteristics for the cultivation of various medicinal herbs such as lavender, helichrysum, and sweet woodruff. With proper soil preparation and specific agronomy practices, medicinal herbs thrive best in neutral soils. Due to a lower supply of readily available phosphorus, careful attention must be given to the application of fertilizers with a high phosphorus content.

Heavy Metal Content

Increased heavy metal content in clays and clayey shales is associated with their ability to adsorb metal ions and the presence of organic matter in sediments, which also acts as an adsorber for heavy metals. Soil contamination with heavy metals disrupts natural geochemical cycles and ecosystem balance (Xu et al., 2022).

The effects of heavy metals on plant growth and development largely depend on the physicochemical properties of the soil and the form and concentration of heavy metals in the soil (AL-Huqail et al., 2022; Xu et al., 2022). The levels of heavy metals in the soil and their forms are influenced by pedogenetic processes (Heravati et al. 2000). High concentrations of heavy metals reduce soil quality, disrupt the biological balance, and damage all other ecosystem functions (AL-Huqail et al., 2022). The critical concentrations of metals in plants, where the dry matter decreases by 10%, depend on the plant species, variety or genotype, and the characteristics of the heavy metal. Metal content was determined using atomic absorption spectrophotometry – AAS, Perkin-Elmer 1100.

Table 3. Values of Heavy Metals in Soil

Parameter, [mg/kg]	Simples					
	I	II	III	IV	V	VI
Ba	90.0	99.3	69.4	66.2	110.7	85.6
Cr	68.8	45.2	52.7	45.3	49.4	42.7
Co	13.5	13.0	12.0	10.9	14.7	8.8
Cu	36.2	33.3	25.3	27.5	23.4	25.3
Ni	37.0	36.9	30.2	31.3	41.8	27.2
V	46.3	42.5	44.1	40.0	48.0	34.1
Zn	70.2	47.1	43.8	41.4	52.7	53.7
Hg	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
[1)] Mo	3.3	1.1	2.3	1.8	0.92	1.3
Sb	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
[1)] Sn	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
[1)] Te	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
[1)] Th	3.1	3.6	2.9	2.2	4.5	2.1
As	10.2	11.8	8.7	8.4	12.9	8.4
Be	0.93	1.1	<0.79	<0.79	1.3	0.84
Cd	<0.71	<0.71	<0.71	<0.71	<0.71	<0.71
Se	<1.9	<1.9	<1.9	<1.9	<1.9	<1.9
Ag	2.3	<1.6	<1.6	<1.6	<1.6	2.3
Tl	<0.44	<0.44	<0.44	<0.44	<0.44	<0.44
Pb	18.2	17.6	13.4	10.4	20.0	15.6

Source: Authors.

Based on the results of testing the soil for the content of heavy metals, the amounts of arsenic, mercury, lead, copper, cadmium, zinc, chromium and boron found are far below the permissible value (MDK). The exception is the nickel content in two samples whose values are slightly above the maximum allowed. Increased concentrations of nickel are found mainly in soils formed on rocks with a high natural content of this element. Previous research has shown that nickel is of geochemical origin and is slightly soluble. The increased content can be a consequence of anthropogenic influence due to the application of waste and sewage sludge, fertilizers, pesticides or the proximity of industrial plants, mines and other pollutants (Bogdanović, 2007). If the soil is neutral and weakly basic, as in the examined case, nickel is found in less accessible forms. There is very little or no likelihood that the plant can remove it through the phytoremediation process (Lu, 2005): Herawati et al. 2000). All analyzed components will show stability due to the neutrality and slight alkalinity of the soil, and there will be no or very little chemical transformation processes and the formation of new harmful complexes.

Analysis of medicinal plants from experimental fields

Samples of medicinal plants from lavender, sage, and sweet woodruff the experimental field were subjected to laboratory analysis for the presence of trace elements, heavy metals and bacteriological analysis. Analyses were done at the Institute for Fodder Plants in Kruševac.

Table 3. Results of chemical analysis of plant samples

Chemical elements	Concentration, [mg/kg]		
	Sage	**Lavander**	**Sweet woodruff**
Cu	27,87	16,64	14,43
Mn	135,56	127,64	143,08
Fe	1768,9	1937,6	1876,5
Zn	60,56	40,43	51,09
Cd	-	-	/
Cr	15,38	16,64	12,32
Ni	4,79	5,54	3,82
Pb	5,76	3,16	3,09
Co	-	-	-

Source: Authors.

Fitopathological Examination and Organic Production

In the laboratory for phytopathology at the Institute of Pomology in Čačak, examinations were conducted to detect the presence of phytopathogenic fungi using the method of isolation and identification through conventional methods. The investigation involved isolating plant tissue samples on PDA and MA substrates. The examined samples revealed the presence of common saprophytic microflora, specifically fungi from the genus Mucor.

Given the organic production context, maintaining a weed-free orchard and using fertilizers and plant protection agents registered in the Lists of registered products for plant nutrition, plant protection, and soil conditioners, which are permitted for use in organic production, is of utmost importance.

Conclusion

On the degraded soil of surface mines, the cultivation of plant crops through reclamation is feasible. Combined measures of technical and biological reclamation, implemented on large areas, would contribute to stability and improve the presence of essential nutrients, especially nitrogen and phosphorus.

Chemical analyses of the soil designated for reclamation revealed that it is alkaline soil with low content of essential nutrients. In soil samples, an increased nickel (Ni) content was observed, slightly exceeding the permissible limits for agricultural soils. However, this elevated nickel content in the soil did not translate into an increased content in the plant material.

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EFFECT OF MILK REPLACEMENT ON GROWTH, NUTRITION COEFFICIENT AND OTHER RELEVANT PARAMETERS IN DAIRY CALVES

Zvonimir Steiner[1], Ivan Babić[2], Vesna Gantner[3], Ranko Gantner[4]

Abstract

The purpose of this study was to ascertain how various milk substitutes affected the way that Holstein calves produced. 239 calves were used in the study; 119 of them were fed the milk substitute supplemented with yeast microorganisms (Saccharomyces cerevisiae) for 49 days (the experimental group), and 120 of them received conventional milk for the first 21 days. The control group experienced larger growth in the first period (21.3:20.7 kg). The experimental group's calves grew more rapidly in the second phase (33.1:31.9 kg of body weight). When comparing the calves in the experimental group to the calves in the control group at the end of the experiment, the total gain was higher for the experimental group (54.13:53.23), but there was no statistically significant difference. The amount of milk substitute consumed by the calves in the experimental group totals 33.3 kg, and there is a considerably bigger increase from the 30th to the 59th day (Student's t-test, p<0.001). The experimental group had a higher cost price per kilogram of gain (1.09 eur/kg) than the control group (0.972 eur/kg), as determined by the use of milk substitute. Additionally, the experimental group's feeding day cost (1.0 eur/FD) is greater than that of the control group (0.877 eur/FD). In comparison to the control group (51.81 eur), the experimental group's cost price per calf (59.05 eur) is higher due to the use of milk replacement.

Key words: *calves, milk substitute, gain, weight, cost price.*

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Introduction

Due to growing concerns about antibiotic resistance, probiotics are being used more often in agriculture practices worldwide as an alternative to antibiotics (Hume, 2011). Probiotics are microbial dietary supplements, which include live bacteria and yeasts. They have been extensively researched as production enhancers and can benefit the host by restoring the balance of intestinal microbes (Hume, 2011). Saccharomyces cerevisiae fermentation products (SCFP) are frequently used as feed additives because they contain compounds that various gastrointestinal tract bacteria, protozoa, and fungi can use, such as oligosaccharides, organic acids, AA, and peptides (Callaway and Martin, 1997; Araki et al., 2000; Mao et al., 2013).The synthesis and absorption of VFA are intimately linked to the development of rumen morphology, which is particularly influenced by concentrations of butyrate and propionate (Saner et al., 1959; Sakata and Tamate, 1978). Saccharomyces cerevisiae fermentation products have the capacity to speed up the generation of VFA (Quigley et al., 1992). The calf's digestive system works like an animal with a single stomach at birth (Drackley, 2008). One method frequently employed to increase the effectiveness of microbial protein production in the rumen is the use of feed additives, such as probiotics (Mwenya et al., 2004). Probiotic addition to feeding systems has been demonstrated to enhance calves' live weight growth following weaning and to promote rumen development in calves at the same time (Theodorou et al., 1990). When ruminant calves are supplemented with SCFP, their survival rate increases, leading to improved ADG, a larger body weight, and a bigger profit margin (Magalhães et al., 2008). (Lesmeister et al., 2004). They postulated that adding SCFP to milk replacer would hasten the rumen and intestinal epithelium's development, enhancing the gastrointestinal health and growth of calves.

Material and Methods

On a cattle farm, research was done in the control and experimental groups to see how milk replacer affected growth, health status, nutritional coefficient, and other pertinent factors. On the home farm, calves in the control group were fed Kalvostart energy milk substitute, whereas calves in the experimental group were fed Mikromilk milk substitute enhanced with yeast microorganisms (Saccharomyces cerevisiae). Both groups (experimental and control) were fed with pelleted fodder mixture (GT-1, 18% SB) and ryegrass hay, in addition to the mentioned milk substitutes.The entire research lasted 59 feeding days. The experimental group consisted of 119 calves, while the control group consisted of 120 calves. The experimental group consisted of 119 calves, of which 62 were male and 57 were female. Unlike the experimental group, the control group had 120 calves, of which 67 were male and 53 were female.Feeding is done according to the previously established protocol. Upon entering the facility, the calves are fed with rehydration solution Power fit dissolved in water at a temperature of 39 oC in a concentration of 1:20 (50 g/liter of water) and an amount of 2 to 2.5 liters per head. In addition to the aforementioned feed, they were offered dehydrated ryegrass hay and pelleted GT-1 18% SB mixture on the feeding table. On the second day, the calves are fed with milk replacer from the automatic feeder DeLaval CF 1000+ in a concentration of 1:7 (143g MZ per liter of water) and further according to the calf feeding program (Table 1).

Table 1. Program for feeding calves with milk replacer on the DeLaval machine CF 1000 +

Calf feeding program				
Weeks	**Day of feeding**	**Liters**	**Milk replacer**	**Drinking limit**
1.	7	4 – 4,5	Mikromilk / Kalvostart	1 – 1,5
2.	14	4,5 – 5,5	Mikromilk/ Kalovostart	1 - 2
3.	21	5,5 – 5,5	Mikromilk/ Kalvolac	1 – 2,5
4.	14	5,5 – 0	Mikromilk/ Kalvolac	1 – 2,5

Table 2. The chemical composition of the milk replacements fed to farm calves

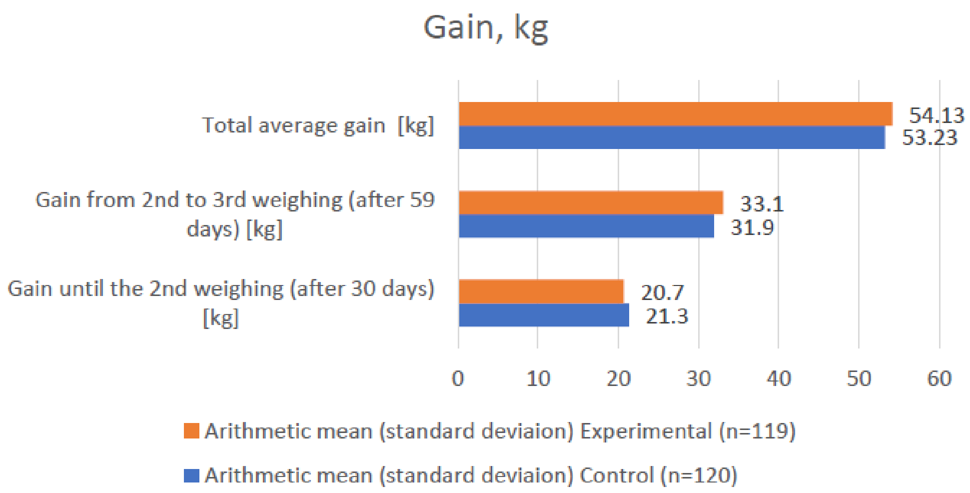
Nutrient	**Kalvolac**	**Kalvostrart, Energy (feeding up to 21 days)**	**Mikromilk**
Crude protein, %	22,0	22,0	21,5
Crude fat, %	17,0	20,0	18,5
Raw ash, %	9,5	9,0	7,0
Crude fiber, %	0,07	0,00	0,30
Lactose, %	39,0	41,0	-
Lysine, %	1,72	2,1	-
Calcium, %	0,59	0,60	0,80
Vitamin A, IJ/kg	55000	55000	25000
Vitamin D_3, IJ/kg	4500	4500	5100
Vitamin E, mg/kg	80	300	105
Vitamin C, mg/kg	120	120	-
ME, MJ/kg	17,52	18,4	17,8
Cost price eur/kg	1,49	1,71	1,77

Statistical significance was tested with the Kolmogorov Smirnov test. A normal distribution of a continuous variable was considered to have a skewness and a distribution smaller than 1. The mean values of the continuous variables are expressed by the median and range for variables that are not normally distributed and for small samples. The ANOVA approach was used to analysed the descriptive statistical parameters. The non-parametric distribution Mann-Whitney U test was used to ascertain the disparity between two independent samples. The Kruskal-Wallis test for non-parametric distribution and the Mann-Whitney U test for post hoc non-parametric distribution were used to determine differences between more than two independent samples. Spearman's correlation coefficient ρ (Rho) for non-parametric distribution was used to determine the relationship. With a significance level of p 0.05, the data was analysed using statistical procedures for testing associations and differences using SPSS 15.0 (SPSS inc., Chicago, IL, USA).

Results and discussion

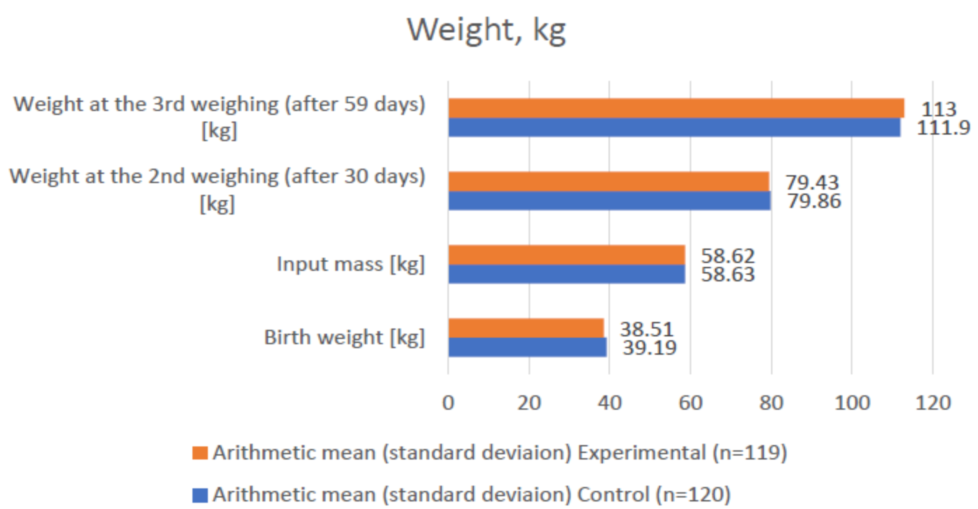
The purpose of the current study was to look into how various milk substitutes affected Holstein calves' ability to produce. The control group experienced larger growth in the first period (21.3:20.7 kg), according to the results. The experimental group's calves grew more rapidly in the second period (33.1:31.9 kg of body weight). When comparing the calves in the experimental group to the calves in the control group at the end of the experiment, the total gain was higher for the experimental group (54.13:53.23), but there was no statistically significant difference. These outcomes align with those of previous researchers (Quigleyjem et al., 1992; Magalhães et al., 2008), who similarly did not find any statistically significant variations in the growth of calves treated with SCY. The amount of milk replacement consumed by the calves in the experimental group is 33.3 kg (SD 1.3 kg) (Student's t-test, $P = 0.017$), and there is a considerably bigger increase from the 30th to the 59th day in the calves in the experimental group ($p<0.001$).

Figure 1. Growth of calves by periods and in total



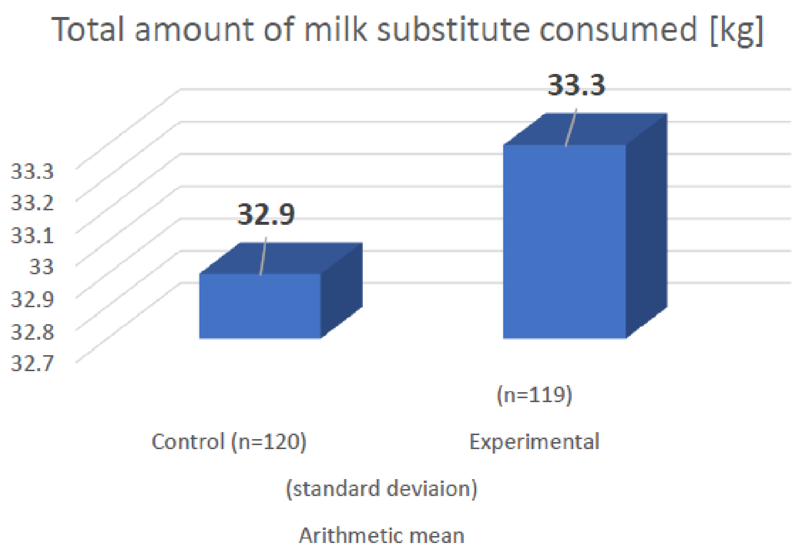
The entry body mass was the same in both groups (58.62:58.63 kg). After 30 days, there are almost no differences between the groups (79.43:79.86 kg). At the conclusion of the trial, the experimental group's average body mass (113:111.9 kg) was 0.97% greater than that of the control group. According to the results, other researchers (Xiao et al. 2016, Hill et al. 2009) also achieved similar results.

Figure 1. Weight of calves by periods and in total



The experimental group consumed 33.3 kg of milk substitute on average, whereas the control group consumed 32.9 kg. This is a 1.2% increase above the control group's intake. After weaning, some researchers (Huuskanen et al. 2015, Hučko et al. 2009) did not find any variations in dry matter intake, however Galvao et al. (2005) saw an increase in dry matter intake.

Figure 1. Total amount of milk substitute consumed



In comparison to the control group (0.972 eur/kg), the experimental group's cost price per kilogram of gain, as determined by the consumption of milk substitute, is higher at 1.09 eur/kg. Furthermore, compared to the control group (0.877 eurFD), the experimental group's feeding day cost (1.0 eur/FD) is higher. When comparing the experimental group's cost price per calf (59.05 eur) to the control group's (51.81 eur), the calculation is based on the intake of milk replacement. The results obtained corroborate those of Lee et al. (2008), who similarly did not find statistically significant differences for calf body mass. Using a milk substitute enhanced with microbes, Geiger et al. (2014) also saw improved outcomes.

The experimental group had a greater daily gain in the second half of the experiment.It is important to emphasize that the reason for the higher daily increase is definitely in the higher level of energy in the comparison of the two milk substitutes that were used in that part of the research (17.8 : 18.32).

The results obtained do not align with the study conducted by Lee et al. (2008), which examined the varying quantities of protein and calories in milk substitutes and did not see any statistically significant variations in terms of average daily gain.

Conclusion

The purpose of this study was to ascertain how various milk substitutes affected the way that Holstein calves produced. Based on the obtained indicators, it can be concluded that the addition of yeast microorganisms (Saccharomyces cerevisiae) can affect the relative increase in growth and body weight. The cost price of milk substitute to which microorganisms have been added is higher than the price per kg of milk substitute without microorganisms, which resulted in a more expensive addition price.

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INFLUENCE OF EFFECTIVE MICROORGANISMS ON BIOACTIVE SUBSTANCES IN DIFFERENT PLANT SPECIES

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Abstract

Due to the pronounced food needs of the growing population, inputs in agricultural production in the form of fertilizers, pesticides and mechanization of agriculture have increased, which has led to higher yields, but also numerous problems in the environment. Although agriculture is highly dependent on climate conditions, it also has a significant role in changing them. All of this has influenced the introduction of measures to replace chemical inputs and protect the health of people and ecosystems. One of the measures is the introduction of different microbiological products into the production technology. In order to test the effect of effective microorganisms in the preparation (EM Aktiv (trade name) on the characteristic bioactive substances of certain plant species, research was conducted on different genotypes: lettuce on the total antioxidant potential and vitamin C, wheat on the grain protein content and corn on the nitrogen content. Research has been carried out for many years in different agro-climatic conditions. Using preparations with effective microorganisms, it is possible to increase the content of biologically active substances in agricultural and vegetable crops and alleviate the stress of plants in unfavorable agro-meteorological conditions.

Key words: *effective microorganisms, lettuce, bean, wheat, corn, bioactive substances.*

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Introduction

Agricultural production has come a long way in development. In the 20th century, it experienced its two major transformations: the industrial and genetic revolutions. The result is the production of large amounts of food and a negative impact on ecosystem health and climate change.

Agricultural production has entered a major technological transformation. Taking into account the need to protect the basic resources for food production, reduce the production of greenhouse gases and produce food with high nutritional value, the concept of measures that can meet the requirements of sustainable food production is being developed. Sustainable food production implies changes in the plant production system. There is a growing need for the inclusion of biological agents in the control and protection of plants from waterborne diseases, as well as in plant nutrition. Knowing that natural resources are limited, sustainable methods of food production are essential to ensure food security for an ever-growing population.

In sustainable agricultural production, the application of so-called EM biotechnology preparations is of increasing importance. Currently, EM biotechnology is used in areas of agriculture such as environmental protection, soil regeneration, crop production, livestock production, agri-food industry and storage. The basis of this technology is a large group of microorganisms that are called effective microorganisms in the professional public. EM preparations contain a mixture of active strains of lactic acid bacteria, photosynthetic bacteria, actinomycetes, fungi, and yeasts in a medium made from sugar cane molasses that ensures low pH values. These groups of microorganisms have different functions, and there is a constant exchange of nutrients between them, which promotes their symbiosis for which there is no withdrawal period (Higa and Parr, 1994). They make a significant contribution in improving soil structure, stimulating growth and preventive plant protection, in livestock production, in agricultural and food technology for biological waste disposal (Gałązka et. al., 2015; Van Vliet et al., 2005).

EM biotechnology in agricultural plant production

In agricultural plant production, EM preparations can be applied within all technological measures of production. By applying them to the soil, soil regeneration is encouraged, sources of infection are eliminated or reduced, Higa (1998), and according to Cvijanović et al. (2019) encourage the development of an indigenous soil microbiome. They participate in the synthesis of humus components, mineralization of organic plant residues and fertilizers in the soil, thereby releasing macro and macro nutrients for the plant. They produce plant hormones (gibberellins, auxins and cytkonins), vitamins, organic acids, antibiotics, polysaccharides that stimulate plant growth (Souza et al., 2015). They are recommended for the treatment of seeds, seedlings, tubers, foliar treatment of plants in vegetation, on stubble before plowing, in the production of high-quality biofertilizer from manure (Pszczółkowski and Sawicka, 2018). In addition, the application of EM in the process of composting solid communal and agricultural waste produces a high-quality soil regenerator and biofertilizer. The advantage of using these preparations is that they do not have a withdrawal period Higa et al., (1994), and they can be used in all physiological stages of plant development through flower leaves and fruits. The direct effect of the use of these preparations is in increasing the yield and biological values of the fruits of the plants (Sawick et al., 2019).

Today, in more than 140 countries on different continents, preparations with effective microorganisms are used in the development of methods for plant biodynamic and organic production (Pszczółkowski et al. 2023). Preparations with effective microorganisms have been tested in Japan, China, Malaysia, Russia, Poland, the Czech Republic, Romania and others. In Europe, this technology is increasingly prevalent at the level of individual farms, especially organic farms (Wu et al., 2013). In Serbia, research is being conducted on the impact of EM Aktiv preparations with effective microorganisms in the production of various plant species. The groups of microorganisms present in EM preparations are isolated from natural habitats. Depending on the origin of the insulation, the composition of the EM preparation also depends. Iriti et al. (2019) point out that lactic acid bacteria mostly predominate. These groups of bacteria have important biotechnological functions because they produce lactic acid that mineralizes organic forms of phosphorus, which is an important nutrient for plant nutrition.

Mechanisms of action of effective microorganisms on plant properties can be direct and indirect. Direct mechanisms imply the participation of microorganisms in the circulation of nutrients, production and synthesis of plant hormones. Indirect mechanisms include the synthesis of antibiotics, the production of sideraphores and enzymes. Direct and indirect mechanisms have a positive effect on seed germination, increasing plant resistance to stress caused by abiotic conditions and the attack of phytopathogenic organisms, increasing plant biomass, increasing the morphological characteristics of plants important for yield, as well as the nutritional properties of fruits.

The use of effective microorganisms as a supplement or replacement for mineral fertilizers is an environmentally acceptable way of food production. Considering the growing demands of the market for food without residues of harmful active substances and with an increased content of bioactive substances, it justifies the application of effective microorganisms.

The influence of the application of effective microorganisms on the bioactive components in fruits

In the research conducted, a preparation with effective microorganisms EM Aktiv was used. EM Aktiv is a yellow-brown liquid with a pH of 3.0–3.5 that includes many strains of effective microorganisms. The microbiological composition of EM Aktiva is protected by patent law and is a trade secret. Therefore, no detailed information is given on the detailed composition of the preparation. This formulation is based on effective microorganism (EM) technology, which involves the use of a mixture of beneficial microorganisms such as different strains of lactic acid bacteria, yeast and other microorganisms to improve soil health, plant growth and overall ecosystem balance.

In several years of research on the application of EM Active in the production of different genotypes of lettuce (*Lactuca sativa* L.), increases in secondary metabolites in lettuce leaves were determined. The value of lettuce, as a low--calorie leafy vegetable, is related to the content of various biomolecules such as vitamins, terpenoids, carotenoids, polyphenols including phenolic acids and flavonoids. Determination of total antioxidant activity is one of the most important parameters from the aspect of food quality. EM active was applied in the production of different genotypes of lettuce in the spring, autumn and winter seasons. The preparation was applied to the soil before planting 4 times during the growing season in the recommended concentration. Antioxidant activity in lettuce leaves was increased by 63-68% on average, depending on the lettuce genotype and growing season, while the increase in vitamin C was 54-56% compared to the control variant. The application of the preparation led to a significantly higher content of vitamin C in spring and winter, while the content of vitamin C was significantly reduced in autumn. Such a response suggests the importance of applying the preparation in combination with varieties and growing season (Stojanović et al., 2022).

Considering the importance of beans in human nutrition, research was conducted on the application of preparations in the production of beans in the period from 2016-2017 in the Bačka Topola region of Vojvodina. Beans (*Phaseolus vulgaris*) are traditionally represented in the diet of people in Serbia. The annual consumption of beans per capita is 5.4 kg. Beans have a high energy value; they contain almost all essential amino acids. In addition, it contains lecithin, as well as potassium, calcium, iron, phosphorus, magnesium, zinc and sodium. It is an excellent source of protein, and unlike other sources, beans are low in fat, so they do not contain saturated fatty acids or cholesterol. As for vitamins, it is an excellent source of folic acid, vitamins B6, K, riboflavin (B2) and B3. Research was conducted with two varieties of beans (Maxa white and Zlatko yellow). The preparation EM Aktiv was introduced into the soil seven days before the beans were planted. Bean seeds were inoculated with compatible strains of nitrogen-fixing bacteria of the genus *Rhizobium*. During the growing season, two treatments with EM Active were performed (in the phenophase of 3-4 leaves and before flowering). An increase in protein content in the grain of both varieties of beans in different agrometeorological conditions was determined from 5.92-9.54% (Table 1).

Table 1. The content of total proteins (%) in the grain of different varieties of beans

Beans	**Method of production**	**2014**	**2015**	**2016**	**Average**	**Deviation (%)**
Maksa	Control	21,97	18,37	19,97	20,10	100
	EM Aktiv	23,26	19,45	21,15	21,29	5,92
Zlatko	Control	20,37	17,03	18,52	18,64	100
	EM Aktiv	22,32	18,67	20,29	20,42	9,54

Source: Dozet et al., 2021

Research on the application of EM actives in the wheat crop (*Triticum spp.*) was conducted in the period 2017-2019 at the location of Vojvodina-Padinska Skela. Nutritional and technological quality, price and adaptability to different environmental conditions have influenced that wheat is one of the main cereals in the world, in terms of production and consumption. Intensive urban, industrial technological development has influenced the mixing of modern and traditional sociological cultures and ways of eating, which contributed to increasing the use of wheat in the diet even in countries where wheat was not traditionally used. The consumption of wheat varies by region, but for the areas of the Republic of Serbia it is around 120 kg per inhabitant per year.

Along with corn and rice, wheat is the main source of plant proteins in human food. The protein content in wheat grain ranges from 8 to 11% in bread wheat and from 10 to 15% in durum wheat. Protein content is determined by both genetic and environmental factors (Altenbach, 2012).

Considering that wheat is present in the production of flour, the quality of flour and bread depends on the protein content. In addition to breeding as a method for improving the amount of protein in wheat grain, the application of different methods also has a significant effect.

In research on the application of the preparation EM Aktiv in wheat production, an increase in protein content in the grain of bread wheat genotypes (Ratarica and Pobeda) was determined. Plant nutrition was provided with 400 kg ha^{-1} NPK (15:15:15) in autumn, and 100 kg ha^{-1} Urea (N 46%) in the spring. The preparation was applied twice at 7 l ha^{-1} during the growing season (phenophase of leafing and flowering) as a supplemental nutrition. An increase in the content of total proteins was determined on average for all three years from 1.56% in the Ratarica variety to 3.98% in the Pobeda variety. The protein content was different depending on the agrometeorological conditions, but in each year of the research, an increase in the protein content was determined, and it can be concluded that the application of the preparation alleviated plant stress caused by abiotic factors (Table 2).

Table 2. The content of total proteins (%) in the grain of different genotypes of bread wheat

Bread wheat	Method of production	2017	2018	2019	Average	Deviation (%)
Ratarica	Control	13,02	13,79	13,40	13,40	100
	EM Aktiv	13,17	13,88	13,79	13,61	1,56
Pobeda	Control	13,19	13,40	13,29	13,29	100
	EM Aktiv	13,78	13,86	13,82	13,82	3,98

Source: *Cvijanović et al., 2022*

Maize (*Zea mays*) is a very dominant crop in the food industry, and in recent years also in the production of bioenergy. Predictions show that by 2025, corn production in the world will increase significantly, while the need for this crop will double in developing countries by 2050 (Rosegrant et al., 2008). Large amounts of nitrogen are necessary to achieve the genetic potential of maize fertility. In the literature, a large number of works can be found in which the influence of N in increasing yields and improving yield components has been examined and confirmed. The amount of applied nitrogen has a linear correlation with the morphological characteristics of maize. That the application of nitrogen is specific is shown by the results of Latković et al., (2010), who determined that different doses of N (40, 80 and 120 kg ha^{-1}) influenced the increase in yield with increasing doses. But the question of economic and ecological justification arises. That is why, in addition to breeding, technologies are constantly being researched that would maintain production with the least negative impact on the environment. Previous research with the application of different groups of microorganisms has given positive results in terms of maintaining the biogenicity of the soil and the height of the yield (Cvijanović et al. 2019).

Considering the increasing presence of maize in human nutrition, research was conducted on the impact of EM Active on the nitrogen content in the grain of various maize hybrids grown in the Valjevo region in the period 2017-2018. Agrometeorological conditions in 2017 were unfavorable because there was a pronounced drought, while 2018 was more favorable for maize production. The application of the preparation was in two variants. In variant EM1, the preparation was applied twice during vegetation (in the phenophase of 5-7 leaves and after 15 days) 6 l ha^{-1}, and in variant EM2 it was applied to the soil 7 days before sowing (30 l ha^{-1}) and twice in during the growing season (in the phenophase of 5-7 leaves and after 15 days).

Nitrogen content was the interaction of hybrids and agrometeorological conditions in the examined years. In the test, both variants of the new preparation gave positive results of nitrogen content compared to the control. In conditions of drought, the application of EM active in both variants, an increase of nitrogen in the grain of 1.31-3.43% was determined, while in the year that was more favorable for maize production, the increase was 3.58-18.19% (Table 3). And in these researches, it was shown that in conditions of unfavorable agrometeorological conditions, the application of preparations with effective microorganisms is necessary and acceptable.

Table 3. Nitrogen content in the grain of different maize genotypes

Years	Hybrids	EM_0 (control)	EM_1	EM_2
2017	ZP427	1.297	1.116	1.514
	ZP548	1.293	1.709	1.444
	ZP 684	1.519	1.427	1.205
	Prosek	1.370	1.417	1.388
	Deviation (%)	100	3.43	1.31
2018	ZP427	1.285	1.376	1.849
	ZP548	1.454	1.345	1.304
	ZP 684	1.449	1.616	1.798
	Prosek	1.396	1.446	1.650
	Deviation (%)	100	3.58	18.19

Source: *Stepić et al., 2022*

Conclusion

Conducted research shows that there is a strong positive relationship between the tested characteristics of the fruits and the application of preparations with effective microorganisms.

The genotypes of the investigated plant species as well as the agrometeorological conditions, which significantly modified the content of the investigated traits, had a significant influence on the content of the investigated traits. In unfavorable agrometeorological conditions, it is possible to achieve a higher quality product by using effective microorganisms.

Further research should be focused on the examination of the combitable relationships of the prepastor with the genotypes of the plant species. It is also important to point out that agriculture and tourism are connected and mutually conditioned. The renaming of such preparations in rural households that are involved in some form of tourism could significantly contribute to the improvement of households.

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RURAL TOURISM IN THE FUNCTION OF SERBIAN AND EU TOURISM DEVELOPMENT

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Apstract

In recent years, there has been an increasing number of recognizable rural tourist destinations, and the reason for this growth is in marketing activities, cultural heritage, the work of various development agencies supported by countries, the formation of EU structural funds, and increased awareness of new trends among tourists. The emergence of new forms of tourism in rural areas. The paper presents an analysis of the state of rural tourism in Serbia and EU countries, in accordance with the basic indicators. The culture of work, the culture of housing, the culture of food, the culture of clothing and forms of folk art (naive painting and sculpture, folklore, music) are among those values of the rural community that especially attract tourists. Realizing that these values are important for the development of tourism, decision makers will seek through marketing to preserve these traditional values, and thus contribute.

Key words: *rural tourism, rural development, Serbia, EU.*

Introduction

In the second half of the twentieth century, the development of rural tourism had slow gone, without any plan or logic. From this distance, it can be said that rural tourism as such did not actually exist, in the modern sense of the word.

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The state did not significantly deal with this segment of the offer, and intensive industrialization led to the aging of the Serbian countryside. Census results in 2011. showed that the demographic trends in Serbia, especially in its rural areas, are increasingly unfavorable. In the 2011–2021 period it was a decrease in the total number of inhabitants by 4.15%, which is primarily a consequence of negative natural growth and departures abroad. In this period, the rural population decreased by 311,139 inhabitants (10.9%), it fell to a level below 3 million, and today it makes up 40.6% of the total population of Serbia. In support of the negative demographic trends in rural areas, the fact that in about 1,000 settlements the number of inhabitants is less than 100, which practically indicates that every fifth settlement is about to be closed; the highest concentration of such settlements is in the south and east of the country, where every third settlement has less than 100 inhabitants (Vujko, Delić-Jović, 2021).

If we look at the period from 1975. until 2022, there is a downward trend in the size of agricultural holdings in the European Union. In the period between 2003 and in 2020, the average rate of decline was the highest for those countries that joined the European Union. For the nine countries that are the oldest members of the Union (for which there is also the largest amount of data), the loss of agricultural holdings accelerated until 2005. and then started to slow down (Hall, 2004; Chambers, 2013; Demonja, 2014). It seems that the economic crisis has significantly influenced the decline in the number of farms in the territory of the European Union. It should be emphasized that the average rates of growth (or decline) in the period from 2005 until 2020, they differ considerably among the member countries. Those countries that have suffered the most from the economic crisis have a lower rate of decline, indicating fewer opportunities for alternative employment and a tendency for farms to hang on during hard times.

In our paper, we will show the state and perspectives of rural tourism development in Serbia and EU.

State of rural tourism in Serbia

The problem when it comes to Serbia lies in the demographic structures, which are quite disproportionate. These changes, which are characterized by an increase in the share of the elderly population at the expense of the young, were especially observed in the period 2011-2021. years. The situation is even more unfavorable in rural destinations, which have recently been struggling with the problem of depopulation with various measures. Every fifth resident of a village in Serbia is over 65 years old, while in the region of Southern and Eastern Serbia it is every fourth (Vujko, Delić-Jović, 2021).

When it comes to the education of residents in Serbia, the situation is as follows. It can be said that most of those who are in the range of completed high school, and such are 47%. The situation is similar when it comes to rural destinations. The population with high school diplomas in the villages is in the interval of 37%. This is very encouraging information because it indicates the fact that the local population of rural areas is increasingly aware of the importance of education. On the other hand, a large number of those without school was still observed in the villages. (Vujko, Delić-Jović, 2021). In line with education, there is also data on employment.

The rural population of working age compared to the urban population has: higher rates of activity (60.9 and 59.5%) and employment (47.9 and 43.4%) and lower rates of unemployment (21.3 and 27%) and inactivity (39.1 and 40.5%), (Bakić, 2010; Bošković et al., 2013; Dedeić, 2015). It could be said that the reason for such data is that rural destinations, by themselves, provide more opportunities for employment to those with lower degrees. On the other hand, the sector with the highest percentage of employees is agriculture. This indicates the insufficient development of tourism in rural areas. Some scientists claim that in the coming period, rural tourism will develop rapidly, which will lead to the creation of new jobs, and therefore to an increase in employment in other sectors (Bakić, 2010; Bošković et al., 2013; Dedeić, 2015).

When it comes to the structure of the land in Serbia, it should be said that the most are those who have a land size of 2ha (48.8% of the total number), and of that number, only 8% is cultivated. This is a small percentage of cultivated land, especially if it is known that in most cases the land on those plots is cultivated conventionally. It is necessary to do a lot of education and projects that will influence the awareness of the local rural population about the importance of different agricultural production of and growing of multi-crops, just like adapting the village to the tourist offer. The opening to tourists represents a new opportunity for the village that should not be missed. By evaluating sustainability indicators, Radović et al. (2013) claim that the most unfavorable situation is in eastern and southern Serbia, and the most favorable in Vojvodina. This is somewhat logical, bearing in mind that Vojvodina is located in the Pannonian Plain and is predominantly agricultural. Also, there are numerous farms in Vojvodina, many of which have already been turned into attractive gastronomic Meccas and tourist destinations, and there are indications that many of them will soon become tourist facilities.

Statistics say that as much as 85% of Serbia is rural. It is clear then what kind of potential for rural tourism we are talking about. Rural tourism is currently underdeveloped, but the Government of Serbia realized the importance of developing and is trying in every way to favor and develop this type of tourism. Currently, about 8,000 beds are registered in rural areas, and about 300 households provide both a top gastronomic offer and about 150,000 overnight stays per year (Vujko, Delić-Jović, 2021). The situation is approximately such that one household spends 750 to 1,500 nights a year, and the average length of stay is 2.8 days. This gives an indication that guests mostly stay on weekends and extended weekends, which fits into the statistics of the Europe States, where rural tourism is considered developed. A total of 10 billion in revenue was generated from rural tourism (5 billion RSD in revenue comes from accommodation and around 5 billion RSD is direct revenue). This represents 16% of the RSD 62 billion of total GDP from direct tourism in Serbia, in 2010. (Calculated by WTTS). Also, the data show that the annual income from rural tourism is about 5,000 euros per year, and in households that provide a more complex and better service, the income goes up to 12,000 euros per year. This means that the average price per night is around 15 euros, which is more favorable than in the most countries in the region.

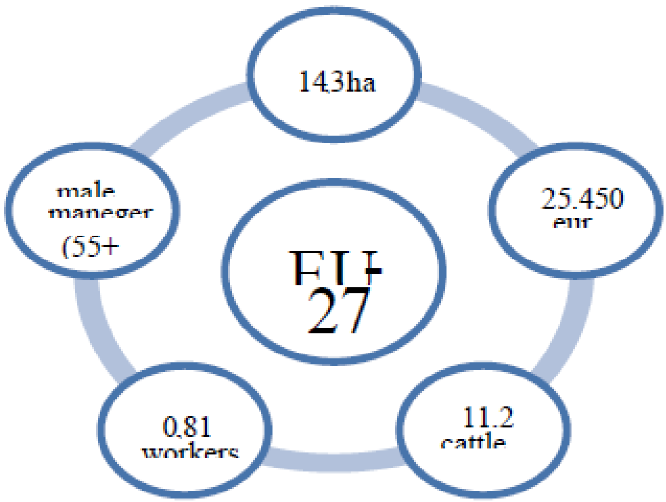
The Tourism Strategy of the Republic of Serbia (2005) defines rural tourism as an absolute priority, especially emphasizing positive indicators of sustainability (economic, sociological and ecological) as a basis for development. Although the situation is currently not at an enviable level, the Government of Serbia is making efforts to change that picture in the future. Various subsidies and projects represent an excellent push-up effect of the development of rural tourism. There are many opportunities for engaging in rural tourism, as it includes recreational activities, gastronomy, wine tourism, eco tourism and the like.

The strategy for the development of rural areas of Serbia is based on the cooperation of the Ministry of Serbia with important UN partners FAO, UNICEF, UNDP and UNEP (Vujko, Delić-Jović, 2021) According to the Master Plan of Strategic Development (Bakić, 2010; Bošković et al., 2013; Dedeić, 2015), Serbia is divided into clusters (groups) according to priority criteria. This means that financial resources are allocated to these clusters according to their priority. The highest priority clusters receive a larger share of financial resources, since it is expected that those rural areas have the highest possibility of returning invested funds. Thus, for example, in Vojvodina, the area of Fruška Gora was declared the area of the highest priority in relation to the area of the upper Danube, Northern Serbia and Southern Banat (Vujko, Delić-Jović, 2021).

State of rural tourism and accommodation capacities in the European Union

The European Commission prescribed 22 measures that must be fulfilled and which are mandatory for all member countries (Knickel, 1990; Pina, Delfa, 2005; Majdak, 2014). The aim of these measures is to help farmers to meet EU standards, as well as to earn as much money as possible, which would later be redistributed according to the framework of the European Rural Policy. Financing is mainly provided from the European Union's rural development fund EAFRD and from national, regional and sometimes private sources. A number of methodological changes which were implemented in the 2010 agricultural consensus makes it impossible to compare data from different research years. For example, the distribution of territorial units was again revised and resulted in the new NUTS 2010 classification, which came into use in 2012. In addition, not all Member States have satisfactory ways of collecting and storing data.

Figure 1. Basic EU-27 rural indicators from 2022.



Source: Vujko, Delić-Jović, 2021.

European Union EU-27 can be described by the following indicators from 2022: 12 million farms, 172 million hectares of agricultural land, 25 million people employed in agricultural production. On average, one farm has 14.3 hectares of agricultural land and earns 25,450 euros in profit per year. It employs less than one full-time worker and has an average of 11 head of livestock. These are mostly family farms run by one owner who is also the manager. According to research, on average, these are men over 55 years old. However, it should be emphasized that this average for all EU countries does not accurately indicate the real situation of all member countries. These average values serve as reference values for comparison between countries and regions.

The regions with the lowest average farm size are concentrated in the eastern and southern parts of the European Union, while those with the highest average are mainly found in Great Britain, France, Denmark, eastern parts of Germany, the Czech Republic, Slovakia and parts of Spain (Hall, 2004; Chambers, 2013; Demonja, 2014). However, compared to other countries in the world, farms in the European Union are relatively small. The reason for this is mainly the differences in climate, topography, soil quality and production structures. Also, the reason partly lies in the inadequate distribution of agricultural land, since in the European Union there is a smaller number of farms that occupy a large part of agricultural land and thus reduce the competitiveness of smaller farms on the market.

The countries with the highest number of self-employed people are Greece, Italy, Poland and Romania with more than 18%, followed by the Czech Republic, Spain, Portugal and Slovakia (between 15 and 18%). The lowest share of the self-employed (below 9%) is in Denmark, Estonia and Luxembourg. It is necessary to mention that the number of self-employed persons decreased significantly in countries that were significantly affected by the economic crisis (Spain, Portugal, Italy, etc.), while in Germany, France, the Netherlands and Great Britain the number of employees increased during that period (Hall, 2004; Chambers, 2013; Demonja, 2014). Rural areas in the EU represent 52% of the total territory and are home to 23% of the total population. In 2022, rural areas generated 16% of total GDP and 21% of total employment. With the growth of the European Union and the accession of new member states, the size of the rural territory did not change significantly. However, a significant decline was observed in the share of rural areas in total GDP and in total employment.

In the EU-27 as a whole, accommodation capacities are higher in rural regions (with 32.2 %) than in urban regions (25.3%). According to the share of the number of beds in rural areas according to the average number of the total national accommodation capacity, the importance of rural tourism for that country is determined. According to this parameter, France (with 27.8 %), Greece (9.1%) and Austria (7.9%) represent the countries in the EU-27 that have the highest share of rural accommodation compared to the average in the total national accommodation capacity. In EU-15 it was France, while in EU-12 it was Hungary (Hall, 2004; Chambers, 2013; Demonja, 2014).

Conclusion

In the European Union, the rural population accounts for an average of 17.5% of the total population, with a minimum of 3% in the Netherlands and a maximum of 67% in Sweden. The following table shows the state and forecast of the population distribution and participation of the rural population on different continents of the world.

Today's rural tourism market in Europe is very developed and is characterized by over 200,000 accommodation facilities with a capacity of over two million beds. The largest receptive, as well as emitting, rural tourism markets are France, Germany, Austria, Great Britain and Italy, which together make up over 77% of the total rural tourism market in Europe. This form of tourism in Europe is characterized by accommodation on farms, in private country houses and in small family guesthouses and hotels, which attracts direct annual tourist spending of around 12 billion euros (Stankov, 2007). Including local added value and multiplier effects, that amount reaches 26 billion euros for the benefit of the European rural economy. The number of direct and indirect employees in this economic branch is estimated at 500,000. If daily visits are included, the total impact of rural tourism in European rural areas is 65 billion euros.

If we start from the fact that rural tourism in Serbia has only been developing for about 50 years and that in the beginning this development was chaotic and unorganized, we conclude that investments in rural destinations and tourism are both necessary and desirable. In order to attract foreign tourists, registration and standardization of services is necessary. Bearing in mind that around 43% of the population of Serbia is rural, the importance of redefining rural destinations to engage in rural tourism is clear. This would first of all mean that young people would stay in the villages, which would stop the process of "dying" of the villages and depopulation in the villages. Rural tourism today it is still not sufficiently structured and organized. It is necessary that the vision of development be aligned with contemporary world trends, i.e. the best world experiences, development models and internal regulatory standards.

It should be borne in mind that the Government of Serbia defined rural tourism as an absolute priority, pointing to positive aspects of development, through indicators of sustainability (economic, sociological and ecological), which gave this form of tourism a desirable epithet: sustainable form of tourism. This primarily means that rural tourists are a desirable category of tourists, and rural tourism is a sustainable and responsible way of managing rural destinations. The state's decision to invest in rural destinations is considered a desirable step by which the state treats rural destinations responsibly. The modern way of life, including the past Covid19 pandemic, indicates the absence of a sufficient number of such destinations that offer prevention before rehabilitation. It is considered that villages are such destinations and that the development of rural destinations should be and is a priority in the leading development strategies for all the states, and for Serbia as well.

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SOCIOECONOMIC EFFECTS OF CATTLE RUSTLING ON THE LIVELIHOOD OF INHABITANTS OF SOME SELECTED RURAL COMMUNITIES IN NORTHERN NIGERIA

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Abstract

A reconnaissance survey on socioeconomic effects of cattle rustling on livelihood of inhabitants of selected communities in Northern Nigeria was conducted. Total of 390 questionnaires were administered. The data obtained was statistically analyzed. The structure of the respondents had the following prevalence: males over females, younger over mid-aged/older, married over unmarried/widowed, and most of them being farmers, with little or no formal education. There is a high level of starvation, loss of investment, deceased income, mental distress, injury and death at Relative Importance Index 66.3% to 84.9%. Least negative impact of rustling affects trading 4.4%, with high negative impact to farming 56.4%. Cattle rustling showed various negative consequences to the inhabitants by devastating their livelihood. The concerned security outfit of the state should be strengthened to curtail the menace in the affected areas.

Key words: *Cattle, Rustling, Livelihood, Rural, Northern Nigeria.*

Introduction

In rural areas, especially in West Africa, livelihood is the ability of that individual to obtain the basic necessities in life, which are food, water, shelter and clothing. But such basic necessities can be affected by social vices such as cattle rustling (Davis et al., 2010). Livelihood in rural communities could be

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agro-pastoralist in nature. Some could also be focusing only on livestock husbandry and crop farming. In similar vein, livestock represents a fundamental form of pastoral capital, and at the same time, it was regarded as the means through which wealth is stored for a “rainy day” (Behnke, 2008).

In most rural areas of the world, approximately 90% of the population is involved in farming as a way of earning a living. Small-scale farming, fishing, raising livestock and non-farm activities are some of the common livelihoods that these populations survive on. Rural livelihood poses a great challenge as these populations are often in a state of poverty where they lack the basic necessities for survival (Hof and Rischkowsky,, 2018).

Cattle rustling is a planned and organized crime involving the stealing of livestock forcefully from another person or from the grazing field by a group of individuals, and for the purpose of commercial gain (Behnke, 2008). Journalists, academics and security practitioners increasingly refer to it as a form of organized crime leading to exposure of animals to various microbial diseases such as fungal, bacterial, viral and parasitic infections, that emanates from lack of care by the rustlers (Momale, 2016). Further, with the involvement of actors such as Boko Haram and the movement of cattle across national boundaries, cattle rustling is also being recognized as a form of transnational organized crime (Okoli & Okpaleke, 2014).

Cattle rustling has become a problem of major concerned in northern region of Nigeria with quite alarming casualty figures in Zamfara State. The government of Zamfara State reported that nearly 500 villages and 13,000 hectares of land were devastated and 2,835 people killed between 2011 and 2018. The aim of this research was to evaluate the socioeconomic effects of cattle rustling on livelihood of inhabitants of selected communities in Northern Nigeria.

Materials and Methods

The research was conducted at some selected Districts within Zamfara State in Northern Nigeria, between 7th and 11th September, 2019. Zamfara State is located between Latitudes 10° 49’N - 13° 7’N of the Equator and Longitudes 5° 00’E - 7° 50’ E of Greenwich Meridian. The State covers an area of 38,418 Square Kilometres (NPC, 2019). It is bounded to the north by Sokoto State, to the northeast by Niger Republic, Kebbi, and Niger states, to the southwest by Katsina and Kaduna states to the east and south respectively. The climate condition of Zamfara State is tropically warm, with temperatures rising to 38°C

(100.4 °F) and above between March and May. Daily temperature in Zamfara ranges between 24°C and 27°C, with the highest temperature in April and lowest in January (Sulaiman et al., 2023).

The primary source of data involved the use of questionnaire designed for the livelihood actors in the selected Local Government Areas (LGAs) of Zamfara State, Nigeria. The questionnaire contained both open and close ended questions. The questions were structured based on the objectives of the study. A total of 390 consented respondents were enrolled for the study, in which validated questionnaires were administered to the respondents (herdsmen and those who have been victims of cattle rustling) using the snowball sampling technique. The responses were compiled and analyzed statistically. The data obtained consisting of socio-demographic characteristics of participants and their rural livelihood activities were analyzed using descriptive statistics such as frequency count, percentages and mean scores. Also, inferential statistics such as Relative Importance Index (RII) was used to examine the effects of cattle rustling on rural livelihood of the studied community (Ken, 2004).

Results and Discussions

Table 1. depicts sociodemographic information of the respondents, in which the predominant 62.7% are males, majoring (43%) of which belongs to age range of 25-34 years, most (53.2%) of which are married.

Table 1. Socio-demographic Characteristics of Respondents in relation to gender, age and marital status

Sex	**Frequency**	**Percent**
Male	245	62.7
Female	145	37.3
Total	390	100
Age	**Frequency**	**Percent**
15-24	59	15.3
25-34	166	43
35-44	90	23.4
45-54	36	9.4
55 and above	39	10.1
Total	390	100

Marital Status	Frequency	Percent
Single	124	31.7
Married	208	53.2
Divorced	33	8.4
Widowed	26	6.6
Total	390	100

The sex, age distribution and the marital status of the respondent in the study area shows that about 63% of the respondents were males while 37% were females. This is an indication both men and women are affected, with high frequency of 44% among respondents of age range 25 to 34 years, with least frequency of 9.4% among age range of 45 to 54 years. The finding aligns with Abdullahi et al. (2017) research on the socioeconomic repercussions of cattle rustling in Gusau Local Government Zamfara State, Nigeria. Regarding the age distribution, 43% of the respondents were between 25 - 34 years, followed by 23.4% accounting for those 35 - 44 years. This depicts the youthful population's involvement in cattle rearing activities. Majority 53.2% of the respondents are married with few 6.6% widowed as documented by Sulaiman et al. (2023). Table 2 shows predominance of lack of formal education among the respondents, with most respondents being farmers earning less than ₦10, 000 per month.

Table 2. Socio-economic Characteristics of the Respondents in relation to level of education, occupation and monthly income

Educational level	Frequency	Percent
Primary	114	29.2
Secondary	98	25.1
Tertiary	126	32.2
No formal education	148	38.2
Total	390	100
Occupation	**Frequency**	**Percent**
Farming	88	22.5
Livestock rearing	22	5.6
Artisanal mining	52	13.3
Fishing	16	4.1

Trading	84	21.5
Transportation	5	1.3
Retail	15	3.8
Civil service	41	10.7
Unemployed	67	17.1
Total	390	100
Monthly Income	**Frequency**	**Percent**
Less than ₦10,000	89	27.5
₦11,000 - ₦15,000	46	14.2
₦16,000 - ₦20,000	51	15.8
₦21,000 - ₦25,000	62	19.2
₦26,000 and above	75	23.3
Total	323	100

It was found that most of the respondents had at least one form of formal education, among which tertiary level (32.2%) accounted for the highest. A quite number of the respondents have no formal education representing 38.2%. Most 27.5% of the respondents reported monthly income of less than N10, 000 (equivalent to USD 12 as of December, 2023). The finding concurs with that of Manu et al. (2014) and Sulaiman et al. (2023) in Zamfara state, Nigeria which revealed that most respondents' average monthly income was less than ₦30,000 and less than ₦10,000 respectively.

Table 3 recorded very high relative importance indence in relation to various livelihood consequences.

Table 3. Consequences of Cattle Rustling at on the livelihood of Individual Household

Consequences	RII	% RII	Degree of Consequent
Death of family member	0.974	97.4	Very high
Decreased income	0.917	91.7	Very high
Asset loss	0.897	89.7	Very high
Livestock loss	0.882	88.2	Very high
Injury and stress	0.873	87.3	Very high

Consequences	RII	% RII	Degree of Consequent
Cattle kept stationary	0.855	85.5	Very high
Hunger and starvation	0.831	83.1	Very high
Mental distress	0.773	77.3	High

RII= Relative importance index

The respondents reported high levels of starvation/hunger, loss of investment/assets, deceased income, stress, mental distress, injury and death at relative importance index of 66.3% to 84.9% as a result of activities of cattle rustling in their various communities. Least negative impact of rustling affects trading 4.4%, with very high negative impact to the farming 56.4% at the community.

Conclusion

The study revealed a least negative impact of rustling affects trading 4.4%, with very high negative impact to the farming 56.4% at the community thereby crippling their economy and agricultural productivity.Cattle rustling showed various negative consequences to the inhabitants by devastating their livelihood through livestock's loss, mental distress, and unfriendly market day, loss of farm produce and destruction of properties.

It is recommended that the concerned security outfit of the state should be strengthened to curtail the menace in the affected areas.

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THE CONTRIBUTION OF TOURISM TO THE DEVELOPMENT OF THE RURAL AREA IN ILFOV COUNTY. CASE STUDY FOR BUFTEA AREA

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Abstract

The article analyzes the development of the most important tourism economic statistical indicators during the period 2015-2021, in Ilfov county, which is part of the Bucharest-Ilfov Development Region, and in the Buftea city area, a component of the mentioned county. Ilfov stretches around Bucharest and is the smallest county in Romania. In the city of Buftea, located in the western part of Ilfov county, there are some tourist attractions with national importance, which are points of attraction for national tourists and also from abroad. To achieve the aim, the authors analyze a series e a series of indicators, available for Ilfov county and also for Buftea city area, such as: the total number of tourist reception structures; the existing tourist accommodation capacity, arrivals of tourists and overnight stays in tourist reception structures, by types of tourist reception structures. During the analyzed period, tourism performance registered a downward trend in Ilfov county, despite the rich resources and accommodation infrastructure it has. The article proposes some solutions for the revitalization of this important sector, which can contribute to the evolution in the EU standards of the rural area in Ilfov County.

Key words: *Buftea area, Ilfov County, rural area, tourist reception structures*

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Introduction

Ilfov County, a component part of the Bucharest - Ilfov Development Region, stretches around the city of Bucharest and is the smallest of Romania's counties, due to its surface area of only 1,538 km² (Figure 1). In its vicinity are the counties of Ialomița, Călărași, Giurgiu, Dâmbovița and Prahova (Portalul comunelor, 2023) and it is composed of 8 towns – Buftea, Otopeni, Chitila, Voluntari, Popești-Leordeni, Pantelimon, Bragadiru, Măgurele, 91 villages and 32 communes (Consiliul Județean Ilfov, 2023).

Geographically, Ilfov county is placed in the Romanian Plain (Câmpia Română) and here, in addition to plain vegetation with its specific fauna, we find pastures, fragments of oak, willow, poplar, beech forests - some remnants of the ancient Vlăsiei Woods (Codrii Vlăsiei), which stretched in this area in the past centuries, lakes (Cernica, Snagov, Buftea, Căldăruşani and Mogoşoaia), as well as rivers that cross the county: Ialomiţa, Dâmboviţa and Colentina (Worldlifetimejourneys, 2023).

Figure 1. Ilfov county in relation to Romania

Source: România pe hartă, 2023

Figure 2. Buftea area at the level of Ilfov county

Source: România pe hartă, 2023

The forests, lakes and rivers of the county are nationally known as natural resources of tourist attraction, where sports competitions and various events take place, but they are also valued recreation and leisure areas for the residents of the county and especially for those from the capital, who escape the hustle and bustle of the city on weekends and look for quiet areas with green spaces.

Thus, the lake and the Snagov Nature Reserve, the Băneasa forest, the Râioasa forest (54.8 ha), declared a forest reserve in 1973, are some of the places appreciated by Romanian and foreign tourists.

Along with the increase in the preferences of Romanians for picnics or, as they say "ieșirea la iarbă verde / going out to the green grass", in the areas of Ilfov county, intended for this type of relaxation, the number of units serving food and drinks has also increased.

Also, Ilfov county is also known for its anthropogenic tourist attractions, which attract visitors:

- Snagov and Scroviştea Palaces – Periş,
- Cernica, Pasărea, Snagov, Căldarușani, Ţigăneşti Monasteries.

Also, these objectives represented starting points for the development of related services and the increase in the number of public catering units.

One of the 8 cities and at the same time the unofficial capital of Ilfov county, the city of Buftea is located in the western part, on the border with Dâmbovița county (Figure 2). It is located in a picturesque area, on the banks of the Colentina river and is surrounded by forest fragments (Mărcuță et al., 2023).

A number of tourist and leisure attractions attract visitors to the area of influence of the city of Buftea:

- Stirbey Palace from Buftea (monument of the 19th century),
- Brâncovenesc Palace from Mogoșoaia (18th century monument),
- The "Calul Bălan" complex from Buftea (restaurant),
- Cinematographic studios from Buftea (built in the 50s, the most famous film sets in Romania),
- The leisure base from Buftea (sports),

The Summer Well Festival, organized at the Stirbey Palace in Buftea, put the city on the map for outdoor concert lovers.

Starting from these considerations, respectively the anthropic and natural tourist resources at its disposal, the article pursues to manifest how tourism can contribute to the economic and social progress of the rural area of Ilfov county.

Materials and method

The statistical data that were extracted and processed for the creation of this article are made available on the website of the National Institute of Statistics. The following indicators were analyzed in this study for the period 2015-2021: the total number of tourist reception structure; the existing tourist accommodation capacity; arrivals of tourists and overnight stays in tourist reception structures, by types of tourist reception structures, for Ilfov county and for Buftea city area.

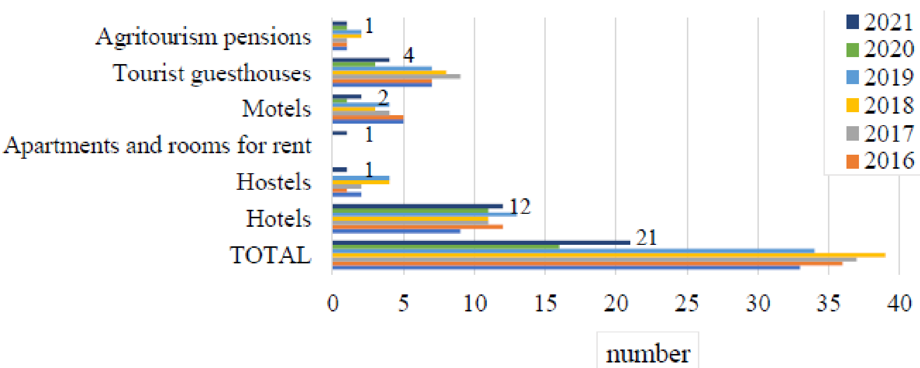
At the same time this article is based on an analysis of existing articles, documents and studies regarding tourism, rural development, and Ilfov county.

Research and Discussion

Ilfov County owns over 700 historical monuments and intangible heritage components. At the same time, there are several amusement parks, health and relaxation facilities, horse riding, karting, parachuting, golf and other sports activities (Consiliul Județean Ilfov and The World Bank, 2020).

However, the contribution of tourism to the economy of Ilfov county is relatively low. The results obtained by this field have shown a downward trend in recent years. Thus, in 2019, the average stay was less than 2 days, and the accommodation capacity utilization index was approximately 30%. This indicates that short-term tourism dominates and existing accommodation capacity is not fully utilized (Consiliul Județean Ilfov and The World Bank, 2020).

Figure 3. The total number of tourist reception structures in Ilfov county, in the period 2015-2021*

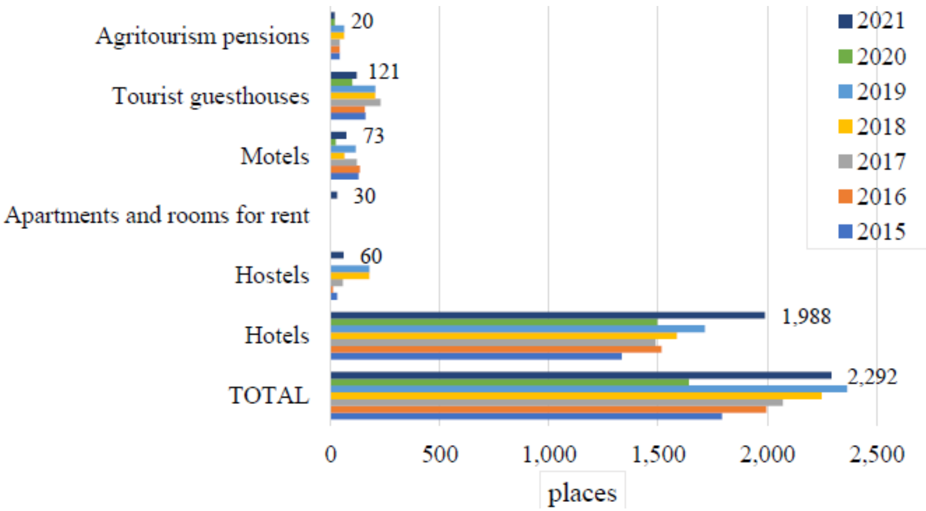


** data presented for 2021*
Source: own representation after INS, 2023

Figure 3 shows the number of tourist reception structures in Ilfov county that operated in the period 2015-2021. A decrease from 33 (in 2015) to 21 (in 2021) in the number of accommodation structures was noted. Of these, hotels represented the highest value - 12, in 2021. Other types of tourist reception structures existing in Ilfov county were: hostels, apartments and rooms for rent, motels, tourist boarding houses and agro-tourism boarding houses.

The existing tourist accommodation capacity in Ilfov county consisted of 2,292 places in 2021, with an increase of 28% compared to 2015 (Figure 4). Most places were available in hotels (about 2,000 in 2021) and tourist guest-houses (121 places in 2021). It should be noted that the number of places in hotels increased by 149% in 2021 compared to 2015, and in tourist hostels decreased by 25% in the same period.

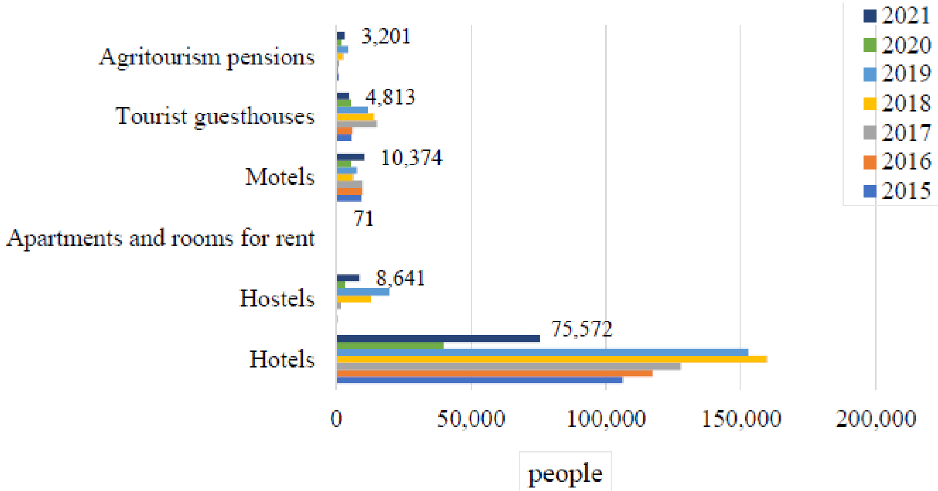
Figure 4. The existing tourist accommodation capacity in Ilfov county, by types of tourist reception structures, in the period 2015-2021*



** Data presented for 2021*
Source: own representation after INS, 2023

Regarding the number of tourists registered in Ilfov county in the period 2015-2021 (Figure 5), the statistical data showed that the number of arrivals in hotels and tourist guesthouses decreased, but increased in the other types of accommodation units. An explanation of the preferences for these types of cheaper accommodation is the fact that workers from Bucharest are also accommodated in Ilfov county, due to the lower prices.

Figure 5. Tourist arrivals in Ilfov county, by types of tourist reception structures, in the period 2015-2021*

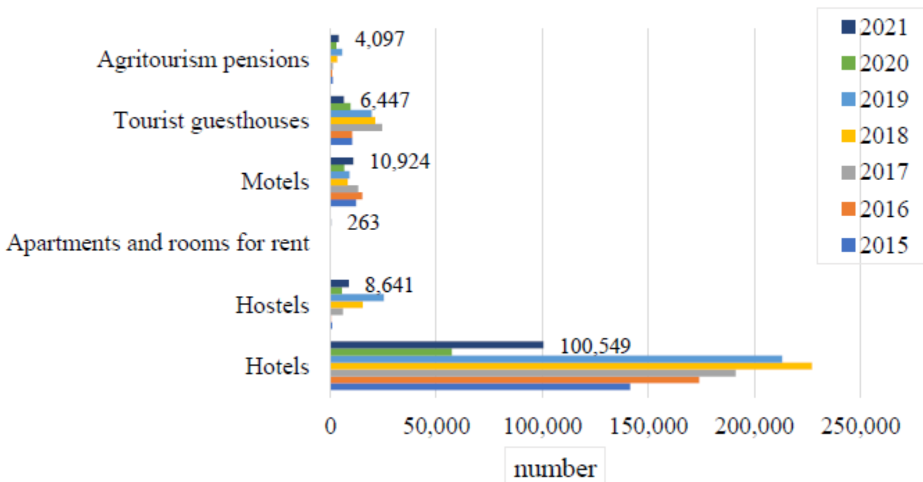


** Data presented for 2021*

Source: own representation after INS, 2023

In direct relation to tourist arrivals, the overnight stays recorded in the statistical data indicated decreases for hotels, tourist guesthouses and, in addition, for motels (Figure 6).

Figure 6. Overnight stays in tourist reception structures in Ilfov county, by type of tourist reception structures, in the period 2015-2021*



** Data presented for 2021*

Source: own representation after INS, 2023

Located near Bucharest, 20 km, in the northwest, the city of Buftea is considered a satellite city of the capital (Imopedia.ro, 2023). Apart from the Știrbey Palace complex, there are also nine other objects listed on the list of historical monuments in Ilfov County: seven archaeological sites, the "Sfinții Împarați" church from Buciumeni (dated 1787) and the Memorial Cross for the victims of the First World War (dated 1928) (Primăria orașului Buftea, 2016).

Table 1. *Statistical indicators for tourism valid for the Buftea city area*

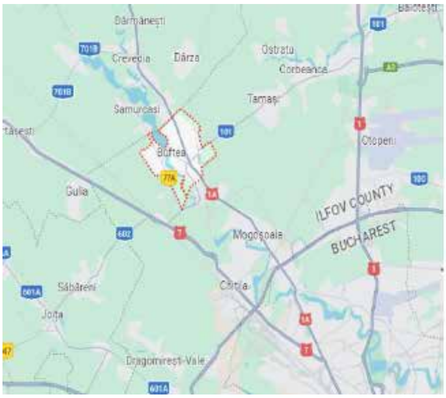
<table>
<tr><th colspan="2">Specification</th><th>UM</th><th>2015</th><th>2016</th><th>2017</th><th>2018</th><th>2019</th><th>2020</th><th>2021</th><th>2021/ 2015 %</th></tr>
<tr><td>"Tourist reception structures with tourist accommodation functions"</td><td>Tourist guesthouses</td><td>number</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td><td>100</td></tr>
<tr><td colspan="2">"The existing tourist accommodation capacity, by types of tourist reception structures"</td><td>places</td><td>24</td><td>20</td><td>20</td><td>20</td><td>20</td><td>22</td><td>17</td><td>70.83</td></tr>
<tr><td rowspan="2">"Arrivals of tourists in tourist reception structures, by types of structures"</td><td>Apartments and rooms for rent</td><td>people</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>43</td><td>-</td></tr>
<tr><td>Tourist guesthouses</td><td>people</td><td>510</td><td>714</td><td>738</td><td>1,092</td><td>1,069</td><td>537</td><td>529</td><td>103.73</td></tr>
<tr><td rowspan="2">"Overnight stays in tourist reception structures, by types of structures"</td><td>Apartments and rooms for rent</td><td>number</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>171</td><td>-</td></tr>
<tr><td>Tourist guesthouses</td><td>number</td><td>1,919</td><td>2,027</td><td>1,666</td><td>2,001</td><td>1,861</td><td>1,378</td><td>931</td><td>48.51</td></tr>
</table>

Source: INS, 2023

The official data, taken from the national statistics website (INS, 2023), and presented in Table 1, indicate that in Buftea the number of tourist guesthouses remained constant in the period 2015-2021, but the accommodation capacity decreased by almost 30 %. And the number of people staying in Buftea increased by 3.73%, while overnight stays decreased by 51.49%. Although on the INS website “apartments and rooms for rent” are not registered under “reception structures”, there are 43 arrivals in 2021 and a number of 171 overnight stays for this category.

We must mention that in the vicinity of the city of Buftea there are accommodation structures of the type “apartments and rooms for rent” and “Tourist guesthouses”, which are registered on specialized websites, in the communes of Mogoșoaia, Corbeanca and in the city of Otopeni – Ilfov county, as well as in Crevedia commune, Dâmbovița County (Figure 7).

Figure 7. The city of Buftea and its surroundings



Source: Google Maps, 2023

Figure 8. Accommodation structures in the Buftea city area

Source: Booking.com, 2023

From Figure 8 we notice that in the Buftea area there are fewer accommodation structures than in the Otopeni area, despite the fact that Buftea has more picturesque tourist resources. On the other hand, Otopeni is in the vicinity of Henri Coandă International Airport and is crossed by Romania’s main road, DN 1. So, the area of Buftea could be used as an alternative to the traffic-congested area of Otopeni, where tourists could find the peace, they need after long and tiring journeys.

Tourism relies heavily on the natural environment. The attractiveness of a region depends largely on climate and the type and integrity of ecosystems (Chereji et al., 2022). In the Buftea area, these conditions are met, therefore the tourism sector can develop more in the future.

In the context of the decline in the proportion of agriculture in the economy, (Mărcuță et al., 2023), rural tourism may improve the financial and economic conditions of rural residents, increase employment level, improve the quality of labor and the living conditions for the population in the rural area (Shakhramanian and Ivolga, 2023, Gajić and Cvijanović, 2023). Therefore, rural tourism will represent a development opportunity for the rural area related to the city of Buftea.

Capitalizing on non-reimbursable European funds in this sector will benefit both entrepreneurs and rural communities (Părnuș et al., 2023).

Some authors consider that joining some well-known tourist resources (for example: Mogosoaia Palace, Stirbei Palace - Buftea city) with others not yet exploited (the military fortifications in the north of the capital) can create an attractive "tourist pole" in the peri-urban area in the north of the capital: Mogosoaia - Buftea - Snagov (Tudorache et al., 2012).

Given the proximity to Bucharest, facilities could be developed in the Buftea area where young people can have fun in spaces such as adventure parks, paintball, they can take routes on foot or by bike to recognize the local flora and fauna, to experience the activities of the farm's vegetables and animal husbandry.

In order to make better use of agricultural land that is still being exploited, family vegetable farms (ecological) could offer housewives in Bucharest accommodation and at the same time the opportunity to harvest and prepare preserves and pickles for the winter right on the farm.

Conclusions

Ilfov County is known for the many natural and man-made tourist attractions, both of local and national interest, located on its territory,

In the area, picnic-type agreement trips or short-term trips for visits to monuments or monasteries are practiced in particular.

In the Buftea area, surrounded by lakes and forests, the development of tourism involving sports competitions (for example sport fishing) could represent a solution for the development of this rural area.

The utilization of existing historical ensembles in new modern tourism projects will attract both pupils, students and people passionate about history, as well as tourists interested in new concepts.

The development of new packages of services in tourism and related to tourism, taking into account the requests of the public, addressed both to the inhabitants of the capital and to those from the country or abroad, will attract tourists of all ages and categories to the area, which will contribute to increasing the level of living in the countryside.

Acknowledgements

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BIBLIOMETRIC ANALYSIS – QUALITY OF LIFE IN RURAL AREA

Daniela Nicoleta Voicila[1], *Diana Maria Ilie*[2]

Abstract

The study of quality of life focuses on elucidating and investigating various aspects of population existence, individuals' satisfaction with their living standards, evaluating different facets of quality of life, and policy initiatives aimed at improving these aspects. The primary objective of this research is to examine the existing body of literature on the quality of life in rural areas at both the European and global scales. This study utilizes a bibliometric analysis of research papers listed in the Web of Science database, focusing on the aforementioned subject.Partea superioară a formularului. In conducting the analysis, the VOSviewer software was employed, facilitating the generation of a descriptive segment of the data. This segment offers an overview of the research theme by visually representing the connections established within the literature. The conclusion of this study indicates that this theme has been thoroughly addressed in various fields in recent years.

Key words: *quality of life, rural area, bibliometric analysis.*

Introduction

The concept of quality of life is widely acknowledged as one of the most complex and challenging to define in post-modern society (Mărginean and Bălașa, 2005). It carries diverse implications that vary depending on the societal context in which the study is conducted. These implications encompass elements such as well-being and access to improved environments and facilities. The evaluation of quality of life is known to differ across countries (Bukenya et al., 2003).

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Globally, numerous researchers have demonstrated a keen interest in defining and exploring data related to quality of life, examining how it manifests in various aspects of existence. (Precupeţu, 2019).

The variety among European countries regarding levels of development and perceived living standards has led to comparative studies of quality of life between urban and rural environments (Shucksmith et al., 2009).

The notion of quality of life surfaced in the late 1960s, characterized as an expanded form of the well-being concept. It includes both tangible and intangible elements, incorporating both objective and subjective data. (Argyle, 1996).

Within the context of rural life, well-being is defined by considering crucial elements such as economic indicators, housing characteristics, social factors, and the surrounding environment. (Brereton et al., 2011).

It's important to differentiate between quality of life and the standard of living, as the latter primarily centers around financial aspects. Quality of life encompasses a broader array of factors that contribute to overall well-being beyond economic considerations (Dolan et al., 2008). Quality of life encompasses a broad spectrum of factors that mold the values individuals prioritize in their lives, surpassing purely material considerations. Acknowledged as a multidimensional concept, a comprehensive set of indicators has been devised and categorized into 8+1 dimensions, creating the foundation for the „quality of life" framework (Eurostat, 2015).

A direct link exists between the environment and the quality of life. (Streimikiene, 2014). Human well-being relies significantly on the quality of the environment, as the physical condition of the surroundings plays a crucial role in determining overall quality of life. (Holman and Coan, 2008).

The concept of quality of life is evaluative in nature and can be explored through two types of methods: sociological methods (such as questionnaires, interviews, focus groups, tests, and scales, which focus on the subjective aspect of quality of life) and statistical methods (such as sample-based selective statistical surveys), which focus on the objective aspect of it (Mărginean I., Precupeţiu, I., 2001).

After conducting an examination of the Quality of Life Index, Bălăşescu Marius and Dovleac Lavinia (2016) reached the conclusion that the quality of life in rural areas of Romania exhibits a comparatively low score in comparison to other European countries. The less-than-optimal advancement of the quality of life index in Romania's rural areas is ascribed to the insufficient implementation of key pillars, such as innovation, education, fund management, and inadequate infrastructure, despite the country's wealth in natural resources within the agricultural sector.

In their work titled „Quality of life in rural areas of Croatia: To stay or to leave?" (2010), Ivo Grgic et al. The research study on the quality of life and migration intentions in rural Croatia aimed to investigate the satisfaction levels of the rural population with their living conditions in local communities. The primary objective was to identify the key factors influencing individuals' decisions to either remain in the rural environment or migrate elsewhere.

The study's findings revealed that the primary challenges in the rural environment are predominantly economic in nature. These challenges include a dearth of employment opportunities, inappropriate professional choices, and lower incomes when compared to urban areas. 20% of respondents were dissatisfied with the living conditions in the rural environment, with the intention to migrate to urban areas, which can have negative consequences.

Through his work, Bernard Josef (2018) contributed to the study of the comparison of quality of life between rural and urban environments by examining territorial variations in this quality, using indices of poverty, satisfaction, and deprivation of opportunities. The study presented three elements: investigating the differences between rural and urban environments along with the variability within the rural environment; secondly, two separate spatial patterns indicative of diverse forms of territorial disadvantage in rural regions; and as a third aspect, investigating the comprehensive influence of the living environment.

In accordance with empirical findings derived from survey data, there was an increase in deprivation of opportunities in rural areas, without a decrease in community satisfaction.

Berbecar and co-authors (2020) contend that various elements contribute to the diminished quality of life in post-communist nations, including Romania. Their study evaluates the impact of social and economic factors, notably access to medical services, on the quality of life. The research methodology employed by the authors involves the use of a questionnaire. By analyzing the main components, four factors were identified for calculating a Quality of

Life Index: sewage system, living area per inhabitant, housing accessibility, and fuel use for cooking. The calculated Quality of Life Index was in line with results found in other research papers that evaluated the socio-economic status of certain areas, being considered a tool in assessing the level of living conditions and setting priorities for interventions.

The proposed research theme, namely the evaluation of quality of life, has been discussed at the global, European, and national levels. In this context, Țoc Sebastian (2021) conducted a study in which he analyzed and synthesized information from various research papers published in the journal „Quality of Life". These studies used indicators such as quality of life, well-being, prosperity, happiness, poverty, and standard of living, along with other relevant dimensions/indicators for the subject. Thus, Romania is ranked among countries characterized by social inequalities and high rates of poverty, with low satisfaction regarding most aspects of life.

Materials and methodology

In order to conduct the present study, data related to quality of life in rural areas were downloaded from the Web of Science platform. Expressions and keywords associated with the subject, such as „quality of life", „health services", and „elderly", were identified in various sections including: title, abstract, author keywords, and Plus keywords. The selected timeframe was 2010-2023 (August), leading to a total of 823 papers that satisfied the selection criteria.

A crucial step in bibliometrics is creating a data map. This map provides an overview of the situation and development stage of the field. There are various software tools available for bibliometric analysis. For this study, VOSviewer, a program developed by Eck and Waltman specializing in co-occurrence and co-citation analysis, was used.

This study showcases yearly patterns, prominent journals, the distribution of keywords, highly cited articles, collaborations among authors, and the journals and authors exerting the greatest influence. Bibliometrics refers to the examination of published data, such as, journal articles, datasets, books and blogs, along with associated information, using statistical methods to illustrate or highlight interconnections between published works.

Specialists utilize a variety of bibliometric techniques, typically classified into two categories: evaluative and relational. Evaluative bibliometrics investigate the attributes of published information.

Relational bibliometrics provides a global perspective on the interactions between various entities involved. The underlying principle of relational bibliometrics is that within the gathered data encompassing diverse entities (such as authors, articles, journals),non-obvious connections can be identified, facilitating an understanding of the overall entity network at a global level. By graphically representing these entities based on these relationships, their hidden structures can be examined (Ninkov Anton, 2022).

Researchers engage in relational bibliometrics by examining the shared occurrences of metadata among entities. The higher the degree of shared metadata among these entities, the more probable their similarity in some aspect. If a set of articles or authors references the same publication or set of publications, it suggests a certain connection between them. between them (Van Eck et al., 2010).Top of Form

Results and discussions

After analyzing the dataset generated following the application of selection criteria from Web of Science, it was observed that when considering document types, the most common type is the article, with a total of 666 records, representing 80.92% of the total publications. In second place are Proceedings Papers, with 77 records, accounting for 9.36% of the total. Additionally, other types of documents are also present, including reviews (47 records), book chapters (19 records), early access (6 records), and editorial materials (2 records). Table 1 provides an overview of the quantity of records and proportions for various document types..

Table 1. Number of document records by their type

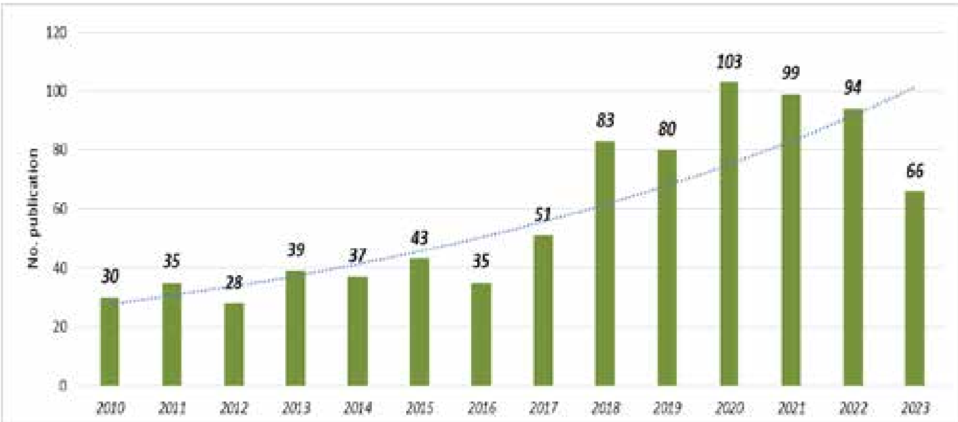
Type of documents	Record	% from total
Article	666	80.92%
Article; Book Chapter	19	2.31%
Article; Data Paper	1	0.12%
Article; Early Access	6	0.73%
Article; Proceedings Paper	3	0.36%

Type of documents	Record	% from total
Editorial Material	2	0.24%
Proceedings Paper	77	9.36%
Review	47	5.71%
Review; Early Access	2	0.24%
Total	823	

Source: Data processed from Web of Science

Figure 1 illustrates the yearly progression of publications pertaining to the examined theme, specifically the quality of life, spanning from 2010 to 2023. In the period from 2010 to 2017, the annual number of publications was below 50, but a significant increase became evident starting from 2018. This growth coincided with an increased interest and concern regarding the mentioned subject, especially in the context of emphasizing the population's way of life. After 2018, research in this area experienced a substantial expansion, resulting in a substantial rise in the publication count, reaching a peak of 103 in the year 2020.

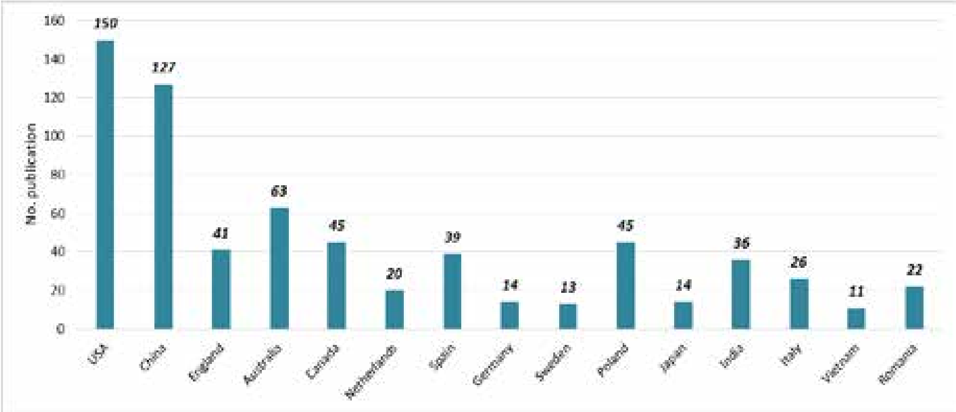
Figure 1. The annual evolution of publications



Source: Data processed from Web of Science

Examining the perspective of specific publications for each country, it can be noted that in the analyzed time frame, 2010-2023 (August), the USA recorded the the highest count of publications, totaling 150, followed by China with 127 and Australia with 63 publications. The European countries that generated the most publications are Poland with 45 publications, Spain with 39, and Romania with 22 publications.

Figure 2. Number of Publications by Country



Source: Data processed from Web of Science

Examining the distribution of works based on the journals they were published in, it is observed that the 832 publications were disseminated across 396 specialized journals. Over half of these journals contain only one published work, accounting for over 76.20% of the total number of journals. It was noted that approximately 23.80% of the total scientific works (198 papers) were published in the top 10 journals. The journal with the highest number of publications is „International Journal of Environmental Research and Public Health," with a total of 49 papers, followed by „BMC Public Health" with 23 papers. Table 2 represents the top 10 journals that recorded more than 9 published works.

Table 2. Top Publications Journals

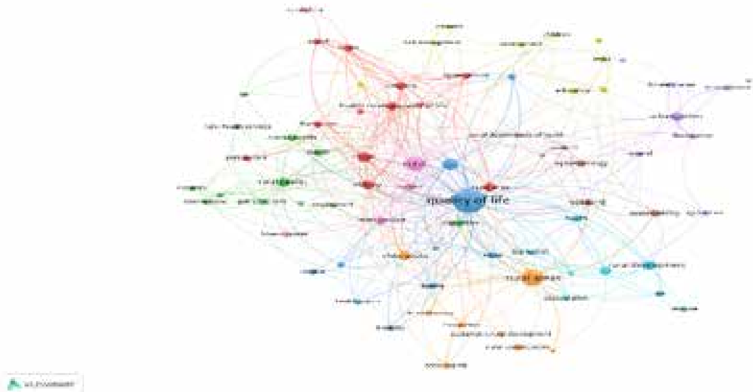
No. ctr.	Journals	No. Publications
1	International Jurnal Of Environmental Research And Public Health	49
2	Bmc Public Health	23
3	Plos One	23
4	Health And Quality Of Life Outcomes	21
5	Sustanability	21
6	Rural And Remote Health	17
7	Quality Of Life Research	13
8	Annals Of Agricultural And Enviromental Medicine	11
9	Scientific Papers Series Management Economic Enginerring In Agriculture And Rural Development	11
10	Journal Of Rural Studies	9

Source: Web of Science database

Subsequently, we delved into the content of the works by examining the distribution of keywords. This procedure included the identification of the leading 10 keywords on the co-occurrence network map, employing the VosViewer software. On this visualization map, we represented both the density of keywords and their associated chronology.

After analyzing the 823 publications related to the studied subject, we identified a total of 2525 keywords. Among these, 79 keywords appeared at least 5 times. The size of the nodes and words in Figure 4 represents the importance of the nodes. The significance of a node or word is directly proportional to its size—the larger, the more important. The distance between two nodes indicates the strength of their relationship, with a shorter distance signifying a stronger connection. Nodes sharing the same color are part of the same cluster.

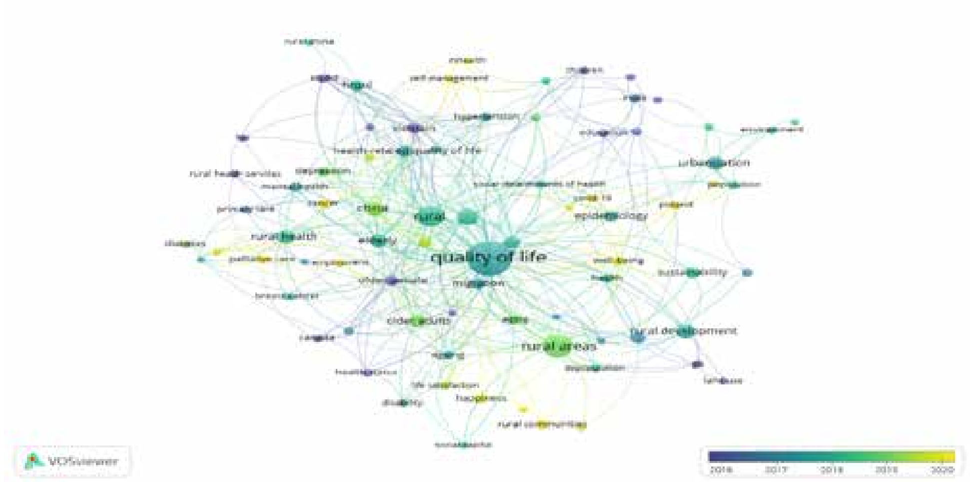
Figure 3. Relationship between Keywords (Co-occurrence)Partea superioară a formularului



Source: Data processed using VosViewer software

Figure 3 illustrates the keywords associated with „quality of life" that were used in research over different periods of time. In the period 2013-2017, researchers were primarily focused on terms such as „rural health", „services", „older-people", „education", and „health status". By the year 2020, the research focus shifted towards „well being", „covid-19", „rural communities", „happiness", and „self management".

Figure 4. Connection between keywords (co-occurrence)



Source: Data processed using VosViewer software

Using VOSviewer, the keywords from the publications were grouped into 13 clusters. The keyword „quality of life" has the highest frequency (118). Other high-frequency keywords include „rural areas" (54) and „rural population" (28).

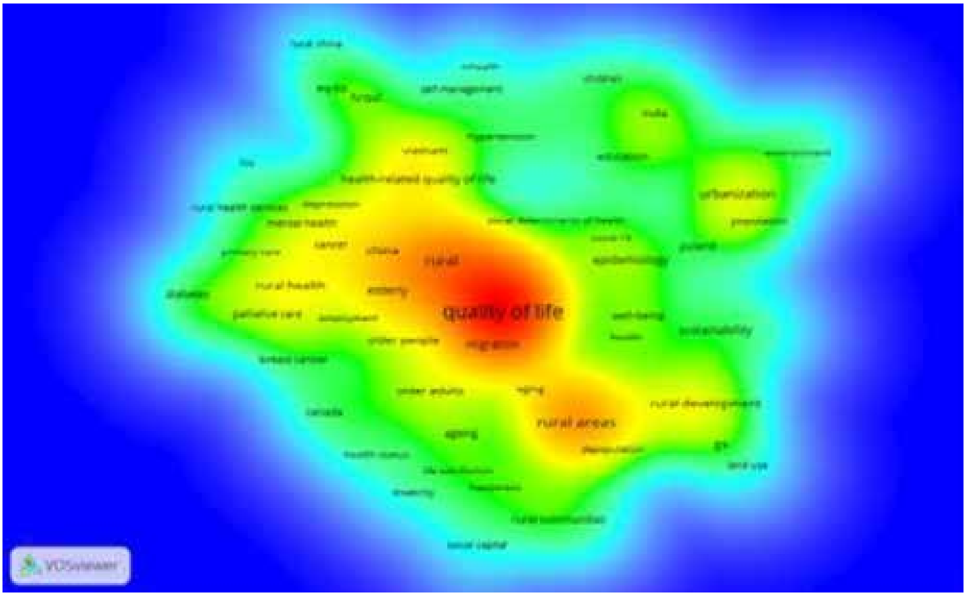
Table 3. Top 10 Keywords Related to Publications

Classification	Keywords	Frequency	Total Links
1	Quality of life	118	154
2	Rural	43	67
3	Rural areas	54	53
4	Rural population	28	37
5	Elderly	19	34
6	Health related quality life	15	27
7	Urban	12	27
8	Older adults	16	26
9	Older people	12	23
10	Well being	9	21

Source: Web of Science database

The strength of the link between two nodes refers to how often they appear together. The node „Quality of life" has strong links with keywords such as „rural areas", „rural population", „health", and „elderly".

Figure 5. Representation of Keyword Density on the Map

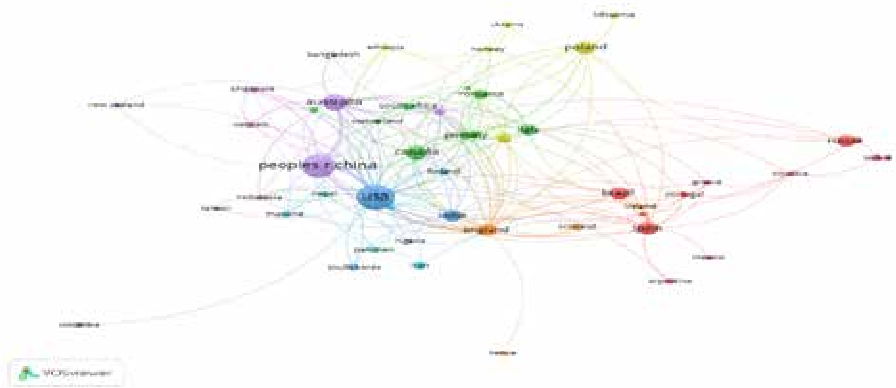


Source: Data processed using VosViewer software.

Through VOSviewer, a density visualization was generated (Figure 5). The representation of keyword density assigns colors to each node based on the density of keywords in that node. The color of a node is determined by the quantity of articles in its vicinity, and keywords in the red zone are encountered more frequently, while those in the green zone are encountered less frequently.In Figure 5, there is a concentration of research in the studied area. „Quality of life” and „rural areas” represent the core keywords in this study.

By examining the co-author frequency based on country, one can observe the degree of interconnection between countries and identify those more actively engaged in researching this subject. Figure 6 showcases a range of colors on the map, depicting the diverse research directions. Larger nodes signify that these countries exhibit significant interest in the addressed issue.The links between nodes represent collaboration between institutions. The distance between nodes and the thickness of the links reflect the level of collaboration between countries.

Figure 6. Connection between Co-Authoring Countries



Source: Data processed using VosViewer software

We can see that the red nodes, especially those in Europe, indicate numerous studies in this area, with close collaboration among contributors. Additionally, the nodes indicated by blue and purple, indicate numerous studies conducted in collaboration with the USA and China (Figure 6).

Conclusions

The undertaken study involves a bibliometric analysis of publications concerning the quality of life in rural areas spanning from 2010 to 2023.Several significant conclusions regarding these publications have been reached. The number of studies conducted has shown a steady increase in the analyzed period, with a noticeable spike after 2020, reaching a peak of 103 published works.

Globally, countries such as the USA, China, as well as European countries, intensely discuss the topic of quality of life in rural areas, as it is a wide-ranging subject studied in detail.

Specialized journals in which these works are published stand out, such as the „International Journal Of Environmental Research And Public Health," ranking first with a total of 49 articles, and „BMC Public Health" with 23 articles.

Analyzing the keywords used in scientific studies, it is noted that terms like „Quality of life", „rural areas", „rural population", „health", and „elderly" represent central aspects with significant connections to various factors that can influence their development, such as „life satisfaction", „social capital", „well-being", etc.

The concept of quality of life encompasses various aspects, influenced by the society and the area in which the research takes place, including aspects related to well-being, access to a better environment, and facilities. The diversity of countries in terms of development level and perceptions of living standards has led to studies on the quality of life in both urban and rural areas. Rural areas are identified as environments requiring financial investments to improve the quality of life index.

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FINANCING THE DEVELOPMENT OF RURAL TOURISM IN SERBIA FROM THE IPARD II PROGRAM

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Abstract

The financing of the development of rural tourism in Serbia is realized with the support of the IPARD II program from 2020. For the purpose of implementing Measure 7 of the IPARD II program, two calls were published, through which investments that contribute to the development of rural tourism are supported, as an activity that most effectively encourages the diversification of rural economies. The aim of the paper is to present the contribution of Measure 7 of the IPARD II program to the development of rural tourism in Serbia. The paper uses the method of analysis, synthesis, historical, desk research, as well as the descriptive method. The authors conclude that in order to make a more significant contribution of the EU pre-accession fund to the development of rural tourism in Serbia, greater available financial resources are needed, as well as better education of the inhabitants of rural areas for writing projects.

Key words: *rural tourism, financing, development, Measure 7 of the IPARD II program, Serbia.*

Introduction

Rural tourism includes all tourist activities that can be realized in rural areas (Radović, 2015). The development of tourism has enabled better living conditions for the villagers (Ciani, 2003). Rural tourism is the activity that most effectively encourages the diversification of rural economies, their economic development, and thus the reduction of regional differences in economic development.

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There are good conditions for the development of rural tourism in Serbia, but it is not sufficiently developed. The causes of this situation are the lack of a growth plan and adequate sources of financing (Radović & Vasiljević, 2016). Financial resources represent a development limitation viewed from the aspect of insufficiency - in quantitative terms, but also due to the lack of sources of financing that would be cheap, available in the long term and aligned with the seasonal character of agricultural production.

Sources of financing

The development of rural tourism in Serbia in the past period has been financed with the support of the state, from loans from commercial banks, as well as from foreign donations and the IPA program of cross-border cooperation. In the previous period, foreign financial resources significantly contributed to the initiation of tourism activities in the villages. The result of these investments is not only of a monetary nature, but also in providing significant guidelines for the realization of this activity (Radović & Pejanović, 2015).

Financing of a greater representation of tourist activities in villages is also realized in Serbia from the IPARD II program. This program was officially approved by the European Commission on January 20, 2015, and its implementation began at the end of 2017. This financial instrument provides 175 million euros for the program period 2014-2020.

Within the framework of the IPARD II program there is a set of measures through which financial support is provided to the development of agriculture and rural development in Serbia. Measure 7 refers to financing the development of rural tourism. Specifically, this financial support is aimed at investments in the diversification of agricultural holdings, the development of non-agricultural activities and the creation of new jobs. All of the above enables the growth of agricultural farms' income, as well as local economic development (http://www.minpolj.gov.rs/ipard-program-2014-2023/#).

Methodology and data sources

The aim of the paper is to present the contribution of Measure 7 of the IPARD II program to the development of rural tourism in the Republic of Serbia. The paper uses the method of analysis, synthesis, historical, desk research and the descriptive method. Data sources are scientific and professional domestic and foreign papers on the subject, as well as data available on the website of the Ministry of Agriculture, Forestry and Water Management – Administration for Agrarian Payments.

Research results

The right to IPARD incentives, as part of the implementation of Measure 7, can be achieved by registered agricultural holdings that are in active status. Entrepreneurs and companies classified as micro or small legal entities in accordance with the Accounting Act are also entitled to these incentives. Through Measure 7, potential users can obtain a refund of up to 65% of the value of realized eligible investment costs.

Investments can be directed to accommodation facilities, tourist facilities, landscaping, construction of areas for tasting food and drinks, as well as make of websites for tourist households. Users can exercise their right to incentives in the amount of at least 20,000 € and a maximum of 300,000 € per request, regardless of the total value of the investment. The user can achieve the total amount of IPARD incentives, through Measure 7, in the value of up to 400,000 €, through a maximum of three projects, during the period of implementation of the IPARD program. By changing the normative framework in 2022, it was made possible for applicants to exercise their right to an advance payment. The advance payment is up to 50% of the approved amount of the IPARD incentive determined by the decision on approving the project, i.e. by the decision on amending the approved project, if the applicants meet the necessary conditions defined by the Rulebook (Rulebooks 2020, 2021, 2022, 2023).

Since the beginning of the implementation of the IPARD II program until now, two calls have been published as part of the implementation of Measure 7. The first call was published on June 8 and was open until October 30, 2020. The total allocated funds under this call were 20,001,446 €, of which the contribution of the European Union was 15,001,085.4 €. The applicant's greatest interest was in investments in "establishment of tourist households and recreational zones". In the structure of applicants, the majority were natural persons - individual agricultural farms, and the majority of submitted applications were from Zlatibor District. The average amount of the investment per submitted request for Measure 7 in the First Call was 226,998 € (Annual Report for 2020).

Table 1. Implementation of Measure 7 of the IPARD II program as of August 31, 2023.

	First call	Second call	Total
Budget - EU contribution 2014-2020.	15,000,000 €	11,251,837 €	26,200,000 €
Total number of submitted projects	311	294	605
Number of rejected projects	95	23	118
Number of withdrawn projects	31	12	43
Number of contracted projects	110	71	181
Number of discontinued projects	2	0	2
Number of contracted projects - number of canceled projects	108	71	179
Realized budget contribution to the EU 2014-2020.	12,437,219 €	10,019,993 €	22,457,212 €
Realization of the available budget	82,91%	89,05%	85,71%

Source: *http://www.minpolj.gov.rs/ipard-program-2014-2023/#.*

The second call for applications under Measure 7 was published on September 23, and closed on December 17, 2021. According to this call, a total of 15,002,450 € was allocated, of which the contribution of the European Union amounted to 11,251,837 €. In the structure of the applicant, and in this invitation, there were mostly individual agricultural farms. Most of the submitted requests were from Šumadija and Western Serbia. The average amount of the investment per submitted request for Measure 7 in the Second Call was 202,906 € (Annual Report for 2021). In terms of the structure of the submitted requests, the dominant interest according to the Second Call was for “establishment of tourist households and recreational zones”, and then for investments in the tourist facilities (Annual Report for 2022).

Based on the processed submitted requests of potential users, as of August 31, 2023, a total of 179 projects were contracted for Measure 7. The number of contracted projects according to the First Call is 108, and 71 according to the Second Call. On both public calls, 605 requests were submitted, but all requests were not in accordance with the defined standards, that is, they could not meet the necessary criteria.

Regarding the utilization of the available budget for Measure 7 of the IPARD II program, it can be stated that it is very high. Utilization of available funds according to the First Call was 83%, according to the Second Call 89%, and when viewed in total, the utilization is 86%. So far, there have been no disbursements of approved funds on the basis of contracted projects.

Conclusion

The interest of rural residents in Serbia in using available financial resources within Measure 7 of the IPARD II program was very high. The utilization of available funds from the EU budget for Measure 7 is almost 90%. For a more significant contribution of this measure to the development of rural tourism in Serbia in the future, a larger amount of the available EU budget is needed, as well as a better preparation of potential users for applying to public calls.

The introduction of an advance payment of up to 50% of the approved amount of IPARD incentives, based on the change in the normative framework in 2022, had a favorable effect on the greater utilization of funds both in Measure 7 and in the remaining three available measures of the IPARD II Program.

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GLOBAL TRENDS AND OUTLOOKS IN AGRICULTURAL DEVELOPMENT AND FOOD SECURITY

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Abstract

The development of agricultural sector and therefore food security in the world, today take place under very changed and quite difficult circumstances. Accordingly, the subject of research in this paper are contemporary global trends in the development of agriculture and expectations in this sector. Thereby, the impact of global environment on food security in the world is also researched, along with assessments of future trends and perspectives in this field. The aim of the research is to indicate the state and the most important tendencies in development of agriculture and food security in the modern global society. The selected issues are researched by using the methods of analysis, synthesis, description and comparison, primarily on the basis of FAO and OECD data. The results of the research show that global factors today greatly influence the development of agriculture and food security around the world, while also determine outlooks in these fields.

Key words: *agriculture, food, world market, contemporary global challenges, sustainable development.*

Introduction

Contemporary global factors that affect the development of agricultural sector and food security are very numerous, diversified, complex, multidimensional and have a multiplicative effect on the entire world economy and society. Accordingly, it is very difficult to predict precisely what we can expect in the coming period at the global level, but it is certainly possible to determine the

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general directions and trends in terms of food security and agricultural development, so bearing that in mind, react proactively at every relevant level, from global to national and local.

The subject of research in this paper are contemporary global trends and expectations in the development of agricultural sector, as well as the impact of contemporary global challenges on food security in the world, along with assessments of future trends and perspectives in these fields.

The aim of the research is to indicate the state and the most important tendencies in the development of agriculture and food security in modern society, from a global perspective.

The research is based on the following hypothesis: If global factors today greatly affect the development of agriculture and food security around the world, then they will certainly determine the future directions of development in these fields. Hence, it is important to consider the current state of agriculture and food supply in the world, and accordingly determine what we can expect in the coming years and decades, when it comes to the development of agricultural sector, as well as the safety, security and sustainability of the food supply.

Regarding the materials and methods used in this paper, it is important to point out that the research relies heavily on the official available statistical data of the FAO and the OECD, while the results of previous research in this field also contribute to the clarification of the identified issues in the paper. The use of methods of analysis, synthesis, induction, deduction, comparison and description contributes to the analysis in a qualitative sense, along with the already mentioned quantitative indicators that are presented in the paper.

Literature review

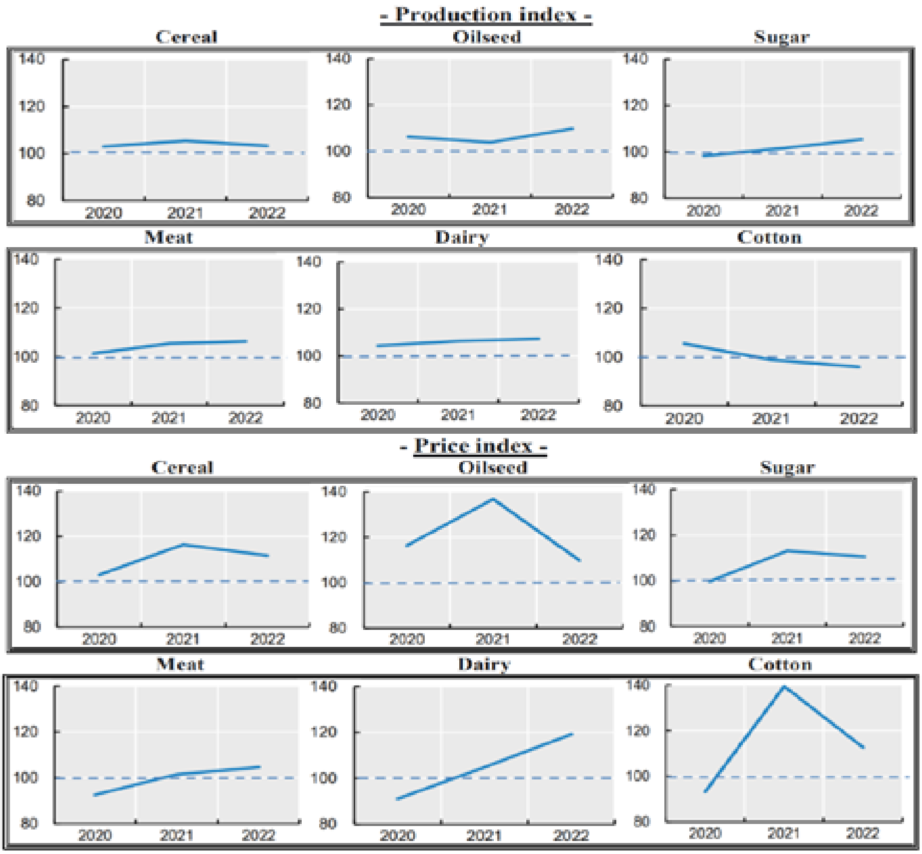
Agricultural development and food security can be seen as two separate questions, but it is very useful to consider them integrally, which many authors do, given that the basic function, among the other functions of agriculture, is exactly food production. Many authors research these issues in detail and from different aspects, so it additionally confirms their relevance, both in earlier decades and today. Thus, it could be said that they will be also important in the future, because they are actually about existential issues for people, that is, about opportunities for improving food production and food security, quantitatively, qualitatively, in continuity and globally sustainable. Accordingly, Vos & Bellù (2019) analyse global trends and challenges for agri-food sector in the 21st century. Braimoh (2013) emphasized in his research that global agriculture needs both science and politics. Agrarian policy is still one of the most important factors in the development of agriculture (Veselinović et al., 2022), so the theory and development strategies of many countries pay attention to this issue, as well as at the global level. In a joint study, the Organization for Economic Co-operation and Development (OECD) and the Food and Agriculture Organization of the UN (FAO), indicate the expectations of agricultural development for the period 2023-2032. In doing so, these organizations link issues of agri-food commodities, policies and expertise in this field with a special focus on agri-food market trends and a regional approach. The aim is to assess the perspectives of national, regional and global markets for agricultural products (OECD & FAO, 2023).

Regarding the security of food supply, it is important to point out that, during its development, the concept of food security has changed, expanded and adapted to new circumstances, so that today it refers to: a) food availability - based on domestic production, stocks, imports or food aid; b) food access - physical, economic and social access to food; c) food quality/utilization - healthy and nutritionally balanced, that is, safety food, in accordance with the law and standards, which provides energy and nutrients, meets the nutritional needs and preferences of people for certain foods necessary for an active and healthy life; d) long-term stability of the mentioned elements, that is, continuous/sustainable security of adequate food supply. Food (in)security is explained by various indicators, such as: FAO Indicator of Undernourishment; Global Hunger Index - GHI; Global Food Security Index - GFSI; Hunger and Nutrition Commitment Index - HANCI; Poverty & Hunger Index – PHI; etc. (Božić & Papić, 2019; FAO, 1996). Manikas et al. (2023) systematize the abundant literature on indicators for determining food security. The subject of research by FAO et al. (2023) is food security and safety in the context of urbanization, the contemporary transformation of agri-food systems and the necessity of healthy nutrition for the rural and urban population. Arsić & Kovač (2022) point out, with very detailed explanations, that food security is an important factor of national security in contemporary conditions. These authors emphasize the connection between the nutrition policy and national security, in order to more expediently deal with modern global and other accompanying challenges.

Development of agriculture in contemporary conditions and expectations in the agri-food sector

According to OECD/FAO data (2023), the wheat production increased globally in the period 2020-2022, while the production of corn and some other grains did not meet demand.

Graph 1. Production index and price index of key agrarian commodities in the world, for which OECD/FAO data are available (average 2013-2022 = 100)

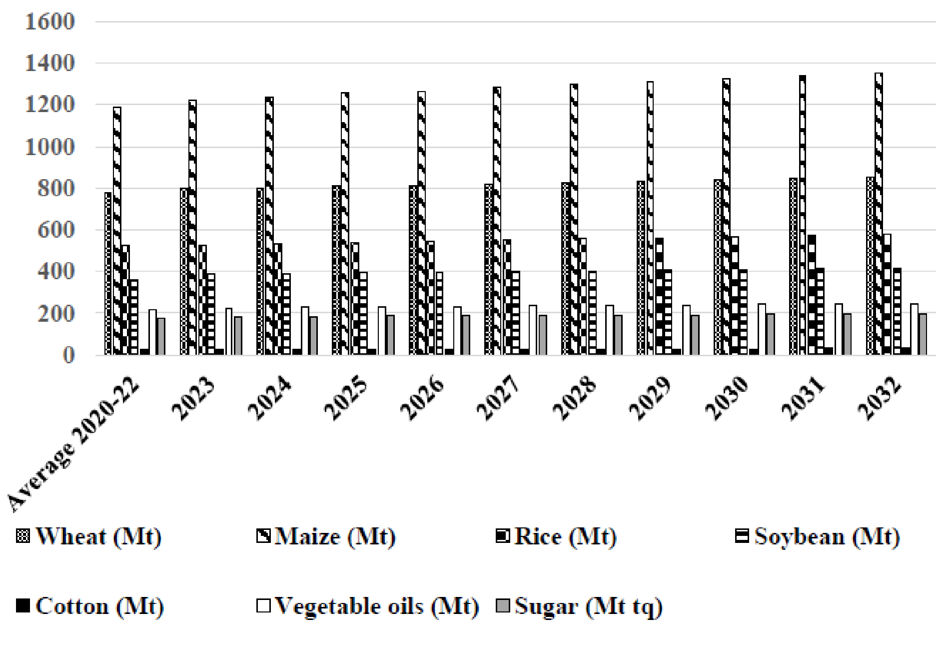


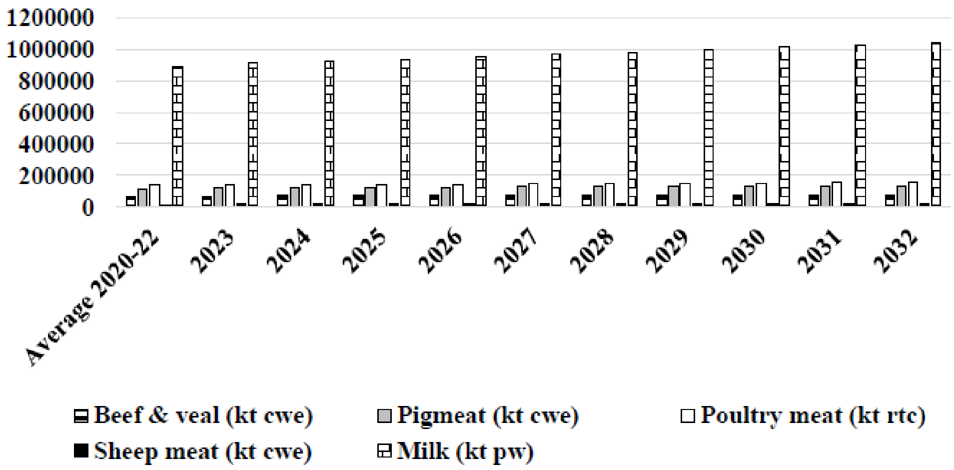
Source: *OECD/FAO, 2023*

In 2021/2022, the prices of wheat and many other grains were the highest recorded in the last 20 years, although they started to fall in mid-2022. Although the rice production was above average, the rice prices remained relatively high. The oilseed prices fell in 2022, but still remained above average levels, with the drop in prices mainly encouraged by the global recovery in production of soybeans, rapeseed, etc. The recovery of sugar production in certain countries, which are among the world's leading sugar producers, only partially offset the pressure on sugar prices in the world. The meat prices in the world were relatively high in 2022, except for sheep meat, where a slight decrease of prices was recorded. The various factors, such as animal diseases, rising input prices and extreme weather conditions, were obstacles to greater growth in meat production. Despite these challenges, some increase in meat production has been achieved, mainly due to increased production in Asia. The prices of milk and milk products have increased in the world, primarily due to the increase in the prices of inputs for this production. At the same time, the increase in milk production was slower in the year 2022, and the trade in dairy products decreased. The global consumption of cotton decreased in 2022, and as a result, cotton prices fell, while the production decreased slightly (Graph 1).

Graph 2 shows the projections of production for some of the most important agrarian commodities in the world (OECD/FAO, 2023).

Graph 2. Projections of world production for some of the most important agricultural commodities, until 2032

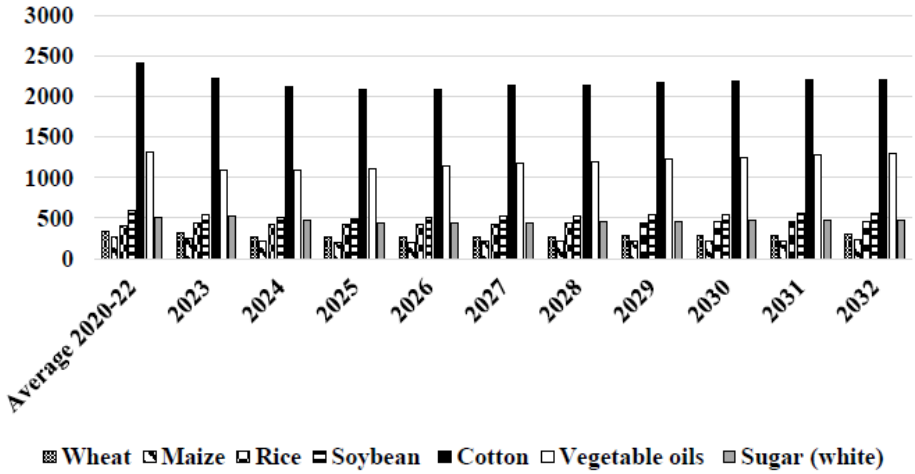




Source: *based on the data OECD/FAO, 2023*

Graph 3 presents the OECD/FAO (2023) projections regarding the prices of some of the most important agro-food products in the world until 2032, where it can be seen that relatively stable prices, as well as production, are predicted, without major changes. However, the COVID-19 pandemic and the armed conflicts in the world have shown us that turbulent and unpredictable changes are very possible, so projections should be taken with a certain reserve.

Graph 3. Price projections for some of the most important agro-food products in the world until 2032 (in USD/t)



Source: *based on the data OECD/FAO, 2023*

Indicators of food security in the world

Global Food Security Index - GFSI, created in 2012, measures food security in 113 countries, based on affordability (price), availability (quantity on the market), food quality and safety, as well as sustainability/resilience and adaptability. Table 1 shows the 2022 GFSI for the best 10 and the worst 10 ranked countries in the world. Serbia is not in this table, because it is ranked 61st of 113 countries (with the index of 61.4 of the maximum possible 100).

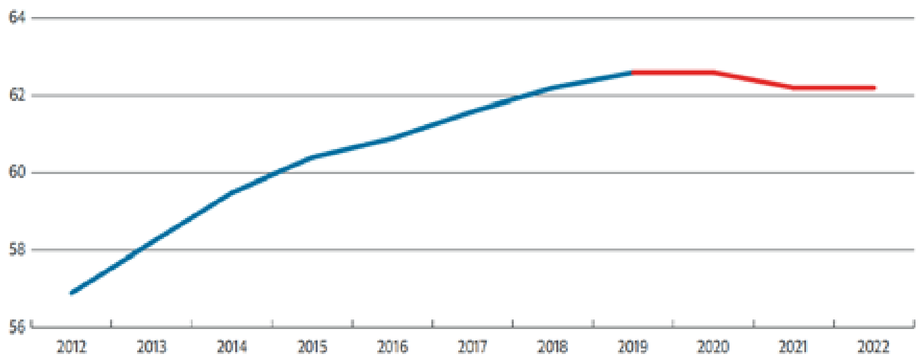
Table 1. GFSI 2022 - the best and the worst ranked countries

The best - top 10 ranked countries (1st-10th place)	GFSI 2022	The worst 10 ranked countries (113th-104th place)	GFSI 2022
1. Finland	83.7	113. Syria	36.3
2. Ireland	81.7	112. Haiti	38.5
3. Norway	80.5	111. Yemen	40.1
4. France	80.2	110. Sierra Leone	40.5
5. Netherlands	80.1	109. Madagascar	40.6
6. Japan	79.5	108. Burundi	40.6
7. Canada	79.1	107. Nigeria	42.0
8. Sweden	79.1	106. Venezuela	42.6
9. UK	78.8	105. Sudan	42.8
10. Portugal	78.7	104. Congo (DR)	43.0

Source: *Economist Impact, 2022*

After increasing in the period 2012-2018, food security has not improved since 2019, that is, since the period of the COVID-19 pandemic, the Ukrainian crisis, etc. (Graph 4).

Graph 4. Average GFSI in the world, in the period 2012-2022

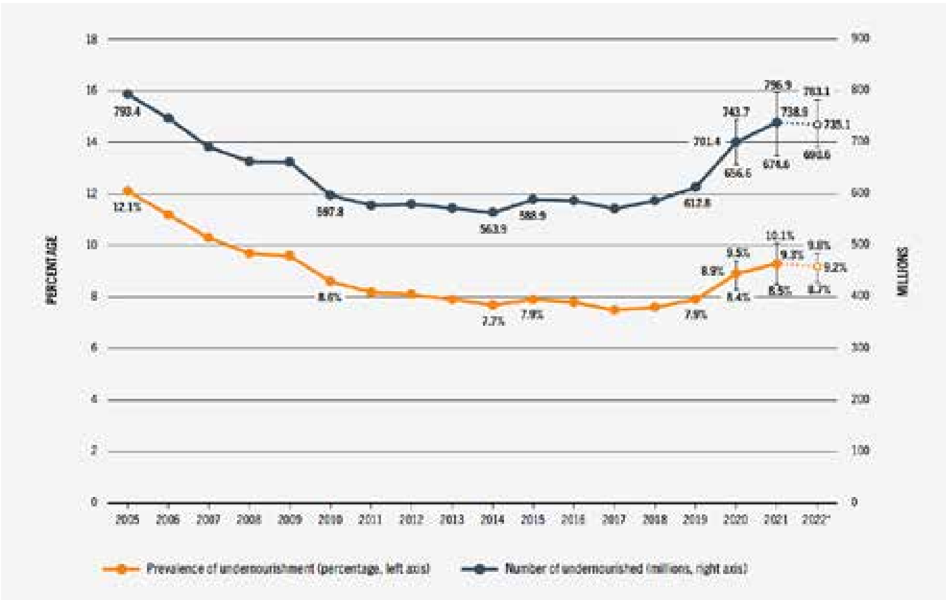


Source: *Economist Impact, 2022*

GFSI 2022, compared to the earlier period, indicates a very unfavourable situation regarding the global food system, which today is under enormous pressure from the various negative influences it is facing, especially the consequences of the COVID-19 pandemic, armed conflicts in the world, global climate changes, etc.

Globally, the prevalence of hunger, measured by the prevalence of undernourishment (an indicator under the Sustainable Development Goals - SDGs), remained almost unchanged in 2022 compared to 2021, but is still far above the level before the COVID-19 pandemic. Namely, it includes 9.2% of the world's population in 2022 compared to 7.9% in 2019. It is estimated that the number of hungry people in the world in 2022 was between 690.6 and 783.1 million people (Graph 5). Taking into account the projected mean value (about 735.10 million people in 2022), it means that in 2022 about 122 million more people faced the problem of hunger than before the pandemic in 2019, and according to some estimates that number is still rising. Such tendencies are also indicated by the 2023 Global Hunger Index-GHI (Von Grebmer et al., 2023).

Graph 5. Global hunger problem - share of undernourished people in the total world population (in %) and number of undernourished people (in millions), 2005-2022



Source: *FAO et al., 2023, based on FAO, 2023*

Conclusion

The state of agriculture and food security in the world indicate that global factors today greatly determine the development of agriculture and human nutrition. A number of negative factors have been observed, which considerably slow down the development in these fields. First of all, it refers to the consequences of the pandemic, worsening political and economic relations in the world, climate change, etc. The aforementioned global challenges are not too encouraging when it comes to expectations in agricultural development and food security in the world, although statistical predictions do not indicate huge problems. Therefore, it is necessary to monitor permanently relevant global trends, analyse them quantitatively and qualitatively, and react proactively in accordance with all assessments.

This research presents a picture of the current state of agriculture and food security in the world, created on the basis of available statistical data, with a deeper analysis, which took into account the effects of contemporary global challenges, pointing to some uncertainties. Research confirms that global factors today influence the development of agriculture and food security in the world, and will represent an important determinant in the future. Therefore, it is necessary to continue theoretical and empirical research in these fields.

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CHALLENGES OF GREEN TRANSITION IN RURAL AREAS

Marija Inđin[1]

Abstract

Investing in the development of rural areas is important for every country, in order to encourage balanced economic growth in all regions of the country. By investing in the development of rural areas, conditions are created for the return and revival of underdeveloped parts of the country and the prevention of population migration to larger cities, so that the local population could live decently from their work. We have witnessed that on a global level it is desirable, almost necessary, for new technologies to include the so-called green approach in solving technological processes. As a rule, such investments in the application of green technologies require larger or significantly larger investments, due to this fact investments in the revitalization of rural areas further complicate the significant activity of the state, because it is necessary to provide an additional increase in funds for the realization of such projects .

Key words : *green technology, rural area, employment, investments*

Introduction

Every country strives to have equal development in all regions. By investing in the development of rural areas, it is possible for the local population to remain in the place where they were born, to be able to invest in the further development of the rural area, thereby reducing rural-urban migrations, enabling the life of rural areas, and thus contributing to the prosperity of the entire region, and even the country as a whole.

By investing in green technologies, it is possible for people to find employment, to use unused natural potentials, but only where they exist, where they would not damage the wider picture and the importance of the natural and environmental environment.

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Methodology

Using the descriptive method, important conclusions were reached regarding the factors that influence the development of rural areas and the level of green investments. When writing the paper, the author used methods of studying literature, both domestic and foreign authors.

Attracting green investments

The development of rural areas is one of the goals that every country strives for, so that all parts of the country are equally developed. According to the data of the Republic Institute of Statistics, the largest part of the poor population of the Republic of Serbia lives in these areas, which gives even greater importance and importance to the development of these parts of the country. According to the available data, almost 14.5 billion dinars in 2023 are expected from the Ministry of Agriculture for the development of rural areas[2]. According to the Agriculture and Rural Development Strategy of the Republic of Serbia for the period 2014-2024 (2014)[3], there are 6,158 settlements in Serbia, of which only 3.1% are considered urban settlements (191 settlements), and the rest can be subsumed under other settlements that we can consider rural areas, i.e. 6158-191=5967 settlements. This only means that a large number of the population lives in rural areas, which makes the possibility of developing rural areas even more important. About 55% of the population lives in rural areas on the territory of our country, according to the data of the Republic Statistical Office (RZS).

Employment in rural areas of the Republic of Serbia

If you look at figure 1, the trend of the employment rate according to the data of the Statistical Office of the Republic of Serbia (RZS) for the year 2022, it can be seen that the employment rate is the highest in the Belgrade region, light blue color, while the highest unemployment rate is precisely in rural areas, i.e. . areas of the region of eastern and southern Serbia. In the mentioned

2 Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia (2023) “Public announcement”, http://www.minpolj.gov.rs/istorijski-budzet-ministarstva-poljoprivrede/?script=lat

3 Government of the Republic of Serbia (2014) “Strategy of agriculture and rural development of the Republic of Serbia for the period 2014-2024.” year”, http://www.minpolj.gov.rs/download/strategija-poljoprivrede-i-ruralnoj-razvoja-republike-srbije-za-period-2014-2024-godine/ p.38

region, the unemployment rate is 6% , which is a very large percentage compared to the number of inhabitants living there. If you look at the percentage of the population out of the labor force, which is shown in purple, you can see that the highest percentage of the population out of the labor force is precisely in the region of southern and eastern Serbia. According to the labor force survey [4]in 2022, rural areas are characterized to the greatest extent as areas where the population has the impossibility of realizing all social rights based on work, such as residents of the capital, who also have a high rate of hidden unemployment, because it is very difficult to measure and come to the real situation on the ground.

Figure 1. Trends in the rate of employment and unemployment according to the data of the Republic Institute of Statistics for the year 2022 in the regions given in %

Source: Republic Institute of Statistics (2023) "Labor Force Survey in the Republic of Serbia 2022", Bulletin, Belgrade, p. 15 https://www.stat.gov.rs/sr-latn/oblasti/trziste-rada/anketa-about-workforce/

Based on Figure 1, it can be concluded that the highest unemployment rate of 6% is in the region of Southern and Eastern Serbia, followed immediately by the region of Šumadija and Western Serbia, which are very devastating data.

From table 1, it can be seen that there are more women without school than men, if we look at the population outside the labor force, who live mostly in rural areas. The majority of the population, mainly in rural areas, lives from their work, or is forced to live from it, because based on the data it can be seen that they do

4 Republic Statistical Office (2023) "Labor Force Survey in the Republic of Serbia 2022", Bulletin, Belgrade, p.69 https://www.stat.gov.rs/sr-latn/oblasti/trziste-rada/anketa-o-workforce/

not have some basic rights that residents of larger cities, such as the capital, (Belgrade), Niš and Kragujevac have. In order for people to return to rural areas and in order to reduce urban-rural migration, it is necessary for them to have basic conditions for life, first of all accessible road infrastructure, a health center, and electricity. One of the possibilities that would ensure this is the construction of an existence based on renewable energy sources, which would be maintained in the country itself, so it would contribute to the construction of not only the road infrastructure, but also the highway of the entire region, and even the entire country if a factory was opened for servicing parts for small hydroelectric power plants or other plants based on renewable energy sources (wind turbines, solar panels).

According to Bogdanov (2007), 55% of the population lived in rural areas: about 33% of employees worked in the primary sector, 45% of the active rural population worked in low-productivity agriculture, the economy was insufficiently versified, rural business was insufficiently developed, and the level of social services is low. Therefore, the characteristics of agriculture are insufficient equipment of farms with the necessary mechanization

Table 1: Population outside the labor force according to education, sex, region and type of settlement

Table 4.2. Population not in the labor force (15–89 years) by education, sex, region and type of settlement, 2022 (in thousands)

	Republic of Serbia							
	In total	Serbia - North		Serbia - South			[illegible]	
		area-urban region	Region Vojvodina	Region Šumadija and Western Serbia	Region South and Eastern Serbia	Region Kosovo and Metochia	the rest of the city	
Idle population strength	2555.9	580.6	698.9	694.0	584.4	—	1515.7	1040.2
There is no school	41.2	7.7	13.0	10.8	9.7	—	13.8	27.4
Lower	1040.5	162.6	288.0	325.3	294.7	—	476.5	564.0
Medium	1173.3	291.6	326.4	303.0	252.3	—	774.4	398.9
High	300.9	118.7	69.5	55.0	57.7	—	251.0	49.9
Men	1007.8	222.0	268.7	277.9	241.1	—	595.3	412.4
There is no school	10.0	2.3	3.6	2.1	1.9	—	3.9	6.2
Lower	356.9	53.4	93.8	116.1	93.7	—	156.9	200.0
Medium	503.7	114.8	140.0	131.5	117.4	—	321.1	182.6
High	137.2	51.5	29.3	28.3	28.1	—	113.5	23.7
Women	1548.1	358.5	430.2	416.1	343.3	—	920.4	627.7
There is no school	31.1	5.4	9.4	8.8	7.8	—	9.9	21.2
Lower	683.6	109.2	194.2	209.2	171.0	—	319.6	364.0
Medium	669.6	176.7	186.5	171.5	134.9	—	453.4	216.2
High	163.7	67.2	40.2	26.7	29.8	—	137.5	26.2

Source: Republic Institute of Statistics (2023) "Labor Force Survey in the Republic of Serbia 2022", Bulletin, Belgrade, p.69 https://www.stat.gov.rs/sr-latn/oblasti/trziste-rada/anketa-about-workforce/

Based on table 2, it can be concluded that the employment rate of the young rural population is 26.7%, while the share of young farm managers is up to 35% compared to those over 55 years old, only 4.9% according to data from 2018, on the basis of which it can be concluded that a very small percentage of the young population returns to rural areas and wants to take over work and care for the household.

Table 2. The possibility of employment of the rural population

Indicator	Base value	Target value
Share of the employed rural population in the total employed population (%)	43.7 (2020)	45.0
Employment rate of young rural population (15–24 years old) (%)	26.7 (2020)	32.0
Number of young farm managers (up to 35 years old) compared to older ones (over 55 years old) (%)	4.9 (2018)	5.5
Share of women in the total number of managers (%)	15.3 (2018)	
Share of young women (up to 35 years old) in the total number of managers (%)	0.25 (2018)	0.35
% of farms with income from additional farm activities	12.3 (2018)	13.0
% of farms with income from additional farm activities exceeding 50% of total income	1.4 (2018)	2.0

Source: Government of the Republic of Serbia (2022) “Draft of the national rural development program for the period 2022-2024”, p. 45, http://www.minpolj.gov.rs/nacionalni-program-ruralnoj-razvoja-za-period-2022- 2024-godine/?script=lat

Investing in renewable energy sources

According to Vukadinović S, Ješič J. (2020), only 25-30% of renewable energy sources are used for electricity production, while biomass potential is used with only 20%, while hydro potential is 40% unused. These numbers and percentages show that, first of all, there is a great potential that needs to be used and that will help in the development of rural areas because, first of all, renewable energy sources are mostly found in rural areas.

Some of the goals of the Green Agenda that concern the Republic of Serbia are precisely related to the reduction of environmental pollution and the harmonization of the EU regulatory sector with the legal framework of Serbia, where the following elements are most important [5]:

- climate action i
-energy efficiency,
-sustainable food systems,
- protection and investment in ecosystems.

Table 3: Costs for environmental protection in 2022

1. Costs according to environmental protection activities

Republic of Serbia

	Total, one million RSD		Participation, %	Changes compared to the previous year	
	in 2021	in 2022	in 2022	difference, mil. RSD	Growth rate, %
Costs of environmental protection Air protection	68676.3	69251,2	100.0	574.8	0.8
Waste water	13707.0	17077,1	24.7	3370.2	24.6
management Waste management	5889.1	5721.3	8.3	-167.8	-2.8
Other2)	42851.5	38193.8	55.2	-4657.7	-10.9
	6228.8	8259.0	11.9	2030,1	32.6
Investments for environmental protection Air protection	29903.3	27231.8	100.0	-2671.5	-8.6
Waste water	12536.2	15548.1	57.1	3011.9	24.0
management Waste management	1945.4	972.4	3.6	-973.0	-50.0
Other2)	13690.8	7711.0	28.3	-5979.8	-43.7
	1630.8	3000.3	11.0	1369.5	84.0
Current costs for environmental protection Protection	38873.1	42019.4	100.0	3146.3	8.1
Air Waste water	1170.7	1529.0	3.6	358.3	30.6
management Waste management	3943.7	4748.9	11.3	805.2	20.4
Other2)	29160.6	30482.8	72.5	1322.1	4.5
	4598.0	5258.6	12.5	660.6	14.4

2) protection and rehabilitation of soil, underground and surface water, protection against noise and vibrations; Protection of Nature; Other activities related to protection

Source: Republic of Serbia, Republic Institute of Statistics (2022), Department for Statistics and Environmental Accounts, p.2. https://www.stat.gov.rs/sr-Latn/publikacije

Based on table 3, it can be seen that Serbia is taking measures, but the effects of those measures are showing very slowly. Growth rate of waste management in 2022. compared to 2021 is 4.5%, while the largest percentage change in the percentage of air pollution is as much as 30.6%.

5 Regional Cooperation Council (2020) Action Plan for the Implementation of the Sofia Declaration on the Green Agenda for the Western Balkans 2021–2030, https://www.rcc.int/docs/596/action-plan-for-the-implementation -of-the-sofia-declaration-on-the-green-agenda-for-the-western-balkans-2021-2030

Conclusion

In order to develop rural areas, large investments are necessary, primarily in the construction of traffic infrastructure, schools, hospitals and other facilities necessary for people's life and work. States, by influencing rural areas, encourage uniform growth and development of the entire country. Serbia can see how much investment is necessary in order for the population to return to rural, abandoned areas and to encourage their growth through the development of agriculture, energy and other economic sectors in order to reduce migration in the territory of rural and urban areas so that people can live from their work, where they were born, and they don't go to bigger cities.

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SOCIO-DEMOGRAPHIC CHARACTERISTICS OF SERBIAN HOUSEHOLDS AND SUSTAINABLE DEVELOPMENT

Marija Popović[1], Sreten Jelić[2]

Abstract

The main goal of this paper is the analysis of the socio-demographic characteristics of Serbian households according to the 2022 census, and the changes that have occurred since the beginning of this century (census 2002, 2011) until today and sustainable development. Data analysis showed that the number of households increased in the inter-census period in urban settlements, and decreased in other settlements. There are more and more households with 1 and 2 members, and the number of households with 3 or more members is decreasing in relation to the total number of households. The structure of households was analyzed according to the type of household, gender, level of education in Serbia and by regions. Sustainable development has become one of the most important factors today in the face of significant climate changes, growing population pressures and limited natural resources. Our country is affected by climate changes and limited natural resources where households play an important role in sustainable development.

Key words: *households, characteristics, Serbia, regions, sustainable development.*

Introduction

In our country, from the total number of households, 64.69% are in urban settlements, and 35.31% are in other settlements (Statistical Office of the Republic of Serbia, 2023). They are important for the development of urban and rural areas, because they have important resources and are the main subjects of the production of sustainable development.

The 2011 census recorded a decline in the total number of households for the first time, which is a consequence of the closure of a large number of single

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and elderly households in the Region of Southern and Eastern Serbia. In rural areas, there are fewer and fewer young people and more and more old people. Particularly, fewer and fewer households have younger members, and more and more households have older members, and the number of elderly households has increased. Depopulation is pronounced in Serbia, where the average number of household members continues to fall, as some authors point out. Accordingly, in 2002, the average household had less than 3 members for the first time, and in 2011, results indicate that the trend of decreasing average household size continues (Mitrović, 2015; Jelić and Jovanović, 2018; Jelić and Popović, 2019; National Programme for the Revival of the Villages of Serbia, 2020).

The most widespread definition of sustainable development is one which defines sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987). In view of the changes in the socio-demographic structure of households, the role of sustainable development is undoubtedly due to the increasing concern for the future of the planet, where the complex relationship between the environment and development is emphasized (Potter and Evans, 1998). Sustainable development requires harmony between sustainable models of production and consumption, maintenance and restoration of healthy ecosystems and eradication of poverty and sustainable social systems (Bogdanov, 2007).

The potentials available to households in rural areas are significant and enable their members to engage in various activities and in this way, they affect the development and modernization of other settlements, the development of rural areas and households, and sustainable development (Jelić, 2008; Jelić and Popović, 2023).

This paper aims to indicate the sustainability of socio-demographic characteristics of households and the changes that occurred in them in the period 2002-2022 and sustainable development.

Material and methods

For the research in this paper were used databases and publications of the Statistical Office of the Republic of Serbia and other available and relevant literature, where some characteristics of households which were shown, are based on the censuses 2002, 2011 and 2022 statistical data and sustainable development. In this respect, an analysis of the structure of households in the indicated period was made according to the type of settlement, gender, level of education in Serbia and by region. Based on the presentation of data in the table and graphs, changes in the structure of households are indicated and sustainable development.

Research results

The total number of households in Serbia according to the 2022 census is 2,589,344, of which 1,675,091 (64.69%) are in urban settlements, and 914,253 (35.31%) are in other settlements. The number of households with 1 and 2 members is increasing, and the number of households with 3 or more members is decreasing in relation to the total number of households. There are 57.38% households with 1 and 2 members, and with 3 or more members are 42.62% of the total number of households (Table 1). Of the total number of households in urban settlements, 38.17% have 1 or 2 members, and 26.52% have 3 or more members. In other settlements, of the total number of households, with 1 and 2 members are 19.22%, and over 3 or more members in households there are 16.09% in relation to the total number of households.

In this period of analyzing data by censuses 2002-2022. there was an increase of households in urban settlements and the reduction of households in other settlements in relation to the total number of households in Serbia. Households in other settlements make up about 35% of the total number of households. The average number of members of rural households decreased continuously, so that there are more and more households with a smaller number of members.

Out of the total number of districts in our country, nine have a smaller number of members in the household which is below the average of the Republic of Serbia, and these are North Bačka District, Central Banat District, North Banat District, South Banat District, West Bačka District, South Bačka District, Bor District, Zaječar District and Pirot District. Out of the total number of municipalities, 40% have a smaller number of household members compared to the average of the Republic of Serbia (Jelić, 2008).

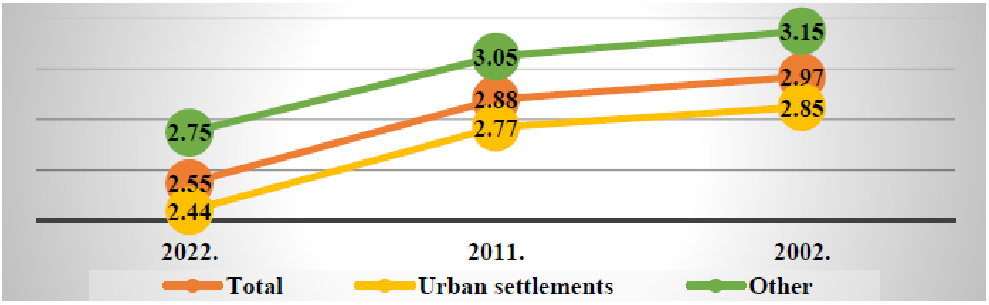
Table 1. *Structure of households according to number of members and type of settlement in Serbia, censuses 2002-2022.*

Type of area	Total	1	2	3	4	5	6 and more
2022.							
Total	2.589.344	773.945	711.946	459.926	375.565	156.050	111.912
Urban settlements	1.675.091	528.823	459.497	308.956	248.449	84.307	45.059
Other	914.253	245.122	252.449	150.970	127.116	71.743	66.853
2011.							
Total	2.487.886	555.467	638.091	476.642	454.127	197.506	166.053
Urban settlements	1.533.866	350.052	396.450	318.151	295.790	105.726	67.697
Other	954.020	205.415	241.641	158.491	158.337	91.780	98.356
2002.							
Total	2.521.190	504.775	625.301	480.181	535.963	205.979	168.991
Urban settlements	1.481.304	305.294	363.057	312.233	343.196	101.043	56.481
Other	1.039.886	199.481	262.244	167.948	192.767	104.936	112.510

Source: https://www.stat.gov.rs/sr-cyrl/

The mentioned tendencies of changes in households have continued and are more dynamic. In the period 2002-2022, in two decades the number of households increased from 2,521,190 to 2,589,344, which is 68,154 more households. However, the average household size recorded a drop from 2.97 members to 2.55 members, which indicates that households are with fewer members and the dominance of one and two-member households (Graph 1).

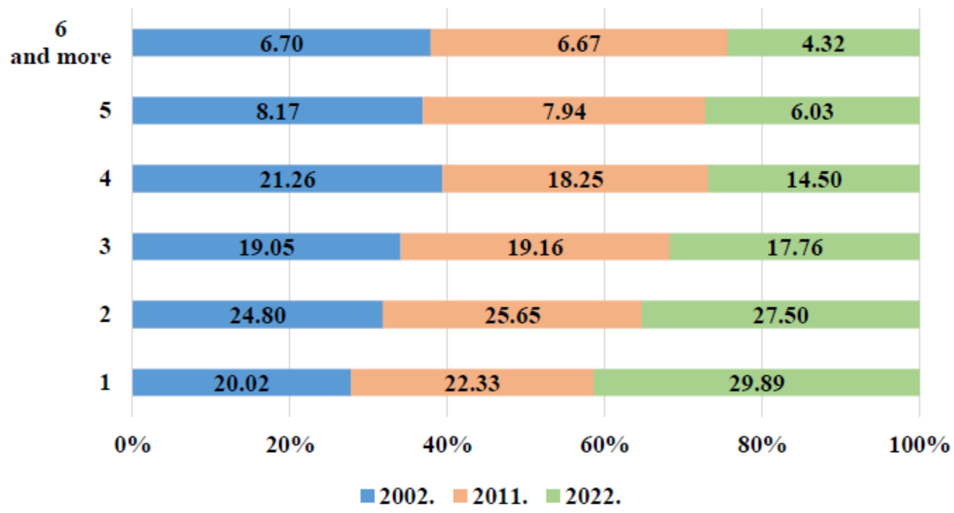
Graph 1. *Average number of household members in Serbia, censuses 2002-2022.*



Source: https://www.stat.gov.rs/sr-cyrl/

Analyzing the structure of households according to the number of members, the data show that the number of smaller households is growing out of the total number, and households with one or two members are dominant. There are similar trends of change in urban and other settlements, where we have more than half of the households with 1 and 2 members out of the total number of households in these settlements. The last census from 2022 indicates significant changes in the structure of households, where there was a significant increase in the number of households with 1 or 2 members, and a decrease in the households with 3 or more members (Graph 2).

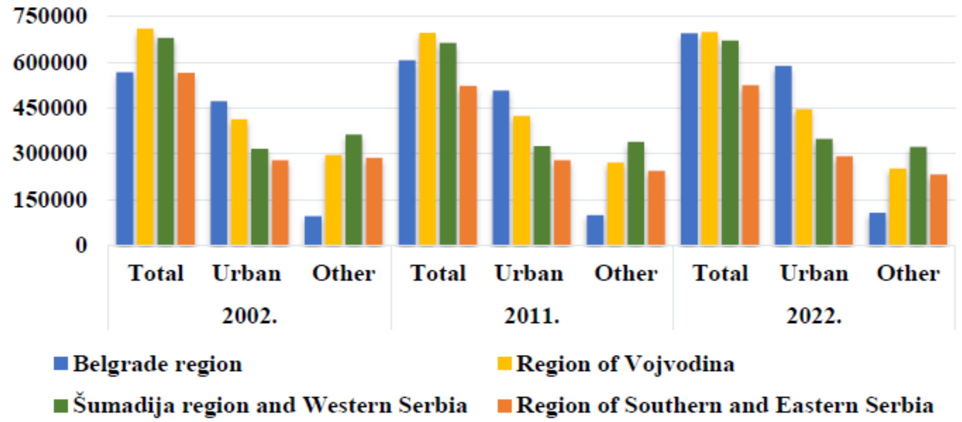
Graph 2. *Households by number of members (%) in Serbia, according to censuses 2002-2022.*



Source: https://www.stat.gov.rs/sr-cyrl/

Analysis of the structure of households by regions of Serbia indicates that special changes in the structure of households occurred in the Region of Southern and Eastern Serbia, where the number of households in 2022 was significantly reduced compared to the census from 2002 by 40,400 households (Graph 3). The number of households in the Šumadija and Western Serbia Region indicates that, according to the 2022 census, households are more numerous in urban areas than in other settlements. In the Region of Šumadija and Western Serbia and in the Region of Southern and Eastern Serbia, there is a higher share of households with 6 or more members compared to the Belgrade region, where the largest number of single households is recorded.

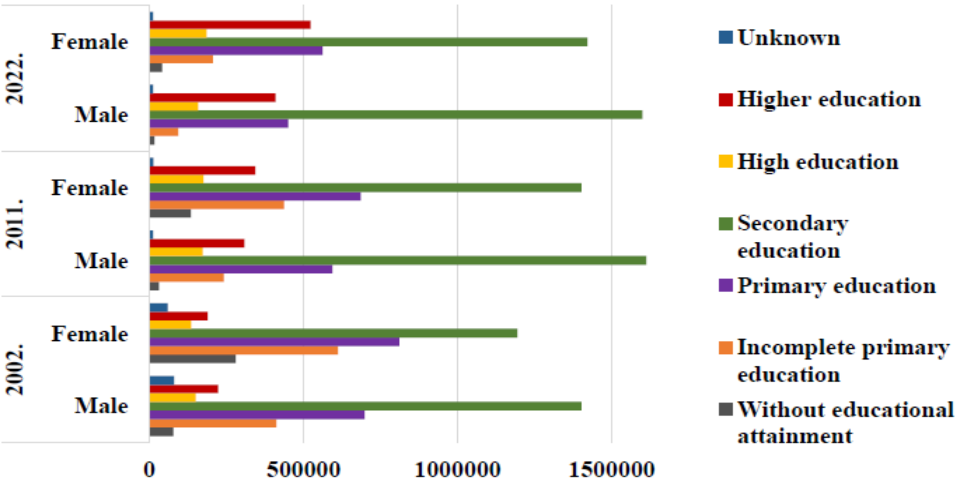
Graph 3. Total number of households in Serbia by regions and type of settlement, censuses 2002-2022.



Source: *https://www.stat.gov.rs/sr-cyrl/*

The educational structure of household members in the indicated period shows that there have been significant changes, especially an increase in household members with secondary education from 41.07% to 53.08%, as well as an increase in higher education, especially for women, from 2.99% to 9.20 % (Graph 4).

Graph 4. *Educational structure of the population aged 15 and over by level of education and gender, censuses 2002-2022.*



Source: *https://www.stat.gov.rs/sr-cyrl/*

Education is a key factor in promoting economic, environmental and cultural values for sustainable development. It is inevitable to improve the educational structure of household members, which will affect the more intensive development of our society and modernization. Given that in other settlements, there are 35.31% of households out of the total number of households, the development of agriculture, rural tourism and other branches that household members deal with depends on the level of education. Certain areas of the regions have an unfavorable educational structure, which slows down the development of a number of activities. The educational structure differs depending on the type of households and is particularly unfavorable in agricultural households.

The changes that occurred in the structure of households led to the movement of household members from other settlements to urban settlements, which led to the fact that there are more and more one and two-member households and elderly households, especially in border settlements and mountainous areas, which calls into question sustainable development. That is why it is necessary to make efforts and improve the infrastructure in other settlements and find opportunities to retain the population, especially young people in them. Therefore, sustainable development in the settlements depends on the quality of water, air, communal infrastructure and institutional arrangements in local communities. Accordingly, the demographic movements and mobility of the population towards the cities and the concentration of the population in them and the unbalanced distribution of the population in them affect the emergence of a number of problems because there is an unsustainable use of resources, which certainly affects sustainable development.

Conclusion

Our households changed and went through a series of changes and processes where they adapted to the challenges they faced. The number of members in households has been decreasing for a long period from decade to decade, so that there are more and more small households in Serbia in urban and other settlements. Primarily, the number of single and elderly households increased.

Based on the socio-demographic characteristics of Serbian households in the period between the 2002-2022 censuses significant changes occurred in the structure of households according to the number and type of settlement, and special changes occurred in the structure of households in the Southern and Eastern Serbia Regions. In our country, out of the total number of households, the majority are with 1 and 2 members in the household, which is about 50% of the total number of households. Average households are shrinking and have fewer and fewer members. Considering the potentials available to households in urban and other settlements and the comparative advantages and conditions for the development of various economic activities, it is necessary to involve all competent institutions of the community and individuals and develop those branches of the economy for which there are conditions, which will also contribute to the sustainable development of households.

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OBSERVING CHANGES OF SETTLEMENT SIZE IN VITICULTURAL ZONES OF SERBIA USING VIIRS NIGHTTIME LIGHT DATA

Radmila Jovanović[1], Claudete Oliveira Moreira[2], Debajit Datta[3]

Abstract

Nighttime lights (NTL) data provides a comprehensive view of the spatial distribution of global human activities, especially in terms of population concentration, level of urbanization, estimation of economic growth, population mobility, determination of depopulation areas, etc. This article aims to map the spatio-temporal distribution of night lights of settlements in the wine-growing areas of Serbia using The Visible Infrared Imaging Radiometer Suite (VIIRS) NTL datasets from 2015 to 2019, explore the emerging spatial patterns, and compare these patterns with the database of census 2022. Results reveal that the wine-growing areas in Serbia illustrate population redistribution and settlement size change, as it includes larger cities as per the last wine-growing rezoning, reflecting the spatial redistribution of populations. Moreover, urbanization pattern and settlement size variations occur in cities or at their vicinities, with a prominent decrease in settlement size as people move away from cities, indicating a clear depopulation and delimitation of city areas.

Key words: *Geospatial analysis, Settlement size, Spatial analysis, VIIRS data, Viticulture zone.*

Introduction

Positive population policy and spatial distribution of the population have an important impact on the economic and social development of the country. Population censuses are an important source of data and their spatial

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distribution (Zeng et al., 2011). The traditional census of the population does not reflect the real, spatial distribution within one territorial unit. To obtain the numerical value of the number of inhabitants, satellite images, open-source night lighting data, and the use of geographic information systems (GIS) are used. The advantage of using modern geographical detectors in the investigation of spatial differences is in the application of quantitative and type data. On the other hand, there is still a strong influence on the study of the population, which is based on the census and data from statistical yearbooks with the application of various statistical methods.

In developing countries, the spatial dynamics of the population is monitored through the population census, although these countries do not have a trend of regular and accurate censuses (Bennett & Smith, 2017). In classic, traditional censuses, data on population density are obtained by the ratio of the number of inhabitants to the area of a given area, but this does not show the real dynamics of the population (Stevens et al., 2015). Census data and remote sensing techniques, especially night-time light data, are now combined to estimate population density (Doxsey-Whitfield et al., 2015; Pozzi, Small, & Yetman, 2003). Nighttime light (NTL) remote sensing data, widely used in buildings and infraestructures, is frequently used to investigate human activities (Chen, et al., 2021; Croft, 1978; Elvidge et al., 1997; Falchi et al., 2011; Li et al., 2018), namely urbanization processes (Liu et al., 2024; Sutton et al., 2001; Elvidge et al., 2014; Yu et al., 2018)

One of the biggest problems with the traditional population census is represented by sparsely populated areas. One example is Western China, where the census is held every 10 years and where it is difficult to obtain data on the population in a real space-time period. Collection, combination and integration of data with other data is of great importance for such sparsely populated areas and the spatial-temporal distribution of the population in real time (Chen & Nordhaus, 2015). These are data obtained using remote sensing techniques and geospatial research technologies, such as: remote sensing (RS) due to its fast and wide coverage (Xu et al. 2021).

Some researchers to obtain data on the population of different regions used data methods or by applying the kernel density method, and obtained a map of continuous changes in regional population density, area weighting (Bakillah et al., 2014; Wang et al., 2023), geographically weighted regression (Wang et al., 2018; Yuan et al., 2020; Wang et al., 2023) and zone density mapping (Qiu & Cromley 2013; Lin & Cromley, 2015; Wang et al., 2023).

There are 2 types of monitoring data (Elvidge at al. 1997; Levin & Duke, 2012):

1. The first type of data is used for large-scale monitoring (100 m-1 km) with a coarse spatial resolution at the regional level, where night light images are used to map various socio-economic activities)

2. Another type of data is used for monitoring smaller scales (<100 m) at the local level. These images are used in combination with Local Based Service (LBS) data and in the analysis of the spatial distribution of the population.

On the basis of such analyses, settlement mapping is done and they represent a realistic description of the spatial distribution of the population.

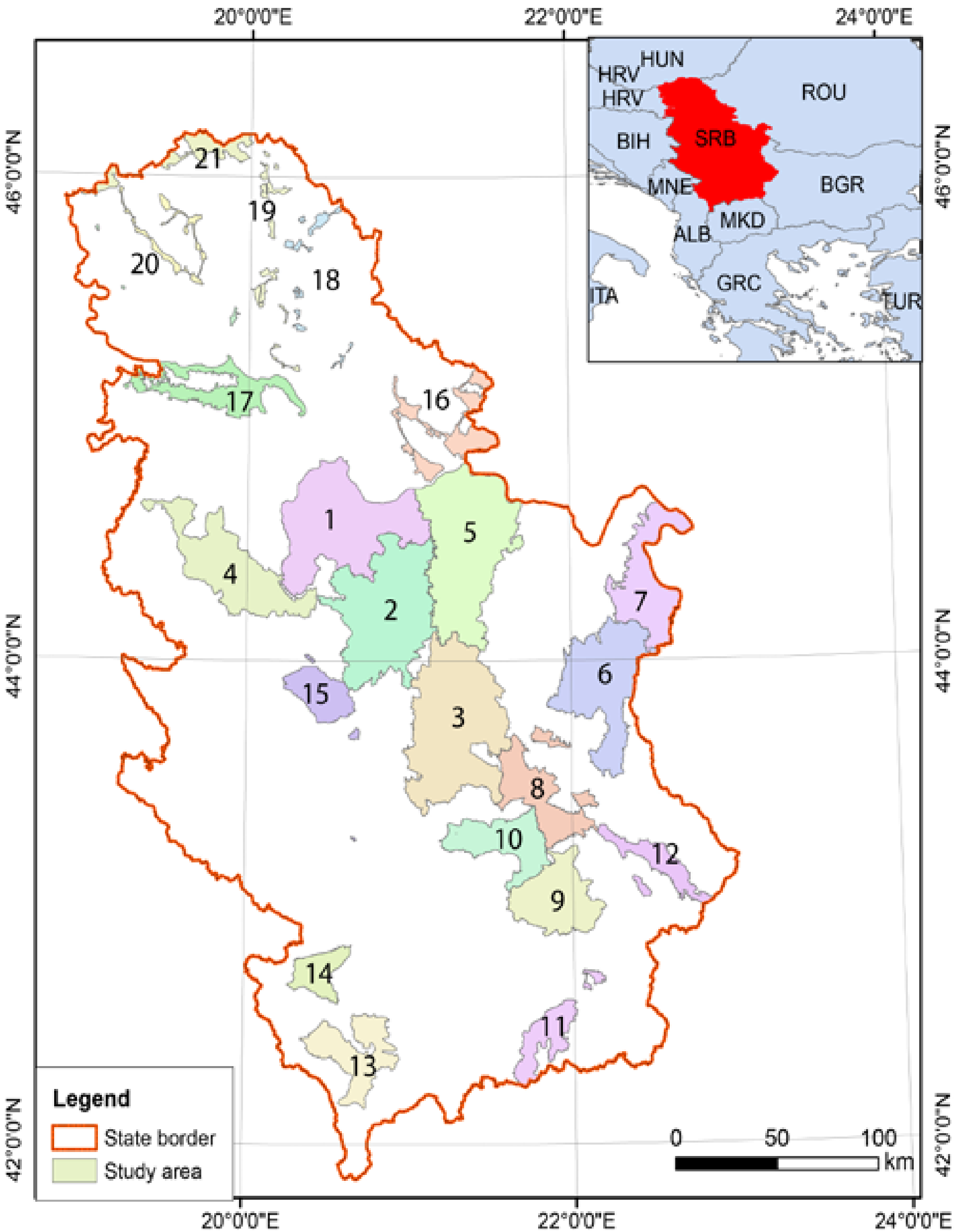
The main goal of the article is to look at the space and distribution of the population through other sources of data collection and quantitative indicators in demography, in addition to the traditional population census of Serbia. In the wine-growing zone of Serbia, there are peripheral areas that are empty or partially empty (such as the southern and southeastern parts), and others are densely populated (urban areas) and with the application of alternative methodologies (e.g. satellite images of the night world) it is possible to more precisely determine the size of the inhabited area.

Study area

The wine-growing region of Serbia is a good example of different populations, size of settlements and spatial distribution of population. The wine-growing borders include densely populated cities (Belgrade, Kragujevac, Niš, etc.), and on the other hand, partially populated and displaced areas of Serbia (especially the southern and southeastern parts).

Grape vines in Serbia are grown on hilly terrain between 80 and 500 m above sea level. Serbia is located in the zone between 41°50' and 46°10' SG, which enables the conditions for growing different varieties of vines, and as a result, the production of quality grapes and wine. The viticultural area of Serbia covers a total area of 23,675 km² (99.86% includes the belt up to 800 m above sea level, and from 800 m it covers the area of 31.42 km², i.e. 0.13%). The largest wine-growing unit in the wine-growing area of Serbia is represented by wine-growing Serbia. Within wine-growing Serbia there are viticultural areas: region, region, vineyard (Rulebook on the rezoning of viticultural geographical production areas, 2015; Jovanović, 2020) (Figure 1).

Figure 1. *Study area - wine-growing regions in Serbia*



Source: Elaborated by authors

Wine-growing regions:

1	Belgrade	12	Nišava
2	Šumadija	13	South Metohija
3	Three Morava	14	North Metohija
4	Pocerina-Valjevo	15	Čačak-Kraljevo
5	Mlava	16	South Banat
6	Knjaževac	17	Srem
7	Negotin	18	Potisje
8	Niš	19	Banat
9	Leskovac	20	Teleč
10	Toplica	21	Subotica
11	Vranje		

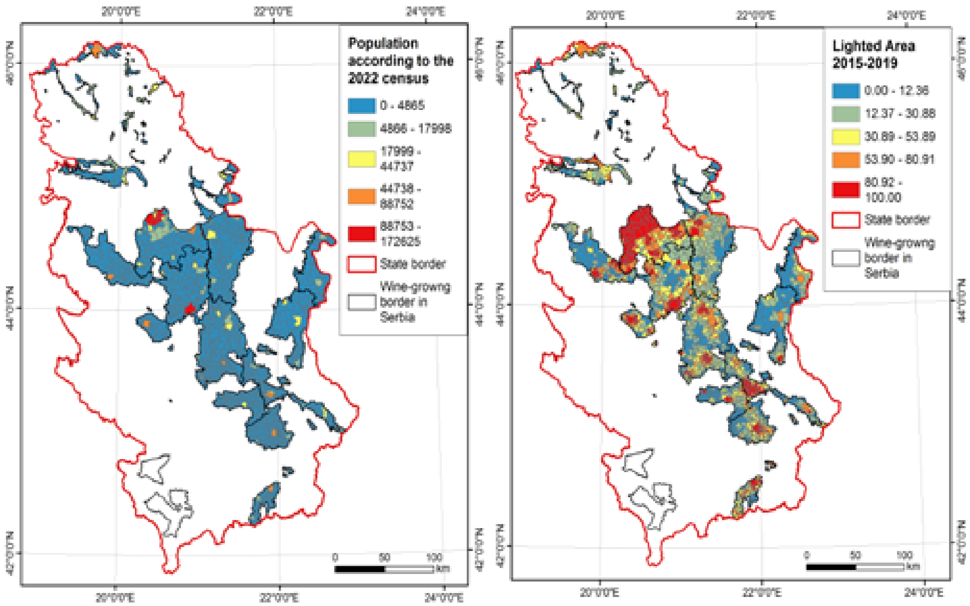
According to the 2011 census, in the analyzed area, for the period 1961-2011, there was a spatial distribution of the population from villages to urban areas. According to the 1961 census, 2,629,774 people lived in wine-growing areas where grapes were grown, and according to the 2011 census, 3,139,914 inhabitants. According to the last population census, from 2022, the number of inhabitants is 2963715 (Comparative overview of the number of inhabitants, 2014; Jovanović, 2020). On the basis of remote detectors and the GIS and the last population census, research, quantified assessment and comparative analysis of the population density of a certain part of the wine-growing area of Serbia was carried out.

The main limitation and shortcomings of the study is that the use of VIIRS night light data is related to a certain period of time, as well as the ability of satellite sensors to capture individual light sources in areas that are not heavily populated.

Results

Data from VIIRS NTL datasets from 2015 to 2019 obtained for areas with different intensity of NTL. In the case of settlements of a rural character, which are small and scattered, they are not considered as much as comparing the size of urban settlements where the population density is high and the NTL values are high.

Figure 2. Comparative overview of the size of the population census (2022) and illuminated wine-growing area (2015-2019) of Serbia



Source: Elaborated by authors

Source data: https://data.gov.rs

Based on the obtained results, it can be inferred that the spatial distribution of the population and the size of the settlement is greater on the data obtained from the VIIRS NTL datasets from 2015 to 2019, than from the census of the number of inhabitants in 2022. This difference is especially noticeable in wine-growing areas where larger cities of Serbia (with a range of 50,000 to over 1,500,000 inhabitants): Belgrade, Kragujevac, Valjevo, Niš, Leskovac, Knjaževac, Negotin, Vranje. In the 2022 population census, a similar identity (red color in Figure 2) can be seen and compared with VIIRS NTL datasets from 2015 to 2019 only in the cities: Belgrade, Kragujevac (red color in Figure 2) and significantly less in the cities of Vranje, Leskovac , Niš (which are marked in orange or yellow).

Conclusions

In addition to the classic way of censusing the population, the use of modern remote sensing techniques in night light is of great importance. With the help of this technique, it is possible to detect and provide reliable information for population density modeling, because NTL is related to human activities. Some further monitoring of the movement and distribution of the population can be observed through the point of interest (POI). POI and LBS data have easy access, high positioning accuracy compared to the traditional way of data collection. POI and LBS data can also serve as a modeling factor for percentage population density.

A special advantage can be provided by the combination of POI and LBS data with VIIRS data.

Also, the future of large-scale dense population mapping should be viewed through machine learning, which would enable the simulation and modeling of population and territory, changes in these variables, through an adequate tool.

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DEVELOPMENT OF SPECIAL FORMS OF TOURISM WITH THE AIM TO REVITALIZE THE RURAL AREA OF PLJEVLJA MUNICIPALITY

Sara Stanić Jovanović[1], Dragana Vuković[2], Nevena Miletović[3]

Abstract

*The municipality of Pljevlja is the third largest municipality in the northern part of Montenegro. The administrative center of the municipality is the town of Pljevlja, which is one of the highest settlements in Montenegro. The southwestern part of the municipality of Pljevlja is partially located on the territory of the Durmitor National Park. The proximity of the route E-763 (Belgrade-South Adriatic) stands out as a special advantage of the municipality's location, in the form of opportunities for transit tourists on the way to the Montenegrin coast, and especially for those who want to avoid the dangerous section of the road through the Morača Canyon and use an alternative sea direction Pljevlja-*Žabljak*-Nikšić-Boka Kotorska. From the image aspect, and based on natural resources and anthropogenic values, the municipality of Pljevlja can be positioned in the minds of consumers as a peaceful and small tourist destination with preserved authentic, autochthonous, unique and traditional attributes, which are based on specific tourist products. The development of some of the special forms of tourism (agro, event, hunting, fishing, apitourism, tourism of special interests, etc.), along with numerous economic benefits, will contribute to the revitalization of the rural area of the municipality of Pljevlja.*

Key words: *Revitalization, tourism, village, development, possibilities, Pljevlja.*

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Introduction

The municipality of Pljevlja is located in the mountain range of the northernmost part of Montenegro. It covers an area of 1,346 km², which is about 10% of the total territory of Montenegro and is the third largest municipality in Montenegro (after Podgorica and Nikšić). The administrative center of the municipality is the city of Pljevlja. The territory of the municipality represents the northern gate of Montenegro, bordered by wooded and tame mountains and intersected by the Tara, Ćehotina and Breznica rivers (as well as a dozen of their tributaries). The municipality's rich cultural and historical heritage, as well as its favorable geographical location, conditioned the development of Pljevlja as an urban environment. The Pljevlja area belongs to a particularly high mountainous part of the territory, intersected by river valleys, which represents the 'green space of Montenegro' and which, according to the features of the relief, in many of its parts, has the appearance and features of an alpine-type landscape. The municipality of Pljevlja is one of the richest municipalities in Montenegro, both in terms of diversity and natural resources and the amount of mineral raw materials. It has an exceptional natural and cultural-historical heritage that it can use as its key comparative advantages for the development of various forms of tourism and tourist offer, but tourism as an economic branch has hardly developed at all in the past period (Strategic Development Plan of the Municipality of Pljevlja, 2020). The paper uses field research carried out in the framework of the project 'Development of rural tourism through education of the client's employees' of the Rico Training Center from Belgrade, for the needs of the AD Pljevlja Coal Mine, implemented in 2023.

Concept and characteristics of special forms of tourism

With the increase in the number of participants in tourism trips and the transition of tourism from an elite to a mass phenomenon in the last two decades of the 20th century, there was a depletion of ecological, economic, socio-cultural resources and a threat to the survival of certain tourist destinations. Another negative phenomenon that the mass population brings with it is the saturation of the tourist demand, which is always eager for something new. This is precisely why there is a desire when regarding the demand for something new, new markets and new ways of spending free time. Accordingly, the destinations had to adapt and specific or special forms of tourism began to develop (Šimičević, 2023). There are a few different definitions of special forms of tourism depending on the author.

There are several terms that are simultaneously used in domestic and international literature to describe the term specific forms of tourism. The three most common terms used are specific, special and selective forms of tourism. All three terms refer to the same phenomenon, i.e. to the same trend in the tourist market (Štetić et al, 2013). Hall and Weiler point out that 'specific forms of tourism imply that the motivation and decision-making process of tourists are determined by some special interest in which the activities are focused and/or destinations and their surroundings'. In contrast, some authors define specific forms of tourism as 'quite the opposite form of mass tourism with a focus on new forms that have the potential to meet the needs of tourists including rural tourism, adventure travel, nature travel, cultural content and heritage travel, as well as festivals and events.' (Trauer, 2006). The term special forms of tourism refers to a rather broad and diverse group of tourist movements that are determined by a number of factors that separate them from conventional mass tourist movements. In addition to the term special forms of tourism, a number of other terms are used to describe the relationships that arise during these movements, and which have their own special characteristics or specificities in relation to mass tourism. Therefore, the terms specific forms of tourism, selective forms of tourism, special interest tourism, niche tourism, alternative tourism and the like are also used interchangeably (Štetić et al, 2014). Selective forms of tourism refer to trips whose primary reason or goal is the realization of a special interest and enjoying it, which can be a hobby, physical activity, interest in a certain topic or a certain type of destination, i.e. attractions.

These types of tourism include consumers whose travel is motivated, first of all, by the desire for new localities and authentic 'products', which largely depends on which destination they choose. Among the terms used to denote special interest tourism is 'thematic tourism', where the emphasis is on a special theme that pervades the tourist product intended for consumers interested in a specific theme, activity, method of travel and accommodation, type of attractions and the like (Rabotić, 2012).

Numerous authors and theoreticians of tourism emphasize the negative impacts of mass tourism, while the predictions of the World Tourism Organization speak in favor of the reduction of mass as opposed to small forms of tourism. They are characterized by predominantly individual or smaller group trips, as well as more educated, more experienced and responsible participants, often with higher payment options compared to typical tourists, participants in mass tourism (Stanić Jovanović, 2015). Special forms of tourism have become very popular in recent years, such as an alternative to the concept of mass tourism development (Stanić Jovanović et al, 2023).

Natural potentials for the development of tourism in the municipality of Pljevlja

The municipality of Pljevlja geographically extends in the northern part of Montenegro, between 43°21´05´´ north latitude and 19°21´09´´ east longitude. The area of the municipality is 1,346 m2 (i.e. 10% of the territory of Montenegro, the third largest municipality). From the northwest and west it borders with Bosnia and Herzegovina (76 km long), from the north and northeast with the Republic of Serbia for a length of 50 km. On the southeast and east, it boarders the municipalities of Mojkovac and Bijelo Polje, and on the southwest it is separated from the municipality of Žabljak by the Tara river. The municipality is partially located on the territory of the Durmitor National Park (southwestern part). Its territory is mostly mountainous, and the average altitude is about 1200 m.a.s.l. The mountainous areas in the territory of the municipality belong to the Dinaric mountain range, running southeast-northwest, which is also its direction. As a border municipality, it is also an important traffic hub (international road traffic) in the transit tourist route Central Europe-Belgrade-Užice-Prijepolje (Serbia)-Pljevlja-Žabljak-Nikšić-Trebinje (BiH)-Dubrovnik (Croatia), with a branch from Pljevlja - through Nikšić to Boka Kotorska.

Figure 1. Draga river canyon

Source: https://pljevlja.travel/mjesta/kanjon-rijeke-drage

The municipality of Pljevlja, due to its geographical position, generally has a moderate continental climate, with the characteristics of a specific mountain climate, although in winter, in the mountainous regions of Durmitor, there is a mountain climate characterized by low temperatures and snowfall. Part of the territory of the municipality, with an area of 76.5 km2, is located within the area of the Durmitor National Park (canyon of the Tara River along the right bank and its right tributary Draga, total area of 68 km2). Within the protected zone near the Durmitor National Park, there is also an area that does not formally belong to the park, but forms a natural and organic whole with it. The territory of the municipality is intersected by valleys and basins of the rivers Ćehotinja, Brežnica, Vezišnica, Tara, Maočka River and other smaller streams, as well as karst springs such as: Kutlovača, Breznica, Jugoštica, Vrelo, Zmajevac, Mandojevac and Tvrdaš. Climatic conditions and relief and geomorphological features have caused diverse vegetation and biodiversity. The Pljevlja basin with 29,364 ha has the largest total agricultural area in Montenegro (mountain meadows and pastures make up about 51% of the total area of the municipality).

Agriculture is mostly oriented towards livestock rearing, and to a lesser extent farming. The most numerous and specific forms of flora and fauna are located in the area of the Pljevlja part of the Durmitor National Park. Areas with diverse forest vegetation comprise about 70% of the total area of the municipality (101,931 ha). The pine community on Ljubišnja Mountain stands out as a protected natural species. 94 species and meadow vegetations have been registered: 57 species of aromatic and medicinal plants, 26 species of forest fruits and 11 species of edible mushrooms.

Fauna is also diverse, especially in the mountainous regions, from small to large game, some of which are also rare animal species (brown bear, gray European wolf, chamois, wild boar, etc.) and various bird species, such as: bald eagle, three-toed woodpecker, pygmy owl, grouse, etc. Among the most significant natural potentials on the territory of the municipality of Pljevlja are: the Ljubišnja and Kovač Mountains, the Draga and Ćehotina Rivers, the Borovičko Lake, the plateau of Kosanica, Kozica and the valley of the Kozicka River, Vrulja and Maoča, as well as a large number of picnic spots and attractive viewpoints, such as Krakalica, the city Vodice Park, Perova luka, Mejtef, Zeleni vir, Rudnica and others (Project ‘Development of rural tourism through education of the client’s employees’, 2023).

Anthropogenic values for the development of tourism in the municipality of Pljevlja

The territory of Pljevlja municipality is a place where two cultures meet, Christianity and Islam, which is why the architecture, lifestyle and customs of this multi-ethnic environment are intertwined. Their spiritual oases are part of a rich cultural and historical heritage and objects worthy of attention. Pljevlja is an area with a long and rich past, a place where different civilizations met, which for centuries represented a crossroad for different commercial and cultural aspirations. In the Middle Ages, the settlement was called Breznik, named after a river that flowed through it. At the beginning of the 15th century, the current name appears, which is mentioned in Dubrovnik sources in 1430, and originates from the chaff on the monastery's property. An important trade route passed through the town, connecting Dubrovnik with Thessaloniki (via Skopje) and Constantinople (via Niš). The territory of Breznica parish was part of the state of Duklja in the 11th century, although the supreme authority of the Roman emperors was generally recognized. At the end of the 12th century, the area of today's Pljevlja came under the rule of the great prefect Zavida and his son Stefan (Nemanja), and then it became part of the Kingdom of Serbia (Stefan Prvovenčani). Nahija Kukanj, of which Pljevlja was the center, was founded immediately after the fall of this part of old Herzegovina under Ottoman rule. In Ottoman sources, Pljevlja is mentioned as Pazar (square) of Pljevlja, but also as Taslidža (stone spa). In the 16th century, they were known as *karavan-saraji*, used for the rest of travelers and merchants. During the Turkish occupation, Pljevlja belonged to the Herzegovinian Sanjak (Pljevlja kadiluk).

Figure 2. Holy Trinity Monastery

Source: https://pljevlja.travel/vrsta-mjesta/manastiri-i-crkve/

Among the anthropogenic resources for the development of tourism in the area of the municipality of Pljevlja, the following stand out: the Monastery of the Holy Trinity from the 16th century, formerly an important copying center; the remains of the medieval fortified town of Koznik, better known as Jerina's town; Husein Pasha Mosque, the most important religious building of Islamic architecture from the 16th century; Kukanj fortress, former summer residence of the famous Herceg Stjepan Vukčić-Kosača; monasteries from the 16th century: Dubočica with the Church of St. Nicholas, as well as the monastery of St. Archangel Michael, located on the right bank of the Tara River in the village of Đurđevića Tara, the hamlet of Luka; the Church of the Holy Great Martyr George, the Church of Saint Petka, the Monastery of Dovolja and the Local Museum in Pljevlja with a rich collection of finds and objects from all historical periods of cultural heritage in the entire territory of the Pljevlja municipality. A significant number of steles, medieval stone tombstones in the villages of Mataruge and Vrulja represent an unavoidable cultural and artistic heritage and a testimony to the artistic importance of the Pljevlja region during the Middle Ages (Project 'Development of rural tourism through education of the client's employees', 2023).

Special forms of tourism as a chance for the revitalization of the rural area of the municipality of Pljevlja

Revitalization can be defined as a set of planned (continuous and occasional) measures, investments and actions initiated at different levels - state, regional, subregional and local (municipal), aimed at mobilization and rational spatial organization in the function of market-oriented exploitation of natural, demographic and material resources of rural settlements and their administratively (atari) and functionally belonging territories (Stamenković, 1999). Governments of many countries, especially from the European Union, in their development strategies and plans give great importance to rural tourism due to its direct and indirect positive effects that it has not only on local communities in rural areas, but also on national economies as a whole (Panić, 2013). The small population of problem areas and the lack of jobs are the biggest obstacles to their revitalization (Mandić, 2019).

Tourism is an activity that can be developed in rural regions and thus affects the improvement of living conditions in those areas and their integral development. This implies the revitalization of rural areas based on available potential through optimal development strategies of the rural economy as a whole. It includes primary agricultural production, local ecologically established food industry, all types of economic and service activities, renovation and innovation of economic, communal, traffic, social, health, educational and cultural infrastructure (Štetić et al, 2014). The development of the rural economy beyond the scope of agrarian rurality has proven to be a suitable instrument for providing adequate living conditions to that part of the rural population that is unable to live from agriculture, but also to all those owners of rural farms who want to increase their sources of income through additional activities. Rural tourism belongs to the so-called 'other profitable activities' that can solve numerous accumulated social and economic problems in rural areas (Vuković, 2019). Special forms of tourism, among which rural tourism is significant, can significantly contribute to the development and 'revival' of rural areas. The product of rural tourism refers to a stay in a rural environment and the natural environment is a symbol of traditional hospitality and cultural values of the local population. A form of rural tourism, based on heritage and cultural-historical values, is an integral part of the economic strategy, which emphasizes cultural-historical resources and influences their strong promotion (Cvijanović et al, 2022). Regarding that the largest part of the municipality is agricultural land, agriculture should play one of the important roles in the development and creation of an appropriate offer of rural tourism. In the long term, if one were to invest in the development of tourism, creativity is important in the creation of appropriate tourist stay programs, which must be present in order to achieve greater success. In a strategic approach, it is important to respect the rules and principles of sustainable development. In this way, potential and current tourism resources would be useful both for current and future generations (Vuković, Mihailović, 2017).

Bearing in mind that the spatial diversity of natural potentials, height differences in the mountain relief and its morphology, hydrographic characteristics, preserved natural environment and biodiversity of the area, the emphasis is not only on agrotourism, rural and transit tourism. This area also offers various opportunities for various sports and recreational activities throughout the year - both in winter and in summer. It also offers hunting and fishing, gastronomic, special interest tourism as well as other forms of tourism. The degree of attractiveness of anthropogenic tourist motives in the territory of the Pljevlja municipality can be defined as extremely high, since it includes numerous cultural tourist resources, such as cultural and historical monuments from different periods, among which the most valuable are certainly monasteries, churches and mosques, as well as original types of settlements, folk architecture, folklore and more. The tangible and intangible cultural heritage represents the ever-present value of the history and culture of Pljevlja. Based on available data from the Registry of the Institute for the Protection of Cultural Monuments of Montenegro, two cultural monuments of category I (monuments of exceptional importance) and four of category II (monuments of great importance) were recorded in the municipality of Pljevlja. In addition to the already mentioned, legally protected cultural monuments, remains of old cities and necropolises with steles in the territory of the municipality of Pljevlja there are dozens of almost forgotten remains of monasteries, churches and churchyards, medieval cities and fortifications, necropolises and tumuli from different historical periods, and even different eras. The high degree of attractiveness of anthropogenic tourist motives favors the enrichment of the offer of stays in agrotourism and the development of religious, cultural and event tourism as well as different thematic types of tourism that are intended for special market segments.

Conclusion

Together with the tourism sector, agriculture represents the most important development and economic priority in the territory of the municipality of Pljevlja. The agriculture sector plays a very significant role in the overall economy of the area: in rural areas, it is the main activity of the local population and the main source of income for the third of the population of the municipality of Pljevlja. A prerequisite for the development of tourism is developed agricultural production. The construction of the tourist offer in the territory of the Pljevlja municipality is not at a satisfactory level. The total tourist offer, that is, the existing accommodation offer, is characterized by structural deficiencies, low rates of utilization of hospitality capacities, as well as the absence of quality and authentic, unique hospitality and tourist offer. The development of the municipality of Pljevlja as a tourist destination of special forms of tourism is motivated by the creation of a quality tourist product of the municipality that can be placed on the tourist market. The integral rural and agrotourism product at the level of the tourist destination of Pljevlja can be broken down into several partial tourism products, which are created by individual carriers of the tourist offer: rural, agro, tourism in rural households, tourism in domestic crafts, thematic tourism products, such as hunting, fishing, gastronomic, religious, event tourism, as well as special event tourism - eco, ethnic, health tourism product, with thematic tours - apitourism, dark, business, volunteer, cultural and camping tourism. The basic features of the municipality of Pljevlja as a specific tourist destination of thematic tourism are characterized by the specificity of the space, attraction motifs, tourist offer and products, where some specific features of the tourist offer are specifically mentioned: a smaller number of people involved, frequent individual trips, each tourist has individual needs. The thematic tourist product of the municipality of Pljevlja represents a potential development opportunity, and can include: api-tours, dark themed tours, cultural tours, MICE tourism, volunteer tours and camping tours.

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RURAL TOURISM: EMPOWERING RURAL DEVELOPMENT

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Abstract

Rural tourism is an activity that directly and indirectly contributes to the development of rural areas. It encompasses various activities and services provided by rural residents on their properties to generate additional income. Rural tourism significantly stimulates entrepreneurship, fosters the establishment of small family businesses, and contributes to employment and improved living standards for rural populations. It promotes local culture and the traditional hospitality of rural communities. Developing rural tourism requires good communal and transportation infrastructure, enhancing the overall quality of life in local communities. This study aims to analyze the role of rural tourism in the development of rural areas. Best practices in Europe are presented to showcase the contribution of rural tourism to rural development.

Key words: *rural tourism, development, rural areas.*

Introduction

The initial beginnings of rural tourism development are connected to the distant past when privileged social classes spent their leisure time in rural environments (Vuković et al., 2010, p. 49). Visiting rural areas has a particularly long history in Western Europe (Lane, 2009), when wealthier individuals left urban areas in the summer months to enjoy their stay and recreation in the countryside. English aristocrats, in particular, stood out, spending summers in rural areas where they engaged in numerous recreational activities such as hunting. Countryside vacations, which represented a form of social leisure in the second half of the 18th century, reflected a desire for nature experience (Svržnjak et al., 2014, p. 19).

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Today, the reasons for vacationing in rural areas have not fundamentally changed, considering that there is still a human need for a temporary escape from large, noisy cities to peaceful, rural environments. Motives for this type of vacation, such as peace and quiet, untouched natural surroundings, meeting and interacting with rural residents, local food, a slower pace of life, and the opportunity for recreation, contribute to the development and sustainability of rural tourism (Đenadić et al., 2016, p. 517). Rural tourism significantly contributes to the development of rural areas, stimulating entrepreneurship, contributing to employment, and improving the living standards of rural populations, thus influencing the better quality of life for local residents. The focus of this paper is the analysis of the role of rural tourism in the development of rural areas. Through examples of rural tourism in Europe, the goal is to highlight the significant contribution of rural tourism to the development of rural areas.

Literature review

In scientific and professional literature, there are different opinions regarding the definition of rural tourism, primarily influenced by the specific characteristics of rural areas and the resources available for the development of rural tourism (Dimitrovski et al., 2021). According to Rabotić (2013, p. 49), rural areas are characterized by natural resources, cultivable land, and rural settlements.

Key factors influencing the development of rural tourism include rural landscapes, authentic rural scenery, the lifestyle of rural populations, and diverse agricultural products, which enable the development of local gastronomic offerings (Lin et al., 2011; Avieli, 2013). Consuming local food and drinks provides tourists with the opportunity to familiarize themselves with local culture and tradition (Sims, 2009). Rural tourism, combined with gastronomic and wine products, can be a primary driver of the development of a rural area (Plummer et al., 2005).

The primary motives for tourists to visit rural areas include relaxation in untouched nature, engaging in agricultural activities, tasting local gastronomic specialties, brandies, and wines, participating in the preparation of traditional dishes, harvesting forest fruits or mushrooms, attending local events, getting acquainted with the culture and customs of rural communities, and engaging in recreational activities such as hiking, horseback riding, hunting, fishing, and more (Cvijanović & Ružić, 2017; UNWTO, 2004).

Milićević & Đorđević (2015) emphasize that rural tourists primarily seek to connect with nature while simultaneously getting acquainted with the culture, tradition, and way of life of rural inhabitants. They have the choice to spend their time in rural areas actively (e.g., participating in agricultural activities with their hosts) or passively (e.g., through a relaxing vacation in an authentic rural environment). Robinson & Murray (2020) note that rural tourism encompasses several specific types of tourism taking place in rural areas, overlapping with each other: ecotourism, nature-based tourism, gastronomic, wine, adventure, sports and recreational, hunting, fishing, cultural, ethnic, and event tourism.

Some authors, like Fleischer and Pizam (1997), highlight the economic aspect of rural tourism, defining it as leisure that focuses on tourists' recreational activities in a rural setting. For the rural host, this becomes a commercial activity, as they welcome tourists into their homes and generate income from it. Similarly, Muhi (2013, p. 130) emphasizes that rural tourism encompasses a broad spectrum of activities and services provided by rural populations on family estates to attract tourists and create additional income.

Through the development of rural tourism, rural areas can achieve numerous benefits, as it contributes to (Rural Tourism, 2023):

1. Providing additional income and employment opportunities for rural populations;
2. Developing rural infrastructure;
3. Reducing gender and other social inequalities;
4. Strengthening community bonds within the local population;
5. Preserving natural and cultural values;
6. Rehabilitating abandoned structures and putting them back into use;
7. Mitigating population migration from rural areas, and more.

Rural tourism significantly contributes to the development of rural areas and the improvement of the living standards of rural populations. This form of tourism plays a crucial role in the employment of women in rural areas and inactive segments of the population (Njegovan et al., 2015). It enables additional income for rural residents (Dimitrijević et al., 2022) through the sale of agricultural products and homemade goods, fostering entrepreneurial activities and the establishment of small family businesses. Rural tourism is not merely a supplementary activity to agriculture for additional income; it can be a primary occupation through which rural populations engage professionally (e.g., managing ethno households, ethno restaurants, or horseback riding schools) (Dimitrovski et al., 2021).

Rural tourism also helps prevent the decline of rural settlements. Tourism necessitates quality water, sewage, and transportation infrastructure, influencing the overall quality of life for rural residents and shaping the rural landscape. From a socio-cultural perspective, rural tourism is crucial (Vesić et al., 2022) as it facilitates interactions between rural populations and tourists from different parts of the world, encouraging the exchange of knowledge and experiences, especially significant for remote rural areas. Rural tourism effectively showcases the traditional hospitality of rural populations, their values, and provides an opportunity for the preservation and promotion of cultural material and non-material heritage (George et al., 2009).

Rural tourism in Europe and examples of good practices

Europe is a global leader in offering rural tourism (Muhi, 2013). The development of rural tourism in France, Germany, Austria, the United Kingdom, and Italy is based on identical goals: maintaining and strengthening agricultural production on family farms, social cohesion through the possibility of indirect employment, significant income generation through tourism services, and reducing depopulation in rural areas. For these reasons, rural tourism has become a strategic national interest manifested in various ways (Gašić et al., 2014, p. 39).

The best examples of successful rural tourism development can be observed in Alpine villages. Alpine destinations provide diverse tourist offerings, including courses on preparing traditional food and beverages, presenting authentic culture, traditions, and old crafts of rural areas, acquainting visitors with the local plant and animal life, and introducing them to traditional agricultural production, etc. (Pasinović, 2006).

Austria is known for its excellent model of rural tourism development. In the mid-20th century, the mountainous regions of Austria began facing depopulation, village abandonment, and developmental lag. Approximately 5,000 agricultural farms were ceasing operations annually. To counter this negative trend, the Austrian government decided to initiate the development of alternative non-agricultural activities, with rural tourism playing a significant role. They made the decision to introduce specific incentives and support for rural populations, aiming to preserve the unique Alpine agricultural production and promote the original traditions of these regions through the development of rural tourism (Demirović, 2016, pp. 32-33). They established a special national organization for rural tourism (Urlaub am Bauernhof) with the goal of supporting rural populations interested in developing tourism on their farms (Farm Holidays in Austria). Today, this organization represents over 2,200 of the most beautiful and best farms across all parts of Austria. It provides advisory services to farmers, assists in creating and promoting unique tourist offerings, conducts research on the tourism market, organizes training programs for rural populations, and advocates for their interests in the government. The organization facilitates entrepreneurial ventures related to rural tourism for farmers. Farms offer diverse tourism packages, including Activity Holiday in Summer, Family Holiday, Holidays for Couples, Holiday for Food Lovers, Healthy Holiday, Camping on the Farm, Vineyard Stay, Holiday in the Mountains, and Winter Holidays. These unique certified farms are categorized into 10 types: 1) Family farms; 2) Mountain cabins and chalets; 3) Country houses; 4) Vineyards; 5) Farms for babies and kids; 6) Organic farms; 7) Farms adapted for people with disabilities (Accessible farms); 8) Farms specialized for horse enthusiasts (Horse Farms); 9) Farms focused on vitality and longevity (Vitality farms); 10) Extraordinary farms. According to standardized procedures of this association, the quality of the tourist offerings is regularly monitored and evaluated, encompassing aspects such as courtyard aesthetics, farm facilities, and the variety of services and amenities offered to tourists. In line with this, each farm receives its categorization, represented by 2, 3, 4, or 5 flowers (Milićević et al., 2015; Urlaub am Bauernhof, 2023).

Rural tourists today prefer accommodation in authentic lodgings as they seek an experience of the original rural atmosphere (Pivac et al., 2016; Li et al., 2020). The rural tourist household is the most widespread form of accommodation in rural destinations (Dimitrovski et al., 2021). However, there are other types of accommodations that are highly attractive to rural tourists. One of them is the scattered hotel, which has been popular in Europe for many years. In England, this type of hotel is called a Widespread hotel or Scattered hotel, in France, it's known as Hôtel horizontal, and in Italy, it is referred to as Albergo diffuso. This type of accommodation is located in the historical core of a village and can encompass the entire village or several dispersed lodging units in the village (houses, rooms, apartments). The concept originated in the 1980s in the Friuli region of Italy, following a significant earthquake that caused extensive damage to many houses. The idea emerged from the need to revitalize old, abandoned, and ruined buildings and rural settlements. The goal was the revitalization of the historical core through tourism and the development of authentic rural tourist facilities. The emphasis was placed on preserving and promoting traditional culture and generating income for the rural community. It is not a conventional hotel but rather a collection of lodging units owned by different individuals scattered around the village, approximately 200 meters from the town center and the hotel's common areas (reception, restaurant, etc.). All lodging units are organizationally connected through a central reception. Each unit is uniquely decorated, with a focus on local tradition and authenticity. Creating such a hotel does not require constructing anything new; instead, it involves restoring existing houses and apartments in line with the local cultural and historical context and connecting already-existing facilities (UNDP, 2011; Svržnjak et al., 2014; Cvijanović & Ružić, 2017; Dimitrovski et al., 2021).

Conclusion

The examples of rural tourism development in Europe presented in this paper lead to the conclusion that rural tourism can be viewed as a catalyst for the development of rural areas. It stimulates the establishment of small family businesses and employment, particularly for women and inactive segments of the population. Additionally, it facilitates rural residents in selling their agricultural and other products, thereby generating additional income. All of these contribute to an improved standard of living for rural populations. Furthermore, rural tourism plays a role in preserving rural settlements from decline. Quality infrastructure is essential for the development of rural tourism, reflecting in an enhanced quality of life for rural residents. From a socio-cultural perspective, rural tourism is significant, enabling rural populations to interact with tourists from other countries and learn about their cultures and histories. On the other hand, rural tourism effectively showcases the traditional hospitality of rural populations, fostering the preservation and promotion of their cultural heritage.

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OPPORTUNITIES AND CHALLENGES FOR RURAL AREA TRANSITION TO GREEN GROWTH

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Abstract

In developing countries, such as Serbia, the transition to green economy models represents one of the key prerequisites for realizing sustainable rural development. Present study deals with the rural areas ecosystems and challenges connected to transitional process from brown to green economy. The aim of the paper is to point out problems for underdeveloped and developing countries correlated to the major challenges for rural areas. Also, study presents one of possible approaches for assessing the agricultural systems sustainability - the Sustainability Assessment of Food and Agriculture Systems (SAFA) indicators. Special focus is on describing holistic framework for assessing sustainability along the value chain of both the food and agriculture industries. As the innovation are suggested tool for green growth, the innovation projects in the fields of agriculture, food technology and food industry which are successfully implemented in Serbia where analyzed. Result showed that the largest number of green projects in the total number of projects, partly funded by The Innovation Fund of the Republic of Serbia, in the fields of agriculture, food technologies and food industry is approved within Collaborative Grant Scheme Program and Technology Transfer Program.

Key words: *agricultural systems, indicators, rural development, green growth, sustainability.*

Introduction

Green economy is defined as an economy that improves human well-being and reduces inequality, while not exposing future generations to significant

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environmental risk or ecological scarcity (UNEP Green Economy Initiative). This definition can be simplified into the form - green economy implies the reduction of the carbon footprint, while promoting resource efficiency and social inclusion. In addition to the term green economy, the term green growth is used by the World Bank (WB), Organization for Economic Co-operation and Development (OECD) and Global Green Growth Institute (GGGI), (Fedrigo-Fazio and Brink, 2012). Green growth involves fostering economic growth and development, while ensuring that natural assets provide the resources and services on which well-being is based (OECD Green Growth Report, 2011). These two terms are often equated, but the definition of green growth can be seen as an extension that refers to improving the resilience of ecosystems to changes (climatic and economic), as well as reducing the loss of biodiversity and ecosystem services. In addition, green growth in the context of economic benefits includes efficient sustainable business, the development of new skills and professions, the development of new products (processes and markets), and as particularly important, the revitalization and prosperity of communities in rural areas (European Network for Rural Development, 2017).

In addition to green growth, it is also important to mention extension of green growth syntagm inclusion green growth, which is interesting for developing countries. Inclusionary green growth is a synergy of green growth and inclusive growth (raising the standard of living). In this way, it is ensured that green growth is necessary, efficient and affordable (WB, 2012). This novel term is focused on the ecosystem and its resource conservation, which in conjunction with economic growth and social determinants, ensures that the principles of sustainability govern through all three spheres - economy, society and the environment.

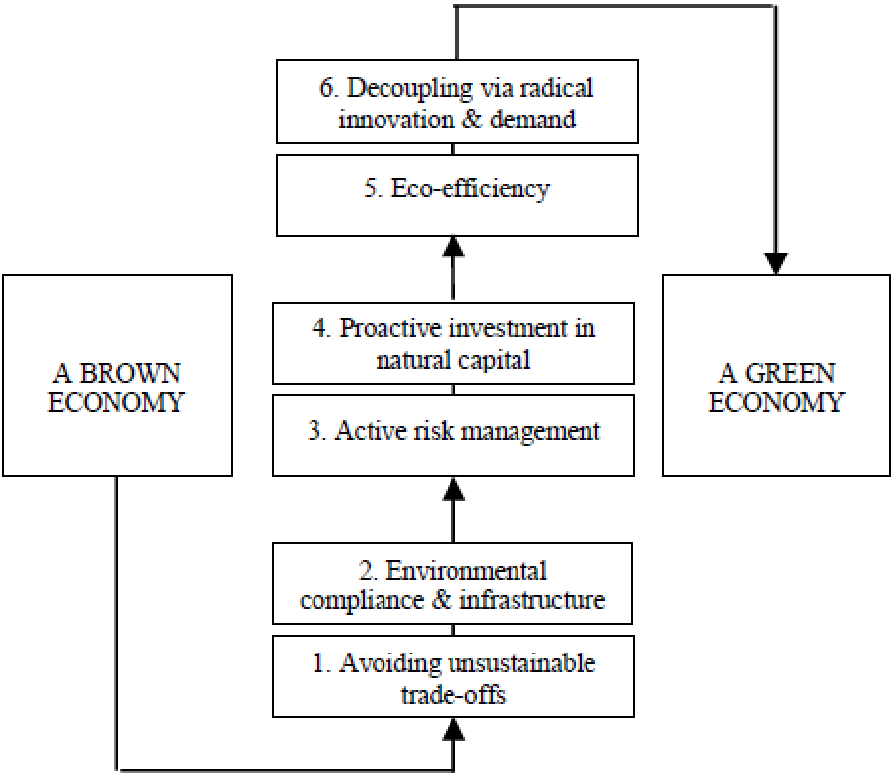
All defined phenomena are based on planetary boundaries (i.e. processes – nitrogen and phosphorus cycles, climate change, biodiversity changes, new chemicals, land use, water consumption, ocean acidification, depletion of the ozone layer) proposed by Rockström et al. (2009) where anthropogenic development is based on the state of the planet - natural systems limits and potential. This concept correlates to the rural areas ecosystems and challenges connected to transitional process from brown to green economy.

Sustainable development and green growth

The transition from the brown economy to the green economy requires a series of adaptations, which are a challenge for all countries and societies, depending on their state or development in different areas (natural resource quality and availability, education, technology, economy, social determinants, EU membership, communication with neighboring countries etc.), (European Network for Rural Development, 2017). In underdeveloped countries there are problems related to the lack of food, water, energy sources, but also adequate sanitation, health, transport and education systems, and poverty is an accompanying social determinant. In developing countries, industrial production is often not sustainable, that is, resources are used irrationally, with increased waste production, there are problems with waste management, with a strong negative impact on the environment and health. Developed countries, that is, societies that have high adaptation to sustainable development, challenges are related to further ways of reducing the carbon footprint, the efficiency of production processes and the use of renewable resources, the transition to green occupations, etc.

The listed problems for underdeveloped and developing countries correlated to the major challenges for rural areas. Additionally, the six main foundations of the transition from brown to green economy for rural areas are defined as (Figure 1): 1 - avoiding unsustainable trade, 2 - environmental compliance and infrastructure, 3 - active risk management, 4 - proactive investment in working capital, 5 - eco-efficiency, 6- separation through radical innovations and demanding changes. These foundations relate to the way of doing business (1 and 2), active management of the environment (3 and 4) and achieving environmental sustainability (5 and 6), (Fedrigo-Fazio and Brink, 2012). Challenges for achieving rural green growth are often related to developing countries and concern the analysis the impact of various factors such as regional characteristics (such resources, industry, education, market of agriculture and its products distortion, unequal environmental legislative implementation).

Figure 1. Six building blocks in the transition to the green economy in rural areas



Source: European Network for Rural Development, p. 6.

One of the factors recognized as a driver of economic development in modern society are innovations. The link between innovations and growth can be explained through the link between technological progress and productivity growth on both the social and production levels (Jia et al., 2023). In addition, the implementation of biotechnology, the use of waste as a resource and promotion and implementation the principles of circular business model will enable reduction the need for new resources consumption. The essential step for innovation implementation in practice are realization projects based on technology transfer, product upgrade (improvement or production *up scale*) and clean / green technology development and connection of academic sector with industry.

Framework for assessing sustainable food and agriculture industry

Back in 1992, at the United Nations Conference on Environment and Development held in Rio de Janeiro, two important documents were adopted: Agenda 21 and the Declaration on Environment and Development. These documents later were used as the basis to the promotion and implementation of sustainability concept. In the context that we consider in this work/paper, it is important to note that the aforementioned Agenda 21 devotes an entire chapter to sustainable agriculture and rural development. Sustainability is a topic that is at the center of all current debates in the social, political, economic and environmental fields. It is a concept that is not easy to analyze, perceive and follow, so it requires an integral and multidisciplinary framework. Creating the methodologies and tools to assess sustainability has become an increasing area (Binder, Feola & Steinberger, 2010).

Although agriculture continues to be an important lever for growth and development, the fact is that it faces constraints such as the devastation of natural resources, climate change, genetically modified organisms, soil degradation, loss of biodiversity, intensive use of agrochemicals, resulting increase in rural poverty etc. New directions are emerging that strive for sustainable development of agricultural production, paying much more attention to ecological standards.

Sustainable agriculture preserves diversity, improves soil resources, protects waterways, provides healthy food, reduces producers' dependence on external sources and provides a reliable source of income for producers. There are many of context-generic frameworks that have been made for those purposes of agricultural systems.

The one of possible approach for assessing the sustainability of agricultural systems developed by FAO (Food and Agriculture Organization of the United Nations) - the SAFA (Sustainability Assessment of Food and Agriculture Systems) indicators. It is a relatively young methodology (framework) since it was presented in the fall of 2013. The specificity of SAFA is that „*covers a wider range of industries (cropping, livestock husbandry, forestry, fisheries and aquaculture) and a wider range of sustainability dimensions and aspects – especially in relation to the governance dimension – and it targets a diversity of stakeholders (e.g. supply chain stakeholders, policy makers and non-governmental organizations*)“ (Gasso et al., 2014; Gasso, 2014).

SAFA is a holistic framework for assessing sustainability along the value chain of both the food and agriculture industries. Its characteristic is that it is applicable on a global level. It has been prepared so that companies, whether large or small, that are involved in production, processing, distribution or sale, understand the components of sustainability and the means and methods for its improvements. The target group of the SAFA project is small, medium, large companies, organizations and all other interested parties involved in agriculture, livestock, forestry and fishing.

Table 1. Overview of SAFA default indicators per themes and sub-themes

<table>
<tr><th>Sustainability dimension (4)</th><th>Themes (21)</th><th>Sub-themes (58)</th><th>Number of defaults indicators (116)</th></tr>
<tr><td rowspan="16">GOOD GOVERNANCE

(5 Themes, 14 Sub-themes, 19 default indicators)</td><td rowspan="2">Corporate Ethics</td><td>Mission Statement</td><td>2</td></tr>
<tr><td>Due Diligence</td><td>1</td></tr>
<tr><td rowspan="3">Accountability</td><td>Holistic Audits</td><td>1</td></tr>
<tr><td>Responsibility</td><td>1</td></tr>
<tr><td>Transparency</td><td>1</td></tr>
<tr><td rowspan="3">Participation</td><td>Stakeholder Dialogue</td><td>4</td></tr>
<tr><td>Grievance Procedures</td><td>1</td></tr>
<tr><td>Conflict Resolution</td><td>1</td></tr>
<tr><td rowspan="4">Rule of Law</td><td>Legitimacy</td><td>1</td></tr>
<tr><td>Remedy, Restoration and Prevention</td><td>1</td></tr>
<tr><td>Civic Responsibility</td><td>1</td></tr>
<tr><td>Resource Appropriation</td><td>2</td></tr>
<tr><td rowspan="2">Holistic Management</td><td>Sustainability Management Plan</td><td>1</td></tr>
<tr><td>Full-Cost Accounting</td><td>1</td></tr>
</table>

Sustainability dimension (4)	**Themes (21)**	**Sub-themes (58)**	**Number of defaults indicators (116)**
ENVIRONMENTAL INTEGRITY (6 Themes, 14 Sub-themes, 52 default indicators)	Atmosphere	Green House Gases	3
		Air Quality	3
	Water	Water Withdrawal	3
		Water Quality	4
	Land	Soil Quality	5
		Land Degradation	3
	Biodiversity	Ecosystem Diversity	5
		Species Diversity	4
		Genetic Diversity	5
	Materials and Energy	Material Use	4
		Energy Use	4
		Waste Reduction and Disposal	4
	Animal Welfare	Animal Health	2
		Freedom from Stress	3
ECONOMIC RESILIENCE (4 Themes, 14 Sub-themes, 26 default indicators)	Investment	Internal Investment	1
		Community Investment	1
		Long Ranging Investment	2
		Profitability	3
	Vulnerability	Stability of Production	2
		Stability of Supply	3
		Stability of Market	1
		Liquidity	2
		Risk Management	1
	Product Quality and Information	Food Safety	3
		Food Quality	1
		Product Information	3
	Local Economy	Value Creation	2
		Local Procurement	1

Sustainability dimension (4)	**Themes (21)**	**Sub-themes (58)**	**Number of defaults indicators (116)**
SOCIAL WELL-BEING (6 Themes, 16 Sub-themes, 19 default indicators)	Decent Livelihood	Quality of Life	2
		Capacity Development	1
		Fair Access to Means of Production	1
	Fair Trading Practices	Responsible Buyers	1
		Rights of Suppliers	1
	Labor Rights	Employment Relations	1
		Forced Labor	1
		Child Labor	1
		Freedom of Association and Right to Bargaining	1
	Equity	Non-Discrimination	1
		Gender Equality	1
		Support to Vulnerable People	1
	Human Safety and Health	Workplace Safety and Health Provisions	3
		Public Health	1
	Cultural Diversity	Indigenous Knowledge	1
		Food Sovereignty	1

Source: adopted according to SAFA Sustainability Assessment of Food and Agriculture systems indicators, p. 3-7.

As it is presented above in Table 1. SAFA framework is structured according to several hierarchical or aggregation levels (i.e. dimensions, themes, subthemes and indicators). The most general level comprises four sustainability dimensions. At the intermediate level, each dimension comprises a few themes (21) and subthemes (58) that are the elements associated with specific sustainability goals and objectives. At the most specific level, each subtheme comprises indicators (116) that are measurable and verifiable factors based on a five-scale performance rating (i.e. best performance, intermediate performances with room for improvement, and unacceptable performance), (FAO, 2013).

SAFA is focused on supply chains and treats a lot of elements such as an analysis of the inputs, outputs and environmental impacts. It can be useful for: 1. Food and agriculture enterprises (for self-evaluation of operations and identifying hot-spots for performance improvement), 2. Non-governmental organizations

(NGOs) and wider communities (monitoring outcomes of impacts of projects, sharing of, and global learning on best practices) and 3. Governments, investors and policy makers (informing the establishment of Sustainable Development Goals, implementation of regional planning, local procurement, investment or the development of legislation etc.), (Scialabba, 2013, p. 5).

Transition to green models of rural development in Serbia

In developing countries such as Serbia, the application of green economy and its concepts of circular economy and bioeconomy represents one of the key prerequisites for realizing sustainable rural development. Their simultaneous application can enable efficient transformation of local economy (new job openings on farms, diversification of activities by enabling new job in secondary and tertiary sectors and improving life quality in rural areas) owing to numerous economic, social and ecological effects. Sustainable development of rural areas means promoting green development based on using rural resources more efficiently, preserving and improving the rural environment, sustainable management of land and the protection of biodiversity (Josipović, 2018).

The transition to green models of rural development in Serbia is hindered by numerous problems such as: the usage of outdated technological machinery, insufficient training of agricultural producers in implementation of necessary quality standards, low efficiency of agro-food sector, unfavorable age structure of rural population, structural problems in job market performances, insufficient human capital due to unfavorable educational structure of rural population, low prevalence of entrepreneurial activities and underdevelopment of entrepreneurial spirit among rural population, low quality in terms of public services provision, the underdevelopment of rural infrastructure etc.

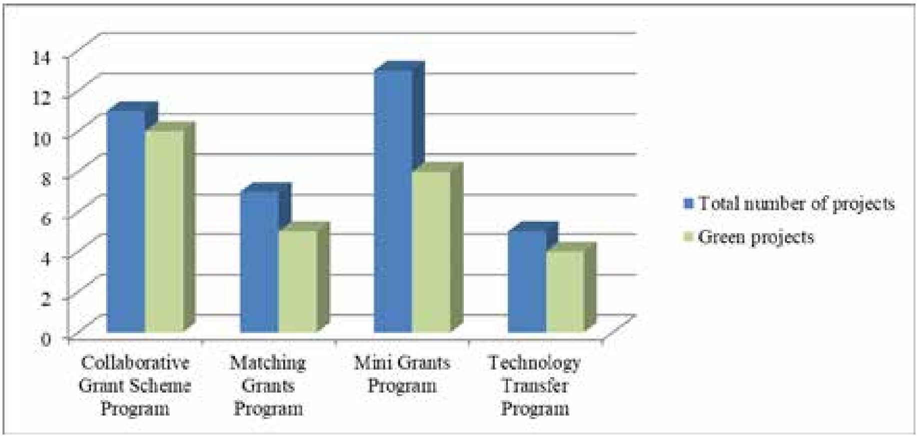
In order to improve the efficiency of agro-food sector and preserve natural resources and the environment, it is necessary to provide financial support for the realization of green investment projects. The key characteristics of efficient projects that support and encourage the transition to green economy are (European Network for Rural Development, 2017, p. 2): they are led by demand and occur as a response to social problems and economic conditions, innovative projects (they include new products, new services, new technologies, new business models and/or upgraded old ones etc.), create balance between economic, social and ecological goals, involve multiple actors from public and private sphere, heterogenous financing sources (private capital and public financing sources), publishing and promoting results etc.

The Innovation Fund of the Republic of Serbia (IF RS) supports the development of rural economy through different projects in the fields of agriculture, food technologies and food industry. The aim of these projects is to increase the competitiveness of agriculture, to improve the food quality and promote the development of small and medium-sized businesses and entrepreneurs. They are approved within four programs:

- *Collaborative Grant Scheme Program* – focused on strengthening the co-operation between science and economy through scientific research projects and development projects;
- *Matching Grants Program* – focused on strengthening the competitiveness of private enterprises by giving support to the development of innovative technologies, products and services;
- *Mini Grants Program* – focused on giving financial support to new enterprises which develop technological innovations, and
- *Technology Transfer Program* – focused on giving support to research projects with a view to efficiently commercializing the developed inventions.

Most projects in the fields of agriculture, food technologies and food industry that are approved withing the four mentioned programs promote the application of the principles of green economy and can be defined as green projects for the development of rural economy. Graph 2 shows the total number of projects and the number of green projects approved in the fields of agriculture, food technologies and food industry partly funded by IF RS.

Figure 2. Projects in the fields of agriculture, food technologies and food industry supported by IF RS



Source: adopted according to Innovation Fund of the Republic of Serbia

Within the four programs shown on Graph 2, 36 projects in the fields of agriculture, food technologies and food industry were approved in total. Their total value is €7,504,123, while Innovation Fund granted €5,234,641. Out of the total number of projects, 27 can be categorized as green projects. Their total value is €5,847,686, while Innovation Fund granted €4,089,620.

The largest number of green projects in the total number of projects in the fields of agriculture, food technologies and food industry is approved within Collaborative Grant Scheme Program and Technology Transfer Program (91% and 80% respectively). Within Matching Grants Program, they take up 71%, while within Mini Grants Program 62%.

Agriculture will continue to be important in the transition to green rural economy, but no longer from the perspective of providing jobs for rural population, but from the perspective of environmental and natural heritage protection (Josipović, 2019, p. 60). Rural areas in Serbia are characterized by good climate and rich natural resources suitable for different types of agricultural production. Based on previous they have a chance in the following fields: the development of organic plant and livestock production, the possibility of branding new products and services which are based on local identity and tradition, and which have recognizable characteristics and quality and the development of different types of rural tourism (Josipović, 2018, p. 178). Multifunctional agriculture, the diversification of rural economy, branding and promoting high-quality local products, local entrepreneurial initiatives and the preservation of rural ecological, social and cultural values represent the main components of future green growth of rural areas in Serbia.

Conclusion

Sustainability is a topic that is at the center of all current debates in the social, political, economic and environmental fields. New directions are emerging that strive for sustainable development of agricultural production, paying much more attention to ecological standards. The transition from the brown economy to the green economy requires a series of adaptations, especially in the field of food and agriculture industry that is one of the key sectors of the development of rural areas. SAFA is a holistic framework for assessing sustainable food and agriculture industry. In Serbia the application of green economy is one of the key prerequisites for realizing sustainable rural development. Green projects that are funded by the Innovation Fund of the Republic of Serbia are important for the achievement of the goals of sustainable rural development.

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THE IMPORTANCE OF QUALITY IN THE DEVELOPMENT OF RURAL TOURISM IN ARANDJELOVAC

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Abstract

This paper explores the importance of quality in improving rural tourism, focusing on the municipality of Arandjelovac as an example. It examines how the quality of accommodation, services, offers, and the environment contributes to the development of the tourist attraction of the rural areas of the municipality of Arandjelovac. Through the SWOT analysis, the strengths, weaknesses, opportunities and dangers that affect the quality of the tourist offer in rural communities are listed. This paper also explores the possibilities of improving the quality of services through educating the local population, promoting sustainable tourism, as well as investing in infrastructure and diversifying the tourist offer. The goal is to understand how quality can be a factor in improving rural tourism at the local level, using the municipality of Arandjelovac as a case study.

Key words: *rural tourism, quality, Arandjelovac, village.*

Introduction

Rural areas in the district of Sumadija represent an exceptional potential for growth and development. In this paper, the main emphasis is placed on the importance of quality in rural tourism, which occupies an increasingly dominant role. Specifically, the topic of the work is based on the quality of rural tourism development in the territory of the municipality of Arandjelovac, as well as the importance of quality in the provision of services in the entire tourist offer. The identification of the potential of rural resources in this area is significant, and the implementation of tourism activities additionally emphasizes the importance of rural areas in the economic and social context.

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Rural tourism

Contemporary tourism trends are characterized by an increasing orientation towards rural destinations, increasingly pronounced personalization, increased special interests and a significant concentration of tourists on non-standard tourist products (Čomić, 2002). Rural tourism is a common name for activities and forms of tourism that develop in rural areas (Ružić, 2009). Thanks to the natural, ecological (Cvijanović, et al, 2003) and ambient characteristics, different rural environments are a very interesting and perspective area for the development of this specific type of tourism (Vuković, et al, 2010). The quality-of-service provision is, as confirmed by many studies, one of the crucial factors that tourists name when they rate their stay in a tourist destination (Vujović, et al, 2012).

Quality of services in rural tourism in the municipality of Arandjelovac

The quality of services and content has a key role in the development of rural tourism, and the example of the municipality of Arandjelovac can serve as an illustration of how quality can be implemented to improve this type of tourism. For the development of rural tourism, it is important to ensure a high standard of services and experiences for visitors. This includes preserving the authenticity of local culture, traditions and natural beauty, as well as providing quality accommodation, food, recreational activities and opportunities to learn about the local way of life. The importance of providing high-quality services is essential in order to provide visitors with an authentic rural tourism experience (Hill, 2005).

Promotion of local traditions, amenities, folklore heritage is done through various cultural manifestations, workshops or museums (Marble and Sounds Exhibition, National Museum of Arandjelovac municipality, art colony "Sergejev san", painting colony in Orasac, etc.). The quality of accommodation and catering services is possible through the provision of various accommodation options (Vila "Aleksandar" in Orasac, a large number of country houses and households, etc.). For a better experience of the rural environment, it is necessary to develop more sports and recreational activities, such as hiking, cycling, horseback riding (there are a large number of trails on Bukulja, a bicycle trail that goes from Arandjelovac, which through the village of Banja leads to Topola, the equestrian club Arandjelovac). Sustainability and environmental awareness are very important for rural tourism, i.e. raising awareness of the importance of preserving the environment, encouraging environmentally responsible practices and supporting local initiatives that encourage sustainable development.

Quality in rural tourism is not only reflected in services, but also in the overall experience that visitors gain while staying on the countryside. This can include a sense of welcome, authenticity of experience and the opportunity to interact with the local culture. The municipality of Arandjelovac can improve its offer in rural tourism and become an even better example of successful development of rural tourism, with the implementation of high-quality standards.

Municipality of Arandjelovac

The municipality of Arandjelovac, as a part of Šumadija district in central Serbia. The distance between Arandjelovac and Belgrade is 75 km, from Mladenovac about 24 km, while the distance from Kragujevac is 52 km. According to statistical data, the municipality of Arandjelovac ranks third in the district in terms of its size. It occupies an area of 367 square kilometers, of which 68.1% is agricultural land and 23.7% forest land. The municipality of Arandjelovac consists of 18 more rural settlements that are rich in natural resources and which are in the tourist offer of the city of Arandjelovac. Authentic products, unique services, numerous contents are just some of the many factors that rural settlements provide to interested visitors. The rural settlements of the municipality of Arandjelovac are: Banja, Bosuta, Brezovac, Bukovik, Venčane, Vrbica, Vukosavci, Garaši, Gornja Trešnjevica, Darosava, Jelovik, Kopljare, Misača, Orašac, Progoreoci, Ranilović, Stojnik, Tulež. Today, according to the data of the last population census (2022), there are about 41,301 inhabitants living at the territory of the municipality of Arandjelovac. The most developed branches are agriculture and farming, and animal husbandry. The most fertile land in the Arandjelovac municipality is located at the Kubršnica valley. Orchards occupy 3,200 hectares, with plums and apples as the leading fruts. In the past two years, the number of raspberry, blackberry, blueberry and hazelnut plantations has increased. In the territory of the Šumadija district, in the last five years, the growth of vineyards and the number of wineries has been observed. Vineyards in the municipality of Arandjelovac occupy about 300 hectares. Meadows and pastures cover about 5,500 hectares.

The largest number of farms are family farms (99.85%) and the rest are legal entities. A total of 313 farms are specialized in sheep, 505 of them deal with mixed livestock mainly for grazing and not for milk production, however there are most of those dealing with different combinations of crops and livestock (970). In total, 11,078 people are engaged in agriculture in Arandjelovac. According to the above data, rural settlements have a great potential for rural tourism.

Agriculture

Based on the data presented, rural households in the municipality of Arandjelovac show potential for expanding of their activities. The development of additional activities, such as tourism, can significantly contribute to the growth of these households. The construction of new facilities has the potential to attract tourists and encourage their arrival in these rural areas. Rural tourism as well as agritourism take place in the village and represent a chance for the development of such areas. The return of young people to rural farms leads to the revival of remote rural households with the realization of numerous benefits.

In the rural settlements, there are a large number of registered households that provide tourist services and offer their authentic products. Tourists who visit a rural household have the opportunity to participate in various activities as well as to try numerous specialties prepared in the traditional way. The hospitality and traditional values of the Sumadija region are recognized throughout Serbia and beyond, and for this reason, attendance is increasing year by year.

Table 1. Basic information

	Number of
Agricultural households	4.782
Annual work units	4.756
Two-axle tractors	2.977
Livestock	11.946

Source: *Popis poljoprivrede, RZS, http://devinfo.stat.gov.rs/ (retrieved 25.12.2023)*

Table 2. Agricultural land in use (hectares)

	Number of
Yard	468,57
Arable land and gardens	9.155,13
Orchards	1.451,49
Vineyards	61,26
Other permanent orchards	0,06
Meadows and pastures	5.306,08
Total:	16442,59

Source: *Agricultural census*, *RZS*, *http://devinfo.stat.gov.rs/ (retrieved 25.12.2023)*

Table 3. Livestock, 2012.

	Number of
Cattle	4355
Pigs	17810
Sheeps	28158
Poultry	89503
Total:	139826

Source: *Agricultural census*, *RZS*, *http://devinfo.stat.gov.rs/ (retrieved 25.12.2023)*

Rural households

Table 4. Registered rural households

R.B.	Rural tourist households	Number of stars	Accomodation units capacity
1.	Garaške breze	4	14 beds, 21 persons
2.	Bukovički mir	4	3 beds, 4 persons
3.	Vajati Bosutica	4	2 objects, 4 beds, 8 persons
4.	Kuća za odmor Gornja Trešnjevica	4	3 beds, 6 persons
5.	Paunove stene	3	5 beds, 6 persons
6.	Vajat Orašac	3	1 bed, 2 persons
7.	Šumadijska kuća	3	5 persons

Internet source: *https://arandjelovac.org/seosi-turizam/(retrieved 25.12.2023)*

Based on the collected data from the Republic Institute of Statistics, 226 farmers were registered in the territory of the municipality of Arandjelovac. Below, there is a description of rural tourist households that provide overnight services, as well as other contents. The data was collected from the tourist organization of Arandjelovac.

The mentioned rural households offer tourist services to interested visitors and thus deal with tourism, which they improve every day. Promotion is carried out through the Arandjelovac tourist organization. Tourist traffic records growth from year to year. The quality of rural households is also shown through the categorization of buildings. The organized infrastructure significantly contributes to the increase in the number of visitors.

Tourist traffic

The following is an overview of tourist traffic in the territory of the municipality of Arandjelovac collected from the Republic Institute of Statistics in 2022 (table 5). It should be emphasized that domestic tourists dominate in the number of visits as well as in the number of overnight stays.

Table 5. Tourist traffic in the municipality of Aranđelovac, 2022.

Turists			Overnight stays			Average number of stays	
Total	Domest. tour.	Forign tour.	Total	Domest. tour.	Forign tour.	Domest. tour.	Forign tour.
34808	29283	5525	106277	89172	17105	3.0	3.1

Internet source: *https://www.stat.gov.rs/sr-cyrl/oblasti/ugostiteljstvo-i-turizam/turizam/ (retrieved 25.12.2023)*

In rural households, the most common are visitors who stay there for a short time, usually on weekends or during holidays. Families with children or couples often choose this type of vacation. The rural area offers a wide range of activities that tourists can enjoy during their stay. Agritourism additionally enriches the experience of tourists. Table 5 provides data on tourist arrivals and overnight stays in 2022, and Table 6 provides data for 2021. There is a noticeable increase in the number and arrivals of tourists in 2022. This increase is attributed to innovations in tourism and new households engaged in rural tourism. Promotion and marketing played a significant role in promoting the rich tourist offer of Arandjelovac and its surroundings. The following is a presentation of the realized tourist traffic in 2021, according to the data of the Republic Institute of Statistics.

Table 6. Basic data on the number of domestic and foreign tourists in 2021.

Tourist stays	Number
Domestic (2021)	25542
Foreign (2021)	4041
Overnight stays	
Domestic (2021)	62855
Foeign (2021)	12954
Average number of overnight stays	
Domestic (2021)	2.5
Foreign (2021)	3.2

Source: *Statistical Office of the Republic of Serbia*[4]

4 Internet source: http://devinfo.stat.gov.rs/, *(retrieved 25.12.2023)*

An example of the most visited rural households in the municipality of Arandjelovac

The quality of services in rural tourism is of great importance. Visitors' satisfaction comes first. Categorization of facilities guarantees tourists a certain quality, which is shown by the number of stars. The most visited rural households that provide accommodation services and have a high rating on the Booking.com platform at the territory of the municipality of Arandjelovac are: *Vajati Bosutica, Bukovicki mir, Garaske breze*.

Vajati Bosutica, located in the village of Bosuta, 19 km from Arandjelovac and 95 km from Belgrade. They are categorized with four stars. Each of the two buildings has four beds. This farm offers a variety of activities, tailored to the needs of tourists. In the complex are: swimming pools, sauna, gym, massages, table football, volleyball courts, badminton and indoor football. There are five hiking trails ranging in length from 3 to 15 km. The bicycle path leads from Bosuta to Belanovica, and guests can use free bicycles. The food offered is homemade and traditional.

Rural household *Bukovički mir* in the village of Bukovik, 5 km from Arandjelovac. The categorization of the facility with four stars indicates a high quality of services. This accommodation, which offers three beds for four people, is equipped with a modern kitchen, bathroom, internet, swimming pool, parking, a spacious yard and a summer house.

Garaske breze is located in the village of Garaši, which is 13 km from Arandjelovac and has four stars. Garaske breze consists of four houses of different accommodation capacity, where a total of 22 people can stay. All houses are equipped with kitchen, fridge, TV, bathroom and each has its own terrace. In addition, Garaske breze has a restaurant for 35 people.

SWOT analysis

Table 7. SWOT analysis of the quality of rural

Strenghts	Weaknesses
Accessibility and proximity to major cities Categorization of objects Facilities in harmony with the environment Authentic products and services Active tourism in rural households Traditional values Cultural and historical contents Arranged footpaths Proximity to Bukovička Spa and thermal mineral springs Cooperation with TO Arandjelovac	Insufficient familiarity with rural tourism trends Insufficient education of the local population Investments and subsidies Underdeveloped environmental protection Lack of newly built accommodation facilities Seasonality Climatic conditions Lack of tourist guides
Opportunities	**Threats**
Raising awareness regarding the importance of the environment Construction of these accommodation units Cultivation of new varieties of agricultural products Involvement of tourists in agrotourism Enhanced marketing promotions Introduction of additional signaling and road signs	Lack of accommodation units Lack of subsidies Lack of professional staff Migration to cities Climatic conditions Seasonality

By looking at a rural tourism and the quality of services provided by rural households at the territory of the municipality of Arandjelovac, a SWOT analysis was made that looks at the strengths, weaknesses, opportunities and dangers for the development of rural tourism. Innovations introduced every day attract many tourists.

Measures for improvement

Based on the SWOT analysis, measures can be taken to improve the development of rural tourism in the territory of the municipality of Arandjelovac:

- Education of the local population through programs and trainings,
- Raising awareness of the importance of the environment,
- Influence on local self-government for additional subsidies,
- Construction of new accommodation units in accordance with the environment,

- Seasonality is generally present in the tourism industry, so it is necessary to adjust the offer of rural products and services to tourists in each season,
- Climatic conditions affect agricultural products, this should also be worked on, with the application of certain measures and instruments that will be based on the protection of agricultural crops from negative climate changes,
- The lack of tourist guides can be overcome in cooperation with the local self-government, by allowing qualified persons to obtain a license.

Conclusion

The quality of services offered in rural households is a key link in attracting and satisfying visitors. The main factors that attract tourists are: categorization of facilities, the emphasized presence of authentic products and services, traditional values, and variety of activities. In addition, the analyzed facilities, such as *Vajat Bosutica*, *Bukovički mir* and *Garaška breza*, which are highly rated on platforms such as Booking.com, emphasize the importance of quality in the provision of accommodation services. Given the emphasized importance of visitor satisfaction, the focus on maintaining the high quality of services in the rural tourism of the municipality of Aranđelovac is crucial for the further development of this sector.

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OPTIMIZING AGRICULTURAL SUSTAINABILITY THROUGH INDOOR SMART GARDENS[1]

Branko Mihailović[2], Vesna Popović[3], Katica Radosavljević[4]

Abstract

This study explores the integration of indoor smart gardens as a pivotal element for advancing sustainable development in agriculture. The implementation of smart technologies within indoor gardening systems offers a transformative approach to agricultural practices, fostering resource efficiency, environmental conservation, and increased crop yields. The research delves into the technological aspects of smart gardening, emphasizing sensor networks, automated climate control, and data-driven decision-making processes. By leveraging these innovations, farmers can maximize resource utilization, minimize environmental footprint, and boost agricultural productivity. Additionally, the study investigates the economic feasibility and scalability of indoor smart gardens, considering their potential to address food security challenges in a rapidly changing global climate. The findings highlight the significance of smart agriculture in contributing to sustainable development goals and shaping the future of agriculture. The primary objective of this research is to provide valuable insights for policymakers, farmers, and technology developers. This will contribute to the development of a more resilient and sustainable agricultural sector.

Key words: *indoor smart garden, sustainable agriculture, smart technologies, resource efficiency, agricultural productivity.*

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Introduction

Agriculture plays a crucial role in sustaining human existence by providing the essential nourishment needed for survival (Olawepo et al., 2020). As a result, the pursuit of sustainable development in agriculture has gained significant importance due to pressing global challenges, including population growth, climate change, and resource scarcity. Home gardening is recognized as a vital modern trend, reflecting society's growing environmental consciousness. The effective use of smart sensors for wireless communication offers economical solutions for real-time home gardening management systems (Min, Park, 2018). Indoor smart gardens have emerged as a promising solution to address these challenges by integrating advanced technologies and controlled environments. These gardens leverage smart technologies such as Internet of Things (IoT) devices, sensors, automation, and data analytics. By doing so, they offer a potential pathway towards achieving sustainable agricultural practices.

The main aim of this study is to investigate the contribution of indoor smart gardens to sustainable development in agriculture. Through a comprehensive review of the existing literature, our objective is to analyze the advantages and challenges associated with implementing indoor smart gardens. Furthermore, we will explore the implications of these gardens for promoting sustainable agricultural practices. Swift technological advancements have found application in numerous domains, including agriculture (Hadi et al., 2020). Indoor smart gardens offer a controlled environment where critical parameters such as light, temperature, humidity, and nutrient levels can be precisely regulated. This controlled environment offers several advantages over traditional farming methods. By mitigating external factors like adverse weather conditions, pests, and diseases, indoor smart gardens contribute to improved crop productivity and reduced yield losses. The controlled environment also enables year-round production, ensuring a consistent supply of fresh produce to meet the demands of a growing population.

The automation of garden monitoring processes has the potential to revolutionize garden irrigation. It can transform the traditional manual and static method into a smart and dynamic approach. This results in increased convenience, improved water efficiency, and reduced human supervision required (Al-Omary et al., 2018). The integration of smart technologies in indoor smart gardens enhances resource efficiency and reduces environmental impact. With the utilization of IoT devices and sensors, these systems facilitate real-time monitoring and data collection. This enables data-driven decision-making and adaptive control, enhancing the overall efficiency and effectiveness of the garden management process. Advanced data analytics techniques can optimize resource utilization, minimizing water consumption, nutrient waste, and energy usage. Moreover, the targeted application of nutrients and the reduction of chemical pesticides contribute to improved food safety and environmental sustainability.

While indoor smart gardens show great promise for promoting sustainable agriculture, their widespread adoption faces certain challenges that need to be addressed. Key considerations include the initial investment costs, technological requirements, and scalability of these systems. Overcoming these challenges requires continuous research and development efforts, as well as the establishment of supportive policies and market mechanisms.

Through an exploration of indoor smart gardens as a catalyst for sustainable agricultural development, this study seeks to contribute to the scientific understanding of resource-efficient farming practices. The research findings have the potential to inform policymakers, farmers, and stakeholders, enabling them to make informed decisions regarding the adoption and integration of indoor smart gardens into their agricultural systems.

Application of smart technologies in modern agriculture

Smart agriculture has transformed from being a mere technology for improving human life to becoming a necessity, if not an obligation. This transformation is driven by the pressing need to meet the ever-increasing global food demand, which continues to multiply at an alarming rate (Bhuvaneswari, Priyanka, 2021). The Earth's water resources are facing significant challenges due to population growth, rapid urbanization, and the impacts of climate change. To address this issue, the implementation of wireless networks of soil-moisture sensors can play a crucial role in monitoring soil water content. This approach enables highly efficient utilization of water resources, ensuring their effective management and conservation (Abbas et al., 2014).

The application of smart technologies in modern agriculture has revolutionized the way we cultivate crops and raise livestock. The collective advancements in agriculture, often referred to as "Precision Agriculture," hold immense potential for increasing productivity, minimizing resource wastage, and fostering sustainable farming practices. One exciting innovation within this field is the concept of an indoor smart garden.

Namely, indoor smart gardens are a testament to the evolving landscape of agriculture. These systems leverage various smart technologies to cultivate plants indoors, regardless of external environmental conditions. Let's delve into the key aspects of indoor smart gardens and their role in modern agriculture. These gardens exemplify the innovative application of smart technologies in agriculture. These systems provide a platform for efficient, year-round cultivation with minimal environmental impact. As technology continues to advance, we can expect Indoor Smart Gardens to play an increasingly pivotal role in urban farming, local food production, and sustainable agriculture practices. Key components of indoor smart gardens:

- Sensors: indoor smart gardens are equipped with a variety of sensors that continuously monitor and collect data on crucial environmental conditions. These sensors measure parameters such as temperature, humidity, light levels, and soil moisture, providing valuable insights for efficient garden management. This data is crucial for ensuring optimal growing conditions. Advancements in technology are facilitating the retrofitting of existing machines with automation, giving rise to the emerging field of Internet of Things (IoT) (Kuppusamy, 2016).

- Automation: automatic garden monitoring and control involve the continuous, autonomous monitoring of all parameters without the need for human intervention (Ramya et al., 2021). Automation is a core element of these gardens. Based on data from the sensors, automated systems can control lighting, watering, and nutrient distribution, ensuring that plants receive the right care at the right time.

- LED grow lights: in the current era of mechanization, it is difficult to conceive of any activity that does not rely on technology (Muhtasim et al., 2018). To compensate for the absence of natural sunlight, indoor smart gardens use advanced LED grow lights, which can be customized to mimic the spectrum of natural sunlight. This boosts plant growth and helps maintain a steady supply of fresh produce year-round.

Indoor smart gardens function by utilizing a network of sensors and automated systems within a controlled environment. This setup enables precise monitoring and adjustment of variables such as humidity, light, temperature and soil moisture. LED grow lights replicate natural sunlight, hydroponic or aeroponic systems provide optimal nutrient delivery, and automation ensures timely watering and care, facilitating year-round, resource-efficient, and climate-resilient cultivation, while minimizing pesticide use and offering educational opportunities.

Review of the leading smart garden brand

In the pursuit of greater resilience and a commitment to resource conservation, individuals are showing an increased inclination towards cultivating their own food. However, they often lack the necessary gardening expertise and education in water conservation practices (Penzenstadler et al., 2018). While farming and gardening have seen continuous improvements through the integration of computers and electronic devices over the years, the term "smart garden" typically pertains to compact indoor systems that employ diverse methods to signal users when it's time to supplement nutrients (https://www.pcmag.com).

If one desires to cultivate herbs in a domestic setting or seeks to infuse vitality and vibrancy into their workspace or living area, Click & Grow emerges as the preeminent solution for smart indoor gardens. For those lacking innate botanical acumen, the endeavor of home cultivation may remain unexplored. However, Click & Grow, as the frontrunner in the realm of smart gardens, empowers individuals to engage in indoor plant cultivation through its streamlined installation process and low-maintenance garden systems. Exhibiting commendable proficiency in facilitating the growth of edible herbs, fruits, vegetables, as well as aesthetically pleasing ornamental plants and flowers, Click & Grow excels in simplifying gardening practices while ensuring optimal efficiency (https://www.takealot.com).

The act of growing herbs within the confines of one's abode not only enhances the convenience of meal preparation but also facilitates the consumption of organically nurtured produce free from pesticides and toxic substances, thereby imbuing each culinary experience with self-nurtured nutrients. Nevertheless, the benefits of owning an indoor garden extend beyond the consumption of personally grown produce. While contemporary urban landscapes predominantly consist of concrete edifices, the splendor of nature remains unparalleled. When seeking respite from urban enclaves, individuals rarely seek solace in another urban environment, as the presence of nature constitutes an essential element of the human experience. Herbs and plants, among other organic entities, offer profound emotional, mental, and spiritual benefits merely through their presence and interaction.

For those with an inherent agricultural inclination or embarking on their maiden foray into home farming, Click & Grow provides an unparalleled opportunity to sow seeds and reap the rewards firsthand. The rapid growth and the immersive experience of the entire process prove astonishing. Distinctive to these smart gardens is their remarkable low-maintenance nature. Merely setting up the system, plugging it in, and periodically monitoring water levels suffices. As the plants approach the overhead LED light, the primary task entails adjusting the distance between the light source and the plant by adding suitable attachments. Commence your journey into indoor gardening today, and revel in a more invigorating ambiance within the confines of your home or office.

Click & Grow offers a diverse selection of smart soil pods and smart indoor gardens, ranging from modest 3-pot systems to expansive 51-pot arrangements. From strawberries and tomatoes to basil and beyond, the possibilities for kitchen-based cultivation are virtually boundless with Click & Grow at one's disposal (https://www.clickandgrow.com).

The integration of aerogarden: a smart indoor garden revolutionizing home plant cultivation

With the evolution of digital technology, contemporary society is becoming increasingly knowledgeable and interconnected, with interactions occurring among humans, objects, and networks (Woo, Suh, 2021). If one is already acquainted with the seamless integration of the iPhone into daily life, they are undoubtedly aware of the heightened efficiency and enhanced experiences it brings to both work and leisure activities. The iPhone empowers users with control over calendars, communications, and overall connectivity. However, despite its remarkable capabilities, one domain that remains beyond the iPhone's reach is the autonomous cultivation of fresh produce. Enter AeroGarden, the smart indoor garden engineered to bridge this gap and revolutionize home plant cultivation.

For those harboring a desire to embark on home gardening endeavors but exhibiting hesitancy in testing their green thumb, AeroGarden seamlessly assimilates into one's everyday routine, much like the iPhone. Functioning as a low maintenance garden, AeroGarden shoulders the burdensome tasks associated with home cultivation, liberating individuals from the arduous responsibilities (https://www.aerogarden.com).

In a manner befitting the iPhone's classification as a smartphone, AeroGarden assumes the role of a smart garden. Consequently, its operation entails minimal effort on the part of the user. Merely setting up the system initiates its enchanting capabilities. Ponder a world devoid of your iPhone's presence. To make a phone call, one would need to journey to the abode of a friend or family member and request the use of their device. A similar analogy can be drawn between AeroGarden and the local grocery store. While procuring fresh produce, including herbs and vegetables, from supermarkets has become second nature, envision the convenience of strolling over to your indoor garden and harvesting produce of your own creation. AeroGarden empowers individuals to cultivate vegetables within the confines of their homes, enabling the growth of salad essentials or the introduction of aesthetically pleasing plants to enhance their living spaces. The icing on the cake? Unlike traditional soil-based methods that necessitate weeks of anticipation, AeroGarden accelerates the growth process, yielding homegrown goodness five times faster.

Analogous to the iPhone's extended battery life that outlasts most individuals' social stamina, AeroGarden emerges as the smart indoor garden that packs a mighty punch in plant cultivation. Nevertheless, it is imperative to dispel any misconceptions. This indoor garden does not rely on batteries for operation; instead, it adopts a straightforward plug-in and setup configuration. AeroGarden nurtures plants by providing an optimal growing environment where their roots are exposed to a combination of air and water (https://www.amazon.com/AeroGarden-901100-1200-Harvest-Black/). This symbiotic relationship ensures an ideal nutrient balance, expediting the growth trajectory. The installation process merely involves inserting the plant pods, adding water and the provided plant food, switching on the system, and relinquishing control as the automated marvel takes charge, allowing users to unwind and indulge in relaxation.

Distinguished from its counterparts in the realm of smart indoor gardens, AeroGarden harnesses the full spectrum of plant-growing light to expedite the sprouting process. However, thanks to its fully automated system, users need not burden themselves with the intricacies of the scientific mechanisms at play.

For individuals harboring aspirations to cultivate vegetables, plants, or any other form of produce within the confines of their homes, AeroGarden emerges as the supercharged smart garden solution, redefining the parameters of home plant cultivation.

Contribution of indoor smart gardens to sustainable agricultural development

Home gardening is an increasingly important trend driven by growing environmental consciousness in society. The use of smart sensors with wireless communication capabilities offers cost-effective solutions for real-time management systems in home gardening (Olawepo et al., 2020). Indeed, home gardening has emerged as a significant trend that reflects society's increasing environmental awareness. By leveraging efficient wireless communication through smart sensors, cost-effective solutions for real-time home gardening management systems can be achieved. Indoor smart gardens, an innovative application of precision agriculture and technology, offer significant contributions to the advancement of sustainable agricultural development. From a scientific standpoint, the following points emphasize their role (Mihailović et al., 2023):

- Resource efficiency: indoor smart gardens epitomize resource efficiency through precision agriculture. These systems utilize a suite of sensors and automation to fine-tune the conditions in which plants grow. By delivering the exact amount of water, nutrients, and light required, they minimize resource waste. This precision also leads to higher crop yields and quality, maximizing the efficient use of resources while reducing the need for excessive irrigation and fertilization.

- Year-round cultivation: traditional agriculture often faces seasonal limitations due to weather conditions. Indoor smart gardens, however, operate independent of external factors, allowing for uninterrupted crop cultivation throughout the year. This year-round production can significantly bolster food security by ensuring a continuous supply of fresh, locally grown produce. Moreover, it reduces the need for expanding farmland, which can lead to deforestation and habitat destruction.

- Climate resilience: as the world faces the challenges of a changing climate, indoor smart gardens offer a degree of resilience. By providing a controlled environment, these gardens can shield crops from extreme weather events, temperature fluctuations, and shifting precipitation patterns. This resilience is vital for maintaining stable food production in the face of unpredictable climate conditions.

- Reduction of pesticide use: the precise monitoring and early detection capabilities of indoor smart gardens empower growers to detect and address pests and diseases in a targeted manner. As a result, the reliance on chemical pesticides, which can have detrimental environmental impacts, is reduced. The diminished reliance on pesticides promotes healthier ecosystems and minimizes chemical residues in the harvested produce, enhancing food safety.
- Local food production: indoor smart gardens are well-suited for urban and localized food production. By bringing agriculture closer to consumers, indoor smart gardens help to minimize the carbon footprint associated with transporting food over long distances. This aligns with sustainable agricultural principles, emphasizing the importance of locally sourced products, which can support regional economies and reduce emissions from food transportation.
- Educational opportunities: indoor smart gardens serve as valuable educational tools. They engage individuals in hands-on experiences related to agriculture and horticulture, fostering a deeper understanding of plant growth and ecosystem dynamics. This education encourages more people to become involved in sustainable food production and promotes the adoption of eco-friendly practices. Additionally, these gardens can be integrated into educational institutions, further strengthening the knowledge base on sustainable agriculture.

In summary, indoor smart gardens offer multifaceted contributions to sustainable agricultural development. Their resource-efficient nature, year-round cultivation capabilities, climate resilience, reduced pesticide use, promotion of local food production, and educational potential collectively make them a powerful asset in addressing the challenges of modern agriculture while promoting environmental sustainability.

Conclusions

The indoor smart garden is not merely a technological innovation but a transformative force in agriculture, with far-reaching implications for sustainable development. Its multifaceted contributions, from resource efficiency and year-round cultivation to climate resilience and reduced pesticide usage, underscore its vital role in mitigating the environmental impact of traditional farming practices.

By promoting local food production and serving as an educational tool, it bridges the gap between consumers and producers, fostering community resilience and fostering a deeper understanding of the food production process. In an era marked by climate uncertainty and growing global populations, the indoor smart garden emerges as a crucial solution for ensuring food security and environmental sustainability. As we advance further into the 21st century, this technology stands as a beacon of hope, guiding us toward a more responsible, resilient, and sustainable future in agriculture.

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THE SIGNIFICANCE OF DIGITAL TRANSFORMATION IN AGRICULTURE FOR SUSTAINABLE DEVELOPMENT

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Abstract

This paper examines the crucial role of digital transformation in the agricultural sector for global sustainability and progress. Focusing on the integration of advanced technologies such as precision farming, data analytics, and artificial intelligence, the study explores their impact on optimizing processes and increasing productivity. The paper emphasizes how digital transformation empowers farmers with real-time data, facilitating informed decision-making on crop management, resource utilization, and environmental conservation. It also discusses the socio-economic benefits, including improved market access for smallholder farmers and rural development. In the context of the COVID-19 pandemic, the paper highlights the significance of digital technology in communication, knowledge-sharing, and virtual platforms for trade. Additionally, it emphasizes the importance of application of digital technologies in agricultural education, particularly for remote rural areas. The article also addresses the challenges within the agricultural supply chain and investigates the current state of blockchain technology, focusing on its potential to transform agriculture.

Key words: *Digital transformation, Agriculture, Sustainable development, Artificial intelligence (AI), Education, Blockchain technology.*

Introduction

In modern agriculture, digital transformation is a defining force, steering the sector towards global sustainability and progress. This paper explores its crucial role in reshaping agricultural practices, emphasizing sustainability on a global scale. It lays the groundwork for an in-depth examination of the impact of digital technologies,

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including precision agriculture, data analytics, and artificial intelligence, on optimizing processes, increasing productivity, and contributing to overarching goals of global sustainability. A key aspect is empowering farmers through real-time data, facilitating informed decision-making in crucial areas like crop management, resource utilization, and environmental conservation. Mobile phones and the internet, as highlighted in a recent World Bank report, play a transformative role in agriculture by enhancing inclusion, efficiency, and innovation through overcoming information barriers, improving market access for small-scale farmers, and revolutionizing agricultural supply chain management, yet the full realization of these benefits is hindered by persistent barriers in poorer countries. (Deichmann et al., 2016)

Beyond the environmental impact, the paper also sheds light on the socio-economic benefits that accrue to smallholder farmers from digital technology. This includes not only improved access to markets but also the stimulation of rural development through the adoption of these digital solutions. The integration of such technologies goes beyond simply boosting productivity and it actively contributes to economic growth within agricultural communities that have historically been overlooked. The core message is that the adoption of digital technologies, including IOT (Internet of Things), cloud-based tools, and UAV (Unmanned Aerial Vehicles)-based remote sensing, has greatly improved the efficiency and productivity of agriculture. This allows farmers to remotely manage their farms, utilizing data from sensors and drones to make real-time decisions. The integration of these technologies offers a more streamlined and data-driven approach to farming practices, leading to increased overall productivity in the agricultural sector (Abiri et al., 2023).

The COVID-19 pandemic highlights the vital role of digital technology in agriculture, specifically in communication, knowledge-sharing, and virtual trade platforms. The paper explores how digital solutions have maintained connectivity within the agricultural sector during challenging times, emphasizing their significance in agricultural education, particularly in remote rural areas, to ensure accessible knowledge and information for all. Very important prerequisite for digital transformation is road infrastructure and education, especially for rural areas. (Trendov et al., 2019)

The paper explores blockchain technology's potential to revolutionize agriculture, addressing challenges in the supply chain by offering transparency, traceability, and security. Blockchain can combat fraud and inefficiencies, contributing to a more robust and reliable agricultural ecosystem. In the European Union, the Common Agricultural Policy (CAP) seeks to improve farming through various methods, ensuring market stability, farmers' well-being, and fair prices for consumers. The main goal is to make sure there's enough food for people in the EU, and it does this in a way that helps the environment and makes rural areas diverse and prosperous. It's important that the success of rural areas doesn't only depend on farming (Constantin et al., 2021).

The paper advocates widespread adoption of digital transformation in agriculture for global sustainability and progress. Emphasizing the importance of ongoing research and development in digital technologies, it promotes their application in education, communication, and supply chain management to unlock the full potential of a digitally empowered agricultural sector.

Methodology

The methodology used in this research paper involves a comprehensive analysis of the role of digital technologies in reshaping the agricultural sector. The research encompasses various aspects, including the implementation of precision farming, data analytics, and artificial intelligence (AI) in agriculture, the model of sustainable development in agriculture, challenges within the agricultural supply chain, the impact of COVID-19 on digitalization in agriculture, and the current state of blockchain technology in agriculture. Throughout the paper, the methodology involves a thorough examination of each topic, providing insights into the implementation of digital technologies, sustainable development practices, challenges, and the role of blockchain technology in agriculture. The information is supported by examples, data, and a holistic view of the evolving landscape of agriculture in the digital era.

1. Implementation of precision farming, data analytics, and AI in agriculture

1.1. Precision farming in agriculture

Precision farming optimizes agricultural practices through tailored inputs, utilizing GPS, satellite imagery, drones, Variable Rate Technology (VRT), automated machinery, and data analysis. This approach enhances resource efficiency, minimizes environmental impact, and increases crop yields by reducing waste. GPS technology tracks equipment and guides resource allocation, while satellite imagery and drones monitor crop health. VRT customizes input rates, and automated machinery ensures precise farming operations. Data management empowers informed decision-making. This transformative practice aligns with evolving sustainable and efficient agricultural needs, improving economic outcomes for farmers and fostering an environmentally responsible sector.

1.2. Data analytics in agriculture

Data analytics in agriculture extracts insights from extensive data on weather, soil, crop health, and machinery performance, enhancing decision-making and productivity. Predictive analytics anticipates future scenarios like crop yields and disease outbreaks, aiding planning. Precision agriculture, guided by data analytics, provides insights into spatial variability for precise resource application. Real-time monitoring using sensors, satellite imagery, and drones minimizes the risk of crop loss. Beyond the farm, data analytics optimizes the agricultural supply chain by forecasting demand, managing inventory, and improving logistics. Big data analysis in agriculture addresses weather conditions, distribution, and storage issues, playing a crucial role in the industry. It proposes a solution involving real-time analysis of weather, soil, market conditions, and storage capacity using big data analysis with the Hadoop framework. The paper employs Pentaho BI for reporting and decision-making, providing interactive reports and customizable dashboards for easier understanding and decision-making at the user interface. (Kumar et al., 2017)

Farmers benefit from data-driven decision support systems, powered by analytics, providing recommendations based on factors like weather conditions and market trends. Machine learning algorithms improve tasks such as crop classification, disease detection, and yield prediction, continuously enhancing accuracy. The environmental impact of farming, covering water usage, soil health, and ecological sustainability, is also evaluated. Analytics transforms varied datasets into actionable insights, empowering farmers to make informed decisions, optimize resources, and efficiently advance sustainable farming practices.

1.3. Artificial intelligence (AI) within the agricultural sector

The integration of AI in agriculture is driven by technological advancements such as big data analytics, robotics, IoT, drone technology, and widespread internet access in geographically dispersed fields. (Eli-Chukwu, 2019)

Precision farming utilizes AI data analysis, sourced from satellite imagery, to optimize processes and increase resource efficiency. Predictive analytics, powered by AI, assist in anticipating crop yields, weather patterns, and market trends, which are crucial for strategic planning in agriculture. Smart irrigation systems use AI to optimize water usage, taking into account factors such as soil moisture and weather forecasts. The growing global population and expanding food processing industry necessitate addressing rising food needs through enhanced supply chain management, reduced food waste, and improved delivery and storage, with artificial intelligence and machine learning playing a crucial role in achieving these goals by optimizing supply chains, predicting maintenance in food processing machinery, detecting crop diseases, enabling smart irrigation, predicting crop yields, tracking perishable foods, analysing soil and weather data, and more. (Pallathadka et al., 2022)

AI has significantly contributed through the optimization of processes and resources, improvements in the quality and reliability of production, prevention of work stoppages due to necessary maintenance, and the formation of teams composed of humans and robots. (Dash et al., 2019)

1.3.1. Crop Monitoring and Management

Crop Monitoring and Management, facilitated by AI technologies, represents a significant advancement in agriculture. AI-driven Crop Monitoring analyses drone or sensor-captured images using computer vision, precisely identifying diseases, pests, and nutrient deficiencies. This empowers farmers with targeted interventions for proactive and effective crop health management, streamlining the monitoring process and providing actionable insights.

1.3.2. Precision Farming with AI

AI is instrumental in precision agriculture, leveraging data from diverse sources like satellite imagery and sensors. This analysis provides farmers with profound insights into crop conditions, allowing precise adjustments of resources-water, fertilizers, and pesticides-tailored to the specific needs of each field section. The application of AI extends to autonomous vehicles, equipped with advanced AI capabilities, ensuring exceptional precision in tasks such as planting, harvesting, and weeding. The significance of AI in Precision Farming is multifaceted. Firstly, it facilitates the analysis of large datasets, offering valuable insights for optimized resource allocation. Secondly, through autonomous vehicles, AI enhances precision in various agricultural tasks, minimizing losses and boosting overall productivity. Thirdly, AI's role in sustainability is evident through reduced resource consumption and minimized environmental impact. In essence, AI's importance in Precision Farming lies in its capacity for resource optimization, increased yields, and the sustainable management of agricultural processes.

1.3.3. Predictive Analytics

AI revolutionizes precision agriculture by analysing data from sources like satellite imagery and sensors, providing profound insights into crop conditions. It enables precise adjustments of resources water, fertilizers, and pesticides tailored to each field section's specific needs. AI extends to autonomous vehicles, ensuring exceptional precision in tasks such as planting, harvesting, and weeding. Its multifaceted role includes analysing large datasets for optimized resource allocation, enhancing precision in agricultural tasks, and promoting sustainability by reducing resource consumption and environmental impact. In essence, AI's significance in Precision Farming lies in resource optimization, increased yields, and sustainable agricultural management.

1.3.4. Smart Irrigation

AI optimizes smart irrigation systems by employing advanced algorithms to meticulously consider factors like soil moisture, weather forecasts, and crop types. This ensures efficient irrigation practices, minimizing water waste and enhancing crop yields. The dynamic and responsive approach of AI in real-time adaptation to environmental conditions further conserves water resources. Smart irrigation, driven by AI, promotes environmental responsibility and increased productivity in crop cultivation, underscoring its transformative impact on resource efficiency and agricultural sustainability.

1.3.5. Supply Chain Optimization

AI revolutionizes supply chain management, optimizing logistics, enhancing demand forecasting, and streamlining inventory. This approach ensures the efficient flow of agricultural products, minimizing wastage and fostering sustainability. AI applications bolster productivity and usher in an era of smarter, data-driven decision-making, reducing delays and strategically allocating resources for a sustainable and efficient agricultural distribution ecosystem. In conclusion, AI's profound influence on supply chain management showcases its potential to redefine the future of agriculture through ongoing technological advancements.

1.3.6. Farm Robotization

In agriculture, the deployment of AI-driven robots revolutionize agriculture by automating tasks like planting, weeding, and harvesting, reducing reliance on manual labour for heightened operational efficiency. This intervention not only cuts labour costs but also minimizes human errors in agricultural processes. AI driven robots ensure precision and accuracy in crop management, leading to higher yields and improved product quality. Aligning with sustainability goals, farm robotisation promotes resource efficiency and reduces environmental impact. The ongoing integration of AI into farm operations highlights the potential for increased productivity and sustainable farming practices.

1.3.7. Chabot's and Virtual Assistants

AI-driven Chabot's and virtual assistants enhance the agricultural landscape by providing real-time support to farmers. These tools offer instant access to dynamic data, including current weather conditions, market prices, and optimal farming practices. Empowered with this information, farmers can make informed decisions promptly, adapting to changing agricultural environments. Virtual assistants, with natural language processing capabilities, contribute significantly to decision-making by interpreting queries and providing valuable insights seamlessly. The integration of AI powered Chabot's streamlines decision-making processes, increasing efficiency and productivity in agriculture. Their intuitive nature fosters inclusivity, catering to the diverse needs of farmers in day-to-day operations.

1.3.8. Disease and Pest Detection

AI algorithms revolutionize disease and pest detection in crops using image recognition and sensor data. Swift identification of signs enables an early warning system for farmers, allowing timely interventions to mitigate potential adverse effects on crop yields. AI's capability to accurately recognize visual cues and interpret sensor data empowers farmers to implement precise strategies, contributing significantly to the resilience of agricultural practices. By facilitating swift responses to emerging issues, AI-driven disease and pest detection helps protect yields and promote sustainable farming practices.

1.3.9. Climate Resilience

AI is instrumental in assisting farmers to adapt to climate change by offering insights into dynamic weather patterns and recommending adaptive farming practices. Through AI driven decision support systems, complex datasets are analysed to provide actionable insights, offering recommendations on optimal planting times, fertilizer utilization, and pest control strategies. This integration of artificial intelligence significantly enhances efficiency, minimizes resource waste, and promotes sustainable farming practices. As technology advances, AI is anticipated to play an increasingly vital role in addressing the challenges confronting the agricultural sector. In conclusion, the implementation of digital technologies in agriculture is unmistakably impactful, optimizing processes, and fostering increased productivity.

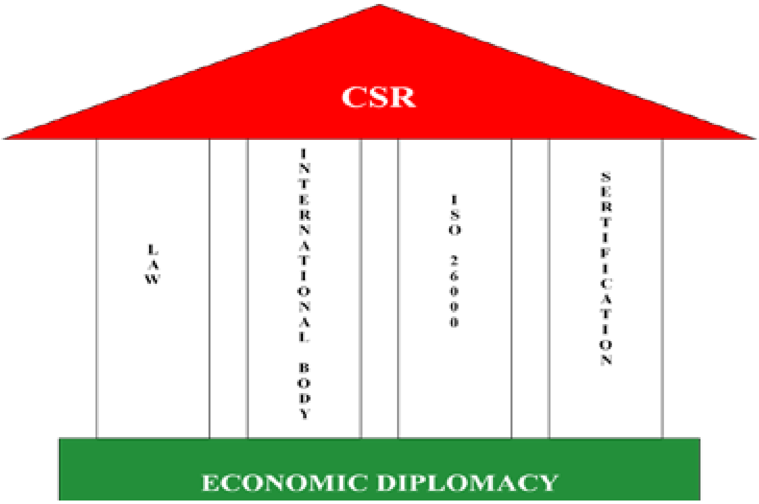
2. Model of sustainable development

The Sustainable Development Model in Agriculture integrates environmentally conscious and socially equitable practices, promoting economic, social, and environmental sustainability. It encompasses precision farming, organic agriculture, and resource-efficient technologies to optimize crop yields while minimizing environmental impact. This model aims to foster responsible land use, biodiversity conservation, and fair labour practices, benefiting farmers, local communities, and the ecosystem. By implementing this model, agriculture can evolve into a sustainable and resilient system that meets present needs without compromising future generations.

The Governance Assessment Checklist by the Enterprise Europe Network - European Union, introduced to evaluate sustainability in business practices, particularly for SMEs, aligns with UN Sustainability Development Goals. This checklist assesses governance, environmental and social practices, economic impact, and supply chain sustainability, providing a final score for a company's sustainability level and areas for improvement. Initiated in 2020, this framework, developed by an expert group within the Enterprise Europe Network, aims to enhance sustainability practices at different organizational levels, with insights from distinguished experts contributing to impactful sustainability practices which included co-author Sanja Popović Pantić. (Sustainability support services for SMEs – how to create sustainability assessment checklist introduced by the. Enterprise Europe Network - European Union, 2020). The Social Impact and Environmental Impact Assessment Checklists complement governance assessment by addressing aspects like sustainable personnel management, diversity, gender equality, health measures, waste reduction, resource conservation, and carbon footprint. Together with the Economic Impact Assessment Checklist, evaluating the company's appeal to environmentally conscious consumers and investment in R&D for sustainable innovations, these checklists form a comprehensive methodology to assess and improve sustainability practices across various organizational dimensions.

Meadows' model suggests that the agricultural sector, utilizing half of habitable land, poses a critical limit to human civilization's growth due to environmental pollution and global warming; however, modern digital technologies, including AI and drones, hold the potential to enhance agricultural efficiency, reduce waste, and alleviate environmental impact, thereby extending the limits to future human civilization growth. (Bogomolov et al., 2021). The crucial for adequate implementation of socially responsible behaviour is appropriate model which can be the atomic structure of CRS or house of socially responsible behaviour. It is essential to clearly define measurement criteria through the enactment of CSR laws, the establishment of an international body adhering to the ISO 26000 standard for CSR control, and the certification of socially responsible companies. Success in implementing CSR relies on a strong foundation, economic diplomacy, and pillars that prioritize legal compliance, including the formation of a body for the control and certification of companies in accordance with the ISO 26000 standard. (Dejanović, 2015)

Picture 1. Foundations and pillars of successful CSR implementation



Source: Dejanović, M., (2015). Socially responsible behaviour and economic diplomacy. Zadužbina Andrejević, 75-75.

2.1. Challenges Within the Agricultural Supply Chain

Challenges in the agricultural supply chain, impacting efficiency, sustainability, and productivity, include logistic inefficiencies, unstable raw material prices hindering long-term planning, transparency issues affecting quality management, climate-related production risks, diverse regulatory standards, and a technological gap limiting efficiency and innovation. The world is currently grappling with significant challenges, primarily cantered not only on an energy supply crisis but, more importantly, on producing an adequate amount of food. This challenge is influenced by factors such as energy availability, fertilizers, protective measures, climate conditions, and disruptions in the supply chain, exacerbated by the rising costs of transportation. The concern extends beyond a potential food shortage to include a risk of diminishing the quality of human nutrition. With the economic crisis and escalating prices, there is a looming danger that consumers may resort to cheaper, lower-quality products, leading to a reduction in the quantity of purchased goods. (Dejanović, 2023).

A lack of education and support for farmers in accessing information and resources can hinder the adoption of best practices and modern technologies. Addressing these challenges is crucial to enhance the agricultural supply chain, optimize resources, and promote sustainable agricultural practices.

Recently, people have been using operations research or to make farming better, but not many farmers are using it because it's tricky. It's hard to show all the complicated things happening in farms with math. As we try to use this math in bigger areas and include more people to make farming stronger and better for the environment, we need to stop just looking at one thing and start looking at everything together. (Higginset et al., 2010)

There are new ways of using complicated science to understand how farms work, like using computer models and looking at how things are connected. Farmers and experts need to think about farms as tricky systems that can change and adapt for the future to succeed. Implementation of digital technology changing farming and rural areas, showing examples how it helps in agricultural development and what things are needed, like better infrastructure and education. (Mironkina, et al, 2020)

2.2. COVID-19 and digitalisation in agriculture

Digital technologies have become pivotal in overcoming the challenges posed by the pandemic, allowing for remote monitoring, reducing supply chain disruptions, and enhancing overall resilience. The COVID-19 pandemic prompted diverse policies, not only in medicine but also in global economies. Protectionist measures emerged, contradicting the traditional neoliberal economic policy and principles of globalization. This shift reflected a prioritization of safeguarding national economies, indicating a revaluation of the balance between global interconnectedness and national interests. (Dejanović, 2022)

Digitalization aids in economic recovery post-pandemic, boosting productivity and profitability. It enables efficient resource management, process optimization, and adaptation to market changes. Online platforms become vital for sales during movement restrictions, maintaining connectivity between producers and consumers. However, concerns arise regarding unequal access to technology, particularly for farmers with limited resources.

Inflation, driven by factors like demand-pull, cost-push, and built-in mechanisms, affects input prices in agriculture. The analysis of data from 1973 to 2022 reveals varying correlations between the implicit price deflator and different input categories, suggesting that input prices for labour and machinery are more closely aligned with general inflation than those for items like feed, seed, fertilizer, and fuels. (Langemeier, 2022)

Ensuring data security is crucial for the sustainable integration of digital technologies in agriculture, particularly amidst the COVID-19 pandemic. This safeguards operational stability, enhances efficiency, and contributes to a sustainable future in agriculture.

3. Current state of Blockchain technology in agriculture

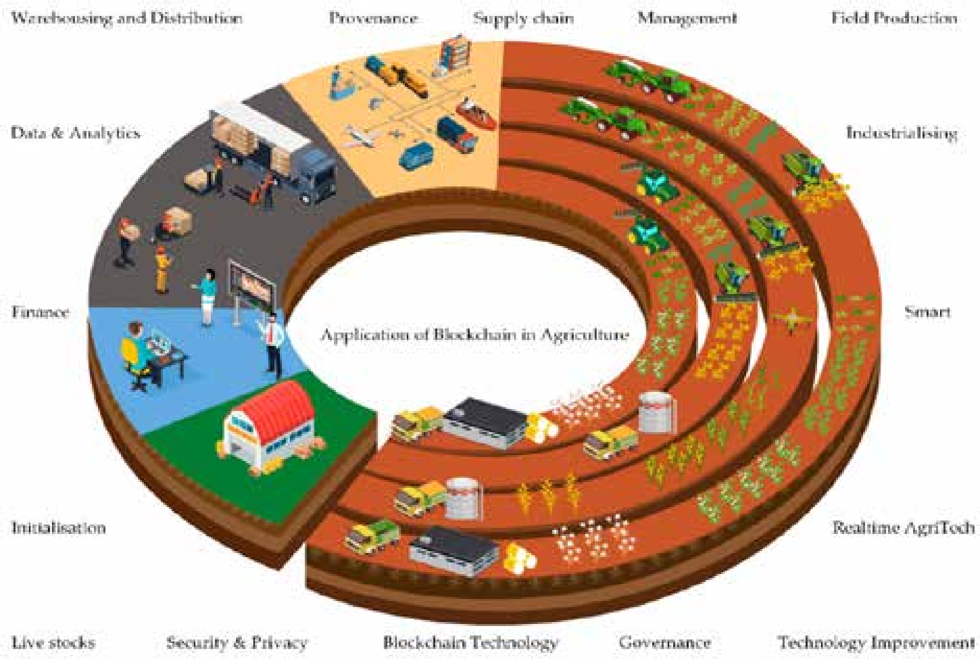
Investigation into the current state of blockchain technology and its potential to revolutionize and transform agriculture. The agricultural sector plays a crucial role in the global economy but faces a range of challenges, including supply chain complexities, the need for transparency, and data security. In this context, blockchain technology, as a distributed database with features such as traceability, transparency, data immutability, and security, becomes a revolutionary solution that can reshape the agricultural sector. This innovation enables tracking every step in the food supply chain, from production inception to end consumers, and is already being applied in various projects and companies. For instance, IBM Food Trust and Agri Digital use blockchain to enhance transparency in the supply chain, while projects like Provenance and TE-FOOD demonstrate how the technology can be utilized for tracking product origin and authenticity. All participants in the supply chain have access to the same information thanks to blockchain, contributing to a reduction in the risks of fraud and counterfeiting, while simultaneously improving food safety. Recording every step-in production, from the field to the store, provides consumers with a crucial tool to trace the food path. This is particularly important for ensuring product quality and efficiently tracking product origin, especially in situations where product recall is necessary. The application of smart contracts on the blockchain allows the automation of key processes, such as monitoring weather conditions, inventory management, and dynamic price adjustments, facilitating more efficient resource management and business optimization for farmers. The direct connection between farmers and investors through smart contracts offers opportunities for microfinancing, easing access to finances and providing farmers with favourable conditions to market their products. Interoperability and integration of blockchain with other technologies, such as the Internet of Things (IoT) and artificial intelligence (AI), open up new possibilities for improving efficiency and productivity in agriculture.

For example, integrating IoT devices allows for precise monitoring of field conditions and gathering large data sets. This data, when combined with blockchain technology, ensures secure collection and storage, providing insights that can optimize resource use and reduce waste. Such technological synergy not only aids in data and process standardization but also facilitates compliance with national and international regulations, which is crucial in a globalized food supply chain. This integration is anticipated to foster a comprehensive approach in food handling, where factors such as environmental change, human behaviour, and economic aspects are combined to assess food safety hazards, with blockchain further enhancing data privacy and security. (Bhat et al., 2021)

The environmental aspect of blockchain technology is also vital. Tracking ecological practices and verifying them through this technology allows farmers to document their sustainable methods and increase consumer awareness of environmental issues. This, in turn, can stimulate demand for sustainably produced food, contributing to biodiversity preservation and reducing carbon footprint.

Despite the numerous advantages it offers, blockchain technology in agriculture faces significant challenges, including scalability, latency, privacy, cost, energy consumption, and interoperability. (Nurgazina et al., 2021) Key issues such as the scalability of the technology, the high costs of implementation and maintenance, the necessity for specialized technical knowledge, regulatory hurdles, and concerns related to privacy and compliance with standards all require careful consideration. The costs associated with adopting blockchain technology can particularly pose a barrier for smaller farmers, underscoring the need for developing solutions that are both more accessible and scalable. The widespread adoption and optimal use of blockchain in agriculture hinge on overcoming these technical and regulatory challenges, as well as providing support to smaller agricultural producers to help them navigate and adapt to this new technological era.

Picture 1. Application of blockchain in various verticals of the agriculture domain



Source: Krithika, L.B., (2022). Survey on the Applications of Blockchain in Agriculture. Agriculture, 12(9), 1333.

Conclusion

In conclusion, this paper underscores the transformative impact of digital transformation in agriculture, optimizing processes, increasing productivity, and fostering global sustainability. Integration of advanced technologies like precision farming, data analytics, and artificial intelligence empowers farmers with real-time data for informed decision-making on crop management, resource utilization, and environmental conservation. Socio-economic benefits, including improved market access for smallholder farmers and rural development, underscore the significance of digitalization. Amid the COVID-19 pandemic, digital technology is pivotal in communication, knowledge-sharing, and virtual trade platforms. The paper stresses the importance of digital technologies in agricultural education, especially in remote rural areas. Addressing challenges within the agricultural supply chain, the study explores the potential of blockchain technology to enhance transparency and efficiency. The paper advocates for widespread adoption of digital transformation in agriculture as a crucial strategy for achieving global sustainability and progress, calling for continued research and development to unlock the full potential of a digitally empowered agricultural sector. The ongoing digital transformation is reshaping the future of agriculture, optimizing processes, and boosting overall productivity. Precision farming, automation, data analytics, IoT, blockchain technology, and farm management applications are key components of this evolution. Empowering farmers through real-time data is pivotal for well-informed decisions and sustainability. The significance of digital technology is further highlighted during the COVID-19 pandemic, fostering communication and ensuring agricultural continuity. In education, digital technologies play a crucial role in bridging gaps and empowering aspiring farmers, particularly in remote rural areas. This collective integration of digital solutions is propelling a more sustainable and technologically-driven future in agriculture.

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DIGITALIZATION OF THE SALE OF AGRICULTURAL PRODUCTS AS A CHALLENGE TO THE CRISIS

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Abstract

The paper presents a study of the crises impact on the sale of agricultural products. The purpose of the performed research is to analyse adjustment of local agricultural producers to the sale of products in crisis. The analysis was conducted after the Covid-19 Pandemic as a basis for studying sales in the period of crisis. The aim of this work paper is based on the focus of digitization of the sale of agricultural products of small local producers. The conducted research is based on special knowledge methods application and marketing research methods. The theoretical research is based on the historical method. The method of survey was used for analysing experiences and attitudes of local agricultural producers and sellers at the Kvantaška market in Novi Sad. The research conclusion implies to changes in urban areas buyers' habits when it comes to crisis situations, and also the tendency to digitize purchase. The limitation of the research is connected to the disorganized digital sale of agricultural products and therefore the impossibility of overall effects measurement.

Key words: *agriculture products, digital sales, agriculture producers, urban environments, challenges of the crisis.*

Introduction

The Covid-19 pandemic that affected the world economy caused a work force, health and business crisis during 2020. In accordance to (UNDP, 2020a:3) one of the most affected areas of life is food supply, employment decline,

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trade, tourism and other areas, and also social protection. For the first time, a great pandemic of infection also affected the rich (Bjelajac et al., 2020). It follows from the above that the research goal, based on practical experience, is to adjust life and economy at the local level to the new system of work and development of potential. The emphasis of the research is on the local vegetable producers' adjustment from direct sales to digital tools, with the purpose of supplying the population with food, in this case vegetables. The fruits and vegetables sale on the market places is still mainly related to smaller producers, and also organic products producers (Kuzman et al., 2022). In organic production irrigation, water quality is highly important (Kuzman et al., 2019). The purpose of executed research is recognition of the possibilities of adjustment of local producers who sell vegetables wholesale (Kvantaška market), at the local level in for supplying the population in urban areas and building relations with rural areas. The functioning of the public sector is caused by the permanent satisfaction of the general and common society needs (Milojević et al., 2019). The aim is also the comprehension of urban-rural connections on the bases of the direct experience of sellers and applied practice. State grants are part of development and economic policy (Milojević et al., 2020). So, the main motive of government benefits is the increase of production and additional income. The basic determination is in the design of the financial system (Mihajlović et al., 2022). Organized groups with common interest of fresh domestic agricultural products purchase of are considered to be potential buyers using digital sales tools. Another purpose of this work paper is to objectify the possibility of digitization and digital sales that emerged during and after Kovid-19 pandemic conditions. The basic goal of sales digitization is generating an additional income, appliance of new technologies in production and sales, and the wish for business innovation. A closer look at the results shows that sales volume and sales promotion are directly dependent on daily and seasonal fluctuations (Prdić, 2019). The manufacturer's decisions depend on one's capabilities, market, expected benefits and costs (Kaiser et al, 2018). Solutions for innovative agriculture are sought more and more intensively (Kuzman et al., 2023). The modern economic system does not tolerate development neglection (Čavlin., 2022). Namely, technology, innovative agriculture and the overall modern economic system with the application of new sales channels form the basis for the future.

Material and methods

Reviewie of the registered agricultural producers in the area of Juzno-Bački district stored in the database of the tax administration, were taken as the basis for conducting research during May and June 2023. The research was conducted among vegetable growers selling their goods at the “Kvantaška market” in Novi Sad. A survey was conducted with a direct interview with sellers. The interviews lasted fifteen minutes on average. Producers’ attitudes were examined and measured using a Liker scale with possible answers from 1 to 5. The survey questionnaire was conducted on a sample of thirty (N=30) vegetable growers. The interview was conducted with the owners of small farms according to the tax administration categorization. They were referring to production and sales conditions during and after the pandemic, digital sales, as well as socio-demographic characteristics of producers. The collected data were processed using statistical data processing and presented in the form of tables.

Results and Discussion

The research was conducted on a sample of thirty (N=30), registered agricultural growers who sell vegetables at the Kvantaška market in Novi Sad. Manufacturers’ attitudes about doing business during the Covid-19 Pandemic, were measured using a Liker scale with five degrees of agreement as presented in Table 1. (Table 1). The grower’s opinion is that the demand for vegetables increased during the pandemic (mean = 4.38, standard error, SD = 0.58), as well as the number of customers (mean = 4, 11, SD = 0.60). Prices have increased during the pandemic (mean = 3.60, SD = 0.85). When it comes to sales, i.e. their increasing online (mean = 3.10, SD = 1.79). On the other hand, the opinion that online enabled better sales (mean value = 3.05, SD = 1.81), while attitudes about today’s sales are online (mean value = 2.33, SD = 1.49). When speaking about traditional sales as the most important in business (mean value = 4.36, SD = 0.70), and combined (mean value = 2.65, SD = 1.34), that is the view are vegetable growers. Focusing on digital marketing as a cost-effective and technologically acceptable activity (Resnick et al., 2016). During the last few years, there was an increasing trend in providing digital services such as e-commerce, development, software, web hosting and digital marketing (Kostić, 2023). Resilience to crisis implies adapting to new conditions (Bot et al., 2019).

Table 1. Vegetable grower's attitudes about business and operations during the Covid-19 pandemic

Attitudes	Mean	Min	Max	SD
Vegetables demand during the pandemic	4,38	1	5	0,58
Pandemic increased sales (costumers)	4,11	1	5	0,60
There was an increase in prices	3,60	1	5	0,85
Greater online sales	3,10	1	5	1,79
Online enabled better sales	3,05	1	5	1,81
Today I sell online	2,33	1	5	1,49
Traditional selling is most important to me	4,36	1	5	0,70
Combined selling enables growth	2,65	1	5	1,34

Source: Author's research

Official statistics of the Republic of Serbia monitor production (Subić et al., 2023). Peculiar activities can make contribution to sustainable development (Borović et al., 2022). The supply chain system is a serious and complex activity (Gazdić et al., 2022).

The analyze of respondents attitudes, shows the distribution of answers to research questions that vegetable growers considered to be significant for their products sales. From the aforementioned research, we see that the greatest number of respondents (65.8%) believe that sales distribution is the most important problem and that it needs to be improved and enhanced. The respondents gave the lowest percentage (27.2%) to the organization of production, so from the conversation there may be concluded that they have sufficient knowledge and abilities to work. When it comes to insufficient investment in promotion (40.8%), they notice a problem in that segment, while a similar percentage of respondents (42.8%) thinks that problem is the insufficient involvement of the ministry and other authorities that are able to make a contribution to the development of domestic local agriculture.

When it comes to the thematic unit of growers' socio-demographic characteristics, we have the following data overview from the research, presented in table (Table 2).

Table 2. Socio-demographic characteristics of growers and size of property (N=30).

Variable	N=30	f	%
Sex	Male	14	46,67
	Female	16	53, 33
Age 18-29	9	30,00	
	30-45	11	36,70
	46-65	10	30,33
Education	Elementary sc.	0	0
	Secondary sc.	21	70,00
	College	8	26,70
	Faculty	1	3,33
Property size	< 1ha	1	3,33
	1-5 ha	29	96,67
Vegetable production	1	4	13,30
	1,5	6	20,00
	1,7	1	3,33
	2	5	16,67
	2,5	4	13,30
	3	5	16,67
	3,5	2	6,67
	4	2	6,67
	4,5	1	3,33

Source: Author's research

The questions from the questionnaire have answered 30 vegetable producers. By gender criteria, 46.67% of respondents are female, and by age the largest percentage (36.70) belongs to the 30-45 age group, while (30.33%) is from 46 to 65. If the education as a factor in the research, 70.00% of them have secondary school and 26.70% of have a higher vocational education. The property size they hold is from 1 to 5 hectares, and the distribution of production varies up to a maximum of 4.5 hectares. If there is intention that is strong enough, the probability of the behavioral outcome will be higher (Ulker et al., 2020). Consumers desire easily aaccessible and fresh products, and also easy consumption (Hamilton, 2018). Nowadays, social networks and advanced algorithms are used for consumer behavior analyze (Vladisavljević, 2022). The strategy of enabling better arrangement and access to the market will certainly enable greater concentration of supply (Prdić, 2021). Differences in purchasing habits have influence on sales (Babić et al., 2023). Good information reduces risk and it represents an instrument for maintaining competitiveness (Gabril, 2023). Some countries achieve more with less investment in innovation (Ahmetagić et al., 2022). The previous authors point at the advantages of direct communication, but also consumers' turn towards "online" purchase of fruit and other agricultural products.

Conclusion

The Covid-19 pandemic has affected the production and sale of agricultural products both in the world and in our country. The crisis challenges posed a serious problem and question to many farmers about how to do business. The conclusion is that demand for agricultural products and therefore also for vegetables increased, and that also caused an increase in prices and online sales. Manufacturers think that internet sales during the crisis contributed to the sales increase, but they consider the traditional sales and iits combination with digital sales to be their future priority.

The conclusion is that it is necessary in the future to organize digital sales, to make an infrastructure that would connect urban and rural areas, and also to reduce the large gap in sales in situations of crisis. The connection of producers and buyers in digital sales channels in this crisis has shown itself to be the only way of sustaining life in urban areas. The limitation of the research is related to lack of digital sales organization in our country, and thus the verification of the business effects. Also, the constrain refers to the rather small sample of surveyed vegetable producers at the "Kvantaška market", and a greater geographical distribution is necessary.

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SIGNIFICANCE OF INNOVATIONS AND APPLICATION OF INFORMATION - COMMUNICATION TECHNOLOGIES IN AGRICULTURE AND RURAL DEVELOPMENT OF SERBIA[1]

Olgica Zečević Stanojević[2], Dragan Nedeljković[3], Leposava Zečević[4], Boris Stanojević[5]

Abstract

Innovations and the application of information and communication technologies have a driving role in the efficient development of smart agriculture. The application of new information and communication technologies and the digitization of the agricultural sector represent a great potential for improving rural development through increasing profitability, productivity, sustainability and competitivity. Modern communication approaches and technologies, from artificial intelligence and robotics to the Internet of Things (IoT), enable significant support and assistance to agricultural holdings and businesses. The results of the research in the paper indicate the possibilities of encouraging rural development based on the use of information and communication technologies through reducing the digital divide, solving existing challenges in terms of creating reliable access to modern communication technologies, strengthening resources for the application of technologies, encouraging awareness, developing skills and training human resources in rural areas.

Key words: *innovation, rural development, smart agriculture, information and communication technologies, IoT-Internet of Things.*

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Introduction

The level of technological progress, access to information and improvement of acquired knowledge are of great importance for the sustainable development of rural communities. According to the basic nature of agriculture, timely access to quality information in today's conditions of business and life of the rural population can play a crucial role from the point of view of the success of the implemented production and social activities (Subić, Kljajić, Jelocnik, 2017).

The meaning of innovation as a term has changed over time depending on changes in the environment and technological progress. The most commonly accepted definition indicates innovation as a multiphase process in which the organization transforms its ideas into new, improved products, services or processes in order to advance, compete and successfully differentiate itself in its market (Baregheh, Rowley, Sambrook, 2009).The term innovation in agriculture is associated with the application of information and communication technologies in the digitalization of agricultural production management and precision agriculture (Hunt, Daughry, 2018). Other authors give the following definition: "innovation is the application of a new or significantly improved product (goods or services) or process, a new marketing method in business, work organization, or relations between a business entity and its environment (Manual, 2005). In the agricultural sector, innovations include new knowledge and technologies related to primary production, processing and commercialization (Asenso-Okyere, von Braun, 2009). Innovations in agriculture are new outputs and methods used to increase production, yield or quality (Akkoyunlu, 2013). The direct effects of innovation refer to the achievement of higher profitability, while the indirect effects refer to higher productivity and employment growth (Berdegue, Escobar, 2002).

Digital agriculture, smart or "e" agriculture uses a wide range of devices, tools and applications. They range from basic technological solutions to various modern "digital" forms that have integrated systems, various digital platforms, software applications (for example drone control), satellite navigation, drones, robotics, sensors for data collection and software for their processing. and analysis (OECD, 2018).It is indisputable that technological development in agricultural production constantly brings hundreds of new solutions, which are primarily oriented towards stabilization and growth of productivity, while globally a relatively small number of producers decide to implement technological innovations. Therefore, the transformation of traditional agriculture is not only a problem of investing in technological progress, but a problem of choosing an adequate object of investment, which is primarily a task of the available knowledge of the producer (Njegovan, Jelocnik, 2013).

Methodology

During the research, the deductive method, the method of induction, analysis and synthesis was used in order to monitor and analyze the selected data and the comparative method. The research is based on relevant data in the observed period of the past ten years. The structure of the work and ongoing research are aligned with the use of relevant data from the Statistical Office of the Republic of Serbia, as well as with the use of current scientific and professional domestic and foreign literature. Research in the work based on the review of scientific and professional literature, as well as the analysis of the collected data, indicate the trends and possibilities of applying information and communication technology in order to improve agriculture and rural development. This indicates the need for further research in this area in order to develop rural areas.

Results and Discussion

World experience has shown that countries that continuously invest in research and education are economically more successful, that is, more resistant to negative effects resulting from crisis situations (Zubović et al., 2013). In recent decades, a high correlation has been determined between investments in research and development and the degree of sustainability of development of all sectors of the economy. The development of science, education and technology is widely accepted and society must support research and innovative activity that will generate future growth and development (Subić, Kljajić, Jelocnik, 2017).

The field of innovations in Serbian agriculture is largely influenced by the comprehensive financial support of the state. Insufficient and low orientation of the state in financial support towards agriculture indicates that this sector receives a smaller part of state spending in relation to its contribution to the economic value (Paraušić, Roljević Nikolić, 2021).

In table no. 1 presents comparative views of investment in research and development as a percentage of gross domestic product in Serbia and the European Union in the period 2010-2019.

Table 1. Investments in research and development as a % of GDP in Serbia and the EU, 2010-2019.

Year	EU	Serbia
2010	1,92	0,70
2011	1,96	0,68
2012	2,00	0,85
2013	2,02	0,68
2014	2,03	0,72
2015	2,04	0,81
2016	2,04	0,84
2017	2,08	0,87
2018	2,11	0,92
2019	2,14	0,89

Source: Eurostat, 2020.

Investments in research and development as a percentage of gross domestic product in Serbia in the observed ten-year period (table no. 1) show that it is uniform and ranges from 0.68 (2011, 2013) to the highest parameter of 0, 92 in 2018. Despite the slight increase, the data indicate that investments are still far below the European Union average.Investments in research and development from state budgets in the European Union amounted to about 100.7 billion euros in 2020, i.e. approximately 0.8% of the gross national product (EUROSTAT, 2021). In the report of the European Commission on the evaluation of innovations, it is stated that Serbia achieved a significant growth of about 30% in the field of innovations (European Innovation Scoreoard, 2021). This indicates an increase in investment in the areas of human capital, digitalization and the innovative economy. However, data indicate that in 2018, Serbia was at the level of 58% of the European Union average, and that this percentage increased to 66.2% in the next three years, which indicates that it is still below the European Union average (EUROSTAT, 2021). Statistical data also indicate an unfavorable situation in Serbia in the area of investment in research and development in agriculture, as well as when it comes to the index of state expenditures directed at agriculture. The index of state expenditures directed at agriculture represents the ratio of the share of agricultural expenditures in state expenditures and the share in the country's gross domestic product.

Table 2. Index of state expenditures focused on agriculture

Year	Index
2015	0,25
2016	0,24
2017	0,32
2018	0,33
2019	0,33

Source: SORS, 2020.

In the observed five-year period (2015 - 2019), the data from Table 2 indicate a low index of state expenditures aimed at agriculture, whose value is below 1 and ranges from 0.24 to 0.33 (SORS, 2020). This indicates a low level of innovative capacity of the agricultural sector, which leads to stagnation and distance of Serbia from the realization of a number of set sustainable development goals (SORS, 2020).

In order to encourage rural development and social inclusion of the population from rural areas in the application of modern information and communication technologies, it is important to take into account several parameters, among which: data on the use of Internet communication, computer literacy and the educational structure of the rural population. Table no. 3 summarizes the percentage of computer and internet connection ownership and the ratio of that percentage between rural and urban areas.

Table 3. Percentage of the population who own a computer, mobile phone and internet connection

Type of settlement	Computer	Mobil phone	Internet connection	Broadband internet
Urban	81,6	96,3	87,1	87,0
Rural	61,8	90,3	70,4	70,1

Source: SORS, 2020.

Based on the data of SORS from 2020, we can conclude that there is a pronounced digital gap between urban and rural areas in Serbia. This is indicated by the fact that slightly more than half of the households in Serbia own a computer. Two-thirds of households have an Internet connection (SORS, 2020). The main limiting factors should be found in: too high equipment costs

(20.4%), high access costs (10.9%), lack of skills (9.4%), unavailability of internet in certain areas (7.6%) (Jelić, Kolarević, 2021).

Table 4. Population with computer literacy and type of settlement (%)

Type of settlement	**Computer litterature person**	**Person with partial computer skills**	**Computer illiterature person**
Urban	44,09	15,11	40,80
Rural	19,84	14,29	65,87
Gender structure			
Male	20,93	15,58	63,49
Female	18,74	13,02	68,24

Source: SORS, 2020.

Data from table no. 4 summarizes the state of computer literacy and indicate the existence of a large gap in computer literacy, whereby 65.87%, which represents almost two thirds of the rural population, are computer illiterate. Only 14.29% of the rural population has some kind of skills. There is a similar representation if the gender structure is observed, according to which women have a lower percentage of computer literacy (SORS, 2020).

In addition to improving and improving Internet access and reducing costs, the most important prerequisite for the introduction of innovations and the use of new communication technologies is education. Based on the data from table no. 5 we can conclude that the educational characteristics of human resources in rural areas are noticeably less favorable than the urban population. According to the data from table no. 5 in rural areas, there is a dominant representation of human resources with a high school diploma (42.4%).

Table 5. Demographic indicators and educational structure in rural areas

Element	**Serbia**	**Rural areas**
% without formal education	13,7	23,4
% with elementary education	20,8	27,7
% with middle school	48,9	42,4
% higher education	16,2	6,1
% unknown	0,4	0,4

Source: SORS, 2018.

A particularly unfavorable trend is in the structure of human resources in rural areas with the percentage of basic and no formal education amounting to 51.1%. The educational structure of the workforce due to the low representation of highly educated personnel (6.1%) in rural areas is a limiting factor for the implementation of innovative and information and communication technologies. Formal education, especially of farm managers, is low and at an unsatisfactory level. More than half of managers (54%) perform their duties on the basis of experience gained from practice, a somewhat significant percentage graduated from high school (30%), while only 5% graduated from college or university. These data indicate not only the difficult access to innovations, but also the difficult adoption of innovative forms of business. In order to stop such trends, the need to include the rural population in innovative formal and informal educational programs has been expressed (Nedeljković, Zečević. Zečević Stanojević, 2023).

One of the limiting factors is the insufficiently efficient transfer of knowledge and innovations in the agricultural sector and rural areas, as a result of numerous limitations in the functioning of the agricultural advisory service (Djurić, 2020). Also, the high costs of introducing innovations and insufficient motivation of farmers to invest in the application of innovations, because the results are not quickly visible, are one of the limiting factors (Stanojević, 2019). The motivation of the rural population in the application of innovations is largely influenced by the unfavorable management structure in agricultural holdings. The management structure is dominated by older people. This is indicated by the fact that over 40% of managers are in the structure of 65 years old, who are poorly motivated to introduce innovations and are oriented towards traditional forms of business. The data also indicate a low percentage of human resources in rural areas who are represented in the management structure in the age category up to 45 years, whose representation is only 11.8%. Particularly worrying is the fact that the share in the category of younger managers and administrators, who are responsible for the introduction of innovative and modern communication changes in business, is in constant decline (SORS, 2020). Access to information, and through it to compressed knowledge and innovative messages, members of the rural community most often achieve through the available IT infrastructure (including local printed and electronic media) or through the organization of trainings, courses, demonstration workshops and similar activities. It is important to point out the necessity for the mentioned activities to be organized by representatives of the local community, a network of public and private institutions in the function of the development of knowledge transfer and the introduction of innovations in rural areas (departmental ministries, advisory and professional services, schools and faculties, regional development agencies, chambers of commerce

, associations of farmers and agricultural cooperatives and others) (Subić, Kljajić, Jelocnik, 2017).

Innovations contribute to the development of rural areas and the agricultural sector in various ways, primarily in the areas of: establishing a precise analysis of the situation, improving the system of data collection, analysis and processing, increasing yields, improving quality, processing, preservation and storage, increasing productivity, reducing costs, economic and profitability of production. That is why it is necessary to create more favorable conditions for financing innovations and the research and development potential of the agricultural sector of Serbia through improving international cooperation, investing in rural infrastructure, investing in education and raising awareness about the necessity of introducing innovative information and communication technologies, research and advisory services, development of information technology in order to improve business and production capacities.

Application of innovations and information and communication technologies in agriculture

One of the fields that can contribute to better and more efficient agricultural production is information technology. Innovative information and communication technologies such as Cloud computing, big data, artificial intelligence and deep learning have a wide and effective application in smart farming and agriculture. IoT technology - Internet of Things, smart devices, are transforming the agricultural sector, providing farmers with access to real-time data on environmental conditions. Smart electronic devices independently perform some functionality, where they are usually sensors that measure some quantity that is needed for further analysis on the basis of which decisions will be made and actions aimed at improving yields. With the use of actuators, some of these decisions can be implemented. By combining real-time IoT data with accurate geospatial data, farmers can implement precision agriculture, resulting in higher yields, reduced waste and more sustainable practices. These devices have a diverse field of application, and they can also be very diverse. They are used to measure soil parameters, such as, for example, humidity and temperature of the soil, humidity and temperature of the air, strength of UV radiation and others, in order to use adequate agrotechnical measures, irrigation or use of certain preparations (Quy, et al., 2022). They can be combined with video surveillance or aerial crop condition recording using drones in different spectrums. In the case of smart livestock, IoT devices can be placed on each head with various sensors, in order to monitor heart rate and temperature, RFID for access control or access to GPS devices for tracking movement (Shailendra Mishara et al., 2023). It is important to point out the existence of different communication possibilities between devices. These devices can be permanently networked for real-time data monitoring and provide the ability to store and collect data at multiple locations. The main advantage of using these technologies is reflected in the ability to collect a large amount of data that can be used to monitor the desired resource. Based on their analysis, further courses of action can be determined. Some of these measures can be implemented automatically, as in the example of irrigation. Data from the sensors is the basis for creating a map of soil moisture, on the basis of which irrigation systems can be activated only where necessary and to the desired extent. Of great importance is the need to include external data in the decision-making system (for example, making a decision about the need for irrigation based on the meteorological forecast). In order to efficiently use data, quality processing is required. That is why it is important to highlight the possibility of applying artificial intelligence and machine learning in this field (Ribeiro et al., 2022) and the application of Cloud computing. This involves collecting data over local networks that are sent to the Cloud for analysis. In the case of application in agriculture, certain difficulties appear here. The reason lies in the fact that agricultural farms are located in remote areas, without modern infrastructure. Therefore, collecting data and sending it for processing is a big challenge when it comes to rural areas. It is important to highlight the fact that in certain situations in agriculture, the speed of reaction is of crucial importance. That is why it is extremely important to establish mechanisms that will enable fast and high-quality processing and forwarding of data. Since broadband internet is often unavailable or insufficiently reliable in agricultural farms, it is necessary to establish mechanisms that will enable the high-quality application of modern information technologies in such working conditions. That is why Edge computing and Fog computing are extremely important (Kalyani, Collier, 2021.). The task of collecting data from IoT devices is performed over a local network by implementing various technologies. The application of information and communication technologies can be called by one name - smart agriculture. Smart devices collect the necessary data or react to given commands, but they should also be used in an adequate way. Application of modern information and communication technologies and devices through Cloud computing, Fog and Edge computing provides greater safety, security and efficiency in agriculture and rural development.

Conclusion

Research in the work, through the analysis of current trends and parameters, summarized in table 6, indicates advantages in the application of innovations and information and communication technologies. At the same time, research points to numerous challenges that need to be overcome in rural areas in Serbia in this area. The application of new information and communication technologies and the digitization of the agricultural sector represent a great potential for improving rural development through increasing productivity, sustainability and competitiveness. Modern communication approaches and technologies, from artificial intelligence and robotics to the Internet of Things (IoT), can provide significant support and assistance to farms and businesses. Thanks to the application of innovative information and communication technologies and digitization, agricultural farms and businesses can benefit from a simpler value chain, with closer cooperation and better communication between producers, processors, distributors and traders. In addition to numerous advantages provided by the application of modern innovative information and communication technologies and digitalization, there is a legitimate threat that a digital gap can be created between those who have access to and actively use modern communication technologies and those without them.

Table 6. Advantages and challenges of digitization

Advantages	Challenges
Greater economic performance - more effective decision-making - business optimization - increasing productivity and profit - sustainability of the agricultural sector	**Connection** - rural areas don't have reliable internet access - high price internet access -difficult introduction of digital technologies
Environmental sustainability and ecological efficiency -waste reduction using precision agriculture techniques - reducing pollution	**Limited awareness of advantages and benefits -** insufficient conscience about possibilities and benefits of applying technology - underdeveloped skills of human resources - lack of resources for the application of technologies
Competitiveness - increasing competitiveness - innovative solutions - creation of new business opportunities	**System interoperability** -different digital platforms that are not compatible, it makes difficult to exchange data and integrate different applications

Advantages	Challenges
Improvement of working conditions - reduction of physical and mental burden on human resources in agriculture through automation and optimization of digital technology operations	**Human resources skills for using communication technologies** - low level of training and protectionism – protection of privacy and ownership of data, which hinders the exchange of data
Greater supply chain transparency - greater awareness of agricultural products - improved transparency of agricultural products	**Expenses** -high costs of introducing new technologies - the potential benefit cannot be paid off in the short term

Source: Autors based on EU digital strategy 2022.

Therefore, it is necessary to focus more attention on solving existing challenges in terms of creating reliable access to modern communication technologies, strengthening resources for the application of technologies, raising awareness, developing skills and training human resources in rural areas. In order to ensure the wide availability, application and inclusion of information and communication technologies and digitalization, it is important that the competent state authorities, through the adoption of incentive policies, leaders in the industry, as well as providers of technological services cooperate and place special emphasis on promoting the advantages of using innovative technologies and digitalization . Special emphasis should be placed on encouraging human resources in agriculture to train and adopt new technologies. In this way, the agricultural sector can effectively use the benefits of innovation, which directly affects greater profitability and sustainable development.

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PERSPECTIVES OF DIGITAL TOOLS IN THE AGRICULTURAL ADVISORY WORK

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Abstract

Agricultural advisory services aim to enhance farmers' productivity, profitability, and sustainable use of natural resources, with both public and private sectors providing support. However, reaching remote farming households has proven challenging, limiting the impact of these services. Digital tools, such as mobile phones and the internet, have emerged as effective solutions, significantly improving the efficiency, relevance, and reach of advisory services. Analysis of successful digital agricultural advisory services in four regions revealed several key points for improving their reach and sustainability. Successful services address user needs, incorporate bundled services, form multiple partnerships, and have robust business models. However, challenges exist in user involvement during the design phase, particularly for individuals with low ICT literacy. Policy frameworks for promoting digital advisory services vary across regions, with public-led services facing operational challenges and private sector-driven initiatives encountering funding issues. Sequential public-private partnerships may offer a way forward to enhance the impact of digital agricultural advisory services.

Key words: *digital tools, advisory service, sustainability, information and communication technology*

Introduction

Farm Advisory Services (FAS) are vital for supporting over a billion small-scale farmers and rural stakeholders globally. They help address challenges, enhance livelihoods, boost productivity, and alleviate hunger and poverty

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through innovation and enhanced capabilities. The digitalization of extension services has gained renewed global interest, especially in light of the COVID-19 pandemic, increasing accessibility and affordability of online services and emphasizing the need for digital extension tools. With over 600 million farms globally, the majority being family farms, and a significant portion in low-income nations facing malnutrition, FAS are crucial for addressing these challenges.

Agriculture serves as the primary livelihood source for an estimated 80% of people in developing countries, and regions like Africa need to substantially boost agricultural productivity to address food and nutrition insecurity (Christiansen et al., 2021). The World Bank emphasizes that agricultural development is a powerful tool to eradicate extreme poverty and provide sustenance for an anticipated 9.7 billion people by 2050. Extension services grant farmers access to knowledge, information, and technologies, either in person or digitally, and e-Extension aims to facilitate agricultural transformation and enhance smallholder farmers' resilience (Christoplos, 2010). The thoughtful use of digital tools is anticipated to expedite agricultural transformation, enabling smallholder farmers in developing countries to navigate the challenges posed by the pandemic and enhance their resilience.

Perspectives in agriculture

The third industrial revolution, or the digital revolution, began in the late 20th century, marking the start of the information age with the rapid advancement of computers and communication technologies. As we transition into the 21st century, the fourth industrial revolution is unfolding, characterized by automation, data exchange, and artificial intelligence. This revolution integrates advancements in robotics, artificial intelligence, nanotechnology, quantum computing, biotechnology, and the Internet of Things (IoT). In agriculture, this revolution could lead to increased use of smart sensors for real-time information gathering, optimizing plant growth in innovative production systems like hydroponic vertical farming in shipping containers.

The fourth industrial revolution builds upon its predecessors, relying on the rapid exchange of information facilitated by digital technologies. Digital agriculture, a term that surfaced in 2015, involves using digital information to guide decisions across the agricultural value chain. It offers increased efficiency through precise mechanization, automation, and enhanced decision-making. The digital agriculture market was valued at USD 18.0 billion in 2022, projected to increase to USD 29.8 billion by 2027, driven by the adverse impact of ecosystem changes on agriculture.

Digital Rural Advisory Service (RAS) offerings provide continuous access to information, reaching geographically dispersed farmers and enabling two-way communication at scale. However, challenges exist in reaching the required number of farmers and maintaining up-to-date information and services. Digitizing poorly functioning systems may perpetuate existing challenges, and establishing Public-Private Partnerships (PPP) becomes challenging when targeting non-commercialized farmers. When donors withdraw financial support, the public sector struggles to sustain the service, highlighting the need for a supportive environment and the recognition that digital solutions cannot replace the roles of extension workers and local community figures.

ICT Tools for Advisory Services

Traditional information and communication technologies (ICTs) like analogue telephones, radio, and television are now being complemented by digital services delivered through computers and mobile phones. Digital technology solutions are not expected to completely replace traditional methods of agricultural information delivery, but rather to complement and enhance the impact and reach of extension projects. Face-to-face interactions will always have a place, as they are more conducive to delivering complex messages compared to the mass media that digital methods complement. The use of digital extension has reduced farmers' reliance on peers for agricultural advice but has not diminished peer interactions centered on information exchange.

The ICT revolution has reached a tipping point, with the majority of farmers now having mobile phone connectivity, enabling Rural Advisory Service practitioners to deliver low-cost and timely messages to farmers. Extension providers must fully embrace and utilize the latest ICT applications for their work, as these technologies enable nearly instant and personalized communication to farmers across a broad geographic area, covering various aspects of agricultural management (Salasan et al., 2021).

Mobile Phones

Mobile phones have become essential tools for farmers, enabling quick and easy communication and information sharing with Rural Advisory Service (RAS) providers. During the pandemic, mobile phones became a crucial lifeline for farmers, serving as their primary means of accessing information from extension practitioners during lockdowns. They provide access to social media, facilitating wide engagement and information sharing. Bulk text messages can be sent cost-effectively to a large number of users in near real-time. Mobile phones offer instant access to agricultural, financial, and market information, as well as communication apps like WhatsApp and WeChat for easy exchange of messages and media. They also enable continuous access to financial information and services, improving market access, supply chain visibility, and risk management (Cole and Fernando, 2021). The use of mobile phones has been shown to enhance the quantity, quality, and speed of service delivery for farmers, especially in developing countries. The widespread use of mobile phones has helped address the challenge of smaller, resource-poor farmers accessing relevant information in a timely manner.

ICT in Serbia Baseline Analysis

According to the results of the survey that was conducted on representative regions in the area of activity of the advisory service of the Republic of Serbia, the situation in Serbia is shown in the following table.

Table 1. Age structure of the participants in agricultural production

Age range	**%**
18-30	21,1
31-45	26,3
46-60	34,2
More than 60	18,4
Total	100

Local knowledge, experience, tradition, attitude, and mindset of agricultural producers can be a significant resource in improving advisory work and agriculture in general.

Situation in Serbia – Digital literacy and accessibility

The survey was conducted to determine the initial state of skills, but also the availability of digital tools in rural areas. The results are presented below:

Do you or someone in your household have access to the Internet from home?	
	%
Yes	97,4
No	2,6
Total	100,0

Do you personally use the Internet?	%
No, I don't use the internet at all	8,1
Yes - I use it at home	27,0
Yes - I use it at home and elsewhere	64,9
Total	100,0

Use of digital tools and sources of information «Which of the listed devices do you have at home?»

	I don't have it	I have it at home - I don't use it	I have it at home and I use it
Standard TV receiver	18,4	5,3	76,3
Digital video recorder / DVD / Blu-ray player (Blue-ray player)	86,8	5,3	7,9
Radio	34,2	5,3	60,5
Desktop computer	23,7	2,6	73,7
A laptop or netbook computer	44,7	7,9	47,4
A tablet computer (such as iPad, Kindle, Google Nexus)	81,6	2,6	15,8
Mobile phone	15,8	5,3	78,9
Portable or streaming media player	100,0	0,0	0,0
E-book reader	94,7	5,3	0,0
Wearable technology like a smart watch	94,7	5,3	0,0
None of the ones offered	5,3	7,9	0,0

If you use a cell phone, which of these options best describes the type of cell phone you use most often?

	%
I do not know	2,7
A regular mobile phone (not a smartphone) without internet access	24,3
Smartphone	73,0
Total	100,0

Most of the time when you are online, do you usually try new things?

	%
I do not know	11,4
I only use sites or apps that I've used before	31,4
I use maybe one or two new sites or apps that I haven't used before	20,0
I'm using a lot of new sites or apps that I haven't before	37,1
Total	100,0

Are there digital tools (apps, systems, software) in agriculture that you use or are interested in?

	I'm already using	I'm not using yet, but I'm interested	I'm not interested
Access to the market			
Direct Selling Applications (Short Chain)	2,8	97,2	0,0
Online price information system	2,8	86,1	11,1
Internet market (usual sales with the cooperation of farmers to achieve better conditions)	11,1	72,2	16,7
Agricultural advertising	5,9	76,5	17,6
Another approach to the market	30,8	69,2	0,0
e-Government			
e-claim and application for subsidies	8,8	88,2	2,9

	I'm already using	I'm not using yet, but I'm interested	I'm not interested
Client gateway correspondence	25,7	74,3	0,0
Other things related to e-Government	29,6	70,4	0,0

The results of the survey clearly indicate a strong need for improving the knowledge and skills of farmers, which can be properly implemented by advisors from the advisory service. Additionally, the level of technological availability of devices (computers and smartphones) and the internet in rural areas is encouraging. What most strongly indicates the need for implementing projects which are related to this topic as a interest in using digital tools, especially those related to the market and marketing, particularly in applying for subsidies. There is also a great opportunity in constantly increasing the number of applications used to improve life in rural areas, including all available tools for communication, education, collaborative work, social networks, and specialized platforms.

The specific development objectives are to improve the digital literacy of Serbian farmers, simplify the application of digital applications in agriculture, increase the number of farmers using national subsidies, boost the use of digital applications to enhance life in rural areas, strengthen the capacity to accept new knowledge and innovations in agriculture, and improve the production system.

The expected improvement results include an increased number of users who can independently use digital tools and platforms, as well as a reduced number of errors and irregularities resulting from improper use. Additional results encompass the development of methodology and content for training programs, the creation of a program and platform for collaboration, intensified knowledge transfer among farmers, and wide dissemination of digital knowledge using multiple channels.

Conclusion

Emphasizing the fundamental role of people, rather than technology itself, in the adoption of new digital technologies is crucial (Hansen et al., 2022). The needs of individuals should be the guiding principle in the design and implementation of these technologies. In the dynamic landscape of contemporary digital technologies, continuous evolution and rapid changes are the norm, with new technologies emerging almost daily. Similarly, the modern Rural Advisory Service (RAS) professional must adapt and continually enhance their capacity in these new technologies to effectively support the farmers they work with. Providing support and resources becomes imperative to assist extension practitioners in receiving training for the appropriate use of these next-generation extension tools and media (Chander and Rathod, 2020).

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INFORMATION AND COMMUNICATION TECHNOLOGYS IN CATTLE LAMENESS DETECTION

Tina Bobić[1], Maja Gregić[2], Pero Mijić[3], Vesna Gantner[4]

Abstract

Because lameness is a common problem on dairy farms, it is necessary to use techniques that help reduce the frequency of lameness. Using information and communications technology (ICT) to detect and prevent lameness in dairy cows is possible and has a future. Automatic lameness detection methods can collect large amounts of data in a short time, which can improve the accuracy of lameness prediction. Various ICT technologies are present on the market, and can be useful in detection and prevention of cow's lameness. Those technologies can improve dairy production, lower costs and improve animal welfare. It is necessary to include more factors and various experts from different fields to ensure the success of the application of such advanced and expensive technology.

Key words: *ICT, cattle, lameness detection, dairy farms.*

Introduction

Information and Communication Technology (ICT) includes the application of various devices, tools or applications that allow the collection or exchange of data through interaction or transmission. ICT is a collective term that includes everything from the radio to satellite images, mobile phones or electronic money transfer. Through the research and applying technological innovations, i.e. information and communication technologies, encourages the development of Precision Livestock Farming (Benjamin and Yik, 2019.). According to Bewley (2010.), Precision Livestock Farming implies the use of technologies to measure the physiological, behavioral and production in-

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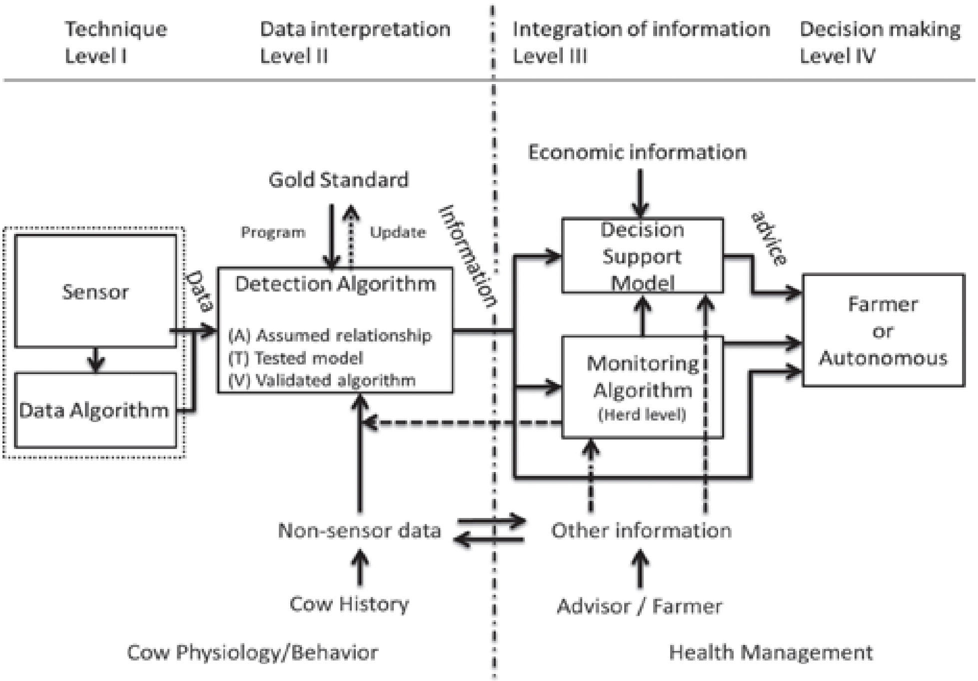
dicators of animals. Methods used in precision livestock production include continuous measurements and monitoring of animal signs or responses and real-time data collection for proper production management (Norton and Berckmans, 2017.). Benjamin and Yik (2019.) state that the application of various sensors, images, sounds and movements in combination with algorithms serves to monitor the welfare of animals and their productivity. Furthermore, provide early warnings of possible violations of animal welfare or illnesses. Andonović et al. (2018.) point out that it is very easy to recognize early signs of animal diseases by monitoring their individual conditions. Digital technologies can be extremely useful because they offer the opportunity to improve and increase the efficiency of production and at the same time provide a safer process of production itself. In recent decades, there has been a great digital revolution, and with it, the methods of automated measurements are becoming more and more widespread.

Various information and communication technologies are present on the market. They are similar to each other in certain points of contact regarding the need for real-time logging, good software and setting thresholds. They differ in the technology of obtaining daily records because it depends on the type of animal, on the type of problem being observed, financial possibilities, etc. Software technologies are applied that include measurement of different states of animals, such as rumination, food consumption, lying down and standing. According to Boldizsár (2012.), today's new ICT technologies should have the purpose of improving the farm management strategy itself and improving production properties. It is necessary to develop and apply technologies that will:

- be as well adapted as possible to animals and their natural behavior, causing as little stress as possible
- influence the increase in productivity
- facilitate insight into the necessary information and data of animals
- serve for early disease detection and thereby reduce the use of drugs and act as a preventive health measure.

Figure 1. The use of sensor information in dairy farm management (Rutten et al., 2013.)



Using of ICT technology's is complex process which includes different pathways (Figure 1.), e.g. from sensor on the farm which getting data's from animals (technique, Level I) to the algorithms in the computer which convert those data's in usable information's (data interpretation, Level II), further to the integration of those information's (Level III) and finely to making some decision (Level IV).

The aim of this paper was to present some of the ICT technologies, which can be used for cattle lameness detection.

Cameras and sensors

In recent times, it was increasing interest in objective analysis of movement and body characteristics of dairy cows by digital cameras. Salau et al. (2015.) stated that camera-based studies have achieved a high rate of lameness detection. Using cameras and image analysis have some advantages, because there no physical contact with animals and one camera can monitor a large group of animals which reducing the costs (Norton and Berckmans, 2017.). According to Marchant et al. (1999.), there are two types of cameras, two-dimensional (2D) and three-dimensional (3D) that provide digital information that can be used to monitor and estimate the growth rate, moving etc., of animals. The application of 2D cameras requires certain spatial conditions such as ambient lighting and a contrasting background. For example, white animals need a black background, etc. Three-dimensional (3D) cameras are sensors equipped with a high-resolution camera, an infrared illuminator, and depth sensor, which produces color. Infrared light is crucial in applications during low light and nocturnal behavior monitoring (Kongsro, 2014., Wang et al., 2018.). According to Mittek et al. (2017.) depth sensors determine the proximity of the animal to the camera. Today's cameras require a built-in cover to protect the sensors from ammonia, dust, moisture, and insects (Benjamin and Yik, 2019.).

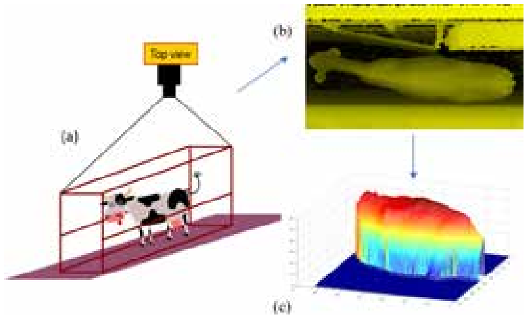


Figure 2. The example of the measurement installation for collection of field data using a top-view camera (a), depth camera image of the walking cow (b), and depth data illustrating the back profile of the cow as it walks under the camera (c) (Norton and Berckmans, 2017.)

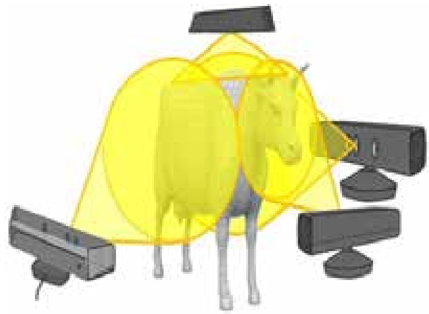
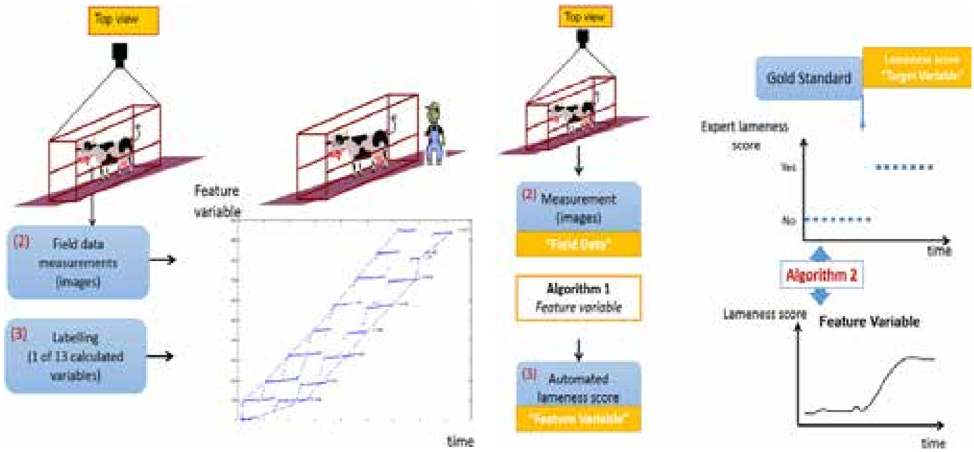


Figure 3. The three-dimensional (3D) optical sensors cameras (Pezzuolo et al., 2018.)

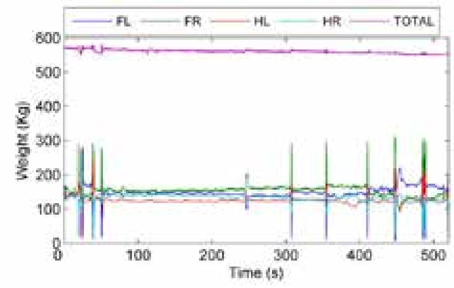
Cameras can be used as real-time monitoring of lameness of dairy cows by using real-time image analysis. Flower and Weary (2009.) have simply explained the possibility of applying data in real time in the following way: "*If we start from the fact that lameness can be considered as deviation in cows gait resulting from pain or discomfort from hoof or leg injuries or disease, than we can detect those deviation in movement and promptly react*". The lameness is one of the biggest problems regarding of the animal welfare in dairy cows. Therefore, the development of a robust algorithm for lameness detection is very important for dairy farmers. Norton and Berckmans (2017.)

emphases that for lameness detection it's crucial to have a continuous monitoring and management tools. The same authors stated that is need to connect a few things: linking field data (e.g. images or videos of cows walking), target and future variable (e.g. step Overlap, stance time, back arch), gold standard, and labeling (Figure 4.). It is very difficult to connect all data in real time and get reliable and usable data, so it is crucial to develop the best possible algorithm. A good algorithm allows linking all field data and including the possibility of error to suggest the possible occurrence of disease.

Figure 4. Measurements, labeling, and gold standard to develop algorithms (Norton and Berckmans, 2017.)



Pastell et al. (2006.) conducted research to develop a system for detecting lameness of cows in a milking robot using sensors, in order to obtain an early warning of possible hoof problems. Figure 5. shows an example of automatically recorded leg load dynamics during milking, and Figure 6. present the connection between leg load index and kicking behavior of cows.



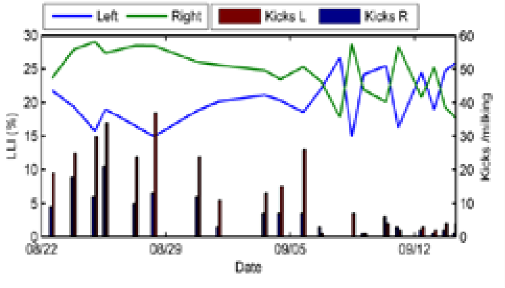


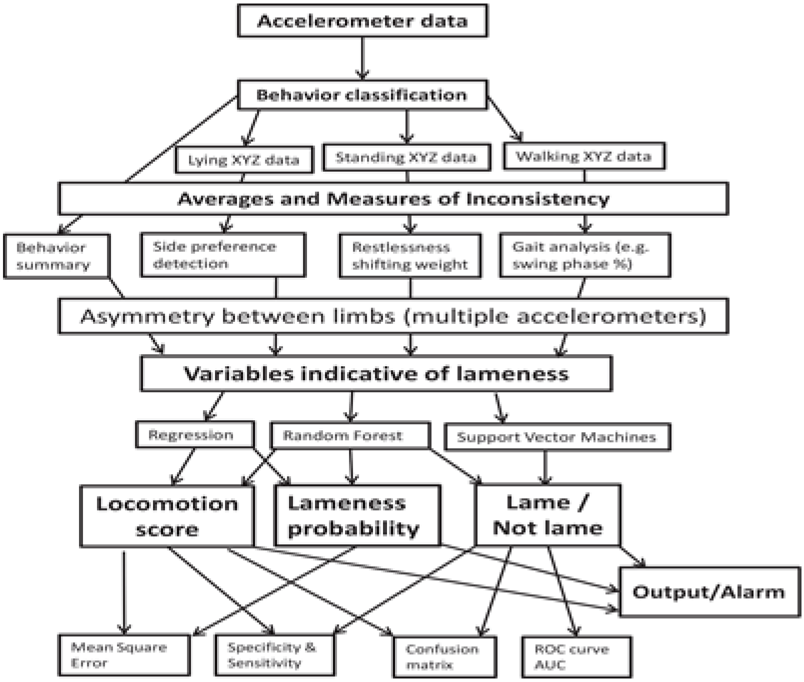
Figure 5. Leg load dynamics of a cow during one milking (Pastell et al., 2006.)

Figure 6. Leg load index (LLI) and the number of kicks per milking with hind legs of a cow during white line separation and after treatment (Pastell et al., 2006.)

Accelerometers

An accelerometer is an electronic device with one or more sensors that measures, records, and transmits acceleration data (relevant to various motor behaviors) in one or all three dimensions. According to Benjamin and Yik (2019.) the best technologies for monitoring the movement and behavior of animals are wearable sensors that contain accelerometers. The data generated by accelerometers and their corresponding systems can be processed by algorithms that have been created to interpret movements into specific behavioral patterns (Chapa et al., 2020.). An electronic unit placed in the animal's collar continuously records individual movements of the neck and muscles using a three-axis accelerometer. When a cow enters the reception area of the base station, which can be located in a pasture or a milking parlor, the measured data on the collar is processed using advanced software and wirelessly transmitted to a computer. The specific status and condition of the cows, as well as warnings, are monitored using a computer. Each collar remembers patterns of behavior and in the event that significant changes occur, a warning appears and based on this, a timely reaction can be made.

Figure 7. A schematic diagram of how lameness classification could be implemented using accelerometers (O'Leary et al., 2020.)



Pastell et al. (2009.) reported that lame cows exhibited higher asymmetry of variance during acceleration compared to healthy cows. Likewise, Chapinal et al. (2011.) reported that lame cows with high gait scores had a greater asymmetry of variance during acceleration in both front and rear legs. O'Leary et al. (2020.) proposed a lameness detection system using accelerometers (one per cow; resolution <100 Hz) with gait measurement capabilities to balance cost and data requirements. The same authors presented a schematic diagram of the use of accelerometers for lameness classification (Fig. 7) and stated that high priority should be given to developing novel gait measurement methods and testing their ability to differentiate between lame and non-lame cows.

Infrared thermography

Infrared thermography is a non-invasive diagnostic tool that can detect lameness and lameness-related hoof pathology by measuring changes in skin surface temperature (Nikkhah et al., 2005.; Alsaood and Büscher, 2012.; Poikalainen et al., 2012.; Bobić et al., 2018.). The hoof surface temperature in dairy herds could be monitored regularly to assess hoof health status, and with infrared thermovision cameras can be detected foot lesions well before the appearance of clinical signs (Bobić et al., 2017.). Detecting the inflammatory process of the hoofs in cows is of great importance, especially during early lactation, because it affects milk production (Racewicz et al., 2018.). The possibility of using infrared thermography in the detection of lameness is reflected in the fact that when inflammation occurs in the legs, an elevated temperature is created that can be detected using infrared thermovision cameras (Schaefer and Cook, 2013.).

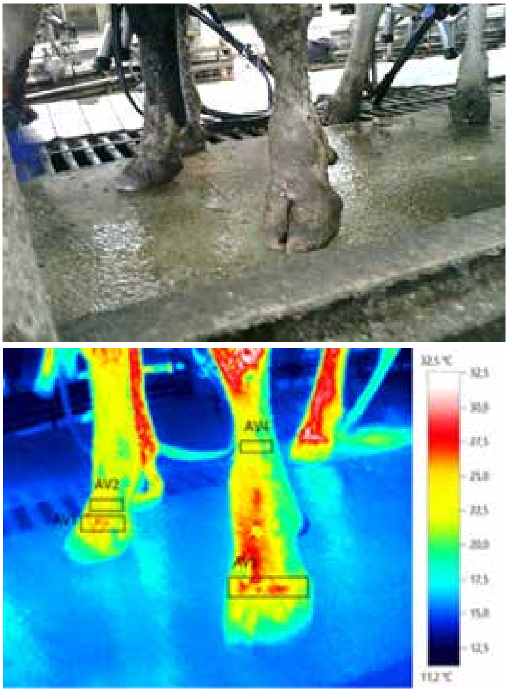


Figure 8. Digital and infrared picture of the cows hoof (Bobić et al., 2020.)

Alsaaod et al. (2015.) state great possibilities in the application of this technology in the detection of diseases on the hooves, but also state the susceptibility to environmental influences, which must be controlled in order to avoid erroneous readings of the results. Lokesh Babu et al. (2018.) state that the application of infrared thermography is possible in the detection of inflammatory changes on the hooves of cows, especially if changes in the temperature of the coronal part of the hooves are observed (Figure 8.). The same authors state that the temperature of the surface of the leg affected by inflammation will be warmer compared to the surface of a healthy leg, and in this way lame cows can be detected as well as those that are about to become lame. Lokesh Babu et al. (2018.) also point out that the application of infrared thermography can help reduce veterinary costs, costs due to reduced production, fertility and costs of excretion from production, but they also entails a number of other standard procedures and factors that must be taken into account and incorporated (Figure 9.).

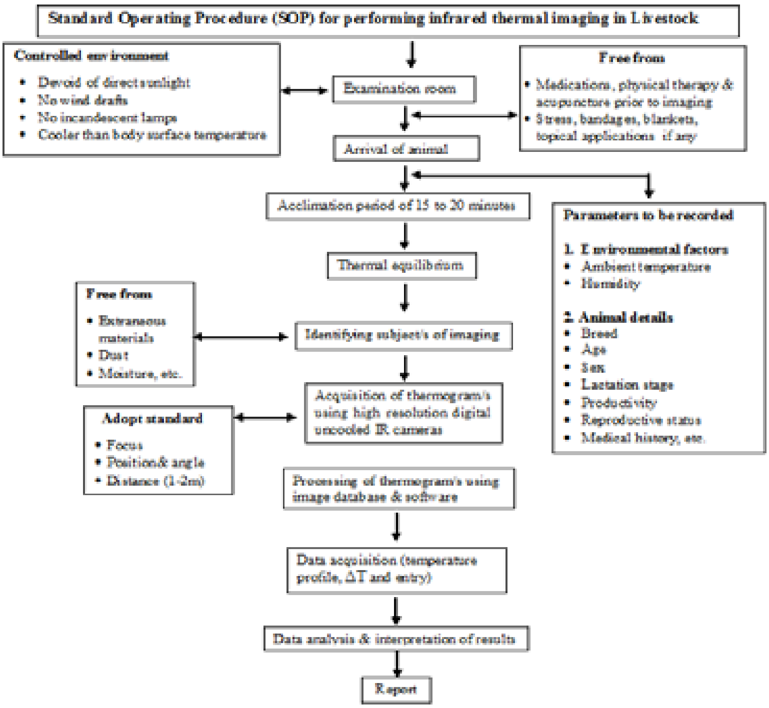


Figure 9. Standard operating procedures for performing infrared thermal imaging in animal production (Lokesh Babu et al., 2018.)

Conclusion

Various information and communication technologies are present on the market, and can be useful in detection and prevention of cow's lameness. Those technologies can improve dairy production, lower costs and improve animal welfare. It is necessary to include more factors and various experts from different fields to ensure the success of the application of such advanced and expensive technology.

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NEW TECHNOLOGIES IN AGRICULTURE AND SMART VILLAGES

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Abstract

By new technologies, we mean, above all, precision agriculture and digitization. Precision agriculture and digitization of agriculture lead to the realization of the concept of smart villages. If the digitization of the villages succeeds, through Internet possibilities such as remote work, e-learning, better health care or shopping via e-commerce, rural areas can gain the attraction that big cities have, and which they have partially lost, which would stop depopulation and deagrarianization of villages. Multiple services can be implemented in a smart village in order to improve the quality of life, living standards of the local population, implement and improve the model of sustainable development and establish effective resource management. The sensors are related to the collection of various data related to weather conditions, soil moisture, soil electrical conductivity, soil pH and crop monitoring. Technical solutions will depend on factors such as the size of the village, available resources and the desired level of data analysis and storage capabilities.

Key words: *new technologies in agriculture, smart villages, precision agriculture, digitization, technical solutions, sensors.*

Introduction

Achieving the Millennium Development Goals, the developmental agenda for the period post-2015, and the United Nations goals for access to energy until 2030 require concerted efforts focused on rural areas, where approximately 70 percent of the world's poor reside [2], [10]. Relying on a more commercialized and highly praised concept and blueprint of smart cities, the concept of smart villages offers a bold, flexible, and scalable system design.

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This design can be implemented in rural areas, providing multiple options for the local community to advance and thrive. The progress and prosperity resulting from this model approach are not limited solely to the rural areas, but also extend to encompass benefits for municipal, state, regional, and international aspects of development.

According to Anthony M. Townsend, an American researcher and author of the book "Smart Cities," he envisions smart cities as projects where computer and information technology intersect with various fields, such as construction, traffic management, ecology and sustainable development, urban infrastructure, household appliances, architecture, and even wearable technology for individuals (e.g., measuring blood pressure, oxygen levels, sugar levels, etc.) [5].

Until today, inefficient and health hazardous kitchen stoves continue to be the only accessible and highly affordable cooking method for 2.7 billion people living in rural areas [2]. This issue stems from an even more daunting reality: 1.3 billion people worldwide lack access to electricity, which is considered a fundamental aspect of civilization. Availability of electricity and energy is a critical prerequisite for these individuals to lead significantly improved and dignified lives. Former Secretary-General of the United Nations Ban Ki-moon stated in this regard, "Energy is the golden thread that connects economic growth, increased social justice, and an environment that enables the planet to progress" [8].

By improving the living standards of rural populations, both qualitatively and financially, smart villages have emerged as a new development model that shares analogous key points with the better-known concept and project of smart cities. The concept and project of smart villages, from the perspective of a modern approach to energy, can be considered as key trigger for initiating progress and ultimately revolutionizing rural areas. They have the potential to bring advancements in healthcare, e-education, drinking water and sanitation management, food standards, business productivity, sustainability, ecological concerns, participation in democracy, and accessibility to energy. By embracing these advancements, the rural population can achieve a healthy and high-quality standard of living, thereby realizing their development goals and developmental potential, as well as be part of the globally connected world through the use of computer networks, leveraging many advantages of urban life while retaining traditional aspects rural life has to offer, giving them the choice between migrating to urban centers or living in a smart village [2]. The key drivers of the developmental benefits in smart villages include the implementation of an electricity source model and the affordability of pollution-free and efficient cooking stoves, all integrated with a focus on sustainability. [2].

Rural areas are susceptible to numerous climate change hazards and natural disasters, such as floods, landslides, droughts, heavy rainfall, strong winds, volcanic eruptions, and tsunamis [3]. They also face risks associated with agrarian market fluctuations, economic volatilities, and outbreaks of epidemics. Climate change tends to intensify these hazards periodically, resulting in frequent natural disasters. In such severe and volatile environments and events, developmental advantages are not only challenging to acquire but also difficult to retain compared to the recent past [3]. Smart village related benefits can provide rural communities much needed resilience and flexibility to the aforementioned hazards [3]. Physical infrastructure, coupled with access to energy, serves as a crucial driver for the implementation of contemporary informational-communicational technologies. These technologies can act as the cornerstone for the adaptation of villages to changing circumstances through [3]:

- Enhancing community-level knowledge through training, education, and the exchange of information, thus creating skills and knowledge on developing resilient infrastructure;
- Establishing communication links and providing resources for pre-disaster warnings, as well as more efficient efforts for disaster response;
- Enhancing healthcare facilities and ensuring adequate and sufficient lighting are especially crucial in villages during and immediately after periods of the aforementioned catastrophes and disasters.

Methodology, Hypothesis, and Sources

The aim of our research is to determine how new technologies in agriculture can contribute to the development of the concept of smart villages.

The methodology of our research is analytical-descriptive. We have studied a large number of literature sources, analyzed them, and drawn appropriate lessons and conclusions. In a multidisciplinary approach (technical, economic, and agro-economic), we have examined the new phenomenon in agriculture - new technologies - and explored their potential applications with the aim of building and implementing smart village models. The main hypothesis of this study is that new technologies applied in modern agriculture can be significant factors for smart villages, a concept that should be developed based on the concept of smart cities.

Smart Agriculture Services

In a smart village, various services can be implemented to improve the quality of life, the living standards of the local population, implement and enhance sustainable development models, and establish efficient resource management. Some of the potential services include: Smart grids and energy efficiency management, Environmental monitoring, Smart agriculture (agriculture 4.0 or 5.0), Smart water management, Smart waste management, Automation of intelligent homes, Improvement of the transportation system, Introduction of E-government.

The service that encompasses multiple aspects of a smart village, in terms of implementing sustainable development models, improving quality of life through automation, enhancing living standards, and efficient resource management, is smart agriculture. Smart agriculture as a service includes technologies such as precision farming tools, various sensors in the soil (e.g. moisture sensors), and crop monitoring systems.

The American National Research Council has provided a definition of precision farming as a "management strategy that uses information technologies to collect data from multiple sources that will influence decisions related to agricultural production" [6]. Another simpler way to define precision farming is "the process of putting the right things, in the right amount, in the right place, at the right time" [7].

Mechanization plays a crucial role in precision farming [4]. Timeliness of work, ease of use, and rational use of inputs are important parameters for increased production. Improving the use of agricultural equipment can increase crop production by 15-20 percent [4]. Certain forms of precision farming have been practiced by farmers since the early days of agriculture (Agriculture 1.0). Agriculture 1.0 developed at the beginning of the 20th century with high human labor involvement and low productivity, where animal-drawn implements dominated as auxiliary tools [4]. The further development of agriculture involves a gradual reduction in the involvement of human labor, with the use of mechanization and increased productivity [4], progressing through Agriculture 2.0 (the so-called Green Revolution), Agriculture 3.0, which introduced the term precision agriculture, up to the present focus on Agriculture 4.0. Agriculture 4.0 represents a smart agriculture service that is significantly developing, not only in terms of increasing market share, but also in terms of innovation and consumption. It includes a system of cheap and advanced sensors and actuators. It consists of the following components: Cheap microprocessors, Broadband network communication infrastructure, Cloud servers (cloud computing), and Big data analytics.

The alternative name for Agriculture 4.0 is Digital Agriculture or Smart Agriculture. This name was introduced when telematics and data management began to combine with the well-known concept of precision agriculture, improving the accuracy of operations [4].

The smart agriculture service network in a smart village includes: A central monitoring system that serves as the core of the smart agriculture network. It is responsible for data analysis, visualization, and decision-making. A Gateway, used to collect data from sensors in the field and transmit it to the central monitoring system. The Gateway acts as a bridge between field sensors and the central system. Sensors deployed throughout agricultural areas to collect various data related to weather conditions, soil moisture, soil electrical conductivity, soil pH, and crop monitoring.

Technical solutions

Specifics of technical solutions include a central monitoring system, a Gateway for collecting and transmitting sensor data, and sensors deployed in the field. The technical solution will depend on factors such as the size of the smart village, available resources, desired level of data analysis, and storage capabilities. The central monitoring system can combine these components to create a comprehensive solution. For example, sensor data can be transmitted to a cloud computing platform for storage and big data analysis.

Subsystem determination

The central monitoring system can utilize big data analytics techniques for processing and analyzing large amounts of data collected from different sensors and devices. Big data analytics helps discover patterns, trends,and provides new perspectives on analyzing collected data.This enables better decision-making based on information quality and improved farm management.

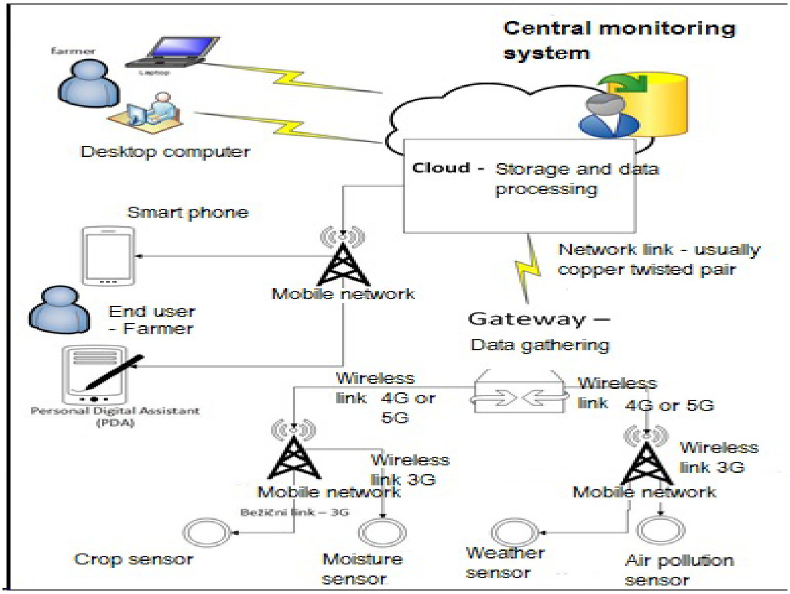
The combination of the central monitoring system with big-data involves using algorithms, statistical models to extract significant information from the collected dataset.

The implementation of a central monitoring system in a smart village can provide multiple services aimed at improving the standard of living for the local population and enhancing the quality and quantity of sustainability models implemented. Among the potential services, smart grids and energy efficiency, environmental monitoring, smart agriculture, water and waste management, automation of smart homes, improvement of the transportation system, and the introduction of e-governance stand out. Smart agriculture is a key service for implementing sustainable development models and effective resource management. This type of agriculture utilizes technologies such as precision tools, sensors for measuring soil parameters, and crop monitoring systems. Timely work and efficient use of inputs are important for increasing crop production. The technical solution for a smart village includes a central monitoring system, data collection Gateway, and field sensors. Communication links can be established through copper wires, optical cables, or wireless technologies such as Wi-Fi, Bluetooth, or Zigbee. Mobile networks like 3G, 4G, and 5G can provide wider coverage for field sensors. The technical solution will depend on the size of the village, resources, and the need for data analysis and storage.

Based on all analyzed information we have constructed a smart village network that includes all necessary and required elements of a smart village model.

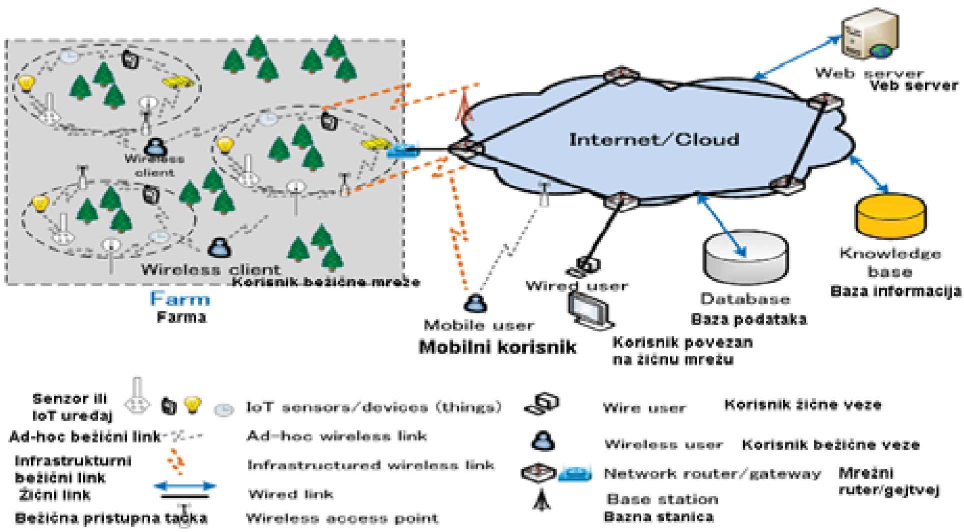
Network diagram of a smart village

Diagram 1: *Smart Agriculture Service Network in a Smart Village*



Source: Authors, diagram created using Microsoft Visio

Diagram 2: *Smart Agriculture Service Networks in a Smart Village*



Source: [9]

Connecting equipment

For long distances between sensors located in the field and the central monitoring system, the following approaches can be considered:

Wireless technologies - Long-range wireless technologies such as mobile networks (3G, 4G, or 5G) should be used for data transmission over long distances. These technologies provide extended coverage and can enable data transmission even in remote areas; Repeaters or Gateways: Installation of repeaters or additional network Gateways is necessary to extend the range of wireless communication. These devices receive data from sensors and forward them to the central monitoring system, bridging the gap between remote sensors and the core network.

Internet connection - If an internet connection is available in the smart village, data can be transmitted over the Internet using protocols such as MQTT (Machine to Machine - M2M network protocol designed for connections with remote locations that have devices with limited resources or limited network bandwidth, such as the Internet of Things), or HTTP (Hyper Text Transfer Protocol). This enables data communication over long distances, making it suitable for remote monitoring and management.

Conclusion

Smart villages offer numerous opportunities for citizens and businesses. If the digitalization of rural areas succeeds, through Internet capabilities such as remote work (home office), e-learning (education from any location), better healthcare (continuous monitoring of blood pressure, etc.), or e-commerce shopping (with fast delivery in the region), rural areas can gain the attractiveness that large cities have, and which they have partially lost [8]. If everything is done properly in this regard - network, devices, services - it would even be possible to slow down or even stop rural exodus. With a powerful Internet connection, there will no longer be a need for people from rural areas to migrate to cities. The first and most basic requirement is stable broadband connectivity for everyone in rural environments, and secondly, appropriate fundamental applications such as e-learning apps in schools and universities, telemedicine, remote work, etc. [8]. In short, new technologies provide great opportunities for revitalizing and developing rural areas in Republic of Serbia, which is also the goal of long-term sustainable development.

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DIGITIZED AGRICULTURE. CASE STUDY ON CROP360 AGRICOVER

Alina Florentina Gheorghe[1], *Mihaela Ivanov*[2]

Abstract

CROP360, developed by Agricover Technology, represents a significant innovation in the context of agriculture digitalization. Launched in November 2021, the platform provides Romanian farmers with a comprehensive range of digital tools, including crop monitoring, easy data import to the Agency for Payments and Intervention in Agriculture, and efficient management of agricultural activities. By integrating solutions for decision support in agriculture, commercial tools, and digital interactions, CROP360 optimizes farmers' processes, bringing considerable benefits in terms of efficiency and profitability. The platform not only improves the working conditions of farmers but also contributes to reducing the negative impact on the environment. Recognizing the essential role of technology in transforming the agricultural sector, CROP360 facilitates the transition to sustainable and competitive agriculture in the digital era, marking a significant advance in the modernization and efficiency of agricultural practices in Romania.

Key words: *digitalization, agriculture, farm*

Introduction

Ecological losses, water deficits, arable land degradation, increased energy demand, and the emergence of new diseases and pests exert significant pressure on the economy. For agricultural enterprises, it is becoming increasingly challenging to conduct profitable activities and meet market demands for agricultural products. In this context, digital technologies represent the future of agriculture, and their neglect hinders progress in the development of the agricultural sector. Studies in the field support that the use of digital techno-

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logy is a practical approach to address contemporary challenges. The process of digitizing agriculture leads to notable enhancements in farmers' working conditions, helps mitigate the adverse environmental effects of farming, and ensures substantial profitability for agricultural enterprises. It is anticipated that in the near future, digital agriculture will gradually replace traditional methods, as producers understand that investments in technology can yield efficient results, such as savings in seed, fertilizers, herbicides, pesticides, and fuel consumption (Amarfii, 2020).

Since March 2017, the EU satellites Sentinel 1 and 2, part of the Copernicus program, have been providing high-resolution images at regular intervals, representing a significant advancement in agricultural monitoring technology by offering these images for free (European Court of Auditors, 2020).

These innovations constitute an essential component of the European policy for the development of member states of the European Union, and the results obtained through these satellites bring significant improvements across all economic sectors, with a particular emphasis on the agricultural sector.

The digitalization of the agricultural sector in Europe can bring substantial improvements to agricultural production, with the increased efficiency of farmers being evident in the sustainability of products and the competitiveness of farms. Newly discovered technologies provide numerous opportunities for the development of agricultural businesses.

Digitization facilitates a more streamlined value chain, fostering enhanced collaboration and communication among stakeholders, including producers, retailers, processors and distributors.

Ensuring inclusive and accessible digitization requires collaborative efforts from policymakers, industry leaders, and technology providers. It is crucial for them to collectively advocate for the advantages of digitization and provide farmers with the necessary training, resources, and incentives for embracing new technologies. This collaborative approach will enable the European agricultural sector to fully leverage the benefits of the digital era, improving the sustainability and profitability of agricultural operations while addressing pressing issues like food security and climate change.

The data from IoT (Internet of Things) technology can assist farmers in improving the decision-making process regarding the distribution and cultivation of crops. It also allows real-time monitoring of animals. Thus, with the help of this information, a farmer can practice precision agriculture, increasing yields and reducing waste, thereby lowering costs.

Another benefit of the new technology is the ability to allow farmers or interested individuals to remotely monitor crops, animals, and the actual farm, thereby reducing labor and security costs and ensuring increased safety.

Virtual representations of farm components, such as agricultural machinery, cultivated land, and existing animals on a farm, can be enriched with data from on-site sensors and cameras. Through digitization, water consumption can be optimized, reducing waste and ensuring that each crop or animal receives the required amount of water. Additionally, seeds and fertilizers can be precisely distributed, resulting in a reduction in pesticide consumption.

However, for this highly beneficial new technology, there may be some challenges, such as the need for a reliable internet network that is consistently available. Another issue arises from data security, where there is a risk to data privacy. In conclusion, continuous developments are necessary to fully harness the potential of new digital technologies. These developments may involve both farmers and those in the industrial sector. (European Commission, 2023).

Methodology and Data Used

About Crop360

Crop360 is a comprehensive digital agriculture platform meticulously crafted to offer farmers swift access to essential services and information vital for their daily farm operations, thereby facilitating on-the-spot decision-making. Through strategic partnerships with Microsoft and ESRI, it harnesses global technologies to not only boost farm efficiency but also align with the stipulations of the European Union's new agricultural policy.

Crop360 is a digital platform developed by Agricover Technology, aiming to streamline the integration of digital agricultural tools into farmers' practices. The platform integrates digital solutions in the following areas:

- Provides decision support in agriculture, including functionalities such as plot geolocation, satellite imagery, and weather information, crop monitoring, and on-field access.

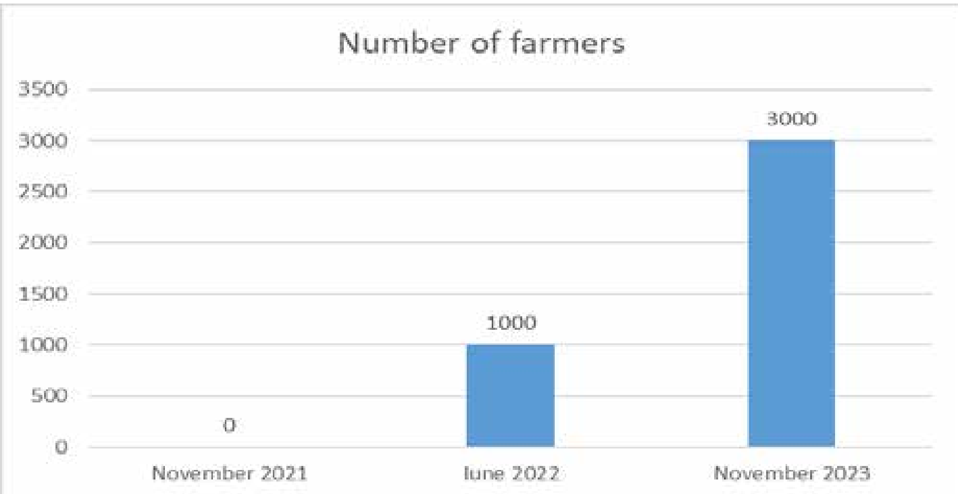
- Offers efficient business tools, such as managing lease contracts, a warehouse management system for inventory (seeds, plant protection products, and plant nutrition).
- Facilitates digital interactions with the Agricover Group through modules like e-care and the e-commerce platform for Agricover Distribution, as well as an online „banking" system for Agricover Credit.

The Agricover Group operates in the agricultural, financial, and technological sectors, with Agricover Holding SA serving as the entity holding the three components of the group: Agricover Distribution (specialized in agricultural technology distribution), Agricover Credit (a non-banking financial institution specialized in financing farmers), and Agricover Technology, which facilitates farmers' access to the latest global innovations in the agricultural sector and essentially contributes to transforming the way farmers conduct their operations through the adoption of digital technologies.

Results and Discussion

In November 2021, Agricover Technology introduced its digital agricultural platform, named Crop360, providing Romanian farmers with access to advanced digital tools for monitoring and enhancing their performance.

Chart 1. The number of farmers using the CROP360 platform



Source: Own conceptualization based on the data provided by CROP360

The CROP360 application represents a complex project in which the design team at Brandfusion was involved in the development of UI and UX, while the technology team at Commergent was responsible for implementation. Advanced digital solutions created in collaboration with leading global developers, including Microsoft, ESRI, and the All-in-One Dynamicweb platform, were utilized.

The goal of the eCommerce application is to simplify the purchase of subscriptions or products closely related to the services offered by the CROP360 portal for farmers. The application is connected to both the CROP360 portal and the Agricover ERP solution, transmitting details about products or subscriptions purchased by farmers.

The user's first interaction with the platform is through the registration page, where they can obtain all essential product information before starting the farm registration process. After authentication, the user is greeted by a control panel providing access to the service administration area, as well as a section with updates proposed by the dedicated Agricover team.

The central module, through a map, provides an overview of all fields on the farm, highlights their administrative status, and offers specific information for each crop: growth stage, vegetation indices, and alerts regarding the risks of diseases or pests.

Using satellite and GPS data, it is possible to precisely track the activity of the entire fleet, and based on the weather forecast, field activities can be planned.

Benefits of using the Crop360 platform:

• Easy import of declared crops to the Agency for Payments and Interventions in Agriculture (APIA). To streamline farmers' work, this advanced digital solution allows the easy import of files containing the declared areas to APIA. This tool facilitates quick plot planning.

• Continuous monitoring of crop development. Digital solutions of this kind are designed to help farmers consistently and remotely monitor the evolution of agricultural crops, benefiting from integrated satellite images.

• Real-time alerts. The digital software provides immediate notifications in case potential issues in crops are forecasted, such as weather warnings or risks of diseases or pests. This allows proper planning of mechanized work in the following days.

• Localization of agricultural equipment. Through this online platform, it is possible to locate agricultural equipment in real-time and view their travel history or current position.

• Easy operational management. Digital collaboration with agricultural material suppliers facilitates the rapid acquisition of inputs needed for establishing or maintaining future crops. Additionally, order status and payment deadlines can be constantly checked.

• Crop planning program. Developing an efficient crop rotation schedule to maximize production, as well as the ability to add and adjust data for multiple plots simultaneously.

In November 2023, a revamped iteration of the Crop360 platform was introduced, aiming to provide a more user-friendly solution for farmers. This updated version incorporates a range of modifications derived from the collective experiences of over 3,000 farmers and the feedback received during the two years since the initial launch of Crop360.

CROP360 2.0 has been reimagined with a special focus on enhancing the multidimensional image of the farm, providing a swift overview of agricultural areas, equipment, and other vital information. This spans from crop planning to the execution of tasks associated with each plot. With enhanced control over the maps and just a few clicks, farmers can precisely and efficiently manage their agricultural plots, easily retrieve statistics and reports, and facilitate data analysis. This empowers farmers to make informed and well-grounded decisions.

The new version of the platform retains features like inventory management and reporting to authorities. Farmers can directly access the National Phytosanitary Authority's (APIA) platform from the application, securing prompt access to the regulated products database to obtain timely information.

Conclusions

Digitization in agriculture, exemplified by the case study CROP360, represents a crucial step in the transformation of the agricultural sector and its adaptation to contemporary challenges. In the context of ecological losses, water scarcity, arable land degradation, and economic pressures, digital technologies become important catalysts for sustainable progress in agriculture.

Research indicates that adopting a pragmatic approach to digitization leads to substantial enhancements in the working conditions of farmers, contributes to mitigating the adverse environmental effects of agriculture, and guarantees increased profitability for farms. Looking ahead, digital agriculture is seen as a progressive replacement for traditional methods, with obvious benefits in resource savings such as seeds, fertilizers, and fuel.

The digital transformation of the European agricultural sector holds the promise of a revolution, fostering efficiency, sustainability, and competitiveness. Emerging technologies such as Internet of Things play pivotal roles in this transformation. CROP360, developed by Agricover Technology, stands out as an innovative solution in the agricultural landscape, contributing to the reshaping of how farmers carry out their activities. The CROP360 platform brings multiple benefits to farmers, facilitating the easy import of declared areas to the Agency for Payments and Interventions in Agriculture. Through this advanced digital solution, easy import of files containing the necessary information for quick plot planning is allowed, simplifying farmers' work.

In summary, digitization in agriculture is not only imperative but also a driving force for the sustainable development of the agricultural sector. With the backing of digital technologies, the agricultural industry has the potential to enhance efficiency, competitiveness, and sustainability, effectively tackling current challenges and positioning itself for the future.

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