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PREFACE

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.

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PROCEEDING

PLENARY SECTION I

THE ANIMAL PRODUCTION PARADOX: NAVIGATING ETHICS AND ECONOMICS IN MODERN FARMING

Barbara Luštrek[1]*, Vesna Gantner*[2]*, Klemen Potočnik*[3]

Abstract

Modern farming methods in developed countries often prioritize efficiency at the cost of animal welfare, environmental sustainability, and public health. Intensive livestock farming contributes to biodiversity loss, greenhouse gas emissions, and resource degradation, raising concerns about long-term viability. While only a small portion of the global population lives in these regions, changes in their agricultural practices have global consequences. This paper explores ethical and economic issues in livestock farming and suggests solutions such as regenerative agriculture, agroecological practices, and digital technologies. For example, regenerative agriculture can restore soil health, improve biodiversity, and reduce carbon emissions, while digital technologies such as precision farming can optimize resource use and minimize waste. The role of smallholder farmers in promoting sustainable, resilient food systems is highlighted, emphasizing their ability to utilize local ecosystems and traditional knowledge. The paper calls for a multidimensional approach that integrates ethics and economics in agriculture. Collaboration between policymakers, farmers, and consumers is essential to create a humane, sustainable, and equitable food system.

Key words: *sustainability, food security, environmental impact, policy development, resource efficiency.*

Introduction

Agriculture in developed countries has undergone significant intensification over the last century, driven by specialization, industrialization, and advances in animal husbandry. This shift has led to fewer people being directly involved

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in farming, with the proportion of farmers drastically decreasing over time (ONS, 2021). As a result, non-agricultural populations have placed increasing pressure on the agricultural sector, often raising concerns about sustainability, animal welfare, and environmental degradation. These concerns are amplified by studies, though the scientific credibility of some is debated, as they often target the general public, which has limited understanding of agricultural complexities. The credibility of some studies has been called into question due to methodological limitations or potential biases driven by economic interests. For example, studies that focus solely on the environmental damage caused by livestock farming may overlook broader agricultural contexts and long-term food security needs, leading to skewed public perceptions.

Economic pressures also weigh heavily on the farming sector. Low purchase prices for primary agricultural products, coupled with public skepticism about farming practices, have raised questions about the future of agriculture, especially in relation to its long-term sustainability.

At the same time, meat, milk, and egg production has increased rapidly in other parts of the world, creating stark contrasts between industrialized and developing regions. In some countries, production has risen by over 100% in recent decades (FAO, 2022). These global differences underscore a critical issue: less than 10% of the world's population has access to sufficient high-quality food, while the remaining 90% face significant food insecurity, with an estimated third of the population experiencing severe deficiencies (FAO, 2020). This situation jeopardizes the development of critical neurological and immune systems in vulnerable populations, particularly among the 1 billion people affected by these deficiencies (FAO, 2020). However, more recent data from the FAO (2022) suggest that global efforts to reduce hunger have been slow, with food insecurity persisting, particularly in developing regions.

In this context, the European Green Deal, which proposes restrictions on agricultural resources, adds another layer of complexity. By focusing primarily on the environmental impacts of ruminants, the Green Deal overlooks broader global concerns about food security and agricultural balance. This has created confusion about its true global impact, particularly regarding the future of livestock farming.

This paper seeks to explore the ethical and economic challenges facing livestock farming, particularly in the context of food security and environmental sustainability. It aims to analyze the consequences of restrictive agricultural policies, such as those introduced by the Green Deal, and proposes a long-term, economically viable strategy that balances the needs of global food security with environmental stewardship. The study also emphasizes the importance of passing agricultural knowledge to younger generations and suggests that each nation must utilize its unique resources to achieve self-sufficiency in food production. We owe this approach to our agricultural heritage, with over 6000 years of farming history in Europe serving as a foundation for future practices (van Andel & Runnels, 1995). The paper ultimately argues for a multidimensional approach that integrates ethics and economics in modern agricultural policy and practice.

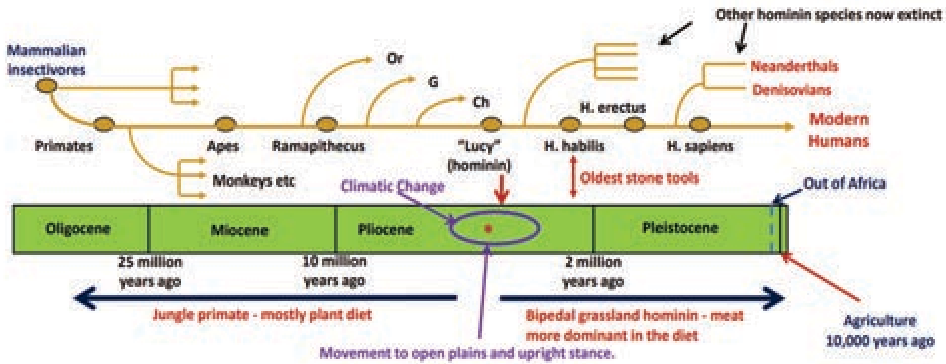
Animal source food in human diet

Meat is a rich source of essential nutrients, including high-quality protein, vitamin B12, heme iron, and zinc. These nutrients are critical for neurological and immune system function, growth, and overall health, particularly in vulnerable populations. In areas where nutritional deficiencies are prevalent, access to animal-source foods can significantly improve health outcomes by providing bioavailable proteins that are harder to obtain from plant-based diets. This is especially important for children, pregnant women, and the elderly, where deficiencies can lead to severe developmental or health challenges (Stanton, 2023).

However, high consumption of red and especially processed meat is associated with an increased risk of chronic diseases, such as cardiovascular disease, type 2 diabetes, and certain types of cancer (Stanton, 2023). These risks have led to growing public health concerns, prompting recommendations for reduced meat intake in many developed countries. Balancing the nutritional benefits of meat with its potential health risks remains a challenge for policymakers and health professionals alike. Moreover, the environmental impact of meat production, particularly related to greenhouse gas emissions, land use, and water consumption, adds further complexity to the debate on sustainable diets.

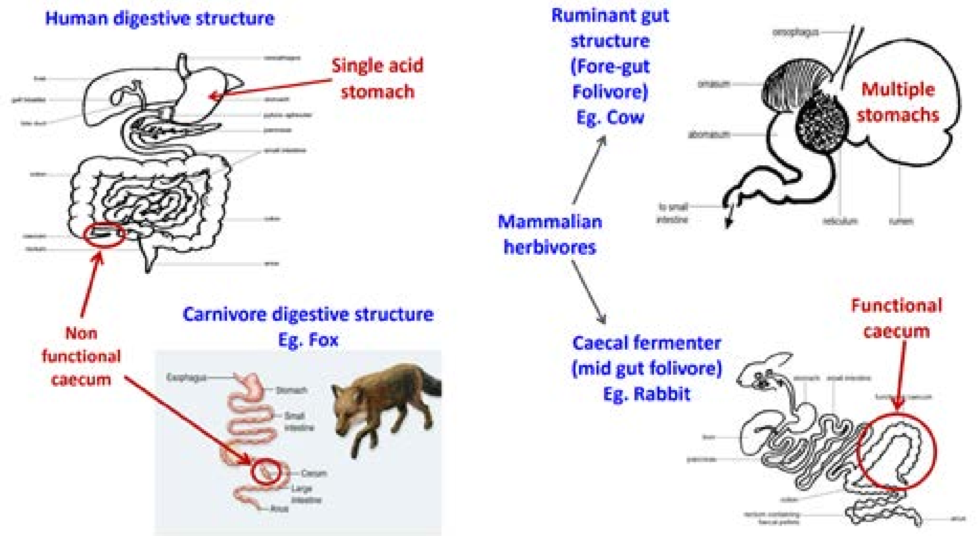
In addition, meat holds significant cultural importance as a central element in social customs and diets worldwide. It is essential to foster a dialog that respects these traditions while promoting ethical and sustainable practices of meat consumption. Stanton (2023) outlines the alarming threefold health burden of malnutrition, based on FAO and WHO statistics: 1.9 billion people are overweight or obese, 850 million suffer from chronic malnutrition, and 2 million experience hidden hunger. This malnutrition burden is closely linked to income levels, but the cost of bioavailable proteins shows relatively little variation. In high-income regions, 10 grams of bioavailable protein costs around USD 0.47, while in lower-income areas, the cost is between USD 0.37 and USD 0.43 (Ederer, 2023). These figures highlight the importance of ensuring access to affordable, high-quality protein, particularly in areas where undernutrition is prevalent.

Figure 1. *Evolution of human omnivorous diet over 4 million years (Stanton, 2023)*



The evolutionary history of humans as omnivores highlights the long-standing importance of meat in our diet (Figure 1). Over the last 4 million years, animal foods contributed significantly to early hominin cognitive development, starting with species like Australopithecus, which began incorporating meat into their diet (Robertson, 2008). As a result, our digestive systems evolved to handle a mixed diet of animal and plant foods (Figure 2). Compared to herbivores, who possess long digestive tracts designed to break down plant matter, or carnivores, who have shorter tracts suited to digesting meat, humans have evolved medium-length tracts reflecting an omnivorous diet.

Figure 2. *Comparative digestive systems of herbivores, carnivores, and omnivores. Humans have evolved medium-length digestive tracts suitable for a mixed diet (Stanton, 2023)*



As animal foods became more common in the human diet, our digestive systems adapted. Today, humans possess simplified digestive tracts with only a single acidic stomach and a non-functioning appendix, reflecting a lower capacity for microbial digestion than herbivores. This evolutionary trajectory underscores our historical reliance on animal-source foods for nutrition, though modern dietary patterns and lifestyles have shifted significantly.

The growing demand for meat, particularly in developing countries, is closely linked to economic growth and urbanization. As incomes rise, so does the consumption of animal-source foods, making it a key factor in improving nutritional outcomes in regions plagued by undernutrition. Yet, despite this growing demand, average meat consumption in some developing regions remains below the epidemiological recommendations of 100 grams per person per day, with some low-income areas falling below 40% of this guideline (Ederer, 2023).

In contrast, the environmental concerns surrounding meat production have gained increasing attention in recent years. Livestock farming is a significant source of greenhouse gas emissions, particularly methane from ruminants. It also contributes to deforestation, water depletion, and biodiversity loss, all of which pose challenges for sustainable food systems. Balancing the need for nutrient-dense animal-source foods with the environmental costs of their production requires innovative solutions such as agroecological practices, improved farm management, and a shift toward alternative protein sources.

GHG Challenges in Animal Production

Greenhouse gases (GHGs) play a critical role in regulating the Earth's temperature, but human activities have significantly increased their concentrations, contributing to climate change. Among these gases, water vapor is the most abundant, responsible for 60-75% of the greenhouse effect. However, its concentration is largely controlled by natural processes like evaporation and condensation, so human activities have little direct influence over it. Carbon dioxide (CO2) accounts for about 26% of global GHG emissions, driven largely by human activities such as the burning of fossil fuels and deforestation. Its concentration has risen steadily from 345 parts per million (ppm) in 1980 to 417 ppm today, and CO2 remains in the atmosphere for a long time, making it a major driver of long-term climate change (Wikipedia, 2024b). Methane (CH4), though present in smaller quantities (around 1.9 ppm), accounts for about 6% of global GHG emissions but is more than 25 times more effective than CO2 in trapping heat over a 100-year period, even though it has a shorter lifespan in the atmosphere (Wikipedia, 2024a; Myhre et al., 2013).

Linking GHGs to Animal Production

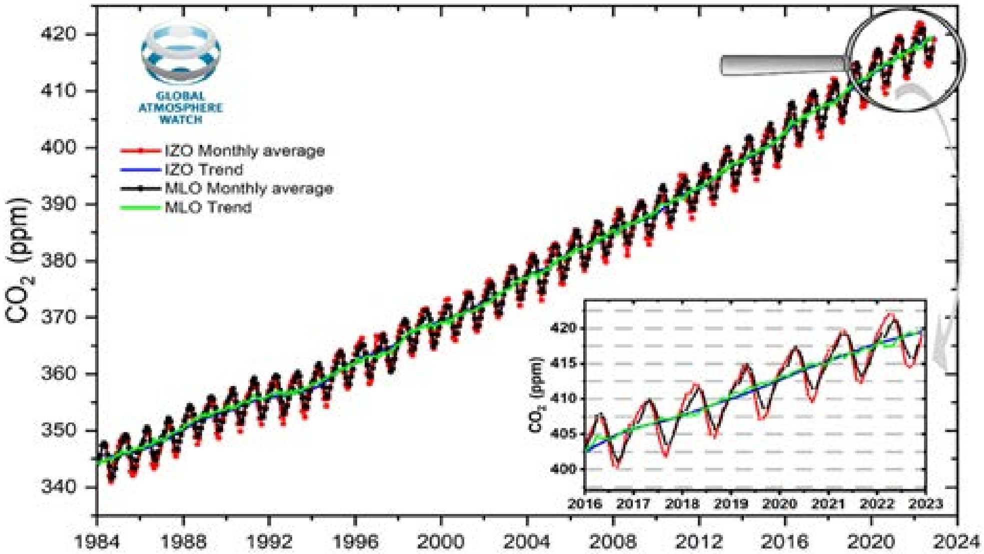
In the context of agriculture, methane is particularly important because it is primarily produced by ruminants (such as cows, sheep, and goats) through a process called enteric fermentation—essentially, the digestive process that allows these animals to break down fibrous plant material (Patra, 2016). Methane is released when these animals burp, contributing significantly to agriculture's GHG emissions. Around 25-30% of human-caused methane emissions come from livestock, mainly through enteric fermentation and manure management (O'Connor et al., 2024).

However, not all methane comes from livestock. About 40-50% of methane emissions are from natural sources such as wetlands, and around 10% comes from termites. Human activities like oil and gas extraction, landfills, and agriculture contribute the remaining portion. Specifically, methane from livestock accounts for about 25-30% of global methane emissions, while oil and gas extraction contribute 20-30%, and landfills account for 15% (International Energy Agency, 2023).

From an animal production perspective, methane is the most relevant GHG, but agriculture also contributes to carbon dioxide and nitrous oxide (N2O) emissions. These come from land-use changes (like deforestation for pastures), the use of synthetic fertilizers, and energy-intensive farming practices. Agriculture is estimated to account for about 9% of total GHG emissions, with around 3% attributed to methane produced by ruminants. In comparison, energy production contributes about 31% of emissions in Europe and 28% in the United States, and transportation accounts for 20% in Europe and 29% in the United States (Majdič, 2020).

Despite these statistics, some interpretations overstate the role of livestock in global GHG emissions. CO2 levels have shown a steady rise over the past 40 years, increasing from 345 ppm to 417 ppm today. This rise occurs in seasonal cycles, with CO2 levels decreasing during the growing season in the northern hemisphere and increasing outside this period. Interestingly, during the COVID-19 pandemic, global transportation nearly halted, but this had no significant impact on atmospheric CO2 concentrations, which continued to rise (Cuevas et al., 2022). This observation suggests that focusing solely on reducing livestock methane emissions will not be sufficient to address the broader issue of global warming, especially without tackling major CO2 sources like energy production and transportation.

Figure 3. *Mean monthly CO_2 concentrations (ppm) at Izaña (red) and Mauna Loa (black) observatories, shown under background conditions with seasonally fitted data (blue and green, respectively) for each station. The zoomed image highlights a slightly greater amplitude and a small lag in the seasonal cycle at Izaña (IZO) compared to Mauna Loa (MLO) (Cuevas et al., 2022)*



Conclusion for Animal Farming

Reducing methane emissions from livestock is essential but must be part of a broader strategy that includes other major GHG contributors. Solutions like improving livestock feed efficiency, agroecological practices, and alternative proteins can help reduce methane emissions while maintaining the critical role that livestock farming plays in global food security. However, efforts must also address the more significant CO2 emissions from energy production and transportation to make a meaningful impact on climate change rise of CO2 in the atmosphere.

Conclusion

The challenges facing modern agriculture, particularly in livestock production, require a multidimensional approach that balances ethical concerns, environmental sustainability, and food security. The Green Deal initiatives that impose restrictions on livestock production should be evaluated in the context of global greenhouse gas (GHG) emissions and their impact on food security. However, addressing these challenges effectively will require more than just regulatory action—it calls for co-operation and innovation across multiple sectors, from policy to farming practices.

Policymakers play a crucial role in shaping sustainable farming practices. They should create financial incentives, such as subsidies or tax credits, to encourage farmers to adopt regenerative agriculture and agroecological methods that improve soil health, reduce GHG emissions, and enhance biodiversity. Incentive programs, similar to those included in the EU's Common Agricultural Policy (CAP), can guide this transition. Governments should also increase investment in research and development to improve livestock feed efficiency and explore methane-reducing technologies, such as methane inhibitors and alternative protein sources like plant-based or lab-grown meat. International collaboration is essential to ensure these efforts are globally effective, as demonstrated by initiatives like the Global Methane Pledge, which seeks to reduce methane emissions by at least 30% by 2030.

Farmers can also take action by adopting precision agriculture technologies to optimize resource use, reduce waste, and minimize their environmental impact. Technologies such as drones and satellite monitoring already offer opportunities to improve resource efficiency in farming. Implementing sustainable livestock management practices, including improving feed quality, using methane-reducing feed additives like red seaweed, and practicing rotational grazing, are proven strategies to decrease methane emissions from ruminants. Farmers should also focus on building resilience through local ecosystems by integrating traditional knowledge with modern practices like agroforestry and permaculture.

Consumers have a significant role to play by promoting ethical consumption. They can support sustainable agriculture by choosing products that are certified as ethically and sustainably produced, reducing the consumption of heavily processed meats, and supporting certifications such as Fair Trade, Rainforest Alliance, or Certified Humane. Additionally, supporting local food sources through programs like Community-Supported Agriculture (CSA), which connects consumers directly to local farmers, helps reduce the carbon footprint of food production and transportation.

Passing agricultural knowledge to future generations is vital for ensuring food security and sustainability. Agricultural education should be emphasized at all levels, from primary schools to universities, with a focus on sustainability and innovation. Mentorship programs, scholarships, and agricultural incubators can support young entrepreneurs in farming and agribusiness, helping to foster the next generation of farmers. Technology transfer is equally important, particularly in developing countries, where young farmers need access to modern tools and techniques. Public-private partnerships and expanded efforts by organizations like the Food and Agriculture Organization (FAO) can help scale up sustainable practices globally.

In conclusion, the future of livestock farming requires cooperation between policymakers, farmers, and consumers to develop strategies that reduce environmental impacts while ensuring food security. By embracing education, innovation, and sustainable practices, future generations can continue to improve farming systems and create a more equitable, humane, and resilient global food supply chain.

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REALITIES AND CHALLENGES IN FINANCING AGRICULTURE IN EU: SOME INSIGHTS FROM THE ROMANIAN PERSPECTIVE

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Abstract

The agricultural sector continues to represent a key area of economic activity within the European Union (EU), providing a substantial contribution to food security, rural development and sustainable economic growth. Access to finance represents a significant challenge, yet an important factor in supporting innovation and improving productivity within the context of the EU's Common Agricultural Policy (CAP) and the pursuit of sustainability goals. Agricultural financing in the European Union (EU) is confronted with a multitude of challenges, including the necessity to adapt to evolving policy frameworks, climate impacts, and technological innovations. The financial landscape of Romania is less diversified than that of other EU member states, with a corresponding reduction in the availability of credit and financing options that are tailored to the specific needs of the agricultural sector. The absence of specialised financial institutions dedicated to the agricultural sec-

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tor, such as cooperative banks, constrains the access of small farmers to capital. Examining the European agricultural policy landscape, funding mechanisms, and the role of financial institutions, the article also aims to highlight the major aspects of Romanian policy challenges and implications for agricultural development in the context of the EU's sectorial approaches.

Key words: *agriculture, Common Agricultural Policy, investments, financing, modernisation.*

Introduction

Romanian agriculture's integration within the European Union (EU) framework continues to attract considerable attention, largely due to persistent financing gaps and the sector's struggle to modernize. Compared to other EU member states, Romania's agricultural industry receives substantially lower financial support per hectare, which constrains its competitiveness and hinders growth. Many studies (Simona, 2015; Andrei, & Radulescu, 2019; Manta et al., 2024; Ban & Buciu, 2025) argue that this underfinancing not only limits the sector's ability to invest in state-of-the-art technologies and sustainable practices but also affects the overall economic progress of rural areas.

This paper's goal is to examine and evaluate Romanian agriculture's particular financial difficulties in the context of the European Union (EU). This study specifically looks at the availability and efficiency of financial tools, structural funding, and support systems provided by the Common Agricultural Policy (CAP) and the European Agricultural Fund for Rural Development (EAFRD). In doing so, it investigates the effects of various financial methods on Romania's rural sectors' economic growth, resilience, and agricultural modernisation (Pîrvu et al., 2022). A significant financial gap exists in Romania's agriculture industry, which may be attributed to both structural barriers to financing and EU regulatory requirements. According to studies (Von Oppenkowski et al., 2019; Falol et al., 2022), Romanian farmers frequently turn to private or informal finance because official credit alternatives are difficult to obtain, even in spite of EU funding initiatives (fi-compass, 2020). To address these issues, initiatives like the CAP's National Rural Development Program (NRDP) were created, providing targeted financial assistance to modernize and boost agricultural competitiveness. However, research indicates that the full impact of these activities is hampered by variables such as small farms' lack of collateral and rural businesses' lack of financial literacy (Dinu, Pătârlăgeanu, Chiripuci, & Constantin, 2020).

In an attempt to address these challenges, various scholars have examined different facets of agricultural financing. For instance, Deac, (2021) underscores how realistic budget planning in Romanian financial statements is essential for the judicious allocation of state resources, promoting increased efficiency in public resource management. Meanwhile, Holúbek et al. (2021) examine global trends in financing that aim to mitigate climate change—an issue with direct implications for agriculture, which is highly vulnerable to environmental shifts. Bachynskyi (2021) builds on this green perspective by reviewing global experiences in stimulating sustainability initiatives for farmers, drawing attention to the obstacles they confront and the need for innovative incentive mechanisms.

Other studies have zeroed in on the EU's own strategies and programs. Walenia (2022) highlights the substantial budget allocated by the European Commission for agricultural and rural development as part of the Common Agricultural Policy, which underscores the EU's commitment to fostering sustainability across member states. Zlati et al. (2023) delve into financing pathways for Romanian agricultural cooperatives, noting key challenges such as inflation, drought, and a lack of viable credit options for long-term investments. Topor et al. (2023) complement this work by focusing on the factors influencing bank loans in Romanian agriculture, detailing how farm size, turnover, and borrower characteristics play pivotal roles in securing funding.

Against this backdrop, Romania's agricultural sector benefits from multiple financing channels—bank loans, EU funds, and national programs. Bank loans can be transformative for expansion and the adoption of modern farming techniques, though smaller-scale farmers often struggle to meet lending requirements (Topor et al., 2023). Romania's agricultural investments are mostly financed by EU structural grants, especially those obtained through the National Rural Development Program (NRDP), offers non-reimbursable support to spur agricultural advancement. Although the goal of these programs is to promote sustainable farming methods, bureaucratic hold-ups and severe compliance requirements frequently compromise their efficacy by preventing timely financial availability to rural stakeholders (Zlati et al., 2023). Absorption rates for these funds remain a concern (Marin, 2019; Dinu et al., 2020), indicating that bureaucratic processes and administrative barriers hamper the effective use of available resources. Public institutions like the Agency for Payments and Intervention in Agriculture (APIA) and the Agency for Financing Rural Investments (AFIR) play key roles in administering funds, helping foster entrepreneurship and support newcomers in the sector (Matei et al., 2021).

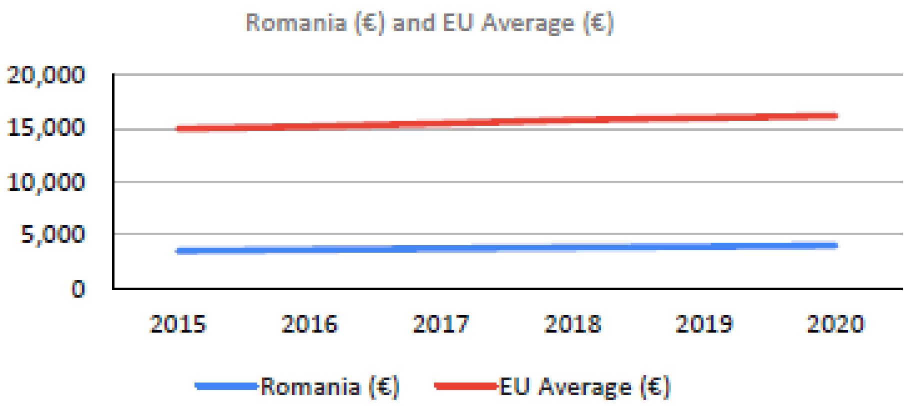
Furthermore, due to a lack of institutional capacity and infrastructure, Romanian agricultural sectors continue to face difficulties in fully utilizing the CAP's market-oriented agricultural policies and rural development strategies, which are designed to boost local economies and promote sustainable land use (Mazăre, 2020). The present research explores these dynamics, offering a thorough evaluation of the advantages and disadvantages of EU funding initiatives in meeting Romania's agricultural finance requirements, particularly for small-scale farms and cooperatives with significant development potential (fi-compass, 2020). Finally, by finding ways to improve the responsiveness and adaptability of rural financing options, this study adds to the conversation of bringing EU financing policies closer to the reality of Romania's agriculture sector (Pîrvu et al., 2022). Despite these opportunities, Romanian agriculture still confronts systemic hurdles, including insufficient absorption of allocated funds and the need for forward-thinking financial policies (Zlati et al., 2023). A more efficient rural finance system—underpinned by regulatory innovation, improved administration of financial services, and a strategic focus on digitalization—could significantly bolster the sector's productivity. Furthermore, strengthening short supply chains and adding greater value in agricultural production are also seen as critical next steps.

Impact of Rising Input Costs on Romanian Agriculture in the EU Context

The difficulties Romanian agriculture confronts in obtaining efficient financial help are highlighted by this assessment, which not only clarifies current financial support methods but also identifies deficiencies. Similar to other EU nations, Romania has relied heavily on the Common Agricultural Policy (CAP), which has two primary pillars: direct payments and rural development funding. With a focus on sustainability, environmental preservation, and climate adaptation, CAP's 2021–2027 framework seeks to update support systems (Feher et al., 2020). Researchers contend that despite the heightened emphasis on sustainability and equitable distribution, these policy changes might not adequately address Romania's particular financing gaps, especially for small farms that lack the collateral and financial literacy required to obtain EU loans (fi-compass, 2020). Given that smallholders, who comprise a sizable share of the agricultural labor, depend on direct subsidies to stabilize their incomes, Romania's agricultural industry has evolved as a result of its reliance on CAP support.

The allocation of CAP subsidies has come under fire due to significant differences in assistance per hectare when compared to other EU nations, which results in imbalances that reduce competitiveness (Dinu et al., 2020). Furthermore, Romanian farmers find it difficult to fulfill the strict application requirements and adhere to EU standards, which is why the bureaucratic procedures related to CAP funding are frequently mentioned as obstacles to effective fund absorption (Mazăre, 2020). According to scholars, Romania's agricultural demands are more extensive than what CAP funding can cover, especially when it comes to modernisation and climate resilience. This problem is made worse by the dearth of private investment possibilities; research indicates that there is a shortage of easily available finance solutions that are suited to Romania's unique agricultural circumstances (Zlati et al., 2023). Without more financial tools or specially designed regulations that promote both public and private investments, Romania's agriculture industry would find it difficult to reach the EU's goals for resilience and expansion.

Figure 1: *The agricultural factor income per annual work unit (AWU) for Romania and the EU average from 2015 to 2020, measured in euros.*

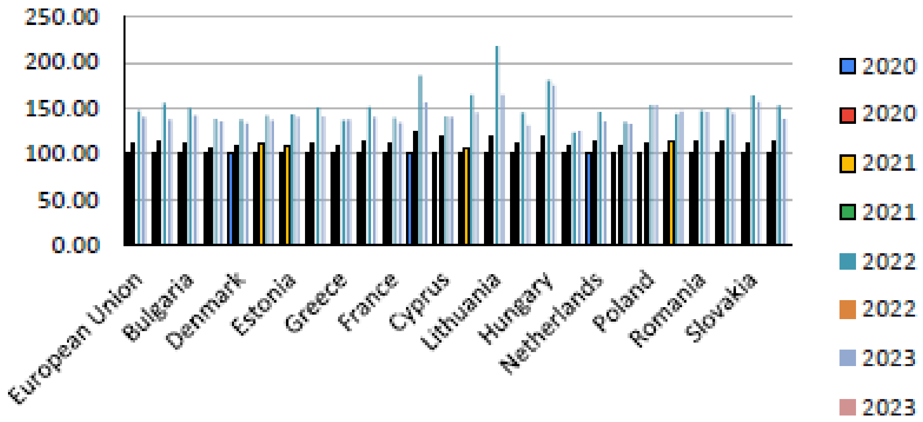


Source: *authors based Eurostat, (2024)*

When comparing Romania's agricultural factor income per annual work unit (AWU) statistics with the EU average between 2015 and 2020 highlights the serious financial difficulties Romanian agriculture faces in the larger EU context. In order to be competitive and sustainable in the EU agricultural market, Romania must overcome underlying structural limits, resource shortages, and budgetary restraints, which are reflected in this income discrepancy.Romania's agricultural revenue per AWU increased little from 2015 to 2020, from €3,500 to €4,000. This is still much less than the EU average, which rose from €15,000 to €16,200 within the same time frame. Romanian agriculture's ability to expand and adapt economically is severely hampered by the fact that the country's per capita income is less than 25% of the EU average. Romania's agricultural structure, which is dominated by small-sized, frequently subsistence farms and lacks the scale economies and mechanization that define many farms in Western Europe, is partially to blame for this income disparity. Due to these systemic barriers, Romanian farmers are unable to increase their production and raise their revenue per unit. This scenario is made worse by their restricted access to development and agricultural finance.

The difference in income also reflects larger financial difficulties that Romanian farmers face, especially when it comes to obtaining funding for modernisation and productivity enhancements. Romania's agricultural environment is dominated by small and medium-sized farms, yet they have a difficult time getting formal credit since it frequently needs substantial collateral, which many smallholders lack. Rural farmers' low financial literacy further restricts their ability to take advantage of existing lending choices, which exacerbates the financing gap and prevents them from making investments that may raise incomes and productivity. As a result, Romanian farmers are frequently unable to fully benefit from technical developments that may enable them to catch up to their European Union counterparts in terms of revenue. Furthermore, this income gap has not been entirely eliminated by the Common Agricultural Policy (CAP), which is intended to promote agricultural sustainability and competitiveness across EU member states. Although the goal of CAP subsidies is to level the playing field, Romanian farmers receive smaller payments per hectare as a result of the program's distribution, which frequently benefits bigger, more established farms in Western Europe. The financial resources available to Romanian agriculture are restricted by this unfairness in CAP allocations, especially when it comes to reinvesting in farm modernisation and resilience, which are critical for economic viability. For smaller Romanian farms, the CAP's intricate application processes and strict compliance standards provide additional obstacles, making it difficult for them to get the funding they seek to address the revenue gap. In conclusion, the difficulties and economic realities of Romanian agriculture inside the EU framework are shown by the agricultural factor income according to AWU statistics. The significant disparity between average agricultural earnings in Romania and the EU is a reflection of structural and financial limitations that will continue to impede Romanian agriculture's resilience and growth if they are not addressed. Romania may attempt to close this income gap and increase the agricultural sector's contribution to the national economy and the larger EU agricultural community by putting targeted financial plans into place, updating CAP allocations, and supporting capacity-building efforts.

Figure 2: *Price indices of the means of agricultural production, input (2020 = 100)*



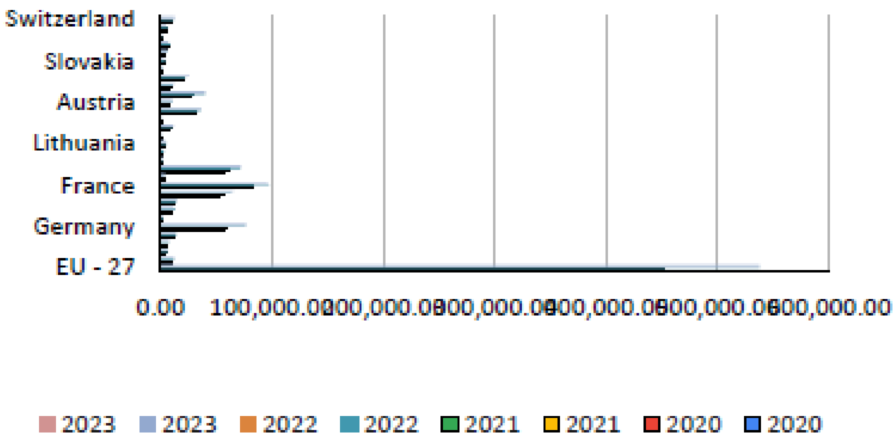
Source: *authors based on Eurostat, (2024)*

Significant difficulties in controlling agricultural expenses and funding requirements are shown by the price indices of agricultural production inputs throughout the European Union, with an emphasis on Romania. The cost of inputs, including electricity, equipment, and fertilizers, increased significantly between 2020 and 2023, highlighting the price instability and rising trend of inputs that have placed a significant financial burden on agricultural operations. To provide a consistent starting point for analysing cost increases throughout the next years, the index was established at a baseline of 100 for all EU nations in 2020.Input prices increased to an index of 112 in 2021 for the entire EU, then increased to 146.98 in 2022 and then significantly decreased to 140.12 in 2023. These variations point to a high level of input price volatility caused by a number of variables, such as interruptions in the global supply chain, inflationary pressures, and rising energy prices. Similar trends were seen in Romania, where input costs increased to 113.74 in 2021, peaked at 147.13 in 2022, and then settled somewhat lower at 145.85 in 2023. This pattern closely resembles the overall EU average, indicating that external pressures on input costs are comparable for Romania's agriculture industry to those of other EU countries. However, the financial burden brought on by increased input costs is exacerbated in Romania by the country's comparatively lower baseline agricultural revenue per worker. Romanian farmers' ability to sustain profitability declines when input prices rise quickly without a matching growth in agricultural revenue, and producers seek to offset rising costs by seeking loans. This situation highlights Romania's need for sufficient and easily available financial assistance to close the gap between rising input costs and stagnating revenue levels. The gap in available capital for necessary agricultural investments and operating expenses widens as a result of Romania's input costs rising by over 47% between 2020 and 2022, which has an impact on the long-term viability and competitiveness of Romanian agriculture.

Agricultural output, financial dynamics and structural changes in the agricultural sector

The reality of funding agriculture in Romania in light of growing input prices necessitates certain policy measures. Increased financial assistance in the form of subsidies, low-interest loans, and credit availability may enable farmers to handle these increased expenses without sacrificing output. To guarantee that less economically resilient nations like Romania are not disproportionately impacted by growing costs, policy changes at the EU level—specifically within the Common Agricultural Policy (CAP)—are also essential. Romanian farmers might be able to acquire the money they need to deal with these financial strains if CAP funds were increased or if targeted subsidies were created specially to address input cost increases. Given the realities of financing agriculture in Romania and the rising cost of inputs, certain policy actions are required. Farmers might be able to manage these higher costs without compromising productivity with more financial support in the form of subsidies, low-interest loans, and credit availability.

Figure 3: *Values at current prices of the agricultural production in some Eu-27 countries*



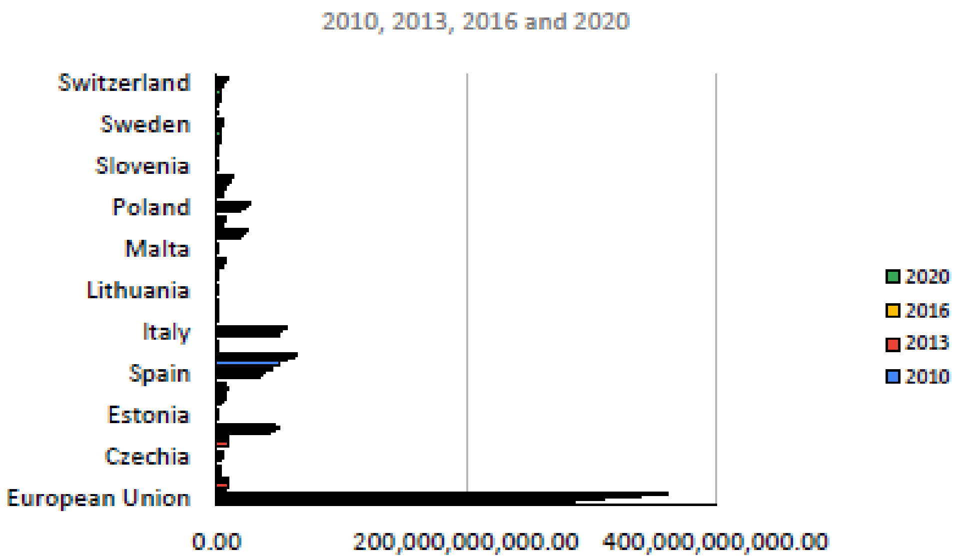
Source: *authors based on Eurostat, (2024)* Changes in EU policy, particularly in the Common Agricultural Policy (CAP), are also necessary to ensure that less economically robust countries like Romania are not disproportionately affected by rising expenses. If CAP funding were raised or if specific subsidies were developed specifically to address increases in input costs, Romanian farmers would be able to obtain the finances they require to cope with these financial difficulties.

Putting a particular focus on Romania's performance in comparison to other EU nations, the economic accounts for agriculture at current prices from 2020 to 2023 show the financial magnitude and growth of agricultural output within the EU. With a rise from €16,824.18 million in 2020 to €25,565.83 million in 2023, Romania's agricultural production values demonstrate a noteworthy development trajectory that reflects the nation's agricultural potential as well as the difficulties in maintaining and funding this expansion.

The agricultural economic production of the EU as a whole increased significantly, from €415,190.60 million in 2020 to €537,128.28 million in 2023. Although some nations saw more noticeable improvements than others, this expansion reflects a larger trend of rising agricultural production throughout member states. With a growth rate higher than that of several EU nations, Romania's performance indicates a significant expansion in its agricultural sector, probably fuelled by favorable crop production conditions, growing global demand, and regional policy initiatives to support food security and rural development. However, this expansion also highlights the structural and financial barriers Romanian farmers confront in fulfilling rising output needs.A combination of resilience and vulnerability may be seen in Romania's agricultural production growth. Despite demonstrating the ability to increase output, the agricultural industry is nevertheless financially limited in comparison to its peers in Western Europe. For example, the output of France, Germany, and Italy, each of which had output figures more than three times higher in 2023, dwarfs Romania's. These differences highlight the continuous financial obstacles Romania must overcome to catch up to better developed agricultural industries in Western Europe. Compared to these nations, Romania's economic output per unit of agricultural land and labor is comparatively lower, which emphasizes the country's restricted access to high-value crop production capacity, financing for modernisation, and innovative agricultural technology.

The Common Agricultural Policy (CAP) at the EU level offers subsidies meant to promote rural resilience and agricultural productivity in all of its member states. However, the distributional processes that frequently favor larger and more developed agricultural economies restrict the efficacy of CAP in assisting Romanian agriculture. Although Romania depends heavily on CAP funding, the amount is still not enough to completely close the output gap with the EU average. A re-assessment of CAP allocation might better assist nations with quickly emerging sectors, guaranteeing that they receive the financial resources required to compete on a more equal playing field, especially in light of Romania's development potential and recent improvements in agricultural output.In conclusion, the data on Romania's agricultural economic accounts at current prices highlights the nation's achievements as well as the ongoing financial challenges it faces inside the EU. While Romania's rising output is encouraging, it also emphasizes the need for more reliable and easily available funding to support and accelerate growth. By addressing these issues with specialized funding, CAP allocation adjustments, and investments in agricultural infrastructure, Romania's agricultural sector would be strengthened, putting it in a position to contribute more significantly to the EU's agricultural economy and boosting the financial stability of its farmers.

Figure 4: *Financial dynamics in the agriculture sector, 2010-2020*



Source: *authors based on Eurostat, (2024)*

The financial dynamics and structural changes in the agriculture sector are illuminated by the statistics on farm indicators across EU member states from 2010 to 2020, which show both growth and enduring differences in economic output. Compared to other Western European nations, Romania's agricultural industry developed at a slower rate, from €9.87 billion in 2010 to €12.09 billion in 2020. This highlights the structural and financial obstacles Romanian farmers confront inside the EU framework. From €287.6 billion in 2010 to €359.98 billion in 2020, the agricultural economic worth of the European Union as a whole increased steadily. This growth is a result of EU-wide investments in technology, policy-driven assistance, and improvements in agricultural production.

Nonetheless, significant differences across member states are concealed by this overall development. Western European nations like France, Germany, and Italy have continuously produced more agricultural goods; in 2020, France's agricultural output reached €64.32 billion, while Italy's was €56.62 billion. Romania and other Eastern European nations, on the other hand, had relatively moderate improvements, highlighting the difficulties these economies confront in reaching similar levels of agricultural output and financial stability.

The comparatively moderate agricultural expansion in Romania highlights a number of financial and structural constraints in the country's farming industry. Small and medium-sized farms, many of which are subsistence or semi-subsistence farms, make up the majority of the nation's agricultural landscape. These farms frequently lack the financial resources, technical infrastructure, and economies of scale that bigger, commercially orientated farms in Western Europe have easier access to. Romania's capacity to compete on an equal footing with bigger agricultural economies is hampered by the ensuing disparity in productivity and economic output per hectare. Lower rates of investment in modernisation and technical advancements, as well as restricted access to cash and financing options catered to smaller farms' requirements, further exacerbate this discrepancy.

Additionally, the figures show that although Romania's agricultural industry has expanded, its rate of growth has lagged behind the EU's inflationary pressures and growing input prices. The cost of basic inputs like gasoline, fertilizer, and equipment is rising for Romanian farmers, which reduces their profitability. These growing expenses put additional burden on the industry and limit reinvestment possibilities that may improve resilience and efficiency in the absence of sufficient access to finance or targeted subsidies. The Common Agricultural Policy (CAP) is elementary in this situation as it aims to level the playing field, but distributional biases that frequently favor larger agricultural economies in the EU hinder its ability to promote Romanian agriculture. As a result, the CAP's influence on Romania is limited, depriving smaller farms of the funding they need to invest in productive upgrades and offset growing expenses.

Conclusions

From Romania's perspective in particular, the EU's support of agriculture highlights a complicated interplay of structural, policy, and economic issues. Romania's agricultural industry is nevertheless limited by restrictions that prevent it from making the most of the EU's Common Agricultural Policy (CAP), which offers vital support for agricultural modernisation and sustainability. Romanian agriculture confronts fundamental challenges, including the predominance of small-scale farms and restricted access to formal financial instruments, notwithstanding recent favorable development trends. Compared to other EU nations, Romania's financial environment is less varied, and the lack of specialized agricultural financial institutions makes the financing gap worse. Romania's competitiveness in the EU agricultural market is hampered by this restriction, which also impacts farmers' capacity to engage in essential modernisation initiatives.

Romanian farmers are under more strain due to price volatility and rising input prices, which exacerbates their financial obligations in the absence of adequate revenue growth. The viability of smallholder farms is threatened by rising input costs as well as limited access to financing and subsidies. The strict compliance requirements of CAP financing, which sometimes penalize smaller farmers, exacerbate these problems. Notwithstanding the endurance and adaptability shown by Romania's agricultural industry, fundamental changes are required for the future, especially with regard to funding and policy modifications. The difference in productivity and income levels between Romania and Western European countries highlights the necessity of more focused, increased assistance for Romania's agriculture industry in order for it to reach its full potential and make a larger contribution to the EU's agricultural production.

Romania must address these urgent issues with a multipronged strategy that includes financial innovation, capacity-building programs, and targeted governmental assistance to increase the agricultural sector's resilience and production. First and foremost, changes to the CAP framework are necessary to guarantee a more equitable allocation of subsidies that particularly attend to the needs of smaller and less financially stable farmers. Adjusting CAP subsidies to include smallholder farms more inclusively might improve their financial resilience and allow them to compete more fairly with larger, more established agricultural firms within the EU, claim Pîrvu et al. (2022). Furthermore, Romanian farmers' access to money would be greatly increased by the establishment of specialized agricultural financing organizations like cooperative banks or rural credit unions. Given the erratic and seasonal nature of agricultural income, these organizations may offer flexible credit choices and low-interest loans (Dinu et al., 2020). These programs would aid in closing the funding gap, especially for small and medium-sized farms who are unable to obtain traditional finance because of the high requirements for collateral. According to research by Fi-compass (2020), microfinance and customized credit facilities have the ability to close these gaps and increase rural farmers' access to and affordability of financing.

Furthermore, funding financial literacy and capacity-building initiatives is essential. According to Zlati et al. (2023), rural farmers who possess greater financial literacy may be better equipped to utilize available funds and more skilfully handle the intricate needs of CAP. Romanian farmers would benefit from training programs that emphasize sustainable agricultural methods, grant application procedures, and financial management in order to optimize the use of both public and private funding sources. The creation of public-private partnerships may also encourage private sector investment in agriculture, which would improve access to contemporary agricultural technology and promote innovation. According to Mazăre (2020), these collaborations may encourage funding for initiatives like digital agriculture, precision farming, and climate-resilient methods. These partnerships would eventually contribute to a more sustainable and productive agricultural sector by giving Romanian farmers the instruments and resources they need to adjust to environmental challenges and market demands.

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CHALLENGES AND OPPORTUNITIES FOR RURAL TOURISM IN THE GENERAL PUEYRREDON DISTRICT (ARGENTINA)

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Abstract

The district of General Pueyrredon (Argentina), with Mar del Plata as its main city, has a large peri-urban territory with scenic, agricultural and cultural characteristics that favour Rural Tourism, based on local cultural traditions and contact with nature. In recent decades, it has become a strategy for economic diversification that promotes sustainable development and careful management of the effects of touristification, which can lead to the commodification of culture and the loss of local identity. The aim is to explore the opportunities and challenges of Rural Tourism in the district of General Pueyrredon, analysing its relationship with sustainable development and the implications of touristification in the region. An exploratory and descriptive study is carried out, consulting bibliographic, documentary, graphic and virtual sources, taking as a case the Estancia Santa Isabel, whose productive diversification allows its positioning as an innovative reference of Rural Tourism.

Key words: *Rural Tourism, Sustainable Development, Touristification, Estancia Santa Isabel (Argentina).*

Introduction

Interest in nature and rural culture favors the development of Rural Tourism, based on the revaluation of traditional agriculture and culture. It acts as a complementary alternative to agricultural activities, diversifies and increases income, reinforces traditions, practices and local knowledge. It requires careful management of the effects of touristification, which can generate the commercialization of culture and the loss of local identity.

In Argentina it has been developing since 1990, as a consequence of political changes that cause a strong increase in taxes on agricultural activity and social transformations in rural areas. Under these conditions, a new rurality emerges, understood as the multifunctionality of rural spaces, the incorpora-

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tion of tourist and recreational functions, complementing the main agricultural and livestock activities. Rural Tourism is positioned as a second activity and economic alternative, which allows the diversification of uses and generates different income.

In the words of Barrera (2006), the modification of the traditional productive function arises with the incorporation of non-agricultural activities and the possibility of entering into the provision of services, generating new commercial alternatives, which aspire to the diversification of risk and the generation of additional income to that of agriculture. Craviotti (2007) states that this new productive scenario generates an increase in the linkages of agriculture with other sectors and the increase of non-agricultural occupations of rural inhabitants, which stimulates an increase in the levels of pluriactivity of the sector.

In the vast territory occupied by Argentina, different estancias, fields, farms and smallholdings receive tourists all year round who seek contact with nature and to participate in agricultural activities. The district of General Pueyrredon (Argentina), with Mar del Plata as its main city, has a large peri-urban territory with landscape, agricultural and cultural characteristics that favor the development of Rural Tourism, promoting the revaluation of traditions and contact with nature. The new activity requires the adaptation of existing facilities, preserving the cultural imprint that characterizes each type of agricultural exploitation; and offers contact with nature, carrying out and participating in daily country activities, such as horseback riding, carriage rides, walks, flora and fauna recognition, preparation of artisanal gastronomy (cheeses, sausages, sweets), and tasting native food (empanadas and barbecue), accompanied by a good wine (Barrera, 2006). In recent decades it has become a strategy for economic diversification that promotes sustainable development and requires careful management of the negative effects of touristification, which can lead to the commercialization of culture and the loss of local identity.

The objective of the research focuses on the analysis of the challenges and opportunities of Rural Tourism in the district of General Pueyrredon, analyzing its relationship with sustainable development and the implications of touristification in the region. An exploratory and descriptive study is carried out, with a qualitative methodological approach, based on the collection of data arising from descriptions and observations, and applied to a case study focused on Estancia Santa Isabel (General Pueyrredon District, Argentina), whose productive diversification allows its positioning as an innovative reference for Rural Tourism. Different data collection techniques are selected: semi-structured interviews with qualified informants from the public and private tourism sector; observation and field visits with semi-structured guides; review and critical analysis of bibliographic and documentary sources; content analysis in photographs and videos; and consultation of websites of official tourism organizations and the private sector.

It is expected that this study will contribute to the development of programs and projects that promote Rural Tourism as an alternative for sustainable development, based on a territorial approach, taking advantage of the potential and strengthening local identity.

Rural Tourism and Sustainable Development

To explain the meaning of Rural Tourism and Sustainable Development, the terms are defined: Tourism, Tourist Space and Rural Space, to then reflect on the contribution of this tourism modality to local development.

According to the World Tourism Organization (UNWTO), "Tourism is a social, cultural and economic phenomenon that involves the movement of people to countries or places outside their usual environment for personal, professional or business reasons, and for a consecutive period of time of less than one year" (www.unwto.org). It includes the activities carried out by people during their trips, for a consecutive period of less than one year, for pleasure, business or other purposes. It integrates all types of motivations (linked to work and the economic system in general) and different types of accommodation (collective or individual), strengthening the relationship between tourism and territory.

López Trigal (2015:228) defines tourist space as "that portion of geographic space in which socio-spatial practices related to leisure, recreation and tourism activities are carried out". It is a real and virtual space, linked by practices of tourist agents and the people directly and indirectly involved in them (local residents and travelers). The tourist space is made up of sites (scenarios of tourist practices), areas (according to different scales of analysis) and flows (tourist flow). It is virtual because it includes spaces dreamed of or thought of as potential touristification, any mental construction about places (subjective dimension), as well as the growing presence of tourism in the virtuality of cyberspace.

Rural space "is a type of geographic space resulting from the different uses and exploitations, not only agricultural, that rural and urban societies make of it" (López Trigal, 2015:226). It is located outside the urban limits and responds to a question of territorial organization in relation to the different functions that society attributes to each space. Traditionally, it was characterized by the presence of inhabitants specialized in agricultural activities, with a low population density, sociocultural homogeneity of its inhabitants, less differentiation, social stratification and social mobility, with more closed systems of social interaction. Nowadays, the classic opposition between town and country is tending to disappear, with a fragile frontier between rural and urban space, which allows the introduction of the concept of rururban and the idea of a new rurality where agricultural and livestock exploitation are confused and coexists with tourist and recreational activities, natural resources, cultural heritage, landscapes and local identities are valued, reflecting a continuity of urbanization in the multifunctional rural territory (Barrado and Calabuig, 2001).

This is how Rural Tourism emerged, which according to the WTO "is a tourism activity where the visitor's experience is related to a wide spectrum of products linked to nature activities, agriculture, rural lifestyle and culture, fishing with rod and visiting places of interest" (www.unwto.org). It is based on the countryside as a resource and on the search for tranquility by people who live in urban areas and a space to dedicate themselves to outdoor recreational activities (Jafari, 2000). It uses a rural house or hotel as accommodation, with the option of developing complementary activities in the natural environment, such as hiking, horseback riding, agro-tourism, green tourism, ecotourism, hunting tourism, among others.

It is an alternative modality to the conventional tourism, with a strong focus on and awareness of the environment, values and local culture, together with recreational practices of leisure and free time outside the urban limits. The rise of this modality is associated with changes in the preferences of tourists; and due to its social and territorial effects, it plays a fundamental role as an instrument of local development (López Trigal, 2015).

Challenges and opportunities for Rural Tourism in Argentina

In Argentina, Rural Tourism is presented as a sustainable tourism alternative that promotes the balanced development of rural territories, respecting their natural and cultural resources, and contributing to the well-being of local communities. This tourism modality seeks to guarantee a harmonious relationship between visitors, hosts and the rural space; and allows recreational and accommodation practices, which can represent a challenge or opportunity in the development of sustainable Rural Tourism.

It presents the following challenges:

- Lack of definition and classification of rural space which complicates the promotion and planning of Rural Tourism.
- Demographic challenges, depopulation of rural areas, lack of basic services (infrastructure, transportation, communications), limited accessibility.
- Heritage preservation versus development, need to balance tourism development with conservation of natural and cultural heritage.
- Unplanned exploitation leads to resource degradation and loss of authenticity.
- Seasonality, dependence and tourist specialization.
- Excessive commercialization, overcrowding and disappearance of cultural and environmental values.
- Installation of foreign companies attracted by the potential of the area and loss of benefits for the local population.

Rural Tourism offers the following opportunities:

- Economic and cultural revitalization, and income diversification.
- Flexibility, adaptation of the offer to the characteristics of the territory.
- Conservation of the environment, sustainable tourism management of natural resources and landscapes, promotion of responsible practices and preservation of the rural environment and local culture.
- Alternative to decongest saturated urban spaces and redistribute economic benefits to rural areas.
- Direct contact with nature and local culture.
- Authentic and personalized tourist modality.
- Promotion of craftsmanship and local production.

Rural Tourism is an economic alternative to agricultural activities, it prevents migration to urban areas and reduces the exclusive dependence on the agricultural sector. It generates employment, contributes to improving the quality of life of the rural population and stimulates local development. The challenge is based on proper planning that avoids overcrowding and loss of traditional values, the entry of exogenous capital and the reduction of benefits for the local community.

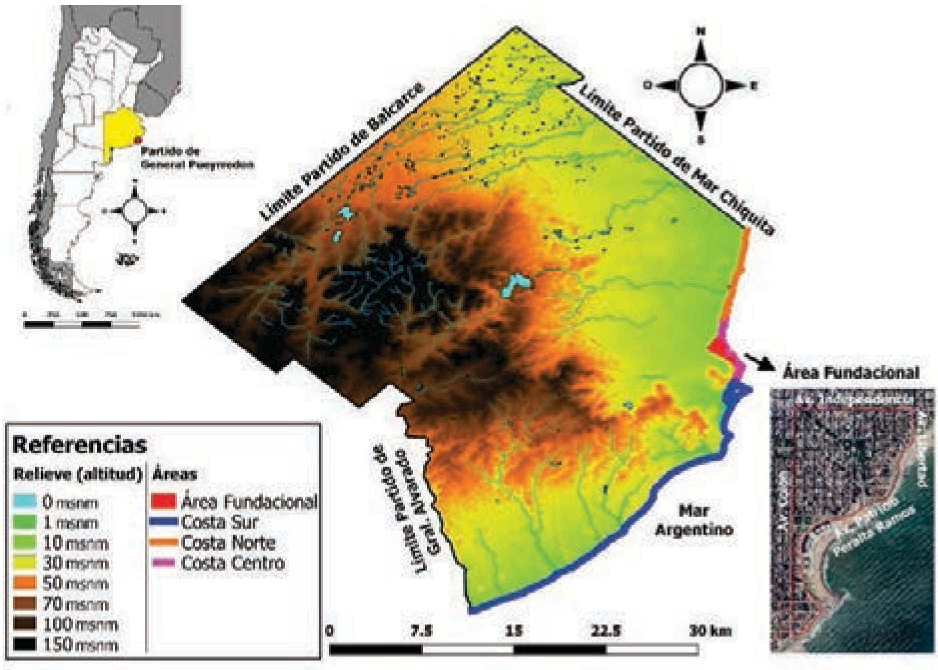
General Pueyrredon District (Argentina). Santa Isabel Ranch

The General Pueyrredon District is located in the southeast of the province of Buenos Aires, Argentina. Its geographic coordinates are 38°00′S 57°33′W. It is bordered to the northwest by the Balcarce District, to the northeast by the Mar Chiquita District, to the southeast by the Argentine Sea, to the southwest by the General Alvarado District. The total surface reaches 1.460,74 km², of which 245,48 km² correspond to the urban area and 1.215,26 km² to the rural space, it has 47 km of coastline. It is crossed by provincial routes 11 (La Plata/Miramar), 88 (Mar del Plata/Necochea) and 229 (Mar del Plata/General Villegas) and Highway 2 (Mar del Plata/Ciudad Autónoma de Buenos Aires). It has a Railway-Automotive Station (with 29 weekly railway services and a bus station where more than 50 companies operate); an Astor Piazzola International Alternative Airport (6 aviation companies with more than 130 weekly services) and an artificial deep-water port (with a fishing, recreational and tourist mooring sector).

According to data published by the National Institute of Statistics and Census (INDEC), there are 667,082 inhabitants in 2022, distributed in 350,607 women and 316,475 men, with a population density of 456.9 inhabitants/km². Mar del Plata (founded in 1874) is the main city and main tourist destination in Argentina, with strong summer demand, receiving 8,500,000 tourists a year. It has 9 smaller localities (urban settlements dispersed in the rural urban space with 2000 inhabitants: *El Marquesado, Chapadmalal, El Boquerón, Santa Paula, Sierra de los Padres, La Peregrina, Estación Camet, El Casal and Batán*). The foundational area is located in the central coastal zone of the city, with extensions to the north and south. The rural area borders the urban area (Figure 1).

In Argentina, the process of land occupation originates with the Spanish conquest and the creation of the Viceroyalty of the Río de la Plata (1776) with its capital in Buenos Aires, where the port of the same name was consolidated as a colonial trade route. A military campaign began to expand the frontiers and advance on the native peoples, with a strategy of territorial occupation based on the ranch or estancia (large extensions of land granted to a person or religious order) for agricultural and livestock exploitation. Many of these estancias are in the hands of powerful families of the 'Bell Époque' in Argentina.

Figure 1. Study area



Source: *Own elaboration with QGIS v. 2.18 software and Google Satellite*.

The estancias were born as a self-sustainable economic unit, with the capacity to supply, defend and solve problems. It was made up of different buildings, both for the permanent and temporary population, facilities for animals and agricultural machinery, a school, a chapel and housing. The main house is called "*casco*" and was designed in European architectural styles, imitating French palaces, with gardens designed by landscapers, with fountains and artificial lakes. Each owner competed with his peers and highlighted the most sumptuous and beautiful design. These old estancias, full of history and secrets, have been incorporated into the accommodation offer from the 1990s, promoting the consolidation of Rural Tourism.

The district of General Pueyrredon preserves several estancias, although they have a smaller surface area due to the succession process of property division, they still preserve the agricultural and livestock production and the gaucho traditions. Estancia Santa Isabel is located 20 km from the centre of Mar del Plata. It was part of the Chapadmalal Estancia with a surface of 25,500 hectares, whose owner José Martínez de Hoz introduced technology and innovation in the field and in the breeding of horses, livestock and agriculture, being his animals recognised in the most demanding markets of London and Paris. When he died (1888), his son Miguel Alfredo received 12,500 hectares with the original farmhouse, the horse and cattle breeding farm; his other son Eduardo received 13,000 hectares dedicated to agriculture, horse and cattle breeding, which he called Santa Isabel. The following heirs divided the ranch and since 1996 the farmhouse, together with 600 hectares, has belonged to the Estrada Mora family, who remodeled the facilities and added new buildings for accommodation and sports facilities.

In 2009 they started a wine project, introducing vine plants brought from Italy, in an experimental area of 10 hectares located 6 km from the coast, under the influence of a temperate oceanic climate. Under the name Bodega Trapiche Costa & Pampa they offer different varieties: Carmenere, Cabernet Franc, Merlot, Syrah, Pinot Noir, Chardonnay, Sauvignon Blanc and Semillon. It is the first experimental winery located on the edge of the Argentine Sea, where the maritime climate and the properties of the land are combined, allowing the cultivation of the vines and the development of a new industry, which is added to the agricultural and livestock activities, the organization of events held in three multipurpose rooms and the possibility of staying in the old part of the Santa Isabel ranch.

Conclusions

In Argentina, Rural Tourism has promoted the multifunctionality of the agricultural sector and the pluri-activity of its actors, acting as a complement to primary activities and revaluing local culture, traditions, practices and local knowledge of the territories. Although there is a wide range of establishments, it is possible to group them into two categories according to the surface area devoted to agricultural production and the modalities of service provision. On the one hand, there are the large estancias specialized in cattle breeding and agricultural exploitation, whose historic centers have a strong heritage, architectural and landscape value and have been refuntionalized to provide accommodation and a wide range of recreational and sporting activities. On the other hand, there are also smaller enterprises dedicated to agricultural exploitation and farm animals (farms, farmsteads, country houses), where the owner acts as host to the visitor, and which are more closely linked to agro-tourism. In recent years, the wine industry has been incorporated into Rural Tourism, adding winery tourism as a new alternative linked to nature.

Rural Tourism in the General Pueyrredon District is presented as an opportunity to promote sustainable development, boost the local economy, diversify productive activities, preserve heritage and decentralize the tourist offer located on the coast of the foundational area. However, it faces challenges related to the lack of a definition of rural space, the provision of infrastructure, and the search for a balance between conservation and development, avoiding overcrowding and the loss of traditional values. Addressing these challenges requires comprehensive planning to maximize the potential of Rural Tourism and ensure its sustainability.

In this context, Estancia Santa Isabel is witness to the historical process of colonization and land appropriation, as well as the evolution of traditional families dedicated to agriculture and livestock exploitation. The ranch house symbolizes the architectural past and represents a cultural element that allows the reproduction of the traditional way of life of the Argentinean landowners. However, due to the fragmentation of land and the reduction of the estancia's surface area, in recent years it has diversified its production, incorporating the cultivation of grapes and the production of wines in a coastal area, with a strong influence of the temperate oceanic climate. The challenge to the atmospheric conditions favored the development of the new industrial activity and the productive diversification, allowing its positioning as an innovative reference of Rural Tourism in the district of General Pueyrredon (Argentina).

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THE IMPACT OF THE EU EMISSIONS TRADING SYSTEM (EU ETS) ON AGRICULTURE: CHALLENGES AND OPPORTUNITIES

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Abstract

The aim of this review was to analyse the European Union Emissions Trading System (EU ETS) and its indirect effects on agriculture. While the EU ETS targets major industries like energy and manufacturing, agriculture is not directly regulated, yet the sector is impacted by rising energy, fuel, and fertilizer costs due to carbon pricing. The increased financial burden may strain farmers, particularly small-scale producers, who may struggle with higher production costs. Additionally, the introduction of the Carbon Border Adjustment Mechanism (CBAM) could intensify global competition for EU farmers, especially those producing carbon-intensive products. Although sustainable practices like carbon sequestration offer potential benefits, many farmers may lack the resources or technology to implement them. The review highlights the need for targeted support to help farmers transition to low-carbon practices without compromising their economic viability, ensuring that EU agriculture can remain competitive while contributing to the EU's climate goals.

Key words: *EU Emissions Trading System (EU ETS), carbon quotas, agriculture, climate policy, Carbon Border Adjustment Mechanism (CBAM).*

Introduction

Carbon quotas refer to mechanisms designed to limit the total amount of carbon dioxide (CO_2) or greenhouse gas emissions allowed by certain sectors of the economy. In the European Union (EU), carbon quotas are part of broader efforts to

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reduce overall emissions and meet climate targets, such as those established under the *Paris Agreement* (United Nations Framework Convention on Climate Change, 2015) and the *European Green Deal* (European Commission, 2019). The primary tool for regulating carbon emissions in the EU is the ***European Emissions Trading System, EU ETS*** (European Parliament and Council of the European Union, 2003). The European Union Emissions Trading System (EU ETS) is a cornerstone of the EU's climate strategy, designed to reduce greenhouse gas emissions through a market-based, cap-and-trade mechanism. Since its inception in the year 2005, the EU ETS has progressively expanded, targeting major emitting sectors such as energy production, manufacturing, and aviation, with the goal of driving long-term emission reductions. Although agriculture is not directly included in the system, the agricultural sector is significantly affected by the EU ETS through indirect channels, such as rising energy and fuel costs, increased fertilizer prices, and evolving sustainability incentives. The introduction of carbon quotas aims to foster green innovation, meet ambitious climate targets, and stimulate investments in low-carbon technologies across industries. This review analysis the main characteristics, rationale, legal framework, and implementation timeline of carbon quotas under the EU ETS, with a focus on their potential effects on the agricultural sector. Through a detailed analysis, it highlights the opportunities and challenges faced by farmers as they navigate the shifting landscape of carbon pricing, sustainability practices, and regulatory frameworks.

The main characteristics of Carbon Quotas (EU ETS)

The main characteristics of Carbon Quotas, ***European Emissions Trading System, EU ETS*** (European Parliament and Council of the European Union, 2003) are as follows:

Cap-and-Trade System

The European Union Emissions Trading System (EU ETS) implements a comprehensive cap-and-trade structure that sets a specific limit, or cap, on the total greenhouse gas emissions allowed within particular sectors. This cap is not static; it is systematically lowered over time, which is indicative of the EU's commitment to achieving long-term climate goals. The gradual reduction of the cap is crucial to ensuring a consistent and significant decline in overall emissions across participating sectors.

Emission allowances

Within the framework of the EU ETS, individual companies and sectors receive a designated number of emission allowances, commonly referred to as quotas. Each allowance authorizes the emission of one tonne of carbon dioxide (CO_2) or its equivalent in other greenhouse gases. This system incentivizes companies to monitor and reduce their emissions. If a company manages to reduce its emissions below its allocated allowance, it can sell its unused permits on the carbon market, thereby generating additional revenue. This trading mechanism promotes effective resource allocation and encourages companies to strive for greater efficiency in their operations.

Market flexibility

One of the core principles of the EU ETS is its emphasis on market flexibility, which enables businesses to determine the most cost-effective approach to reducing emissions. Companies that encounter high costs associated with emission reductions have the option to purchase allowances from others that can achieve reductions at a lower expense. This dynamic creates a financial incentive for overall emission reductions within the market, as it allows for a more economically efficient distribution of resources. Ultimately, this flexibility encourages innovation and investment in cleaner technologies.

Sectors included in quotas

The EU ETS primarily targets large emitters across critical sectors such as electricity generation, manufacturing, aviation, and other industrial activities. As such, these sectors are held accountable for their emissions and play a pivotal role in the EU's climate action plan. Although agriculture is not directly regulated under the EU ETS, it is important to acknowledge that indirect effects can still emerge. Changes in energy prices and increased costs for fertilizers, driven by the emissions trading system, can significantly impact the agricultural sector, thus creating a broader ripple effect throughout the economy. This interconnectedness highlights the necessity for collaborative efforts across all sectors to meet overall emissions reduction targets.

The reasons for introduction of Carbon Quotas (EU ETS)

The EU Emissions Trading System, EU ETS (European Parliament and Council of the European Union, 2003) was established as a cornerstone of the European Union's strategy to combat climate change and meet its greenhouse gas (GHG) reduction commitments. This initiative is closely aligned with the objectives set forth in the *Paris Agreement* (United Nations Framework Convention on

Climate Change, 2015), which aims to curb global warming and promote sustainable development, as well as the *EU Green Deal* (European Commission, 2019)., an ambitious framework designed to make **Europe the world's first climate-neutral continent by the year 2050**.

The EU ETS was purposefully crafted to introduce a market-based mechanism for emissions reduction by implementing a carbon pricing system. By placing a financial cost on carbon emissions, it incentivizes businesses and industries to seek out innovative solutions and invest in advanced low-carbon technologies. This approach not only encourages environmentally responsible practices but also stimulates economic growth within the green technology sector, facilitating a significant transition towards a more sustainable and resilient economy. Furthermore, the EU ETS is integral to supporting the ***2030 Climate and Energy Framework*** (European Commission, 2014), which aims for at least a *40% reduction in greenhouse gas emissions by 2030 compared to 1990 levels*. This framework provides a clear path for a gradual and sustained transition to a low-carbon economy. It also aligns with the overarching goals of the ***European Green Deal*** (European Commission, 2019), which sets forth a bold ambition of achieving *net-zero emissions for all EU member states by 2050*, ensuring a sustainable environment for future generations while maintaining economic stability. Through these comprehensive measures, the EU ETS not only establishes a transparent and effective system for emissions trading but also underscores the EU's commitment to global leadership in climate action and sustainable development.

The rationale behind the Carbon Quotas (EU ETS)

The establishment of carbon quotas and the implementation of carbon pricing mechanisms, such as the EU Emissions Trading System, EU ETS (European Parliament and Council of the European Union, 2003) represent a crucial element of a comprehensive strategy aimed at addressing climate change and fostering sustainability. This initiative was driven by several interrelated goals as follows:

Encourage emission reductions

The core idea behind imposing a price on carbon is to create robust financial incentives for businesses to actively reduce their greenhouse gas emissions. This can be achieved through various means, including the adoption of advanced technological innovations, enhancements in energy efficiency, and the transition to low-carbon alternatives. By making emitting carbon dioxide more costly, firms are motivated to invest in cleaner technologies and practices that will lower their carbon footprint, ultimately contributing to the overall reduction of emissions.

Meet climate targets

The European Union has established ambitious climate goals, notably aiming for climate neutrality by the year 2050. To effectively track and ensure progress toward this goal, the EU has set interim targets, such as reducing emissions by 55% compared to 1990 levels by 2030. These targets serve not only as benchmarks for measuring the success of policies like the EU ETS but also as a call to action for member states and industries alike to intensify their efforts in mitigating climate change.

Promote green innovation

Carbon pricing serves as a catalyst for fostering green innovation by stimulating investment in renewable energy sources, cleaner production techniques, and energy-efficient solutions. This creates a dynamic environment that encourages research and development in sustainable technologies, which are essential for transitioning to a green economy. As businesses strive to comply with carbon pricing regulations, they are more likely to explore innovative practices that not only help reduce emissions but also enhance their competitiveness in a rapidly evolving market.

Prevent carbon leakage

One significant challenge in implementing stringent climate policies is the risk of carbon leakage, which occurs when carbon-intensive industries relocate to regions with less stringent environmental regulations. To mitigate this risk, the European Union has introduced the Carbon Border Adjustment Mechanism (CBAM). This mechanism ensures that industries outside of the EU face similar carbon pricing, thereby creating a level playing field. By doing so, the EU aims to prevent the potential negative impact on its industries while encouraging global climate action, thereby fostering a more equitable international approach to reducing carbon emissions.

The legal framework of Carbon Quotas (EU ETS)

The legal foundation for the implementation of carbon quotas under the Emissions Trading System (EU ETS) is established by ***Directive 2003/87/EC of the European Parliament and Council***, enacted on 13 October 2003 (European Parliament and Council of the European Union, 2003). This directive introduces a framework for trading greenhouse gas emission allowances within the EU and amends Council Directive 96/61/EC. As the cornerstone of the EU Emissions Trading System (EU ETS), it sets the rules for carbon quotas (emission allowances) and governs the trading of these allowances across the EU. The directive has undergone various amendments to adapt to new climate targets and regulatory reforms, including those associated with the ***Paris Agreement*** (United Nations Framework Convention on Climate Change, 2015) and the ***European Green Deal*** (European Commission, 2019).

Subsequent Amendments are as follows:

- Directive 2009/29/EC (amending 2003/87/EC)

This amendment introduced significant reforms to the EU ETS, which included tightening the emissions cap, expanding the system's scope to cover more sectors, and increasing the proportion of allowances auctioned.

- Directive 2018/410/EU (amending 2003/87/EC)

As part of the EU Climate and Energy Framework, this amendment established the Market Stability Reserve (MSR) to address the surplus of allowances in the market and ensure alignment with the EU's climate goals for 2030.

- Directive (EU) 2021/1119 (European Climate Law)

This directive established the EU's legally binding target for climate neutrality by the year 2050 and set the stage for further reforms of the EU ETS to align with the EU Green Deal (European Commission, 2019) and the Fit for 55 package.

Implementation timeline of Carbon Quotas (EU ETS)

The European Union Emission Trading System (EU ETS) was officially initiated in the year 2005. The system began with a pilot phase that spanned from the year 2005 to the year 2007, primarily targeting the power generation and industrial sectors. Since it was launch, the EU ETS has undergone considerable evolution, characterized by increasingly strict emissions caps, broader sectoral coverage, and the implementation of a more sophisticated market mechanism aimed at enhancing the efficiency of carbon trading.

The first phase of the EU ETS (2005 - 2007) was essential for establishing the foundational framework of the system. Its primary objective was to acclimate market participants to the paradigm of trading carbon allowances, thereby paving the way for subsequent phases.

The second phase of the EU ETS (2008 - 2012) coincided with the European Union's commitments under the *Kyoto Protocol*, which sought to mitigate global greenhouse gas emissions. During this phase, the scope of sectors included in the Trading System expanded, and emissions caps were tightened to drive further reductions. As the understanding of carbon markets deepened, the EU ETS underwent several key reforms to enhance its effectiveness during the third and fourth phase of the EU ETS.

The third phase of the EU ETS (2013 - 2020) implied a significant transformation in the trading framework, with emissions caps set considerably lower than in previous phases. A major change during this period was the increased auctioning of carbon allowances instead of offering them for free, which improved market transparency and competitiveness.

The fourth phase of the EU ETS (2021 - 2030)

Under the ambitious *Fit for 55* legislative package, the EU aims for a substantial reduction of greenhouse gas emissions by at least 55% by 2030, relative to 1990 levels. This phase signifies a pivotal advancement in the EU's climate strategy and encompasses several additional reforms.

Key aspects of Phase 4 include further tightening of the emissions cap, extending the ETS coverage to new sectors such as maritime transport, and introducing a ***Carbon Border Adjustment Mechanism (CBAM)***. The CBAM is designed to impose carbon costs on imported goods, thus safeguarding EU industries from competitive disadvantages and preventing carbon leakage, where companies might relocate production to countries with less stringent emissions regulations.

The Carbon Border Adjustment Mechanism (CBAM), initially proposed in the year 2021, was set to be implemented gradually starting in the year 2023. This pivotal policy aims to establish a carbon price on certain imported goods, such as steel, cement, and aluminium, which are often produced in countries with less stringent environmental regulations. By doing so, the EU seeks to prevent its ambitious carbon pricing efforts from being undermined by the influx of cheaper imports that do not account for their carbon emissions. CBAM is designed to create a level playing field for EU producers, encouraging global partners to adopt more sustainable practices while also contributing to the EU's overarching goals of reducing greenhouse gas emissions and meeting climate targets.

In addition to the implementation of CBAM, the EU is actively exploring innovative mechanisms for ***Carbon Farming*** where farmers are rewarded for practices that sequester carbon in the soil. This approach is aimed at incentivizing farmers to engage in agricultural practices that enhance the sequestration of carbon in the soil. By adopting techniques such as cover cropping, reduced tillage, and agroforestry, farmers can enhance soil health and increase carbon storage, which not only supports climate change mitigation but also promotes biodiversity and improves agricultural resilience. The integration of carbon farming into existing carbon pricing schemes represents a promising opportunity to leverage the agricultural sector's potential to contribute to environmental sustainability. This initiative could lead to new revenue streams for farmers while further bolstering the EU's commitment to a circular and sustainable economy.

The effect of Carbon Quotas (EU ETS) implementation on agriculture

The EU Emissions Trading System, EU ETS (European Parliament and Council of the European Union, 2003) is a key policy framework designed to combat climate change, primarily by regulating carbon emissions. While the system directly encompasses several industrial sectors, including energy production, manufacturing, and aviation, agriculture remains outside its direct purview. Nevertheless, the influence of the EU ETS on the agricultural sector is significant and multifaceted, leading to both direct and indirect consequences stemming from broader climate policies and carbon pricing strategies within the EU.

Indirect impact through energy prices

Although agricultural activities are not explicitly included in the EU ETS, the sector is poised to feel the ripple effects as carbon prices escalate in related industries such as energy, transportation, and manufacturing. The implications of these rising prices in the energy sector can be particularly pronounced for farmers through higher energy costs and increased fuel expenses.

Higher energy costs

The EU ETS imposes a price on carbon emissions, which can result in elevated costs for electricity and fuel. For many agricultural producers, energy plays a critical role, especially in energy-intensive operations such as irrigation, greenhouse heating, and running machinery essential for planting and harvesting. Consequently, increases in energy prices could substantially inflate the production costs for farmers, with those engaged in high-energy sectors—like greenhouse cultivation, dairy farming, and intensive livestock production—feeling the strain most acutely.

Increased fuel expenses

The financial burden also extends to fuel costs associated with transporting agricultural goods to market and the operation of heavy machinery, including tractors and harvesters. As carbon pricing drives up fossil fuel costs, the price of fuel needed for these essential activities is likely to rise, further constraining profit margins for farmers.

Impact on fertilizer prices

Fertilizers, especially those rich in nitrogen (urea and ammonium nitrate) are significant contributors to greenhouse gas emissions. The influence of the EU ETS on fertilizer production is twofold:

Carbon pricing on fertilizer production - Fertilizer manufacturers are subject to the EU ETS regulations, which require them to purchase emission allowances corresponding to the CO_2 and other greenhouse gases emitted during their production processes. As the carbon price increases, manufacturers face heightened production costs, which are likely to translate into higher prices for fertilizers, adversely affecting farmers attempting to manage input costs.

Incentives for sustainable practices (to use less fertilizer or switch to alternatives) - The rising costs associated with fertilizers may encourage farmers to rethink their practices. Specifically, the increased prices could motivate them to improve efficiency in fertilizer usage or seek out alternative, lower-carbon agricultural methods. This could manifest in various ways, including the adoption of organic fertilizers, enhanced nutrient management practices, or advanced precision farming techniques aimed at optimizing input use. However, it's important to recognize that not all farmers will be equally equipped to adapt to these changes. Those lacking access to alternative methods or modern technologies may find themselves struggling to cope with the rising costs.

Carbon sequestration and Carbon farming

Although agriculture is not directly included in the European Union Emissions Trading System (EU ETS) at present, the EU has embarked on innovative initiatives aimed at incentivizing farmers to engage in carbon sequestration. This process involves capturing and storing carbon in the soil through various sustainable farming techniques, which play a crucial role in combating climate change. To encourage these environmentally friendly practices, the EU seeks to offer financial rewards to farmers who adopt methods that contribute to reducing greenhouse gas emissions.

Some of the key practices targeted by these initiatives include:

Agroforestry; this approach involves integrating trees into agricultural landscapes, whether alongside crops or in pastures. By planting trees, farmers can significantly enhance carbon capture, as trees absorb carbon dioxide from the atmosphere, while also providing shade and habitat for diverse species.

Reduced Tillage; this method focuses on minimizing the disturbance of soil through less frequent plowing. By maintaining soil structure and its organic content, reduced tillage helps preserve soil carbon stocks, fostering healthier and more resilient soils.

Cover Cropping; farmers can plant specific crops during the off-season, which serve to protect the soil from erosion and nutrient depletion. These cover crops not only enhance soil structure but also capture carbon, returning it to the soil naturally over time.

Organic Farming; various organic farming techniques can lead to an increase in soil carbon levels. Practices such as composting, crop rotation, and the avoidance of synthetic fertilizers contribute to healthier soil ecology and greater carbon retention.

EU's Carbon Border Adjustment Mechanism (CBAM)

In an ambitious effort to combat climate change, the European Union is rolling out the Carbon Border Adjustment Mechanism (CBAM) as a pivotal component of its Green Deal initiative (European Commission, 2019). This innovative mechanism aims to impose a carbon price on imported goods originating from countries that have less stringent climate policies. While the primary target of CBAM encompasses energy-intensive products, such as cement, steel, and various chemicals, its reach could extend to specific agricultural goods, including meats, fertilizers, and foodstuffs known for their significant carbon footprints.

The implementation of CBAM is poised to impact the agricultural sector in two notable ways:

Increased costs of imports; agricultural products characterized by high carbon emissions during their production process could see a rise in import costs when brought into the EU. This increase may translate to elevated prices for consumers, particularly affecting items like meat, dairy, and certain processed foods, which typically require more resource-intensive methods of production that contribute extensively to carbon emissions.

Competitive pressure; European farmers who focus on producing high-carbon products, such as beef and pork, may find themselves under heightened competitive pressure as their counterparts in non-EU countries, operating without equivalent carbon costs, can potentially offer lower prices. Conversely, farmers who proactively embrace low-carbon farming practices may gain a competitive edge in the market, positioning themselves as leaders in sustainable agriculture and appealing to environmentally conscious consumers.

Adoption of sustainable agricultural practices

The EU's climate policies, particularly the implementation of carbon pricing, are poised to catalyse a significant transformation in agricultural practices toward sustainability. By assigning a monetary value to carbon emissions, the EU creates strong financial incentives for both corporations and individual farmers to actively work towards reducing their greenhouse gas outputs. This paradigm shift could manifest in several key areas:

Investment in precision agriculture; advances in technology that enhance the efficiency of resource utilization (such as cutting-edge irrigation systems, optimized fertilizer applications, and precision planting techniques) are essential in minimizing waste and lowering the carbon emissions associated with farming. These innovations not only promise to reduce environmental impact but also enhance crop yields and improve profitability for farmers.

Shift toward plant-based diets; in alignment with the EU Green Deal (European Commission, 2019) and its compelling sustainability initiatives, there is a growing push for populations to adopt more plant-centric diets. This strategic shift is vital for mitigating climate change, as it could drastically decrease overall greenhouse gas emissions associated with livestock farming. Consequently, there may be an increased demand for plant-based agricultural products, including a diverse array of vegetables and pulses. This demand opens new avenues for farmers, allowing them to tap into lucrative markets and diversify their crop offerings.

Organic and regenerative agriculture; the EU's commitment to sustainability may also foster the adoption of agricultural practices focused on long-term ecological health. These include organic farming, regenerative agriculture, and agroecological methods that prioritize soil vitality, promote biodiversity, and integrate sustainable farming techniques. Such practices not only contribute to a healthier ecosystem but also align with the EU's overarching goal of achieving environmental resilience and food security.

Challenges facing small farmers

Economic pressures; small-scale farmers, often operating with limited financial resources and inadequate access to advanced technologies, confront significant difficulties when it comes to adapting to the rising costs associated with carbon pricing. These farmers may struggle to absorb increases in expenses related to energy, fertilizers, and transportation, which can pose a serious threat to their financial viability and overall sustainability.

Transition support; to help mitigate these challenges, the European Union has established mechanisms such as the Common Agricultural Policy (CAP). This policy offers a framework for subsidies and financial support aimed at assisting farmers in adopting more sustainable agricultural practices. However, the actual effectiveness of this assistance largely hinges on its ability to accurately identify and effectively target the farmers who are most in need of support, ensuring that the resources are allocated where they can make the most impact.

Long-term potential for carbon trading in agriculture

Although agriculture is not currently integrated into the EU Emissions Trading System (ETS), there is an ongoing dialogue about the potential inclusion of the sector in the future. Alternatively, discussions are also focused on the possibility of creating a separate carbon trading framework specifically for agriculture. The EU is actively exploring innovative strategies to incorporate agriculture more comprehensively into its carbon pricing initiatives. This could include programs such as carbon farming, whereby farmers can earn carbon credits by implementing practices that capture and store carbon, thereby contributing to the fight against climate change while also potentially generating supplementary income.

Conclusion

The EU Emissions Trading System (EU ETS) has been a central tool in the EU’s efforts to reduce greenhouse gas emissions, but its indirect effects on agriculture pose significant challenges. Although agriculture is not directly included in the system, rising energy, fuel, and fertilizer costs (driven by carbon pricing) can increase production expenses and strain profit margins for farmers. This financial pressure, especially on small-scale producers, may hinder their ability to adopt sustainable practices or invest in more efficient technologies. Additionally, the introduction of the Carbon Border Adjustment Mechanism (CBAM) and changing market dynamics could further intensify competition for EU farmers.

While some farmers may benefit from carbon sequestration incentives, the overall impact of the EU ETS could undermine agricultural viability unless targeted support measures are implemented. To ensure a sustainable agricultural sector, the EU must provide adequate financial and technical assistance to help farmers transition to greener practices without jeopardizing their economic stability.

Appendix 1: Carbon Quotas on non-EU states

Several countries have implemented systems similar to the European Union's Emissions Trading System (EU ETS) to regulate carbon emissions through *carbon pricing* mechanisms like *carbon quotas* and *carbon taxes*. For instance, United Kingdom (UK) in the Post-Brexit period, in the year 2021, established its own ***UK Emissions Trading Scheme (UK ETS)***, mirroring the EU ETS and covering major sectors such as power generation and aviation (UK Government, 2021). The government aims for net-zero emissions by the year 2050 with an ambitious cap and reduction trajectory. Switzerland has its own emissions trading system (Swiss Federal Office for the Environment, 2020) linked to the EU ETS since 2020, covering large emitters. While, Norway participates in the EU ETS and has a domestic carbon pricing mechanism (Norwegian Ministry of Climate and Environment, 2020).

In California (USA) there are ***California Cap-and-Trade Program*** (California Air Resources Board, n.d.). Launched in the year 2012, California's Cap-and-Trade Program covers major sectors and sets a limit on emissions. Businesses are allocated tradable carbon allowances, and the cap is gradually reduced to achieve a *40% reduction below 1990 levels by the year 2030*. Canada have ***Carbon Pricing Mechanisms*** that employs both a carbon tax and cap-and-trade systems (Government of Canada, 2020). Provinces like British Columbia use a carbon tax on fossil fuels, while Quebec operates a cap-and-trade program linked to California. A federal carbon tax applies in provinces without their own systems, increasing over time. Mexico have started with ***Mexican Emissions Trading System (ETS)*** in the year 2020 (Secretaría de Medio Ambiente y Recursos Naturales, 2020). This system initially targeted the power generation sector. The carbon market operates similarly to the EU ETS, with a cap on emissions and tradable allowances. The government aims for a 22% reduction in emissions by the year 2030, with plans to expand the system to other sectors.

China started its ***National Carbon Market*** in 2021 (State Council of the People's Republic of China, 2021), focusing initially on the power generation sector. The market sets emission caps and allows trading of allowances, supporting the country's goal to peak emissions by 2030 and achieve carbon neutrality by the year 2060. South Korea in the year 2015 established ***Korea Emissions Trading Scheme (KETS)*** that covers around 70% of South Korea's emissions and allows for the trading of allowances (Ministry of Environment, Republic of Korea, 2015). The cap decreases to meet targets of a 24.4% emissions reduction by 2030 and achieving carbon neutrality by 2050.

New Zealand introduced ***Emissions Trading Scheme (NZ ETS)*** in the year 2008 covering sectors like forestry, agriculture, and energy (New Zealand Ministry for the Environment, 2020). The system includes a cap on emissions and allows trading of carbon allowances. The government aims for net-zero emissions by the year 2050. Australia had a ***Carbon Pricing Mechanism (CPM)*** in the period from 2012 to 2014 in accordance with the *Clean Energy Act*, that impose a fixed carbon price on major emitters (Department of Industry, Innovation and Science, Australian Government, 2014). The CPM was repealed in the year 2014 due to political opposition, leading the country to rely mainly on direct action policies and the ***Emissions Reduction Fund (ERF)***. Currently, there are ongoing discussions about potentially reintroducing carbon pricing.

Finally, United Nations with ***UN Clean Development Mechanism, CDM*** (United Nations Framework Convention on Climate Change n.d.) and ***International Carbon Action Partnership,*** ICAP (International Carbon Action Partnership, n.d.) promote international collaboration on carbon trading.

Appendix 2: Trump's victory and potential change in current policy regarding Carbon Quotas

Donald Trump's victory in securing another term as president suggests that U.S. climate policy will prioritize deregulation, the expansion of fossil fuels, and a general scepticism toward carbon pricing and global climate agreements. The United States is likely to distance itself from international initiatives such as the Paris Agreement and the European Union's carbon market, while other nations may advance their own ambitious climate policies. Within the U.S., individual states and private sector entities are expected to pursue their own climate initiatives; however, the absence of strong federal leadership could hinder national progress in reducing carbon emissions and addressing climate change.

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PLENARY SECTION II

SUBSIDIES AS A TOOL FOR EMPOWERING SMEs: FROM EMPIRICAL EFFECTS TO FUTURE OPPORTUNITIES IN AGRI-FOOD SECTOR

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Abstract

Subsidies for small and medium-sized enterprises (SMEs) are the most important agricultural policy instruments in developing countries. They can be used to finance various needs of enterprises in primary agricultural production, food industry or in rural tourism. The expected impact of the granted subsidies is aligned with the primary objective of the enterprise's activities: to achieve growing profit as the most significant financial outcome.

The analysis in this paper aims to estimate the impact of subsidies on selected business results of SMEs in Serbia from 2013 to 2018, as well as their alignment with the basic postulates of business activity. The sample consists of 226 enterprises registered for activities belonging to the agri-food sector. The effects of subsidies were estimated using the econometric analysis of panel data, with net profit as the dependent variable and total assets and total liabilities as the independent variables.

Key words: *agribusiness, SMEs, subsidies, profit, panel analysis, Serbia.*

Introduction

Subsidies or incentives are an important agricultural policy instrument, especially in developing countries where the agricultural sector plays a significant role in the overall economy. In Serbia, the right to receive subsidies is granted if the conditions in the tenders of the Directorate for Agricultural Payments within the Ministry of Agriculture, Forestry, and Water Management are met. The incentive system is designed to address the needs of modern farmers, taking into account sector-specific characteristics such as seasonal production,

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sensitivity to climatic conditions, and limited resources, while respecting the budgetary constraints of the Republic of Serbia.

For effective planning and further development of the incentive system, conducting quantitative evaluations is of great importance. This process enables the objective measurement of the economic and social impacts of subsidies and provides convincing arguments for increasing the allocation of funds to support agricultural producers. Research shows that a well-designed incentive system not only stimulates production but also improves the competitiveness of the agricultural sector, promotes rural development, and contributes to poverty reduction in rural areas.

In Serbia, there is a consistent demand from farmers for increased subsidy funding. At the same time, policymakers often promise funding increases without detailed plans or guidelines. These situations showed the need for structured analyses of the effects of granted subsidies. Such analyses can provide important insights into how subsidies influence the business activities of the beneficiary enterprises. This study focuses in particular on legal entities in the agri-food sector, which are significant beneficiaries of subsidies and play a key role in the food value chain.

The unique contribution of this research lies in the application of econometric panel techniques to quantify the effects of subsidies. This methodological approach enables a deeper understanding of the impact of subsidies on the performance of enterprises in the agri-food sector and provides a dual contribution—both theoretical and practical. From a theoretical perspective, the paper enriches the field of agricultural economics by employing advanced analytical methods in the analysis of Serbia's agricultural sector. In practice, the findings can serve as a basis for informed decision-making in shaping agricultural policies and improving the subsidy system, with the aim of achieving sustainable development of the agri-food sector.

Methodology

To assess the effects of subsidies on selected financial outcomes of small and medium-sized enterprises (SMEs) in the agri-food sector in Serbia, econometric analysis was conducted using panel data. Primary agricultural production and the food industry jointly represent the agro-food system of one country (Jovanović & Zubović, 2023). The dataset includes observations where the dependent variable (and some independent variables) varies across two dimensions: time (t) and individual (i). In this case, data were collected for a large number of the same observation units (SMEs in the agri-food sector) over five consecutive periods (T=5). The values were taken from the financial reports submitted by the companies to the Serbian Business Registers Agency.

The basic specification for evaluating the effects of subsidies on SMEs' financial performance relies on individual effects models. Two main types of such models are distinguished in the literature (Cameron & Trivedi, 2010): the fixed-effects model (FE model) and the random-effects model (RE model). According to Dragutinović-Mitrović (2002), the application of the fixed-effects model requires that the independent variable vary both across individuals and over time, while the random-effects model assumes no correlation between random effects and regressors. If both conditions are met, the estimates of both models are unbiased and consistent, with the random-effects estimates being more efficient due to their lower variance (Cameron & Trivedi, 2010).

The Hausman specification test confirmed use of the fixed-effects model to evaluate the impact of subsidies on SMEs' financial outcomes (Hausman, 1978). Business performances were quantified using financial variables such as net profit, net assets, total assets, and total liabilities. The dependent variable was net profit, while the independent variables included total assets and liabilities.

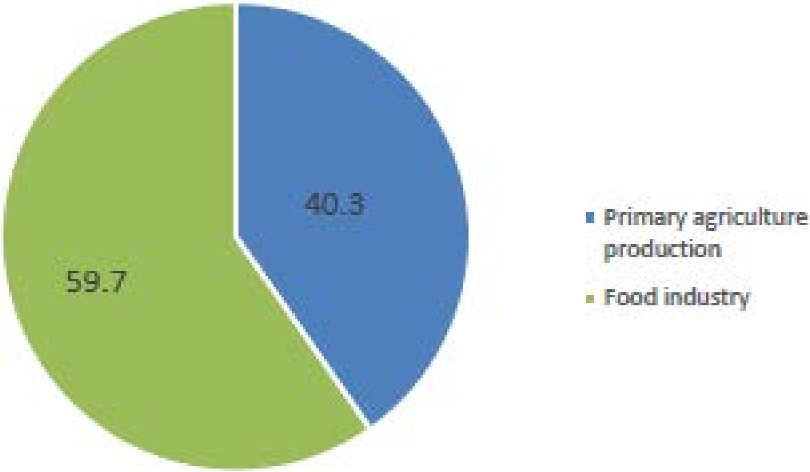
We used the Bisnode database. It is based on financial reports and other documentation submitted by enterprises in Serbia to the Serbian Business Registers Agency. Data were selected for small and medium-sized enterprises whose primary activity codes fall within the ranges 01.1 to 01.7 and 10.1 to 10.9, covering the period from 2013 to 2018.

In most cases within the agricultural sector, balance sheet item 1016 *Income from premiums, subsidies, grants, and appropriations* is linked to subsidies provided through the budget of the Republic of Serbia, specifically via the Directorate for Agricultural Payments. Therefore, it is reasonable to approximate subsidy levels using this balance sheet item.

The total number of small and medium-sized enterprises (SMEs) registered in the agri-food sector, according to the available database, is 5,401. The largest number of SMEs in Serbia's agri-food sector is registered in the *Production of bread, fresh pastry goods, and cakes* (1071), accounting for 17.2% of the total.

The second largest group is *Growing of cereals* (0111), with a share of 14.5%. The third is *Other processing and preserving of fruit and vegetables*, representing 10.5% of the total. The fourth and fifth places in the structure of the agri-food sector are *Mixed farming* (3.2%) *and Growing of other trees and bush fruits and nuts* (3.0%).

Figure 1. *Structure of SMEs in the Agri-Food Sector by type of activity, in %*



Sources: *Author's calculation based on the Bisnode database accessed on February 1, 2020*

The data indicates that more business entities were registered in food production (59.7%) compared to primary agricultural production (40.3%) in line with Figure 1.

In the database, micro-enterprises have the largest share. Nearly nine out of ten enterprises in the agri-food sector are micro-sized. Small and medium-sized enterprises are significantly lower; their combined share is less than ten percent. The analysis in this paper included only enterprises that operated continuously throughout all the observed years. Their financial indicators varied over the years but remained within the intervals defined by the Accounting Law. In other words, the indicators met the required criteria, ensuring that the size of the enterprises remained consistent over time. For instance, there were no recorded transitions of enterprises from the small to the medium-sized category or vice versa.

All outliers that could undermine the reliability of the final conclusions were eliminated from the database. Enterprises that were active for only one year and were deleted from the Business Registers Agency (due to various reasons for their cessation, and it should be noted that these enterprises were not subsidy beneficiaries) were excluded from the database. Due to the nature of the financial analysis, enterprises with a negative value for net assets, known as "loss-making enterprises," were removed from the database. Furthermore, enterprises classified as individual entrepreneurs were excluded from the database, as the subsidy effect analysis refers to legal entities. Therefore, individual entrepreneurs and agricultural holdings were not considered.

Due to unreliable data on *liabilities* in the database, 2013 was excluded from the analysis. The final evaluation used data from the five-year period (2014–2018). The exclusion of 2013 was based on numerous missing values and extreme values for liabilities, which undermined data reliability. As liabilities were an independent variable tested in the model, it was essential to properly manage the data. This resulted in a final sample of 1,130 observations. The literature review indicates that the sample met the criteria of previous authors, with sample sizes ranging from 30 to 500 observations, as defined by Roscoe (1975). Furthermore, the maximum number of independent variables included in the model was four, meeting the criteria set by Green (1991) and Haschim (2010), stating that the number of observations should be 5 to 10 times greater than the number of independent variables, a criterion also applied by Tomaševic (2020).

The selection of *net profit* as the dependent variable is in line with the findings of Carstea et al. (2017) and Sugiyanto and Kusiawan (2018). The main independent variable is the amount of subsidies received from the state budget. During the observed period, there were no other grants from international funds for micro, small, and medium-sized enterprises in the agri-food sector, so balance sheet item 1016 was used to approximate subsidies received from the government. A limitation of the research refers to the availability of data on the subsidies. Since this data is managed by the Directorate for Agricultural Payments and has not been made publicly available or permitted for academic use, it is assumed that balance sheet item 1016 has reasonable reliability. In addition, two other internal determinants were selected, whose effects have been previously tested by other authors: liabilities and the size of the enterprise (Carstea et al., 2017; Sugiyanto & Kusiawan, 2018).

The size of the enterprise was approximated using one of the criteria by which the Agency for Business Registers classifies business entities into micro, small, and medium, such as total assets of the enterprise. The GDP growth rate was chosen as the external determinant of profitabilty, following the literature and previous research, such as Tomasevic (2020). All variables in the model were transformed using the natural logarithm, with the exception of the GDP growth rate. As part of the stationarity check for time series, the Fisher test (Fisher Augmented Dickey Fuller - ADF) was used, in accordance with the relevant literature (Fisher, 1932; Maddala & Wu, 1999; Choi, 2001; Bogunović, 2015; Obradović & Obradović, 2019). The obtained p-values are less than 0.01 for each variable, leading us to conclude that the panel data does not possess a unit root, meaning that it is stationary.

Results

The estimation of the effects of subsidies approved to small and medium-sized enterprises in the agri-food system from 2014 to 2018 is based on the assumption that subsidies for small and medium-sized enterprises in the agri-food system have positive effects on improving their financial performances. The results of the fixed effects model are provided in Table 1.

Table 1. *Results of the evaluation of the effects of subsidies on the profitability of small and medium-sized enterprises in the agro-food system of Serbia in the period from 2014 to 2018*

	Model 1	**Model 2**	**Model 3**	**Model 4**
Subsidies	0,08738*	0,08142*	0,06263**	0,06140**
	(0,03179)	(0,03132)	(0,03046)	(0,03027)
Liabilities		0,03121**	0,01795	0,01819
		(0,01579)	(0,01584)	(0,01594)
Assets			0,43289*	0.43741*
			(0,09225)	(0,09285)
GDP			0,01367	0,01367
				(0,01260)
Const.	2,19338*	2,18565*	-5,36261 *	-5,46741 *
	(0,06115)	(0,06119)	(1,61814)	(1,63021)

Sources: *Author's calculation*

If the regression estimator with the independent variable subsidies shows a positive and statistically significant effect on net profit, this indicates a positive influence of this agricultural policy measure on the improvement of company performance and thus on the further development of the company. Negative or neutral effects indicate a decline in company profits or stagnation

Based on the results obtained from several different models, the following conclusions can be made:

- **Subsidies**: The estimated coefficients for the independent variable *subsidies* are positive in each of the models, with statistical significance confirmed by their respective p-values. In other words, the effect of subsidies on the profitability of small and medium-sized enterprises in the agro-food system is positive and statistically significant. The effect is slightly higher in Models 1 and 2 than in Models 3 and 4, indicating that the econometric analysis suggests that subsidies are an important determinant of the activity of agro-food firms, as a 10% increase in subsidies leads to a 0.61% (model 4) or 0.87% (model 1) increase in the firm's net profit.

- **Liabilities:** The variable *liabilities* is an approximation for the debt of small and medium-sized enterprises in the agri-food sector. Since liabilities were introduced as the second internal determinant of profitability, they appear in three of the four models. The firm's debt is only statistically significant in Model 2, which finds that an increase in debt leads to an increase in the net profit of agri-food firms. In models 3 and 4, the estimated coefficient has a positive sign but is not statistically significant.

- **Assets**: The results indicate a positive and statistically significant effect of company size on profit. In both models (Model 3 and Model 4), the estimated coefficient values are very similar, suggesting that a 10% increase in the enterprise's assets leads to a 4.32% and 4.37% increase in net profit, respectively. In other words, as the enterprise grows, its profitability also increases. This result is consistent with the findings from other studies.

- **GDP**: The impact of the external determinant could not be confirmed, as the regression coefficient estimated in Model 4 was found to be statistically insignificant based on the p-value.

Based on the econometric analysis and the estimated regression coefficients, a clear conclusion can be drawn about the positive effects of subsidies on improving the financial performance of companies. In other words, subsidies have a positive and statistically significant impact on the profits of micro, small, and medium-sized enterprises in the agro-food system of Serbia.

Conclusion

The results of the evaluation of the subsidy policy represent an important contribution to the future formulation of agricultural policy in our country. Strategic documents, development plans, measures, and instruments can be improved and adapted to the needs of the state and farmers if the outcomes of agricultural policy are quantified. Although several documents address the qualitative analysis of the subsidy policy, using descriptive methods, the lack of quantitative assessment has been identified as a major barrier to the modern development of agriculture in the Republic of Serbia.

The results of the comprehensive (qualitative and quantitative) evaluation of the incentive system in the agro-food sector of the Republic of Serbia indicated a positive impact of state support to small and medium-sized enterprises. The positive impact was measured by the increase in financial performance. However, based on the results, problems in the existing system were identified, that should be addressed in the future to accelerate the development of agricultural production. These include the regular implementation of cost-benefit analyses of the subsidy policy, as well as the creation of indicators to monitor the implementation of the incentive system and assess its impact.

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THE ROLE OF REGENERATIVE AGRICULTURE IN SUSTAINABLE DEVELOPMENT

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Abstract

Regenerative agriculture encompasses a range of sustainable development practices focused on soil health, biodiversity, carbon sequestration and a holistic approach. The topicality of regenerative agriculture can be seen at the level of the academic community, farmers and politics. Looking into literature, it can be concluded that the term has not been fully defined albeit the basic principles being well understood; yet concrete practices may differ, with the possibility to adapt or to flex in different contexts. Continuous research aims at determining the effects of regenerative agriculture in crop farming and fruit growing, as well as in integrated systems of crop production and animal husbandry. The importance of regenerative agriculture has been increasing with the need for sustainable systems resistant to climate change

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and economic pressures that improve productivity and the welfare of livestock and preserve ecosystems. The aim of this study is to point out the multiple importance of regenerative agriculture, the need to define the term precisely, to show certain practices in plant production and an integrated system with livestock production, and to point out the role of education on the advantages of these practices.

Key words: *Regenerative agriculture, plant production, animal husbandry, integrated system, education.*

Introduction

Having analyzed the scientific literature and events in professional circles and the public regarding sustainable agriculture, the authors noted a growing need for establishing / developing different production systems, such as organic agriculture, regenerative agriculture, agroecology, agroforestry, permaculture, biodynamic agriculture, and smart agriculture. What these systems of agricultural production have in common is to satisfy three aspects of sustainability: economic, ecological and social, where it can be seen that certain approaches and concepts intersect, all in order to achieve production that benefits people and ecosystems in terms of protecting and preserving the quality of life. According to *FAO (2015)*, the concept of sustainable agriculture is defined as an integrated system of practices in crop and livestock production that provides food while preserving resources, the environment, the quality of life of farmers and society as a whole. One of the systems of agricultural production in the function of sustainable development that has been occupying the attention of the scientific and professional public in recent decades is regenerative agriculture, which focuses on the restoration of natural resources, soil, water, flora and fauna *(Gracin, et al. 2020)*.

The trend of shifting the agriculture towards non-conventional production is becoming increasingly present. It has resulted from solving challenges and giving answers to the following questions. 1) How to mitigate the consequences of using conventional agriculture, as a polluter of the biosphere, whose practices such as intensive tillage, monoculture farming, use of mineral fertilizers and pesticides, as well as the practice of “industrial” production of animal products, have proven to be harmful and unsustainable in the long term? 2) How to respond to the needs of food production, when the human population is growing and it is estimated to reach 9.7 billion by 2050 (*United Nations, Department of Economic and Social Affairs, 2019*), if we know that natural resources are becoming less sustainable? 3) How to reduce the impact of climate change by applying certain practices in agriculture?

O'Donoghue et al. *(2022)* state that the Rodale Institute (USA) is a pioneer in organic and regenerative agriculture, indicating four basic tools of regenerative systems this institute promoted: Soil fertility; Integrated pest management; Plant Breeding and Integrated Crop and Animal Systems. After studying the literature on regenerative practices, it can be noted that a large number of researches aim to confirm the effects of good practices to preserve soil as a resource (*Khangura, et al. 2023)*. Moreover, regenerative practices, as a system of integrated pest management, were the subject of a research of *Barzman, et al. (2015)*. An integrated crop-animal system combines crop farming and animal husbandry to improve soil, farm productivity and environmental sustainability, and it has captured the attention of many researchers on rotational grazing and manure composting *(Carvalho, 2018; Duncan, 2016)*.

Certain practices of regenerative agriculture can be considered universal for crop production, while some of them are specific for crop farming and fruit growing, but the integrated approach of animal husbandry can be applied also in crop farming and fruit growing. Research on confirming positive impacts of regenerative agriculture in crop production has been conducted by a large number of authors (*Khangura et al., 2023; Barzman et al., 2015*), in animal husbandry and integrated crop and animal systems *(Carvalho et al., 2018; Duncan, 2016).* After a thorough study of the available literature, *O'Donoghue et al. (2022)* proposed that regenerative agriculture should not be singled out as a separate system of production, but be considered as part of every agricultural and/or livestock production system that increases the quality of products and availability of resources, which agricultural land, water, flora and fauna, and renewable energy rely on.

Education of the various stakeholders in regenerative agriculture, including farmers, researchers, consumers, local governments and policy makers, can greatly contribute to spreading the practices and to the overall success of regenerative agriculture, taking into account the specific roles and needs of each group (*Alexanderson, et al., 2023*). The aforementioned authors investigated the opinions of farmers who had accepted new practices, including regenerative agriculture, and those who had not, taking into consideration some factors such as the ways farmers acquire knowledge, their openness to risks and how and why they make decisions.

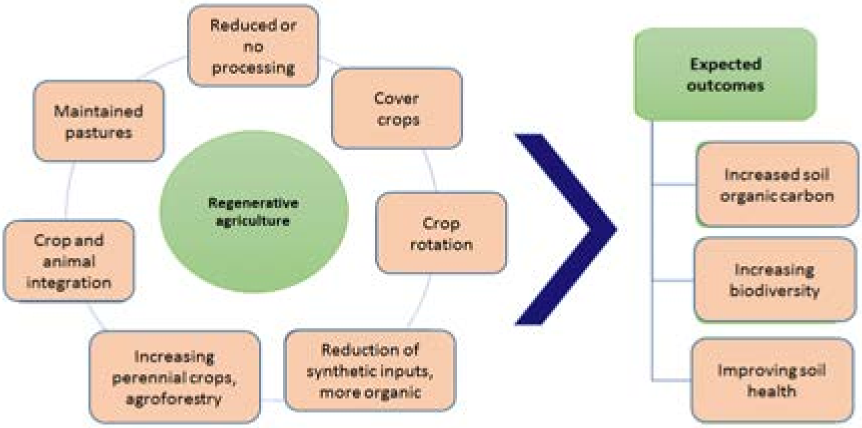
Elaboration

Regenerative agriculture in the framework of sustainable development

Agriculture can be considered the world's largest industry, employing more than one billion people and producing $1.3 trillion worth of food annually *(Bless, et al., 2023)*, and it plays a crucial role in human existence by continuously providing food. The same authors point out the importance of agriculture in terms of the economy, human society and biodiversity, noting that agriculture is one of the most important areas for preserving the planet and the life on it. In recent decades, the primary task of agriculture, to meet the needs of the growing human population for sustainable and safe food, has been burdened with numerous challenges, some of which are land degradation *(McLennon, et al., 2021*), water pollution *(Lam, et al., 2011)* and loss of biodiversity (*Isbell, et al., 2017)*. Climate change and the reduction of the rural population can also be considered a challenge for agriculture. In order to overcome such a complex situation, the scientific and professional public are facing different solutions to eliminate the negative impacts of conventional agriculture, due to the intensive use of artificial fertilizers and pesticides. The solution lies in the establishment / development of agricultural production systems that are productive, environmentally acceptable and socially equitable. Those systems may be different, but what they have in common is that they focus on technologies that ensure sustainable intensification of agriculture.

Comprehending the importance of sustainable development, the efforts of scientific and professional staff in agriculture are directed towards the development of production systems as an alternative to conventional agriculture, among which is regenerative agriculture. Regenerative agriculture includes a number of practices and principles aimed at sustainable development. It focuses on 1) soil health (composting practices, use of cover crops, crop rotation and reduction or no tillage); 2) increasing biodiversity (using different types of crops and animals on the farm); 3) carbon sequestration (improving soil structure and increasing the content of organic matter to combat climate change); 4) sustainable and more efficient use of water (improving soil structure and using cover crops for water retention); 5) a holistic approach (taking into account the entire ecosystem of the farm, i.e. plants and animals, microorganisms in the soil, water resources and the people who manage the farm) and 6) local development of economies and communities (promoting local market chains and creating better conditions for farmers) (Scheme 1).

Scheme 1: *Regenerative agriculture and expected benefits*



Source: *Emily Rehberger et al 2023 Environ. Res. Commun. 5 052001*

Although the concept of regenerative agriculture attracts increasing attention, a review of the literature shows that the mentioned concept has not been fully defined. Despite the basic principles being well understood, concrete practices may differ, which on one hand makes it difficult to define the concept, but on the other side enables adaptability and flexibility in different contexts. An aggravating circumstance is the absence of a single set of standards or a certification system that would precisely define what is considered to be regenerative agriculture, which in certain situations results in different interpretations and practices.

The conceptual framework for the definition of sustainable agriculture shows evolutionary trends in its development. *Schreefel et al. (2020)* performed an extensive analysis of 28 studies and concluded that regenerative agriculture focused on the ecological dimension of sustainability, comprising the topics such as soil health improvement, resource management optimization, climate change mitigation, the improvement of nutrient cycling and water availability, while at the same time aiming to improve the social and economic dimension of sustainable food production. The problem of defining regenerative agriculture was also dealt by *Newton, et al. (2020*). They pointed out that was no legal or regulatory definition, which could lead to different understandings by farmers, researchers, traders, consumers, and decision makers. In order to characterize the term of regenerative agriculture, this group of authors analyzed 229 publications and determined that this term was defined by processes (use of cover crops, integration of livestock, reduced or no tillage) and/or outcomes (improvement of soil health, sequestration of weeds and increasing biodiversity), noting that in certain situations they may be in conflict, and pointing out the importance of users to carefully define the term for any given use and context.

According to *Giller et al., (2021)*, 2016 was a turning point, because the occurrence of the term regenerative agriculture has increased drastically since then, which is confirmed by the fact that 52 scientific papers were published from 2016 to 2020 and about 250 times cited. The same authors emphasize that it is crucial for agronomic research to solve several questions, in order to encourage critical thinking about the agronomic aspects of the mechanisms and dynamics of regeneration, as the conceptual core of regenerative agriculture – What is the problem that can be solved by regenerative agriculture; What needs to be regenerated; Which agronomic mechanisms enable this regeneration; Can this mechanism be integrated into sustainable agronomic practices in the specific context and What political, social and/or economic forces will drive the use of new agronomic practices.

Understanding the need for an integrated approach to regenerative practices with modern technologies is very important *(McLennon, et al., 2021*). The same authors gave an overview of the possibilities of applying different technologies, techniques and tools in order to achieve precise, optimized and regenerative management of production, based on the detection of certain parameters related to soil, nutrition and plant health, the presence of pathogens, with special reference to climate-smart agricultural practices. Some authors (*Kastner, 2016*) have had very bold statements regarding the potential of regenerative agriculture, claiming it can "reverse" climate change, while some authors have expressed caution regarding the potential of regenerative agriculture in relation to sustainability (*Ranganathan, et al. 2020*).

Education of all actors in the regenerative agriculture chain is key to its success; well-informed farmers can implement new practices, consumers can support sustainable products, policy makers can create a legal framework, and researchers can develop innovations that will enable the improvement of regenerative agriculture. Education of farmers is important for adopting practices such as crop rotation, composting, using cover crops and reducing the dependence on chemical inputs, which can improve their economic viability (*Day & Cramer 2022)*. The role of consumer education is to help them understand how these practices can benefit the production of healthier foods, which can be reflected in purchasing decisions. In the education of farmers, the Agricultural Advisory and Expert Services (PSSS) play a major role, whose experts pass on the knowledge acquired through schooling or by studying scientific and professional literature, as part of their advisory work. Among the activities in the field of regenerative agriculture, there are also educations of PSSS advisers envisaged in the Annual Training Plan for Agricultural Advisers in 2022 and 2024, to help transfer knowledge to farmers. Education is also important for decision makers, because they can pass laws to support the application of regenerative agriculture. The exchange and dissemination of knowledge and experiences is also very important for researchers, who play a role in the development of new technologies and practices in the field of regenerative agriculture.

Benefits of regenerative agriculture in crop production

Regenerative agriculture is applied in crop farming and fruit growing, where there are similarities, but also certain rather specific practices, as well as in animal husbandry, which is seen as an integrated system within crop production. The similarities are reflected in the common goals of both types of crop productions, namely the restoration and conservation of the soil as *Ugrenović, Filipović (2017)* state. Cover crops are used to improve the structure, to increase organic matter and prevent soil erosion; compost is added to improve the microbiological activity of the soil; biodiversity is preserved by sowing different crops on the same plot, which increases resistance to pests and diseases; chemical inputs are reduced by biological pest control and using natural fertilizers instead of synthetic ones (*Ugrenović et al., 2020*). The processes aim more at activating and preserving the natural fertility of the soil, and less at the direct nutrition of plants, as is intensive conventional production (*Ugrenović et al., 2024*). Some authors point out that regenerative agriculture essentially refers to healthy soil (*Lal, 2020),* which is important for food production as the second largest carbon reservoir in the world after the oceans, which is directly related to the fight against climate change. Specific farming practices are crop rotation, which is considered a key practice to improve soil health and reduce the risk of diseases and pests, and minimum or no tillage to preserve structure and reduce soil erosion and specificities related to weed and pest management (Figure 1, 2, 3). Specific practices for fruit growing are the use of organic mulch (straw, wood shavings) around trees in order to retain moisture, reduce weeds and improve organic matter in the soil, as well as planting different plants between rows of fruit trees for better disease and pest management.

Figure 1. *Effect of protective tillage (Mulch tillage). (Photo. Ugrenović, 2012).*

Figure 2. *Cover crop based on self-grown oats (Photo. Ugrenović, 2016).*

Figure 3. *Dry mulch from the biomass of the rye cover crop [Ross, Jasa, 2006].*

Benefits of regenerative agriculture in animal husbandry

Animal husbandry, in the context of regenerative agriculture, implies sustainable production with the aim of optimizing costs, productivity and profitability, while satisfying animal welfare, ecosystem sustainability and climate change resistance. Regenerative agriculture takes a holistic approach to animal husbandry that looks into the entire ecosystem of the farm, animals, plants, water resources and human activities in order to achieve long-term sustainability through environmental, economic and social benefits. *LaCanne and Lundgren, (2018),* state that holistic management should improve the regenerative practices of agricultural land with the profitable generation of high quality crops and animals including poultry, i.e. to achieve profitable agricultural production.

Research in the field of regenerative agriculture focuses on the compromise between agricultural production and the impact on the environment. According to *Bonaudo et al., (2014),* combining crops and livestock through integrated systems is an opportunity to improve sustainability. These authors pointed out the need to regenerate the connections between soil, crops and animals while following agroecological principles, and emphasized the importance of multidisciplinary research, which would include agronomy, ecology, economics and social sciences.

Russelle et al., (2007), indicate that integrated systems have been used worldwide since ancient times but that there is now a renewed interest due to concerns over natural resource degradation, long-term environmental sustainability of farms, as well as the profitability and stability of farm income.

Chakraborty et al., (2024), compared native grasslands and integrated crop and animal systems. The management of plant residues in order to increase branch matter was the subject the research of *Prescott et al., (2021),* who pointed out the importance of the problem of soil degradation, which according to *UNCCD (2017),* should be a global priority. Integrated systems of animals, crops and pastures are mutually beneficial for both, given that crop residues can be used as animal feed, while animal manure contributes to soil fertility and carbon sequestration, as indicated by a number of authors (*Reddy & Reddy 2016; Carvalho et al., 2018; Colley et al.,2020*).

In addition to integrated crop and animal systems, an important regenerative practice for maintaining soil health is proper grazing. Continuous livestock grazing, especially with insufficient pasture rest, results in soil degradation, while with proper management of grazing resources, ruminants can play an important role in maintaining permanent soil cover, effective in reducing soil erosion and increasing carbon accumulation. According to some authors, the solution lies in rotational grazing. *Teague and Kreuter (2020)* examined the impact of rotational grazing on vegetation height and diversity, as well as the percentage of land cover in order to determine the ecological impact, with reference to how pastures are affected since the last grazing and by the type of animals (cattle, sheep, poultry), taking into account the type of soil and locality. The authors of this paper pointed out the complexity of the issue of rotational grazing and emphasized its advantage in terms of farm sustainability. Studying grazing management for soil restoration and ecosystem function, they concluded that an approach with short-term periods of grazing and long-term periods of rest, i.e. plant recovery, while adjusting the number of animals, contributed to sustainability, indicating the need to find individual grazing management systems, which can be considered a challenge in scientific and professional circles.

By studying the literature, it can be concluded that the development of regenerative practices in animal husbandry in the coming period will be significant as part of farm strategies in order to define combinations of practices that enable better use of resources and farm sustainability in economic, ecological and social terms as a response to current needs, while respecting the specificities at the local level.

Conclusion

Regenerative agriculture aims for long-term sustainability, creating healthy and productive farms that can respond to the intensification of agriculture, the ongoing climate changes and a growing need for healthy and safe food.

There is a consensus in the scientific and professional literature about restoring soil health, increasing biodiversity, carbon sequestration, sustainable water use and a holistic approach to farm management.

The task of the scientific and professional public in the field of regenerative agriculture is to develop farm strategies, to define a combination of practices that strengthen the integration of crops and livestock, as well as to design future systems of agricultural production that efficiently use farm resources.

Decisions on the application of regenerative agriculture practices should be made in regards how they affect atmospheric carbon sequestration and provide other essential services to the ecosystem and society.

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THE MODEL OF INTERNAL CONTROL FOR AGRICULTURAL COMPANY

Jelica Eremić-Đođić[1], *Jelena Popov*[2]

Abstract

Every agricultural company has its own mission, vision, and goals. Good process management of agricultural company is not possible without the establishment of a solid control framework and well-established internal controls. Internal controls represent a very important tool for the management so they can control the company`s environment as well as the risks that affect its operations and other elements of the COSO framework. Defining the risk, evaluating and prescribing internal control for its elimination helps the management to ensure that the financial statements of the agricultural company are objective, true and accurate.

This paper will present a model made up of a series of internal controls that help to put the key processes for financial reporting in an agricultural company under control. The result of this model is that the company fulfills the obligation that ensure compliance with regulatory legal acts and that the management makes decisions on a more reliable basis in order to achieve the set goals of the agricultural company.

Key words: *internal control, financial statements, managing.*

Introduction

The role and importance of internal controls in an agricultural company

Auditing as an economic branch is very important in the establishment and development of market institutions in our country and also in economic integration with developed countries. Its synergy is reflected in the application of international standards for small, medium and large companies, cooperation through professional associations and other forms and methods of integration.

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Auditing has several branches such as commercial audit, internal audit, IT audit and other forms of audit. What is common to each of them is the use of internal controls that agricultural companies apply in their operations. Each audit evaluates this very model and gives its own opinion. This model is also evaluated by the Ministry of Finance of the Republic of Serbia, the Central Harmonization Unit of which it is a part. Therefore, the role and importance of internal controls in an agricultural company is enormous and essential.

The obligations that agricultural companies have when carrying out their agricultural activities are prescribed by the legal regulations of the Republic of Serbia. Knowing that the topic of work is internal control in an agricultural enterprise, this legal obligation will be clarified in this paper.

Namely, the Law on the Budget System stipulates that the Head manager of the User of Public Funds is responsible for internal controls in the institution he manages and he is obliged to inform the Ministry of Finance of the Republic of Serbia - Central Harmonization Unit every year about what the agricultural company he manages has done in this regard. The same law also defines the fine provisions for failure to fulfill these obligations.

In literature and practice, we find out various types of internal controls defined according to certain criteria. Some of them may be:

- Controls by scope: general and application-specific
- Controls by function: preventative, detective and corrective
- Accounting controls etc.

Financial management and control in an agricultural company

We will focus in this paper on the financial management and control model. In addition to its legal obligation, the importance of its implementation in an agricultural company is as follows:

- provides a clear and unambiguous hierarchy of responsibilities in an agricultural company;
- controlling the targeted spending of funds, it clearly indicates risk areas that may prevent agricultural enterprises from achieving their goals;
- eliminates or keeps “under control” the identified risks in business through internal controls;

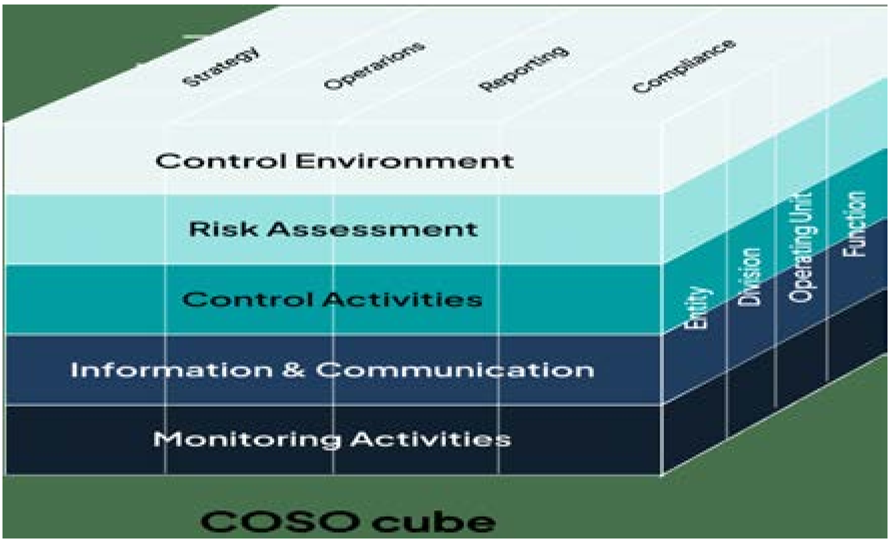
- provides tremendous support for the achievement of the defined goals,mission and vison in the company as well

In order to define the model of internal controls in an agricultural company, it is necessary to look at the elements on which they are based. The Internal Control Manual prescribed by the Ministry of Finance of the Republic of Serbia cites internal control as “a process carried out by the board of directors, the management of the entity and other employees, designed to provide reasonable assurance regarding the achievement of objectives”,[3] of a particular company, which is reflected in its operations and financial reporting.

Before we move to the prescribed rules, it is worth mentioning that “rules are not enough” and that understanding accounting ethics in an agricultural company is extremely important, especially when it comes to conflicts of interest. It affects accountants, auditors, and management.

In the practice of implementing financial management and control in an agricultural company, the internal control model defined by the Commission on Sponsoring Organizations (COSO) is applied. Its mandatory elements are shown in Figure 1. COSO framework below.

Figure 1. *COSO framework*[4]



3 https://mfin.gov.rs/upload/media/s2Uug9_6010215bf36a9.pdf, стр.20, (used on 07.12.2024.год.)
4 https://www.stratsys.com/hsfs/hubfs/coso%20cube%20(1).png?width=957&height=1098&name=coso%20cube%20(1).png, (used on 07.12.2024.)

The implementation of financial management and control within the agricultural company in which it is implemented results in a model of internal controls that represents the best practice of the company. Their application cannot be universal or applicable to a related company. The reason for this fact lies in the diversity of policies, standards, goals, missions, visions, the activities that the company itself carries out in its market operations, personnel, resources, and other characteristics.

Suggested model of internal control in agricultural company

The model of internal control in an agricultural company cannot be universal nor can be applicable to all similar companies. In certain segments, only some of its partial parts can be adapted, namely in the part of limited operations by prescribing similar controls whose activities are defined by legal regulations. Having this in mind, the suggested model of internal control for an agricultural company will process part of the financial operations that every agricultural company must have, and which errors may affect its operations and financial reporting.

An analysis of the initial state in the agricultural company before comparing internal controls revealed that the company had organized its operations in accordance with legal regulations by adopting certain decisions, instructions, rulebooks, and guidelines.

However, the adopted acts do not sufficiently prescribe the activities that employees should carry out in accordance with their powers and responsibilities given by the Rulebook on the Systematization and Organization of Workplaces and the employment contract.

Therefore it was established that management responsibility is partially respected, that existing internal controls are very weak, insufficient or have not even been established in certain parts of the organization.

The anonymous survey method in the form of a questionnaire, listed in table 1 below, is used to analyze the situation.

Table 1. *Anonymous survey-questionnaire*

num-ber	Activity description	Implementation of activities	
		yes	no
1.	Do you deliver all documents to responsible functions via the office, archived in an internal delivery book with a case number?		
2.	Do you make a review of received payment security instruments?		
3.	Do you keep financial records of the contract?		
4.	Do you keep accounting records of the contract ?		
5.	Do you have a person in charge who monitors the implementation of each contract?		
6.	Do you reconcile contract implementation records on a monthly basis?		
7.	When making a payment, do you reconcile the payment amount on the payment security instrument, pro forma invoice, invoice and contract?		
8.	When making a payment, do you reconcile the amount on the payment security instrument with the tender documentation?		
9.	When making payments, do you reconcile the current account with the payment security instrument, pro forma invoice, invoice, contract and tender documentation?		

Analyzing the results of the survey conducted in the form of a questionnaire, we came to the following results:

- Three positive answers and seven negative answers were received to the nine questions asked. This structure of the answers makes it clear that the selected agricultural company has a very weak control framework. This is reflected in the insufficiently developed controls. Based on all of the above, it was necessary to prescribe a set of internal controls that would make the control framework in the agricultural company stronger. Therefor a solid model of internal controls in the agricultural company is formed which enables it to achieve its goals, mission and vision.

• internal control number 1 - review of received payment security instruments

Contract number	Contract date	Bussiness partner	Contract amount	Type of IOP	Expiration date	Extension period SIP	Billing date SIP	Return date SIP

• internal control number 2 - accounting records of contracts

Serial number	Contract number	Contract date	Bussiness partner	Contract amount	Paid amount	Remaining to pay

• internal control number 3 - person who monitors the implementation of the contract

Contract number	Contract date	Bussiness partner	Contract amount	Paid amount	Remaining to pay	SIP [5]	Contractual penalty

• internal control number 4 – Monthly records of contract implementation

Contract number	Contract date	Bussiness partner	Contract amount	Paid amount	Remaining to pay	Bookes amount	Payment difference			Signature		
							F[6]	F[7]	A[8]	F	A	

• internal control number 5 - reconciliation of the payment amount on the payment security instrument with the tender documentation

Contract number	Contract date	Bussiness partner	Contract amount	SIP	Returned SIP	Extension amount SIP	Extension condition SIP from TD[9]	Payment SIP	
								amount	date

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5 SIP-security instrument of payment
6 Financial sector
7 Financial sector
8 Accounting sector
9 TD-Tender documentation

• internal control number 6 - reconciliation of the current account on the payment security instrument, pro forma invoice, invoice, contract and tender documentation

Contract number	Contract date	Bussiness partner	Bank guarantee checking account number	Current account number on pro forma invoice/invoice	Current account number on the contract

The proposed set of internal controls (five) support management accountability in an agricultural company while also adapting it to the control environment, thereby meeting the requirements of the COSO framework.

„The control environment defined by COSO includes integrity, ethical values, competence, organizational structure, management awareness,“[10]etc.

Respecting the provisions of the COSO framework, agricultural companies are strengthening their control framework. This is reflected in more objective financial statements. “At the same time, the company’s management is looking for a way to establish better control over the company, which is a long and continuous process. Internal control provides full support in this.“[11]

Prescribing a model of internal controls is only the first major step in regulating the regularity of operations of agricultural enterprises in the field of internal audit. It is even more important to monitor their implementation that supports the process:

- „continuous internal controlin the company;
- regular reporting on implemented internal control measures for identified deficiencies“.[12]

In this way, we can say that we have paved the way for a higher quality control of financial reporting of agricultural enterprises.

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10 Chorafas, N.D. (2000). Reliable Financial Reporting amd Internal Control, John Wiley&Sons, INC, page 68.

11 Поповић, С., Еремић-Ђођић, Ј.&Мијић, Р. (2014). Интерна контрола у функцији менаџмента. Часопис „Економија: теорија и пракса“, вол.7.бр.2.,стр.74-85.

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Conclusion

Agricultural companies should represent the backbone of Serbian development of the Republic of Serbia. Therefore, it is necessary to take all necessary measures to prevent the loss of their assets and make them as strong as possible for market competition. In addition to other measures, the proposed internal control model provides great support in this.

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MONEY LAUNDERING: A CURRENT MANIFESTATION OF ECONOMIC CRIME IN AGRIBUSINESS

Miljana Barjaktarović[1], *Dragan Cvetković*[2]

Abtract

The economic system of a country can be threatened in various ways, with contemporary threats often involving sophisticated methods employed by criminals and criminal organizations, particularly within the realm of economic crime. A key activity in this context is money laundering, which poses an increasingly serious global problem. There is no area, sector, or entity within the economic and financial system, including agribusiness, that is not vulnerable to money laundering, one of the most severe manifestations of economic crime. Essentially, money laundering involves the legalization of income obtained through criminal activities, which has extremely negative impacts on the economic, political, legal, cultural, and other critical aspects of society, disrupting the smooth functioning of the economy. The purpose of this paper is to emphasize the substantial harmful impact of money laundering on society as a whole and to highlight the importance of the efforts by regulatory authorities and other societal actors in combating this form of crime.

Key words: *economic crime, money laundering, agribusiness and economy.*

Introduction

It is widely known, and scientifically established for a long time, that agriculture brings numerous positive effects in ecological, social, and economic terms. Its primary goal is the production of agricultural goods of high quality (Barjaktarović et al., 2016). Modern information technologies, market globalization, and the internationalization of trade have led to increased international exchange, removing certain barriers and facilitating the flow of goods, services, capital, and information, along with the application of new technologies. However, this development has also brought about new forms of business activities, particularly in the economic sphere, contributing to various manifestations of crime. Economic crime represents a category of offenses with a broad spectrum of different forms,

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appearing in nearly all areas of economic activity. Money laundering, as a specific type of economic crime, is a global issue hindering the smooth operation of the economy and causing significant material harm to society.

"Dirty money" is not an end in itself; rather, criminals and criminal groups seek to use money obtained through criminal activities for their own purposes. Therefore, they need to legalize it, that is, integrate it into the legitimate flows of the economic and financial system. Criminals and criminal groups find ways to "clean" this "dirty money", making it appear "clean". This means they find ways to channel this money into the legitimate economy, into banks and companies, to create the illusion that they are investing legally earned money. In these situations, intermediaries play an important role – individuals who act as nominal owners of businesses and companies. They ensure that the criminals, the true owners, remain concealed and that their names do not appear in official documents.

Perpetrators of criminal activities attempt to legalize the income generated from these illegal actions or present it as originating from legitimate sources, as the fight against crime is focused on the seizure of unlawfully acquired assets and preventing their entry into legitimate financial channels. Money laundering is closely associated with issues such as corruption, organized crime, financial fraud, and smuggling, and it represents an international problem that has become a defining characteristic of the modern financial system.

This phenomenon is present in both developed and underdeveloped countries. Money laundering is a criminal activity with a high degree of social harm, which has not bypassed the agribusiness sector; this area of the economy is also not immune to money laundering. Although money laundering is most commonly associated with areas such as banking, the gambling sector, casinos, insurance, capital markets, real estate, and others, this phenomenon is also present in agribusiness, where "dirty money" is funneled through agribusiness ventures and entities. In practice, the individuals executing money laundering are often those who own registered agricultural holdings and individuals with accounts specifically opened for this purpose in commercial banks.

General Overview of Economic Crime

One of the most well-known definitions of economic crime comes from Edwin Sutherland, president of the American Sociological Association, who uses the term "white-collar crime" to describe this type of crime. Sutherland defines economic crime as "crime that occurs within the realm of business activities" and emphasizes that it most often manifests through manipulations in stock trading, misrepresentation of corporate financial status, deceptive advertising, bribery of business partners and government officials to secure favorable business deals, misuse of funds, tax evasion, and similar acts (Sutherland, 1940). He later expanded this definition, describing "white-collar crime" as offenses committed by individuals of high social status within the scope of their professional activities (Sutherland, 1945).

Božidar Banović highlights that economic crime encompasses all delinquent behaviors (both active and passive) arising from the economic relationships of entities that hold authority over assets, whereby these behaviors directly harm property and disrupt or endanger economic relations (Banović, 2001). According to his definition, economic crime includes both economic offenses and infractions, with liability extending to legal entities as well (Group of Authors, 2021).

The criminal justice system of the Republic of Serbia includes the following categories of criminal offenses under economic crime, as defined by the Criminal Code of the Republic of Serbia (Cvetković et al., 2016):

- against the economy (counterfeiting money, money laundering, abuse of authority in business, tax evasion, unauthorized production and trade, smuggling, causing bankruptcy, etc.);
- criminal offenses against official duties (abuse of official position, violation of law by a judge, public prosecutor, or deputy, misuse of budget funds, illegal payments and collections, embezzlement, accepting and giving bribes, etc.);
- criminal offenses against legal transactions (forgery of documents, forgery of official documents); and
- criminal offenses under specific laws.

The Council of Europe emphasizes that economic crime negatively impacts not only individual victims but also society as a whole, undermining trust in the economic system at both the national and international levels (OSCE, 2006). Although no country has entirely eradicated economic crime, each national system aims to reduce it to a socially acceptable level. A key goal for every state is to combat this phenomenon due to the potentially severe economic damage it can cause (Ferme, 2013). Additionally, preventive measures play a crucial role in addressing economic crime (Jager and Stubbs, 2013).

Authors identify several key characteristics of economic crime: adaptability to new socio-economic relationships, concealment in execution, a high "dark figure" of undetected offenses, complexity of legal regulations, and the specificity of proving these criminal acts. Perpetrators are often individuals with high social standing or officials in business operations, and these crimes are typically driven by profit motives. Globalization and international markets further facilitate the spread of economic crime, posing a serious threat to economies and society as a whole (Group of Authors, 2021).

Research on economic crime reveals that its forms and structures are highly diverse and numerous, often involving a large number of interconnected perpetrators who operate over extended periods and achieve substantial financial gains. The most vulnerable areas within the financial and economic system include the banking sector, domestic and foreign trade, hospitality, industry, transportation, and communications, with crime most commonly manifesting in the sphere of goods trade and production. The agribusiness sector should also be added to these vulnerable areas, as it is exposed to forms of economic crime such as money laundering, fraud, and abuse, for instance, in obtaining subsidies intended for the development and improvement of agricultural production. These incriminating actions can be carried out in various ways, such as falsifying information about agricultural holdings on lands that are not cultivated at all, submitting applications for subsidies based on fictitious farms or fictitious possession of agricultural land. Additionally, cases of misuse of subsidy funds are also recorded in practice.

Conceptual Aspect and Regulation of Money Laundering

Criminals use money laundering to conceal the true nature, origin, and existence of illegally obtained income, thereby masking their criminal activity and enabling unrestricted use of these funds. "Dirty money" can originate from various illegal activities, such as drug trafficking, illegal arms and human trafficking, tax evasion, corruption, organized crime, embezzlement, and fraud. Essentially, any income generated from criminal activities that yields unlawful financial gain is considered dirty money, including assets and values derived from it. This connection establishes an essential link between money laundering and preceding criminal activities.

Money laundering is a specific form of economic crime, distinguished by certain characteristics. Primarily, it is of a derivative nature, meaning it cannot exist without a preceding criminal act. This type of economic crime can be viewed from both broader and narrower perspectives. In a broad sense, money laundering involves the process in which income suspected to be acquired through criminal actions is transferred, transformed, exchanged, or altered in a lawful way to conceal the true nature, origin, purpose, flow, or ownership of these funds. The goal of this process is to make assets obtained from illegal activities appear legitimate. In a narrower sense, money laundering includes any action or attempted action to hide or disguise the illegal origin of funds, making it appear as though they come from legal sources. Regardless of the perspective, the purpose of money laundering remains the same – to present illegal funds as legitimate through a series of financial transactions (Cvetković et al., 2021).

Money laundering consists of three primary stages, although in practice these stages may sometimes overlap or certain stages may be omitted:

The first stage is breaking the direct link between the money and the criminal activity through which it was obtained, known as the "placement" stage. During this stage, illegally acquired money is introduced into legal financial channels. This stage carries the highest risk of detection for criminals, as it is evident that the money lacks a legitimate origin and is most vulnerable to seizure (Schneider, 2008). For this reason, this initial step is crucial for regulatory authorities to identify suspicious transactions using various indicators.

The second stage is called the "layering" or "concealment" stage. The funds are transferred from the accounts where they were initially deposited to other accounts through a series of transactions. The primary goal of these transactions is to obscure the connection between the funds and the criminal activities through which they were obtained. These transactions aim to hide the money trail and complicate investigators' efforts to trace the origin of the funds.

The third stage is the "integration" stage, which represents the final part of this process, after which the "dirty" money appears as money earned through legitimate activities. A popular method for integrating these funds into legal financial channels is purchasing real estate, such as commercial buildings, warehouses, or apartments. Once the money reaches this stage, it becomes extremely difficult, if not impossible, to uncover its illicit origin (Savić et al., 2021).

These three stages do not necessarily have to be carried out in that order, as criminals sometimes choose to directly invest illegally obtained funds in luxury goods or real estate. Additionally, in cases of certain crimes, such as embezzlement or investment fraud, the criminals' money may already be integrated into the financial system, eliminating the need for further placement of funds.

The concept of legalizing illegally obtained income does not follow a single set of rules; methods and techniques are adapted to specific situations. Although methods vary, the stages mentioned in the money laundering process can occur simultaneously within a single transaction, or they may be executed separately, one after the other. Additionally, each of these stages may involve numerous individual transactions.

Every country that is part of the global financial system may be exposed to money laundering, meaning this issue affects not only states with developed market economies and offshore centers. For this reason, the international community has made substantial efforts to combat money laundering on a global level. The Republic of Serbia has actively engaged in the fight against money laundering and terrorism financing through its legal regulations since signing international conventions. For years, Serbia has continuously fought against these phenomena, closely monitoring developments on the international stage and applying best regulatory practices. In Serbia, the laws directly addressing money laundering include the Law on the Prevention of Money Laundering and Terrorism Financing, as well as the Criminal Code.

Under the Criminal Code (Official Gazette of the Republic of Serbia, 2019), specific offenses are defined, including the crime of money laundering in Article 245 and the crime of terrorism financing in Article 393. Money laundering, as outlined in Article 245, paragraph 1 of the Criminal Code, states: "Whoever converts or transfers property, knowing that the property originates from criminal activity, with the intent to conceal or falsely represent the illicit origin of the property, or conceals or falsely represents facts about the property knowing it originates from criminal activity, or acquires, possesses, or uses property knowing, at the time of receipt, that the property originates from criminal activity, shall be punished by imprisonment from six months to five years and a fine". The use of the term "criminal activity" allows that the offense need not be individually identified, and it is not necessary for a prior final judgment for that offense to exist. For the specific case, it is sufficient to establish that the money or property was obtained through an activity that constitutes a criminal offense (Stojanović et al., 2017).

The Law on the Prevention of Money Laundering and Terrorism Financing (Official Gazette of the Republic of Serbia, 2023) contains provisions aimed at preventing money laundering and established the Directorate for the Prevention of Money Laundering, a financial intelligence unit of the Republic of Serbia, whose jurisdiction is defined by this law. This law prescribes actions and measures to prevent and detect money laundering. Under the meaning of this law, money laundering includes: the conversion or transfer of property acquired through the commission of a criminal offense; the concealment or misrepresentation of the true nature, origin, location, movement, handling, ownership, or rights associated with property acquired through the commission of a criminal offense; and the acquisition, possession, or use of property acquired through a criminal offense. According to this law, money laundering also includes activities conducted outside the territory of the Republic of Serbia.

In addition to being regulated by the Criminal Code and the Law on the Prevention of Money Laundering and Terrorism Financing, Serbia is also subject to the European Convention on Money Laundering, Investigation, Seizure, and Confiscation of Criminal Proceeds, which came into force with the adoption of the Law on Ratification of the Council of Europe Convention on Laundering, Search, Seizure, and Confiscation of the Proceeds from Crime and on the Financing of Terrorism. To further strengthen the system for combating money laundering and terrorism financing, the Government of the Republic of Serbia adopted the Strategy for Combating Money Laundering and Terrorism Financing for the period 2020-2024 (Government of Serbia, 2020).

Although there are many different definitions of money laundering, experts and practitioners agree on one key aspect: money laundering is the process of concealing the illegal origin of funds or assets acquired through criminal activities. Activities such as corruption, organized crime, drug trafficking, arms trafficking, and human trafficking generate high-value illegal assets, and laundering such assets can threaten the economy and the integrity of the financial system.

Money Laundering in Agribusiness with Examples

Agribusiness encompasses a wide range of economic activities related to the production, industrialization, and commercialization of agricultural products, and can be viewed as an agribusiness complex. A farm represents a production unit where agricultural activities are carried out and can be organized either as a family farm, where an individual (farmer) and their family members engage in agricultural work, or as a legal entity or entrepreneur. Agricultural products, or agri-food products, include unprocessed, partially processed, or fully processed items intended for human consumption. These products can be ready for immediate consumption or serve as raw materials for the food industry (Zekić et al., 2023).

The intensive development of industry and agriculture, the expansion of transportation and modern human activities, population growth, and especially the advancement of modern agribusiness are closely linked with the general economic development of society, which facilitates the transition of agriculture from traditional to modern forms. Today, society increasingly faces complex issues arising from the inadequate application of measures and practices in agribusiness, as well as from the actions and behaviors of individuals or groups contrary to the "code of good agricultural practices" and in violation of legal and regulatory acts. The spectrum of risks ranges from mild forms within acceptable limits to severe forms of greater magnitude (Subošić et al., 2012).

Money laundering, a scourge and one of the most sophisticated criminal activities today, with a high level of social danger, has not spared the agribusiness sector. Agribusiness is also not immune to money laundering, one of the most complex forms of crime today. Although money laundering is most commonly associated with sectors such as banking, capital markets, currency exchange offices, casinos, and insurance, this phenomenon is also present in agribusiness. Perpetrators often include owners of registered agricultural holdings who open designated accounts in commercial banks as individuals. These individuals typically appear as defendants within organized criminal groups engaged in so-called "professional laundering", where their role is to withdraw funds from agricultural accounts and deliver the cash to organizers or the individuals who hired them. This allows them to transfer and convert funds, effectively acting as the final step in the layering process of "dirty" money. It has also been observed that bank employees often do not thoroughly check the documentation provided by these individuals, despite the fact that the documents generally bear no relation to agricultural activities, a loophole that "professional launderers" exploit. According to the regulations on the registration of agricultural holdings, registration requires proof of a designated bank account, intended for specific transactions such as loans, premiums, rebates, and subsidies. Although the purpose of these accounts is clearly defined, they are frequently misused to receive payments unrelated to agricultural activities (Government of Serbia, 2021; Ministry, 2024).

In one case, a total of 24,706,403.02 dinars was deposited into the accounts of multiple agricultural holdings, which was then fully withdrawn and returned to those who made the deposits. The farm owners, based on falsified documents – receipts showing fake fruit sales – received the money in their accounts. They then withdrew the funds and returned them to the depositors or intermediaries. In this case, the organizers used farm owners who, by agreement, provided presigned purchase lists. The accused filled these lists with false data, representing larger quantities of goods than were actually purchased, based on which they made payments of inflated amounts. The owners then withdrew the money, kept a portion for themselves—either as payment for the “sold” goods or as a commission for the service—and returned the remaining funds to the organizers (Government of Serbia, 2021).

In the Republic of Serbia, specific common methods of money laundering have been identified. The most frequent method involves transferring money through the accounts of multiple legal entities based on fictitious trade of goods and services, with the ultimate goal of withdrawing the money in cash. Another common method includes investing illegally obtained funds in the purchase of real estate, vehicles, other valuable assets, legal entities, or injecting cash into business operations. The third most common form of money laundering in Serbia involves using legal entities, such as craft businesses, entrepreneurs, and agricultural holdings, to transfer and disburse cash based on false obligations (Government of Serbia, 2021).

The following text will present examples (cases) of money laundering in practice within the field of agribusiness. “On March 29, 2024, members of the Ministry of Internal Affairs, UKP, the Anti-Corruption Department, in collaboration with the Special Anti-Corruption Department of the Higher Public Prosecutor’s Office in Kraljevo, arrested 16 individuals on suspicion of committing the criminal offense of money laundering. A criminal complaint for the same offense was filed against a seventy-year-old farm owner, while additional complaints for tax fraud and tax evasion were filed against I. V. (1977), the de facto responsible person of the company ‘Euro AB Team 2021’ LLC Čačak, who is currently in custody, and a thirty-five-year-old formal responsible person of the same company. The arrested farm owners include G. Š. (1961) from Gornji Milanovac, M. B. (1958), B. Đ. (1981), D. D. (1970), D. G. (1973), G. G. (1976), M. K. (1974), V. L. (1981), I. M. (1990), S. R. (1971), M. V. (1986), R. V. (1968), G. P. (1960), D. R. (1947), S. P. (1966), and M. P. (1997), all from Čačak. It is suspected that I. V. and the thirty-five-year-old woman who is the formal responsible person of this company in Čačak unlawfully obtained a tax credit and avoided paying taxes in 2022 and 2023 by recording 171 false receipts for the sale of timber to the detained farm owners in the Tax Administration’s system and the company’s accounting records, amounting to approximately 83.8 million dinars, which was never actually transacted. The money in this amount was allegedly transferred to the accounts of the detained farm owners, who withdrew the funds and returned them to I.V. and the thirty-five-year-old suspect. In doing so, they illegally obtained financial gain in this amount and caused a loss to the state budget of approximately 24.8 million dinars in evaded taxes. The suspects were handed over to the relevant prosecutor's office along with the criminal complaint." (MUP, 2024).

"On May 17, 2023, members of the Ministry of Internal Affairs in Belgrade, the Economic Crime Suppression Department, in collaboration with the Special Anti-Corruption Department of the Higher Public Prosecutor's Office in Belgrade, arrested five individuals, while one is still being sought, on suspicion of committing the criminal offense of money laundering. The individuals arrested are M. P. (1966), S. A. (1962), A. A. (1995), L. R. (1995), and G. U. (1971). The suspects allegedly used the personal data of agricultural holding owners, which the owners provided to them, to submit requests for incentive funds to the Agricultural Payments Directorate in 2018 and 2019. In these requests, they falsely claimed that the agricultural holding owners had a business relationship with a company presented as a supposed supplier. Based on this, the Agricultural Payments Directorate issued decisions approving investment applications eligible for subsidies totaling 14,744,712 dinars. Subsequent checks revealed that there was no business relationship between these individuals and the company, nor were the investments carried out. It is suspected that part of the disbursed funds was kept by the farm owners themselves, while a larger portion was given in cash to the suspects. The suspects have been detained for up to 48 hours and, along with the criminal complaint, will be presented to the relevant prosecutor's office." (MUP, 2023).

"On December 25, 2021, members of the Ministry of Internal Affairs, the Anti-Corruption Department of the Criminal Police Directorate, acting on orders from the Special Anti-Corruption Department of the Higher Public Prosecutor's Office in Niš, arrested four individuals on suspicion of committing the criminal offense of money laundering, while a criminal complaint for the same offense will be filed in regular proceedings against one individual. The arrested include N. R. (1983), owner of an agricultural holding; M. K. (1984), also an owner of an agricultural holding; as well as LJ. R. (1960) and M. R. (1981), all from Niš. A criminal complaint will also be filed in regular proceedings against a 38-year-old man. It is suspected that N. R., from December 2019 until December 25 of this year, falsely represented facts about cash suspected to originate from criminal activities by integrating it into legal channels. He did so by opening agricultural holdings in his name, as well as in the names of M. K. and the 40-year-old man. He also opened bank accounts where he deposited cash totaling 19,320,000 dinars. LJ. R.

is suspected of helping N. R. conceal the illegal origin of the money by creating a fictitious gift contract with him for $335,000, which he deposited into his personal bank account. Additionally, he and M. R. created a false loan agreement for $170,000, which was also deposited into his personal account. The suspects, N. R., M. K., LJ. R., and M. R., were brought before the Higher Public Prosecutor's Office in Niš along with criminal complaints." (MUP, 2021).

Conclusion

Due to the high risk it poses to society, money laundering is considered one of the most serious forms of economic crime, as it severely undermines the foundations of state and economic systems. This illegal activity often goes unnoticed, complicating national and international efforts to implement effective measures for its prevention and suppression.

While money laundering is most commonly associated with sectors such as banking, capital markets, currency exchanges, and insurance, it is also present in agribusiness, where "dirty money" is funneled through agricultural holdings and agribusiness companies. There have been cases in agribusiness where farm owners withdrew money paid by a company under false pretenses of purchasing agricultural products and returned it to the de facto responsible party in that business, the supposed supplier, thereby participating in money laundering activities. Practice has also shown that designated accounts of agricultural producers or companies have been misused in various ways, highlighting the need for enhanced monitoring of these entities, as they undoubtedly represent a risk from the perspective of money laundering threats. Banks must also conduct a more thorough analysis and verification of documents submitted by these individuals to determine whether the documents are genuinely related to agricultural activities, thus hindering "professional launderers" in their efforts.

Continuous education of individual farmers, cooperatives, and small agribusiness owners in Serbia—primarily on basic concepts of criminal activities and their associated risks, as well as on reporting observed criminal actions—could raise awareness of what constitutes acceptable moral behavior versus unacceptable actions. Such education would also raise awareness among farmers and other agribusiness entities about the negative repercussions of criminal activities and help them understand their rights and responsibilities.

Based on all the aforementioned, it is evident that all economic sectors are exposed to the threat of money laundering, which seriously undermines the security, financial, and economic systems of many countries. The Republic of Serbia is making substantial efforts to combat this global problem by implementing activities and measures aimed at preventing, detecting, and adequately prosecuting perpetrators of money laundering and other forms of crime.

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ECONOMIC ASPECTS OF DIGITAL TECHNOLOGIES IN AGRICULTURAL PRODUCTION[1]

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Abstract

Digitalization in agriculture is an increasingly important phenomenon, involving broad range of activities not only in agricultural production, but also in decision making (management) process at farm level, new approaches to financing of farm activities, etc. Nevertheless, growing importance of digital technologies in agricultural production is not followed by sufficient research on its economic aspects, costs related to their application as well as economic efficiency of investments in this field. Therefore, managers of family farms and agricultural enterprises do not have appropriate insight in real economic consequences (but also social, environmental and political implications) of their deeper involvement in production based on information technologies. The goal of this research is to discuss economic aspects of various ways of using digital technologies in agricultural production.

Key words: *information technologies, costs, investments, agriculture, management.*

Introduction

There is no consensus concerning the term digital agriculture. It is assumed that it has the same or similar meaning like terms smart agriculture, smart farming, IT in agriculture, agriculture 4.0 etc. Abbasi et al. (2022) mentioned that this is a fusion of digital technologies, such as big data, artificial intelligence, wireless sensor, autonomous robots, cloud computing, internet of things etc. Abiri

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et al. (2023) enlisted and explained the main benefits of digital agriculture, such as improved agility, time and costs savings, asset management and product safety. Tankosić et al. (2024) stated that term digitalization "is still open to different definitions due to its dynamic character and the multiple aspects from which it can be viewed". According to Sarker et al. (2019), digital agriculture "uses modern technology achieving sustainable agricultural development in terms of crop, fisheries and livestock", while digital agriculture could be used to provide food for growing population. Anyway, it should be taken into account that digital agriculture is not related only to sustainable agriculture, but also to better use of resources (water, energy), cost reduction and increase of productivity. Kitole et al. (2024) mentioned that benefits of digitalization in agriculture were observed in enhancing extension services, better access to market information and improved availability of financial services.

Analyzing the relationship between the use of digital technology and agricultural productivity in the EU countries, Bocean (2024) stated that digitalization provides famers an opportunity to improve "productivity and economic sustainability". Author also stated that digital technologies in agriculture "should be tailored to each EU member state's unique requirements". Research conducted in Spain (Sadjadi and Fernandez, 2023) indicated that "acquisition costs of the machinery, equipment and applications have been the main obstacle" when it comes to financial challenges of digitalization in agriculture. Similarly, results from Brasil (Bolfe et al., 2020) indicated that the most important benefit of digital agriculture is an increase of productivity. On the other hand, investments in fixed assets (machinery, equipment and software) are the main challenges. There are a number of researches conducted in China concerning the effects of digitalization in agriculture. Xu et al. (2024) determined that digital economy positively impacts agricultural technical efficiency while narrowing regional disparities. Fu and Zhang (2022) concluded that "digitalization can significantly raise agricultural total factor productivity".

Authors from Ukraine (Kropyvko et al., 2020) analyzed investments in number of digital tools in agriculture. Applying discounting methods for investment evaluation, authors determined that all the investments were economically efficient. Using the same methodological approach, authors from Indonesia (Khofiyah et al., 2021) determined that investments in renting agricultural drones are acceptable. Ryskeldi et al. (2024) investigated investments in 6 digital technologies (2 in livestock production and 4 in plant production) in Kazahstan, concluding that all of them are economically efficient.

However, in some cases investments in digital agriculture are not economically efficient. Sanyaolu and Sadowski (2024) investigated investments in precision agriculture in Germany, France, Poland and Romania. Farms dealing with field crops were observed, depending on their size (which is expressed by economic size). Authors considered reduction of fertilizers and crop protection costs (due to the use of precision agriculture) as a key benefit for investment analysis. It was determined that "farms with an economic size of less than EUR 100,000 demonstrated a negative net present value (NPV)", while for bigger farms investments were economically efficient. The use of subsidies for such investments is realistic only for the farm size of EUR 50,000–100,000. Other farms are too small, and even subsidies are not effective (unable to provide positive NPV for such investments). Similar topic was discussed by Todorović et al. (2019) for Serbian conditions.

The main goal of this research is to discuss economic aspects of various ways of using digital technologies in agricultural production. Apart from that, this research it trying to analyze changes which occurred in the Republic of Serbia in previous years considering investments in digital technologies.

Material and methods

Economic aspects of digital technologies are discussed through the review of literature dealing not only with economic assessment of investments in digital agriculture, but also other related topics, such as productivity; managerial decisions in digital era; social, political and ecological consequences of digitalization in agriculture.

Analysis performed in this paper presents continuation of research conducted by Todorović et al. (2019). That research evaluated economic efficiency of investments in high precision GPS (global positioning system) guidance systems on specialized crop farms in the Republic of Serbia cultivating between 10 and 100 hectares. Farms were divided into two groups, the first group using 10-50 hectares while the second group cultivating 50-100 ha of arable land. Analysis was based on different level of cost savings enabled by the application of high precision GPS guidance systems. It was concluded that such investments for bigger farms (50 – 100 hectares) are economically efficient without investment subsidies (provided that an appropriate level of cost savings is achieved).

On the other hand, authors proved that investments in high precision GPS guidance systems are not economically efficient for smaller farms (10 – 50 hectares) without subsidies. Such investments are economically efficient for smaller farms only if they use subsidies and provide appropriate level of cost savings (at least 8%). Having that in mind, this research will reconsider only investments in high precision GPS guidance systems for the same small farms, while bigger farms will not be discussed. Previous research was based on average values for two production years (2017/2018 and 2018/2019), while this research assumed average values for the period of five production years (2019/2020, 2020/2021, 2021/2022, 2022/2023 and 2023/2024).

Methodology applied by Todorović et al. (2019) for determining economic effectiveness of investments in high precision GPS guidance systems is also used to assess the period of five production years in this research. This approach is based on the calculation of annual equivalent cost (described by Bierman and Smidt, 2007) of high precision GPS guidance systems. Besides, authors determined breakeven number of hectares for various levels of cost savings (between 2% and 8%).

Results and discussion

Sowing structure of observed farms (cultivating from 10 to 50 hectares) has not changed during the period 2018 – 2019 and period 2020 – 2024, meaning that participation of maize was 47.78%, wheat 27.93%, sunflower 18.63% and soybean 5.66%. Average production costs influenced by investments in high precision GPS guidance systems (seed, fertilizers, pesticides, fuel and maintenance, and labor costs) for the observed periods are presented in Table 1.

Table 1 *Production costs (EUR per hectare)*

Crop	Seed	Fertilizers	Pesticides	Fuel, M&R	Labor costs	Total
2018-2019						
Corn	82.01	278.88	65.00	173.41	17.05	616.35
Wheat	81.00	266.38	21.87	112.65	13.59	495.48
Sunflower	61.69	252.61	67,80	147.86	16.58	546.54
Soybeans	61.46	218.24	43.63	147.69	19.44	490.47
2020-2024						
Corn	85.15	336.39	65.87	185.38	17.88	690.65
Wheat	84.09	321.31	22.16	120.43	14.25	562.23

Crop	Seed	Fertilizers	Pesticides	Fuel, M&R	Labor costs	Total
Sunflower	64.05	304.70	68.71	158.07	17.38	612.91
Soybeans	63.81	263.25	44.22	157.88	20.39	549.54

Source: *Authors' calculation*

Weighted average costs per hectare (Table 2) are determined on the basis of two factors – production costs per hectare (Table 1) and percentage of participation of individual crops in sowing structure. Comparing two periods, average observed cost per hectare increased for 69.85 EUR (12.42%).

Table 2 *Weighted average costs (EUR per hectare)*

Crop	2018-2019	2020-2024	Difference	
			(EUR per ha)	Index (2018-2019=100)
Corn	294.47	329.98	35.51	112.06
Wheat	138.41	157.06	18.65	113.47
Sunflower	101.83	114.19	12.36	112.14
Soybeans	27.75	31.09	3.34	112.04
Total	**562.46**	**632.31**	**69.85**	**112.42**

Source: *Authors' calculation*

Effects of various levels of costs savings in periods 2018 – 2019 and 2020 – 2024 are presented in table 3.

Table 3 *Costs savings (EUR per ha)*

Percent of cost savings	Average for period 2018-2019	Average for period 2020-2024	Difference	
			(EUR per ha)	Index (2018-2019=100)
2% costs savings	11.25	12.65	1.4	112.44
5% costs savings	28.12	31.62	3.5	112.45
8% costs savings	45.00	50.58	5.58	112.40

Source: *Authors' calculation*

Economic efficiency of investments in high precision GPS guidance systems for the observed family farms is determined for two scenarios (Table 4). Scenario 1 is based on the assumption that farmers do not use state subsidies on investments in high precision GPS guidance systems, while Scenario 2 considers state support (investment subsidies) for the purchase of high precision GPS guidance systems. Comparison of two periods indicates lower price of high precision GPS guidance systems in period 2020 – 2024, as well as lower repair costs and annual subscription fee (due to an increasing competition on the market of such systems). Nevertheless, the opposite trend was observed for discount rate, which is a consequence of changes in interest rates.

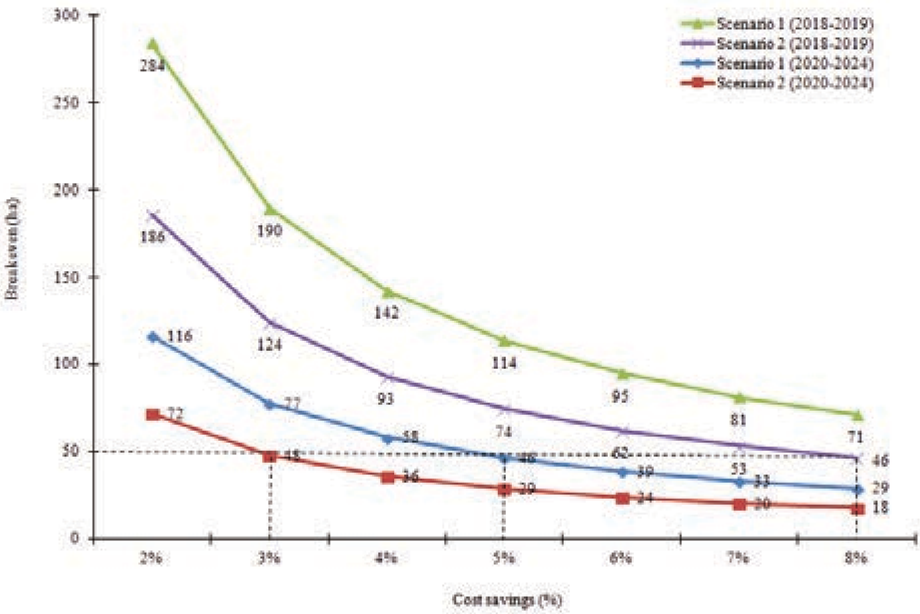
Table 4 *Economic efficiency of investments in high precision GPS guidance systems (family farms cultivating 10 to 50 hectares)*

Elements of calculation	2018-2019		2020-2024	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2
Investment amount – initial outlay (EUR)	12,000.00	12,000.00	6,000.00	6,000.00
Investment subsidy (%)	0%	50%	0%	50%
Investment subsidy value (EUR)	0.00	5,000.00	0.00	2,500.00
Salvage value (EUR)	0.00	0.00	0.00	0.00
Amount to be recovered (EUR)	12,000.00	7,000.00	6,000.00	3,500.00
Discount rate (%)	3.50%	3.50%	4.00%	4.00%
Life of the asset (years)	5	5	5	5
Capital recovery factor	0.22148	0.22148	0.22463	0.22463
Annual equivalent of an initial outlay (EUR)	**2,657.78**	**1,550.37**	**1,347.76**	**786.19**
Annual repair costs (10% of new over life) (EUR)	240.00	240.00	120.00	120.00
Annual subscription fee (EUR)	300.00	300.00	0.00	0.00
Operating costs per year (EUR)	**540.00**	**540.00**	**120.00**	**120.00**
Annual equivalent costs (EUR)	**3,197.78**	**2,090.37**	**1,467.76**	**906.19**

Source: *Authors` calculation*

Knowing the level of annual equivalent costs for various scenarios (and different periods) enabled calculation of breakeven number of hectares (for various levels of costs savings) (Graph 1). It was determined that investments in high precision GPS guidance systems without subsidies during the period 2018 – 2019 were not economically efficient, but it changed during the period 2020 – 2024 (minimal required cost savings are 5%). On the other hand, if farmers used investment subsidies in the period 2018 – 2019 acquisition of high precision GPS guidance systems was economically efficient only for cost savings of 8%. In a new business environment (period 2020 – 2024), circumstances were much more favorable for farmers, so that such an investment was economically efficient for minimal level of cost savings of only 3%.

Fig. 1 *Break-even number of hectares for analyzed periods and scenarios*



Source: *Authors' calculation*

It should be taken into account that managerial decisions in agriculture could be influenced not only by economic results of investments in digitalization, but also by the use of new managerial solutions based on digital technologies. Certain authors discuss internet of things based "application development platforms" (Baseca et al., 2019) while others stated that "digital platforms as data aggregators" could be useful, but "as these systems develop, the efficiency of these platforms becomes more challenging" (Borrero and Mariscal, 2022). Managers also face additional challenges (and opportunities, as well) linked to possibilities to use decentralized finance (which is based on blockchain technology). Such way of financing is especially suited for projects which "require high upfront investment and long payback times" (Pombo-Romero and Rúas-Barrosa, 2022).

Social, environmental and political implications of digital agriculture should not be neglected, as well. Based on the research of perception of Canadian producers regarding digital technologies in agriculture (Abdulai et al., 2024) it was indicated that only 6.7% of farmers strongly agree that digital technologies in agriculture offer a “reliable return on investments”, while 17.1% of them strongly agree that digital technology “increases profitability of farms”. At the same time 23.6% of farmers strongly agree that digital agriculture increases productivity. At the same time, according to Hackfort (2021), there is an inequality linked to the use of digital technologies in agriculture, primarily because “corporate actors largely control and shape the development of infrastructure, products and services”. According to the same author, there are also “inequalities in distribution of benefits from the use of the technologies”, “uneven sovereignty over data, hardware, and digital infrastructure”, etc. Discussing digitalization in agriculture, MacPherson et al. (2022) questioned ability of digital agriculture to provide sustainability. Authors pointed out that it depends on factors such as agricultural policy and “legal settings”. The research indicated that without appropriate policy measures and legal framework digitalization will become just an “instrument for reinforcing” economic efficiency.

As one of the advantages of applying digital technologies in agriculture, positive effect on ecology could be mentioned. Lu et al. (2024) stated that “rural digitalization has substantially amplified agricultural production efficiency while simultaneously notably reducing environmental pollution”. Musajan et al. (2024) showed that digital technologies cause “farmers’ green production transformation” reducing application of pesticides and fertilizers. According to authors, digital technologies also reduce information asymmetry and improve “market access”, while also “enhancing precision management practices”.

Conclusion

Authors addressed numerous issues related to digitalization in agricultural production within the paper. The literature review indicated that digital solutions in agriculture increase productivity, while investments in digitalization are economically efficient mainly for big farms. Smaller farms are dependent on state subsidies to provide economic efficiency of investment in digital technologies, such as acquisition of high precision GPS guidance systems. Nevertheless, an increasing competition among providers of digitalization services in agriculture speeds up wider adoption of digital technologies among farm managers (by decreasing level of investment, which proves to be one of the biggest challenges). It is necessary for policy makers to keep in mind other aspects of digitalization (social and environmental), and to create appropriate environment which could enable digital solution to provide long term sustainability for agricultural production.

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SECTION I

AGRIBUSINESS

AGRIBUSINESS AND SUSTAINABILITY: SUCCESS MODELS AND FUTURE STRATEGIES

Alin-Ionuț Petrică[1], *Dragoș-Nicușor Popa*[2]

Abstract

Sustainability has become a crucial aspect of modern agribusiness, as companies and entrepreneurs seek to balance economic growth with environmental stewardship. This paper investigates the role of sustainable practices in agribusiness, highlighting models of success from around the world. The study emphasizes innovations such as organic farming, resource-efficient technologies, and the circular economy, which enhance productivity while minimizing environmental impact. It also explores how agribusinesses are adapting to global challenges such as climate change and resource depletion. By analyzing successful case studies, the paper identifies key strategies for long-term sustainability in the sector and the role of policy support in fostering sustainable growth. The research concludes that the future of agribusiness lies in integrating sustainability at every level, from production to distribution, ensuring both profitability and environmental responsibility.

Key words: *Sustainability, Agribusiness.*

Introduction

Sustainability is the quality of a human activities to be carried out without depleting available resources and without destroying the environment, so without compromising the possibilities of meeting the needs of future generations.

Sustainability does not offer a definite answer, but we can have a multitude of solutions. Sustainable agriculture is much broader than that because it has several categories of agriculture: agroecology, conservative agriculture, ecological agriculture, regenerative agriculture, precision agriculture, biodynamic agriculture, permaculture. Sustainability in agriculture is a desire to

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thoroughly analyse the impact of agricultural practices on environment, soil health, water resources and biodiversity.

“I see sustainability by trying to make the best use of resources (natural, financial) to get the best results. We can produce as much but at lower costs. This is what we have been trying to do on our farm since 8 years ago, without reducing productivity. But these results came with hard work, labour and testing.” (Doru Gheorghe, Agrofond Invest, Ambasada Sustenabilității în România, 2024)

“Approximately over 50 billion GHGs (greenhouse gas emissions) are emitted almost every year, globally. Humans have increased the concentration to sustainable levels because since the industrial revolution some greenhouse gases occur naturally and because of this there is more carbon dioxide in the atmosphere than ever before. GHG 1 accounts for 17%, the agricultural sector creates the alarming temperature increase at global levels, and at European level it generates 13.3% of GHG. The EU has allocated over 100 billion between 2014-2020 euro from CAP (Common Agricultural Policies) resources for climate action obtained from which 26% is from CAP budget and about 50% 2 of GHG emissions generated from the livestock sector, respected by emissions obtained from soil fertilization 36% and land use and land use change 14%. Climate neutrality in the agriculture, land use and forestry sectors, all to be achieved by the EU by 2035 on the “Fit for 55%” legislative proposal tabled by the European Commission in June 2022.” (Ambasada Sustenabilității în România 2023).

Future strategies

Agribusiness will face many challenges but also many opportunities in the future. The following strategies aim at addressing these challenges by promoting sustainability and at enhancing technological progress. We will look at some strategies.

Sustainability in integrated farms

Integrated farms, where animal husbandry comes with a component of agricultural practices, are one of the main measures for more sustainable agriculture. For example, in 2020, the Cățean farm in Brasov is a model, 90% of animal feed is produced on the farm and silage has been completely eliminated. Also as a sustainability measure, steps are being taken to produce green energy. This is a closed circuit that starts with animal feed and ends with the finished product, which has good results in terms of implementing sustainability measures, thanks to the overall vision you can create. Moreover, because in an integrated farm the chains are shorter and more economically viable, sustainability becomes a natural direction. In the example above we have a farm in Brasov that produces its own food to feed its animals. This farm, in addition to producing its own feed, is taking steps to produce green energy. In order to carry out this plan, the circuit will be repeated so that the finished product is of the same quality and quality.

Sustainability in ecological agriculture

Organic farming is an agricultural method of producing food using natural substances and processes. The Commission has set a target of 25% of agricultural land in the EU to be farmed organically by 2030 - a significant increase from 10.5% in 2022. The European Court of Auditors found that the EU's organic farming strategy lacked important elements such as quantifiable targets or how to measure progress. EU funding for organic farming - more than €12 billion in 2014-2022 - has helped to increase the area devoted to organic farming, but not enough attention has been paid to environmental and market objectives. Moreover, due to data limitations, the impact of the policy could not be assessed. The Court recommended improving the strategy and effectiveness of EU funding for the organic sector**. (https://www.eca.europa.eu/ro/publications/SR-2024-19**

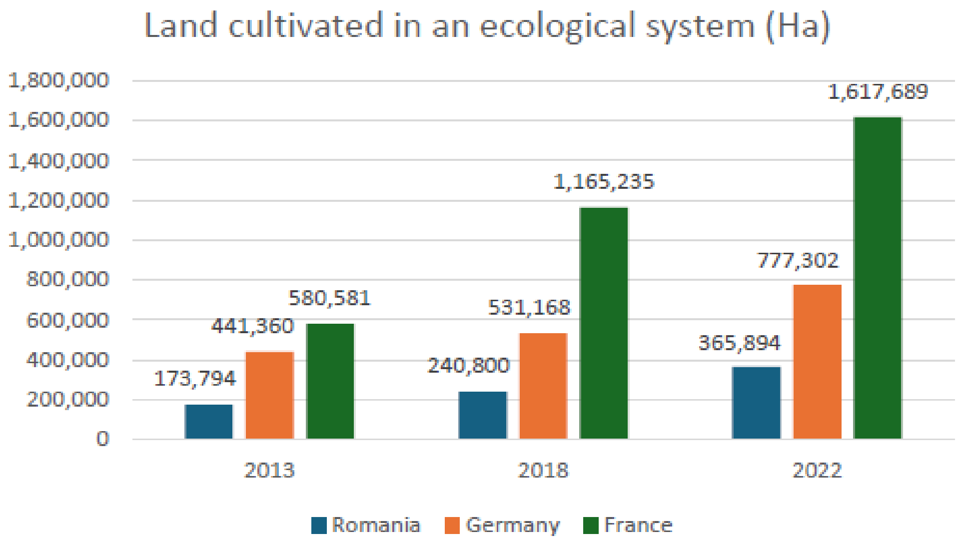
Table 1. *Land cultivated in an ecological system (Ha)*

TIME	2013	2018	2022	2022/2013
Romania	173.794	240.800	365.894	110,5332
Germany	441.360	531.168	777.302	76,11519
France	580.581	1.165.235	1.617.689	178,6328

Source:*https://ec.europa.eu/eurostat/databrowser/view/org_cropar/default/table?lang=en&category=agr.org*

In the table above, we can see that France has the highest increase in the area of organic agricultural land, while Romania and Germany have a steady increase, but Romania has a higher percentage increase than Germany, but still has a lot of catching up in terms of land area (Ha) with Germany.

Chart 1. *Land cultivated in an ecological system (Ha)*



Source:[*https://ec.europa.eu/eurostat/databrowser/view/org_cropar/default/table?lang=en&category=agr.org*](https://ec.europa.eu/eurostat/databrowser/view/org_cropar/default/table?lang=en&category=agr.org)

Precision agriculture

Precision agriculture uses technology to manage and monitor agricultural resources efficiently. Some examples of the technologies used in precision agriculture are navigation and GPS systems that help to accurately guide farm machinery, drones for crop condition monitoring and soil measurement, soil sensors that measure moisture and levels of different nutrients in the soil and other parameters. The role of precision agriculture is crucial for ensuring the profitability and sustainability of modern farms and thus provides farmers with new tools to manage resources efficiently so that agricultural results are as high as possible. Among the benefits of Precision Farming are increased efficiency by reducing wastage of resources, increased yields by optimizing the use of resources, sustainability by reducing environmental impact through precise application of agricultural pesticides but can also have reduced long term costs through more efficient use of resources.

Fig 1. *Iteligent agriculture: technology for efficient crops*

Source:https://tarfin.com/ro/blog/ce-este-agricultura-de-precizie-de-ce-este-important

Education and Awareness

For future strategies, from our point of view we should invest in education and public awareness because they are crucial to ensuring long-term sustainability. Information campaigns and educational programs can add to changing consumer behaviour and increasing demand for sustainable products. A great impact can be made by farmers' education in the aspect of sustainable practices can accelerate their adoption.

Support Policies

Government support policies play a key role in promoting sustainability through policies and regulations already implemented and future policies that support sustainable agricultural practices. A big plus is government subsidies for sustainable technologies, these tax incentives for organic farming as well as strict regulations on the use of pesticides and fertilisers can make farmers adopt more environmentally friendly practices

Adaptation to climate change

It is essential that we adapt to climate change because it ensures the long-term continuity of agribusiness. Through climate change can harm agricultural yields, such as: rising temperatures, rising temperatures, changing precipitation patterns and increasing the frequency of extreme weather events. As a result, all farmers and all companies in the agricultural sector require a strategy to enable them to accommodate change and reduce associated threats.

A few strategies for adapting to climate change would be the development of new plant varieties resistant to unfriendly conditions such as drought but also to flood in certain cases and through which the use of these varieties can help to maintain constant production in changing climatic conditions. Another way of adaptation could include the use of modern irrigation technologies. For the most sustainable future we could implement more efficient irrigation systems such as drip irrigation and underground irrigation, both can make a positive contribution to saving water but also to providing water for crops. Farmers could also implement some regenerative farming practices, for example, implement crop rotation and increase compost use. These practices can improve soil health and its ability to retain water. Useful approach to human resources, such as water and soil, is found a solution for adoption to climate change. This effectively includes such as rainwater harvesting, water harvesting, and, forest protection and sustainable land use.

Strategy	**Description**	**Example**
Cultivation of resistant plants	Development of drought and flood resistant varieties	Drought-resistant maize and sunflower plants
Efficient irrigation technologies	Drip and underground irrigation systems	Drip irrigation in vegetable farms
Regenerative agricultural practices	Crop rotation and use of compost	Crop rotation on organic farms
Management of natural resources	Harvesting rainwater and protecting forests	Harvesting rainwater on urban farms

Source: *Examples from our own college education*

Therefore, adaptation to climate change offers a multi-dimensional approach that includes technological innovations, sustainable agricultural practices and efficient management of natural resources. Thanks to the implementation of each strategy, the, agribusiness can mitigate the weaknesses of climate change, but it can also ensure that sustainability will last.

Other practices for the future of agribusiness

Biofuels will in the future have a very large allocation of land for raw material production. An example of an innovator we found is Celtic Renewables, which amends whiskey residues in biofuel, he said, another example would be Agrivida, which is advancing the enzyme technology for biofuels on the level of non-food crops. Because of the persisting shortage of workforce, automation is gaining importance in agribusiness. All who can offer specialized robots to help them with various agricultural activities will always be at the top of this transformation.

Now we will talk about alternative energy that with the funds of concerns about fuel costs, agricultural enterprises obtain renewable energy sources. An example would be Sundrop Farms which is the leader of solar energy in numerous agricultural operations, which is, while Smithfield Foods is modifying manure into renewable natural gas expressing sustainable farming practices. Farmers to ensure their future profitability began to incorporate more and more both production and processing directly on the farm, which helps them stay or even advance in terms of competitiveness. The adoption of agricultural technology and digitalization leads cutting-edge solutions in the field of agro-technology. These technology companies help farmers make informed decisions about plantings, pesticide application and harvesting through an easy-to-use application that uses real-time data and artificial intelligence that provides information tailored to the location of the region farmer find.

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ANALYSIS OF FOOD SECURITY IN EUROPEAN UNION

Ana Nițu[1]*, Bilent-Marin Gürler*[2]

Abstract

This paper aims to assess the state of the European Union's food sector from a food security perspective and seeks to answer the question 'How has food security evolved in response to recent global events within the EU?'. The research objectives include identifying the current status, vulnerabilities, and external factors influencing food security. To achieve relevant findings, we will analyze statistical indicators such as the average protein availability, food deficit, variability of food production per capita, and the proportion of the underweight population. By evaluating the significance of these results and reviewing relevant literature, we will provide insights into the current living conditions in the European Union with regard to the food sector.

Key words: *food efficiency, food importance, food security evolution.*

Introduction

The concept that food production must expand by 60-70% in order to feed the world's growing population, predicted to exceed nearly 10 billion people by the year 2050, is commonly used to address issues related to food security around the world. Because there will be insufficient food to feed the increasing number of people in the world, the agri-food sector of EU will have a crucial part towards guaranteeing the availability of food by enhancing output, primarily through productivity. In an effort to benefit from the nutritional needs of an expanding global population, the agri-food sector of EU is predicted to strengthen its ability to compete in the international scene (*Food Security Challenges in an EU Context - IFOAM Organics Europe Publications*, 2021). Following the recent global events, the food crisis became substantially worse since the outbreak of COVID-19 and the Russian's invasion of Ukraine, jeopardizing the lives of millions of people. Food inflations is

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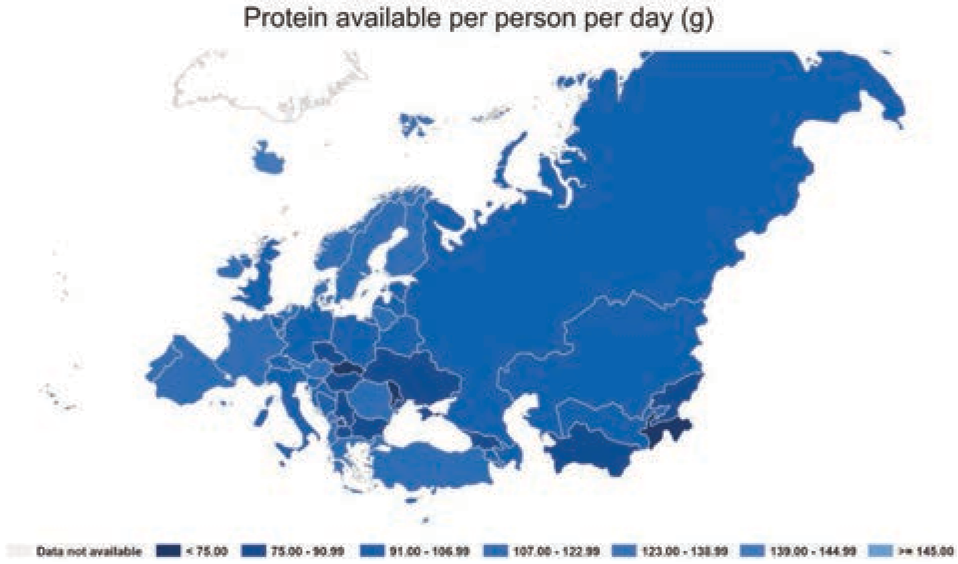
regularly high and is driven by a fluctuating environmental and geopolitical setting, regardless of some positive indicators. In order to cope with the crisis's immediate effects, the EU has committed significant funds. Nevertheless, sustainable agri-food systems will ultimately prove to be the solution to food security. (Roman, 2024).

The destabilization of food security

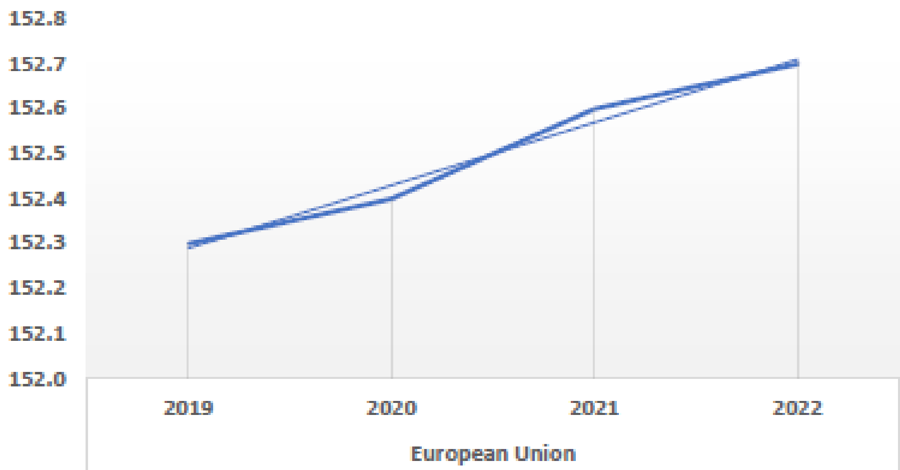
Prior to Russia's invasion of Ukraine, there had previously been a threat to the world's food security. In the second half of 2021, serious disruptions in global agri-food chains and rising costs of energy were the outcomes of the COVID-19 pandemic and the turnaround in the economy which ensued. The pricing and accessibility of fertilizers, a crucial agricultural input whose manufacture is heavily reliant on natural gas, were also impacted by the rising prices of energy, which increased inflationary pressures on consumers and food producers.

The graph shown above displays the general increase of the trend in residential gas prices in the EU from 2020 to 2024. The trend line implies long-term rises, although prices peaked in 2023 reaching a price of roughly 0,12 euros per kilowatt-hour, followed by a modestly fall in 2022. The expenses of the EU's energy switch to green power, increases in inflation, possible seasonal demand variations, followed by political concerns (such as the ongoing dispute among Russia and Ukraine) which affect availability, are undoubtedly the primary contributors of the results presented. Food security is affected by the increasing household gas prices since they raise the costs of production, transportation and fertilizer as well. Families with limited resources may find it difficult to pay for nutritious meals in addition of their already high energy costs. Moreover, expensive supply chains may restrict the availability of food, making it more challenging to find affordable food.



In the figure above, is shown the availability of protein taken from food in many countries from the European region. Many of the countries located in Western and Northern Europe, which include France, Germany and Scandinavia, have a relatively high protein availability (France – 110 g/per/day; Germany – 104 g/per/day; Norway – 116 g/per/day). Western European nations typically have higher protein levels due to advanced food supply and agricultural systems, higher incomes and easier access to a wider variety of food sources. The regions with restricted protein availability located in Central Asia and Eastern Europe are affected by financial factors, dietary variations and restricted access to high-protein foods like meat and dairy. The map highlights variations in the daily availability of protein throughout its bordering regions. The reason that Western Europe often has the highest protein availability per capita are the more robust economies, more varied diets and steady access to food high in protein.

Figure 3. *Number of people unable to afford a healthy diet(millions).*



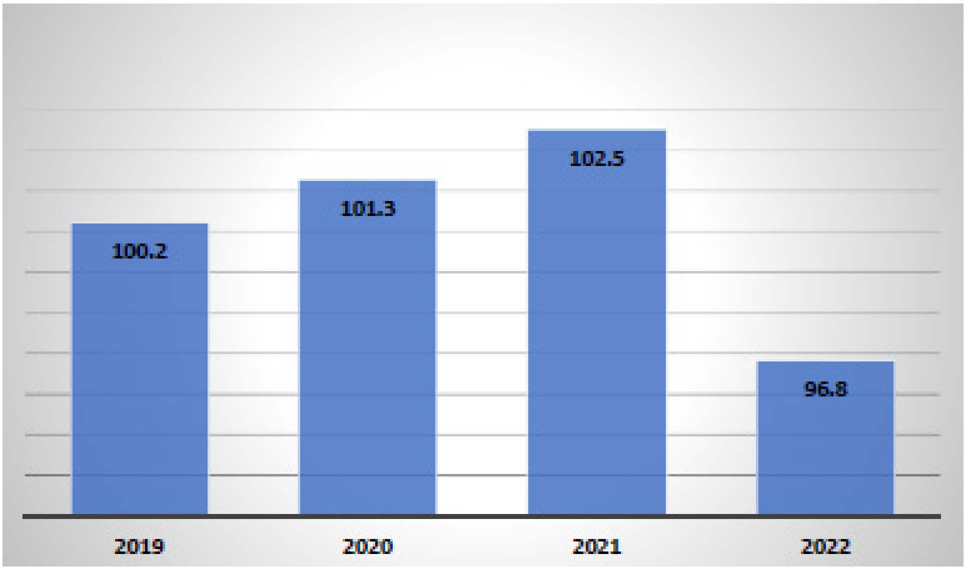
Source: *FAOSTAT*

According to the data, the number of European Union citizens who cannot afford a nutritious meal would gradually rise between 2019 and 2022. Although the rise is slight, the trend over time suggests that a significant section of the EU population is affected by a persistent problem. These figures imply that a sizeable portion of the population still finds it difficult to pay for a nutritious diet, even during periods of economic stability. Millions of people, especially those in lower income groups, do not have much better access to reasonably priced, healthful food as a result of the EU's economic expansion. The minor rises from 2019 onward may have been triggered by the COVID-19 pandemic, which started in early 2020 and undoubtedly made many people's financial and employment uncertainty worse. Rising food costs, broken supply chains and even higher living expenses during and after the pandemic made food insecurity a problem even if government aid programs assisted in some places. Food prices have risen due to growing inflation and higher utility bills throughout Europe, which may be the cause of the 0.1 increase in 2021-2022. More people may find it difficult to buy nutrient-dense meals, particularly fresh vegetables, proteins and dairy, which are often priced higher, when household budgets are strained by rising energy and living expenses. A higher risk of obesity, malnutrition and chronic illnesses (such as diabetes and heart disease) is associated with limited access to a nourishing diet. This trend has the potential to degrade public health outcomes and raise healthcare costs throughout the EU.

The effects on population

The most common problem is that those who cannot afford wholesome foods, may suffer from poor health, which can lower productivity and educational outcomes and keep people and families stuck in poverty cycles, resulting in social inequality. In order to prevent health and food insecurity problems from getting worse, governments may need to give low-income households more assistance, which could put further strain on social welfare and healthcare systems as the number of individuals who cannot afford a balanced diet rises.

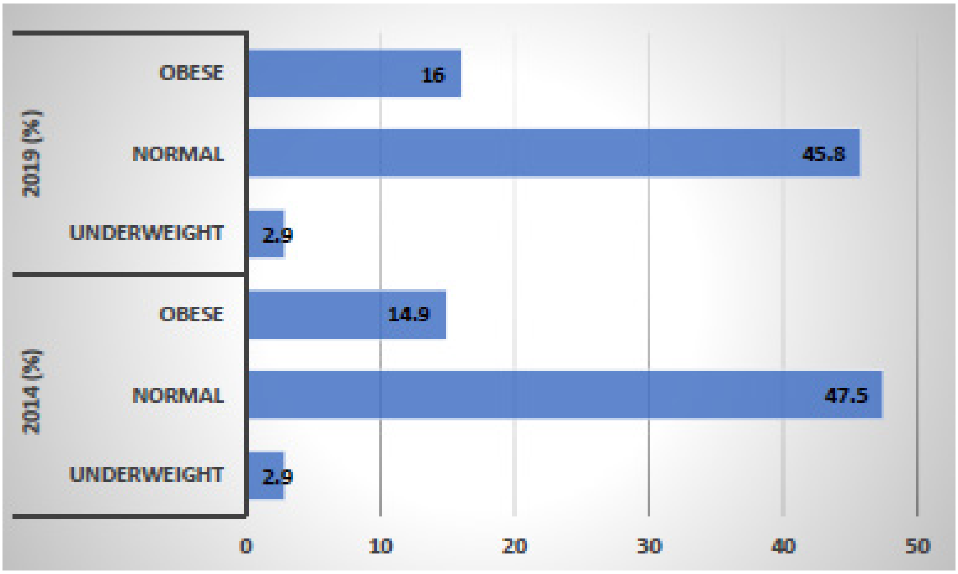
Figure 4. *Gross per capita production index number (2014-2016=100).*



Source: *FAOSTAT*

Using 2014-2016 as the baseline (indexed at 100), the graph above gives the gross per capita production index number, which is the food production for the EU, showing the proportional shifts in the food sector. The evaluation implies a consistent rise in food output per capita between 2019 and 2021 (a 2.29% increase), as a result of better agricultural conditions or increased agricultural efficiency. The score fell to 96,8 in 2022 (a drop of 5.6%), a sign that the amount of food produced per person has fallen below the baseline. The drop marked an abrupt turnaround from the prior growing pattern. As mentioned above, the main causes of 2022 disruptions are cause by the ongoing conflict in Ukraine with Russia. Given that Ukraine is a significant supplier of grains and other agricultural products, food shortages and higher prices for energy, fertilizers and EU transit could have been caused by the conflict. Droughts and heat waves in 2022 are examples of extreme weather phenomena that would have affected livestock and crop production. Issues brought on by climate change are having an increasing impact on agricultural productivity throughout Europe, decreasing the constancy of outputs from year to year. The EU may become more dependent on imports and more susceptible to changes in the world food market if the production of food declines further more. Higher food costs could result from this.

Figure 5. *Body mass index of the EU's entire population.*



Source: *EUROSTAT*

The body weight distribution in the European Union comparing 2014 to 2019, expressed as a percentage of the population is displayed in the figure 5 above. The overall number of underweight people remained constant in the 5 year-span analyzed, resulting in a 2.9% of the whole population. Given that fewer persons are categorized as having a normal weight, the 1.7% decline, from 47.5% in 2014 to 45.8% in 2019, may signal a move toward a higher or even lower weight category. Throughout these 5 years, the share of obese people rose from 14.9% to 16%. The upward trend in obesity shown by the 1.1 percentage point increase, suggests that health problems linked to higher body weight are becoming more of a worry. Increased consumption of processed and high-calorie meals along with a shift towards more sedentary lifestyles may be the cause of the decline in the normal-weight category and the rise in obesity rates. The distribution of body weight cand be affected by the availability of reasonably priced, healthful food. Financial limitations particularly for households with lower income, may result in diets that are greater in calories but fewer in nutrients which raises the obesity rate. Given that older persons are typically more likely to acquire weight and experience related health issues, the EU's aging population may be partly to blame for the region's higher obesity rates. Because obesity is linked to diabetes, cardiovascular disease and other chronic illnesses, rising obesity rates may put further strain on healthcare systems. As obesity rates rise, there is a greater need for effective public health initiatives that encourage active lives and a nutritious diet. In addition, there may be wider economic consequences for the EU as a result of decreased productivity and higher healthcare expenses. (World Health Organization, 2022)

Conclusion

Food security is a complex issue facing the European Union, fueled by social, economic, and current world problems. In addition to raising the price of oil and fertilizer, the COVID-19 epidemic and Russia's invasion of Ukraine have seriously disrupted food supply systems. Food costs have noticeably increased as a result of these factors, which has affected food affordability and put financial strain on lower-income people. Because of this, the number of people in the EU who cannot afford a balanced diet has been steadily rising, highlighting the widening gap in access to wholesome food. Since production and transportation costs have gone up due to rising energy prices in the EU, especially for high-protein foods like meat and dairy, more households are turning to less expensive, calorie-dense, but less nutrient-dense meals. The EU's obesity rate increase indicates a correlation between the dietary change and a rise in obesity, which poses a public health concern. The rise of agricultural productivity is a good sign, however, because of geopolitical difficulties and natural issues, it fell precipitously in 2022. The EU may become increasingly reliant on food imports as a result of this decline in domestic output, leaving it more susceptible to changes in international market. All things considered, the EU has challenging concerns with food security that are impacted by environmental, geopolitical and economic variables. A balanced strategy that promotes sustainable agriculture, fortifies food supply chains, and assists low-income households is needed to address these problems. Without these steps, food insecurity may rise, enhancing health risks, driving up healthcare expenses and widening social inequality across Europe.

Acknowledgments

This research was partially conducted as a result of the Erasmus+ mobility of Nițu Ana and Gürler Bulent-Marinat the Institute of Agricultural Economics, Belgrade, Serbia. The mobility took place from December 8, 2024, to December 14, 2024.

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THE LINK BETWEEN GROWTH, EMISSIONS AND CLIMATE FINANCE FOR SUSTAINABLE DEVELOPMENT: ROMANIA – SERBIA

Ana-Maria Pîrvu[1]

Abstract

The present study titled „The Link Between Growth, Emissions, and Climate Finance for Sustainable Development of Romania and Serbia" explores the interconnections between economic growth, greenhouse gas emissions, and climate finance, highlighting the importance of these relationships in sustainable development. We analyze how economic growth can influence carbon emissions and how, at the same time, investments in climate finance can contribute to reducing negative environmental impacts. The study emphasizes the need for integrated policies that promote sustainable economic development while reducing emissions and supporting the transition to a green economy. Through data analysis and case studies, solutions are proposed to encourage synergies between these critical dimensions, ultimately contributing to achieving global sustainable development goals.

Key words: *sustainable, climate finance, green economy.*

Introduction

In recent decades, concerns related to climate change and its impact on economic development have become increasingly relevant, both globally and in the specific context of Romania and Serbia. These two, as developing countries in South-Eastern Europe, face unique challenges in terms of economic growth and environmental protection.

Rapid economic growth, accompanied by accelerated urbanization, has led to a significant increase in greenhouse gas emissions, which endangers not only the health of the population but also local ecosystems (Holt, 2017). At the same time, access to climate finance becomes crucial for the implementation of innovative solutions that reduce the negative impact on the environment, support the transition to renewable energy sources and promote sustainable development.

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Climate change is one of the biggest challenges facing humanity today. These are mainly caused by greenhouse gas emissions, which are generated by human activities such as burning fossil fuels, deforestation and intensive agriculture (Alexandru.M, 2018). Greenhouse gases such as carbon dioxide, methane and nitrous oxide contribute to global warming by trapping heat in the atmosphere, leading to significant changes in climate.

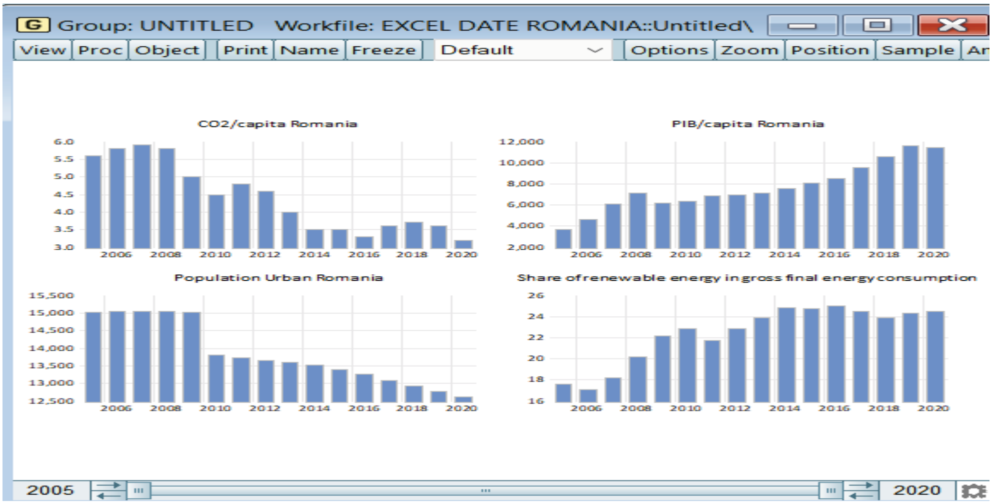
The impact of climate change is felt in Romania and Serbia, but also in the whole world manifesting itself through the increase of average temperatures, the melting of glaciers, the rise of the sea level and the intensification of extreme weather phenomena, such as storms and droughts. These effects have profound implications for ecosystems, economies and human health. For example, agriculture may be adversely affected, leading to lower food production and higher prices.

To combat climate change, it is essential to reduce greenhouse gas emissions by transitioning to renewable energy sources, improving energy efficiency and adopting sustainable practices in agriculture and industry. It is also important to promote public awareness and encourage individual and community action. Only through a global and collaborative approach can we hope to limit the impact of climate change and ensure a sustainable future for future generations.

Thus, a close link between growth, emissions and climate finance is essential. Investments in clean technologies, renewable energy and sustainable infrastructure can boost economic growth without compromising the environment. It is therefore important that development policies prioritize climate finance, so as to ensure economic growth that is aligned with the objectives of sustainability and environmental protection. This approach will help create a more equitable and climate-resilient future.

Econometric analysis of the dependent variable CO2 emissions per capita and independent variables GDP per capita, population density, renewable energy consumption, the urban population of Romania

Figure 1: *Graph regarding CO2 emissions per capita and independent variables GDP per capita, population density, renewable energy consumption and urban population in Romania*



Source: *Eviews*

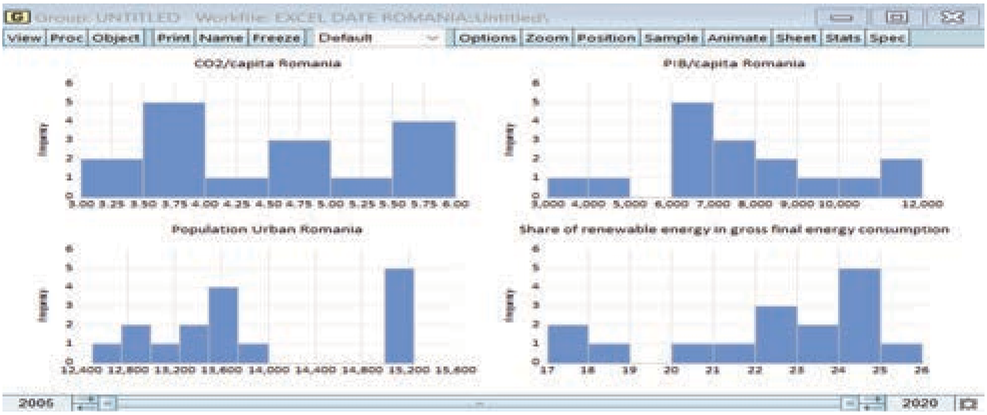
Regarding carbon emissions per capita in Romania from 2005 to 2020, a major decrease was recorded.

On the other hand, with regard to the GDP per capita in Romania during the analyzed period, a significant increase was recorded.

The urban population was constant from 2005 to 2009, then there was a continuous decrease in the number of people in the urban environment.

The consumption of renewable energy initially decreased between the years 2005-2006, and then continued to increase compared to these years.

Figure 2. *Presentation of descriptive statistics*

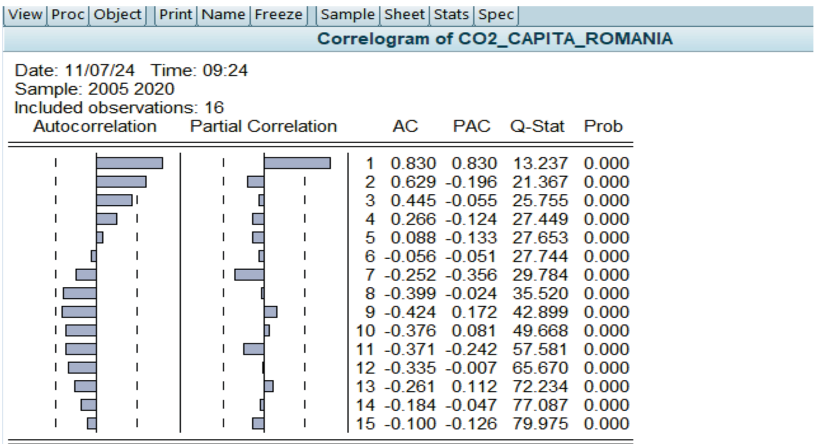


Source: *EViews*

In the figure analyzed above for carbon emissions/capita, the distribution is normal and symmetrical on both sides of the graph of the analyzed variable, and the trend is to the right: Skewness is positive.

For the graphs representing the GDP per capita, the urban population and the consumption of renewable energy from the total energy consumption at the national level, the distribution is normal and symmetrical in both sides of the graph of the analyzed variable, and the trend is to the left: Skewness is negative.

Figure 3. *Correlogram with CO2 emissions per capita and independent variables GDP per capita*



Correlogram of CO2_CAPITA_ROMANIA

Date: 11/07/24 Time: 09:24
Sample: 2005 2020
Included observations: 16

	AC	PAC	Q-Stat	Prob
1	0.830	0.830	13.237	0.000
2	0.629	-0.196	21.367	0.000
3	0.445	-0.055	25.755	0.000
4	0.266	-0.124	27.449	0.000
5	0.088	-0.133	27.653	0.000
6	-0.056	-0.051	27.744	0.000
7	-0.252	-0.356	29.784	0.000
8	-0.399	-0.024	35.520	0.000
9	-0.424	0.172	42.899	0.000
10	-0.376	0.081	49.668	0.000
11	-0.371	-0.242	57.581	0.000
12	-0.335	-0.007	65.670	0.000
13	-0.261	0.112	72.234	0.000
14	-0.184	-0.047	77.087	0.000
15	-0.100	-0.126	79.975	0.000

Source: *Eviews*

The correlogram indicates the trend and seasonality of the data evolution. For the correlogram made for the data sets, we have recorded seasonality because it does not fall within the limits imposed by the dotted lines.

In addition, the autocorrelation against 15 lags is indicated, i.e. the time period analyzed (the number of years analyzed).

Figure 4. *Granger Causality Test*

View Proc Object Print Name Freeze Sample Sheet Stats Spec

Pairwise Granger Causality Tests
Date: 11/04/24 Time: 20:50
Sample: 2005 2020
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
PIB_CAPITA_ROMANIA does not Granger Cause CO2_CAPITA_ROMANIA	14	2.41697	0.1445
CO2_CAPITA_ROMANIA does not Granger Cause PIB_CAPITA_ROMANIA		2.04218	0.1857
POPULATION_URBAN_ROMANIA does not Granger Cause CO2_CAPITA_ROMANIA	14	6.07465	0.0214
CO2_CAPITA_ROMANIA does not Granger Cause POPULATION_URBAN_ROMANIA		2.83043	0.1113
SHARE_OF_RENEWABLE_ENERGY_IN_GROSS_FINAL_ENERGY_CONSUMPTION does not Granger Cause CO2_CAPITA_ROMANIA	14	3.23771	0.0872
CO2_CAPITA_ROMANIA does not Granger Cause SHARE_OF_RENEWABLE_ENERGY_IN_GROSS_FINAL_ENERGY_CONSUMPTION		1.33887	0.3097
POPULATION_URBAN_ROMANIA does not Granger Cause PIB_CAPITA_ROMANIA	14	0.93138	0.4289
PIB_CAPITA_ROMANIA does not Granger Cause POPULATION_URBAN_ROMANIA		23.0336	0.0003
SHARE_OF_RENEWABLE_ENERGY_IN_GROSS_FINAL_ENERGY_CONSUMPTION does not Granger Cause PIB_CAPITA_ROMANIA	14	1.97229	0.1948
PIB_CAPITA_ROMANIA does not Granger Cause SHARE_OF_RENEWABLE_ENERGY_IN_GROSS_FINAL_ENERGY_CONSUMPTION		0.42523	0.6661
SHARE_OF_RENEWABLE_ENERGY_IN_GROSS_FINAL_ENERGY_CONSUMPTION does not Granger Cause POPULATION_URBAN_ROMANIA	14	3.31852	0.0833
POPULATION_URBAN_ROMANIA does not Granger Cause SHARE_OF_RENEWABLE_ENERGY_IN_GROSS_FINAL_ENERGY_CONSUMPTION		7.00136	0.0147

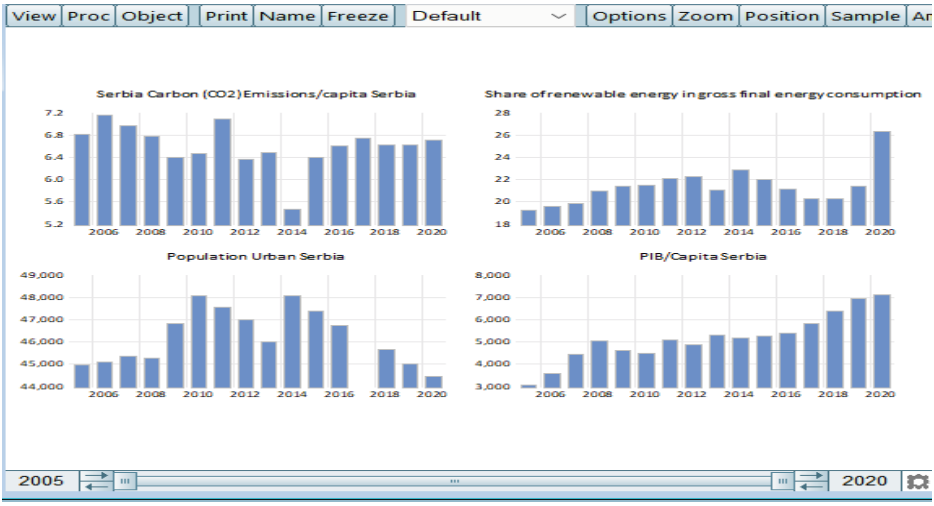
Source*: EViews*

The causality test refers to the establishment of the endogenous (dependent) variable and the exogenous (independent) variable, referring to the probability of the F-statistic. In theory, the probability of the F-statistic must be lower than 0.05 to demonstrate the exogenous character and, respectively, the relationship of dependence between the two realized variables.

In the present case, we note that the probability related to the F-statistic test is in both cases greater than 0.05, which proves that the change in the number of gas emissions generated does not influence the change in GDP and other independent variables.

Econometric analysis of the dependent variable CO2 emissions per capita and independent variables GDP per capita, population density, renewable energy consumption, urban population of Serbia

Figure 5. *Chart on CO2 emissions per capita and independent variables GDP per capita, population density, renewable energy consumption and urban population in Serbia*



Source: *Eviews*

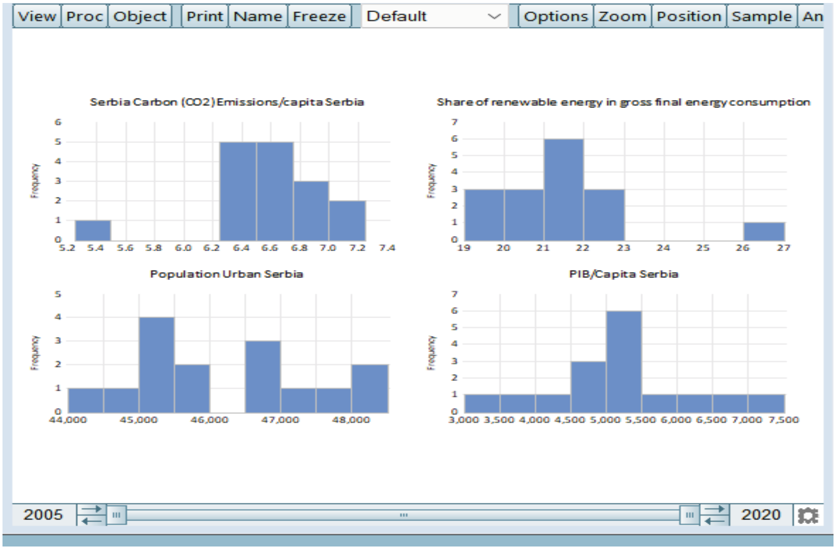
In terms of carbon emissions per capita in Serbia from 2005 to 2020 there were both major decreases and increases. The year with the lowest carbon emissions was 2014.

Also, regarding the GDP per capita in Serbia during the analyzed period, a significant increase was recorded in 2020 compared to the rest of the analyzed years.

The urban population was constant from 2005 to 2020, it had various fluctuations, however, a decrease was recorded in 2020.

The consumption of renewable energy during the analysis period increased significantly every year.

Figure 6. *Presentation of descriptive statistics*

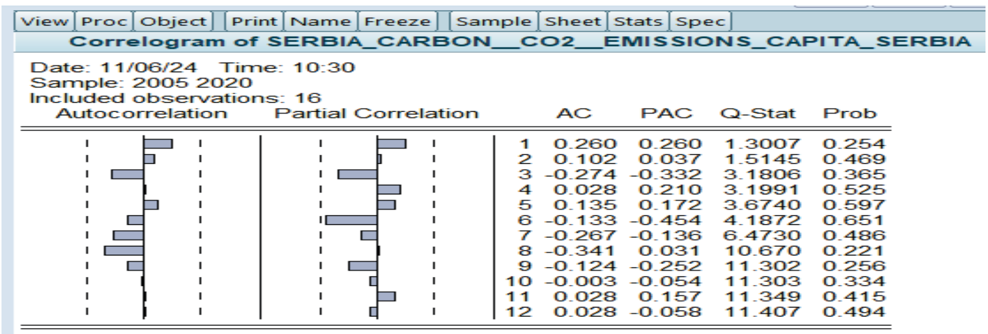


Source: *EViews*

In the figure analyzed above for carbon emissions/capita, the distribution is normal and symmetrical on both sides of the graph of the analyzed variable, and the trend is to the left: Skewness is negative.

For the graphs representing the GDP per capita, the urban population and the consumption of renewable energy from the total energy consumption at the national level, the distribution is normal and symmetrical in both sides of the graph of the analyzed variable, and the trend is to the left: Skewness is negative.

Figure 7. *Correlogram with CO2 emissions per capita and independent variables GDP per capita*



Source*: EViews*

The correlogram indicates the trend and seasonality of the data evolution. For the correlogram made for the data sets, we do not have recorded seasonality because it falls within the limits imposed by the dotted lines.

In addition, the autocorrelation against 15 lags is indicated, i.e. the time period analyzed (the number of years analyzed)

Figure 8. *Granger Causality Test*

View Proc Object Print Name Freeze Sample Sheet Stats Spec

Pairwise Granger Causality Tests
Date: 11/07/24 Time: 08:32
Sample: 2005 2020
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
SHARE_OF_RENEWABLE_ENERGY_IN_GROSS_FINAL_ENERGY_CONSUMPTION does not Granger Cause SERBIA_CARBON__CO2__EMISSIONS_CAPITA_SERBIA	14	0.95246	0.4215
SERBIA_CARBON__CO2__EMISSIONS_CAPITA_SERBIA does not Granger Cause SHARE_OF_RENEWABLE_ENERGY_IN_GROSS_FINAL_ENERGY_CONSUMPTION		0.20268	0.8202
POPULATION_URBAN_SERBIA does not Granger Cause SERBIA_CARBON__CO2__EMISSIONS_CAPITA_SERBIA	11	1.31405	0.3363
SERBIA_CARBON__CO2__EMISSIONS_CAPITA_SERBIA does not Granger Cause POPULATION_URBAN_SERBIA		0.05851	0.9437
PIB_CAPITA_SERBIA does not Granger Cause SERBIA_CARBON__CO2__EMISSIONS_CAPITA_SERBIA	14	0.30809	0.7423
SERBIA_CARBON__CO2__EMISSIONS_CAPITA_SERBIA does not Granger Cause PIB_CAPITA_SERBIA		0.11785	0.8902
POPULATION_URBAN_SERBIA does not Granger Cause SHARE_OF_RENEWABLE_ENERGY_IN_GROSS_FINAL_ENERGY_CONSUMPTION	11	1.30934	0.3374
SHARE_OF_RENEWABLE_ENERGY_IN_GROSS_FINAL_ENERGY_CONSUMPTION does not Granger Cause POPULATION_URBAN_SERBIA		1.37124	0.3233
PIB_CAPITA_SERBIA does not Granger Cause SHARE_OF_RENEWABLE_ENERGY_IN_GROSS_FINAL_ENERGY_CONSUMPTION	14	3.28313	0.0850
SHARE_OF_RENEWABLE_ENERGY_IN_GROSS_FINAL_ENERGY_CONSUMPTION does not Granger Cause PIB_CAPITA_SERBIA		2.18229	0.1688
PIB_CAPITA_SERBIA does not Granger Cause POPULATION_URBAN_SERBIA	11	0.16096	0.8549
POPULATION_URBAN_SERBIA does not Granger Cause PIB_CAPITA_SERBIA		0.07675	0.9270

Source: *EViews*

The causality test refers to the establishment of the endogenous (dependent) variable and the exogenous (independent) variable, referring to the probability of the F-statistic. In theory, the probability of the F-statistic must be lower than 0.05 to demonstrate the exogenous character and, respectively, the dependence relationship between the two realized variables.

In the present case, we note that the probability related to the F-statistic test is in both cases greater than 0.05, which proves that the change in the number of gas emissions generated does not influence the change in GDP and other independent variables.

Conclusion

The research conclusion emphasizes that an integrated approach to environmental issues, which includes technological innovation, public education and community involvement, is essential to meet the challenges of climate change. It is important that all stakeholders work together to promote sustainable practices and reduce greenhouse gas emissions. Only through concerted action can we ensure a sustainable and healthy future for future generations.

The analysis of greenhouse gas emissions in relation to GDP/inhabitant, urban population and renewable energy consumption from total energy consumption in Romania and Serbia highlights the significant differences in the two countries' approaches to environmental management and resource allocation. Romania, with a better defined legislative framework and a deeper integration of environmental policies in the national strategy, has demonstrated a tendency to increase investments in ecological projects. On the other hand, Serbia, although in a process of alignment with European standards, still faces challenges in mobilizing the financial resources necessary for the effective implementation of environmental policies. This comparison underlines the importance of a coherent and sustainable strategy in the management of environmental expenditures, which contributes not only to the protection of the environment, but also to the sustainable economic development of both countries.

After analyzing the statistical data, we created a four-variable econometric model, after being able to draw the conclusions related to the statistical data. Following the analysis of environmental expenses in the 2 countries from 2008 to 2017, respectively 2022, we found that the analyzed model is a valid one that can be applied in reality. We made this conclusion following the analysis of the Granger Causality test where the statistical probability F closest to 0.05 is the gas emissions reported to the urban population.

Following the analysis of the data and specialist works, we have come to the conclusion that both Romania and Serbia have made progress from a sustainable point of view in the analyzed period and have the potential to achieve climate neutrality if they impose policies and pay attention to the financing of environmental problems.

Acknowledgments

This research was partially conducted as a result of the Erasmus+ mobility of Pîrvu Ana-Maria at the Institute of Agricultural Economics, Belgrade, Serbia. The mobility took place from December 8, 2024, to December 14, 2024.

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AN OVERVIEW OF AGRIBUSINESS IN ROMANIA

Andreea Antonescu[1], Felicia-Maria Potcovaru[2], Saian Nasri-Nahar[3]

Abstract

This investigation analyzes the agricultural industry in Romania, focusing on the major players, technological advances, obstacles and sustainability. It highlights that the most important crops and actors in Romanian agriculture are small-scale farming and cereal production. There are discussions on how recent advances in agricultural technology such as automation, precision farming and digital tools could improve efficiency. In addition, issues facing Romanian agribusiness are at the center of the study, such as lack of infrastructure and limited access to capital. At the same time, it highlights opportunities for organic farming and export.

The environmental impact of agriculture is examined, with an emphasis on sustainability efforts and the adoption of greener practices. Government incentives and programs that help the sector are examined, noting both the benefits and drawbacks of policy implementation. Investments in infrastructure and innovation are essential to remain competitive, according to the outlook for Romanian agribusiness. Finally, the study focuses on long-term environmental sustainability issues and aims to align with the EU's environmental objectives. The study found that although Romania faces many challenges, it has many opportunities to grow, innovate and make progress in the environmental field.

Key words: *agriculture, data, technology, investment, growth, sustainability.*

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Introduction

Agriculture is one of the most valuable sectors of the Romanian economy, with 393131350 economic units (2007). Covering only one fifth of the total land area of the country, the utilized agricultural area is 9498 million hectares. In Romania there is a very high need in this sector in terms of labor force, so that 965 500 annual work units represent 965 500 people employed full time.

The agricultural branch in Romania uses a major percentage of labor force, 28.7%, in comparison with European countries, where the percentage is 5.7%, representing 6% of the country's gross domestic product.

The representative products of Romanian agriculture are potatoes, wheat, wine and livestock products. We can emphasize the zootechnics branch, which brings an added value to the agricultural sector, considering that more than 45% is due to the production of milk and pork.

Key players and crops of the Romanian agricultural industry

Ranging from multinational corporations to small-scale family farms, there are a multitude of players in the Romanian agribusiness sector. Some of the most important players in the industry include: - Global companies: Romanian farmers receive seeds, fertilizers and protection products from major multinational companies such as Bayer, Syngenta and Corteva Agriscience. "These global agribusiness giants have leveraged their technological expertise and financial resources to become major players in the Romanian agricultural landscape," said the European Commission in 2020.

- Romanian-based companies, such as Agricover, Holde Agri Invest and Transavia, have established themselves as significant players in the agribusiness industry, which includes operations such as food processing, livestock and crop production. "These national conglomerates have been able to leverage their local knowledge and market relationships to compete effectively with multinational firms," says a study in the Journal of Eastern European Economics in 2021.

- Small-scale producers: In addition to the big players, there are a growing number of small family farms that specialize in growing certain types of fruits and vegetables. According to a 2019 report, the Food and Agriculture Organization noted that "these small-scale producers play a vital role in maintaining the diversity and resilience of Romania's agricultural sector."

Industrial crops, cereals and oilseeds are the main agricultural crops in Romania. The top three crops contributing to the country's agricultural production are wheat, corn and sunflowers. Rapeseed, barley and a variety of fruits and vegetables are other important crops.

Advances in agricultural technology and precision

In recent years, the agribusiness sector in Romania has witnessed a rapid adoption of technology in farmers' and producers' efforts to improve productivity, sustainability and efficiency. Precision farming techniques, using technologies such as GPS, remote sensing and data analytics, have gained ground, enabling farmers to optimize inputs and improve crop yields.

Precision mapping: farmers can use technologies such as drones and GPS to create detailed maps of their fields to see changes in soil composition, moisture levels and other information that helps them make planting and management decisions. "Precision mapping allows Romanian farmers to tailor their inputs and practices to the specific needs of their fields, leading to improved yields and reduced environmental impact," says a 2020 report in Precision Agriculture magazine.

Because it allows targeted application of fertilizers, pesticides and other inputs, variable-rate precision farming reduces waste and reduces environmental impact. According to a 2021 report by the Romanian Academy of Agricultural and Forestry Sciences, "Romanian farmers have been able to optimize input use by adopting variable-rate application technologies, leading to significant cost savings and environmental benefits."

Data Analysis: The use of machine learning algorithms and advanced data analytics is required to process large volumes of agricultural data. This helps farmers make better decisions and maximize profits. A 2019 study published in the International Journal of Agricultural Sustainability says, "The integration of data-driven technologies has enabled Romanian farmers to improve their decision-making, leading to improved productivity, profitability and sustainability."

In addition, precise animal management technologies, automated machinery and intelligent irrigation systems have increased the capabilities of Romanian agro-industries. As a result, efficiency, resource use and product quality have increased.

Challenges and Opportunities in Romanian Agribusiness

Challenges and opportunities in the Romanian agricultural sector: the future development of the sector will be determined by a number of challenges and opportunities. According to a 2020 European Commission report, which highlighted that "the prevalence of small and fragmented farms in Romania is a significant obstacle to the modernization and competitiveness of the sector" (1), addressing fragmentation of land ownership is among the most critical issues. Encouraging the adoption of more environmentally friendly farming practices and consolidating land ownership could address this issue.

The need to improve the sector's infrastructure, which includes processing capacity, storage and transportation networks, is another concern. According to a study published in the Journal of Rural Studies in 2021, "Inadequate infrastructure has prevented Romanian agribusinesses from effectively connecting to domestic and international markets, limiting their growth potential" [2]. Investments in these sectors could help open up all possibilities in the industry.

Despite these difficulties, the Romanian agro-industrial sector also offers a number of significant opportunities. The country's favorable climate, fertile soils and growing population offer great opportunities to increase agricultural and livestock production. In addition, increasing domestic and global demand for healthy and sustainable food products could offer Romanian producers a lucrative opportunity. A study published in 2019 in the Journal of Cleaner Production stated that "growing consumer interest in organic and locally sourced agricultural products represents a promising way for Romanian agribusinesses to differentiate themselves and gain new market shares".

Environmental impact and sustainability

Sustainability and environmental protection are priorities in the agro-industrial industry in Romania. The industry is increasingly focused on adopting greener practices and mitigating its environmental impacts as it grows.

Precision Agriculture: The use of precision technologies in agriculture, such as the application of variable-rate inputs and precision mapping, has helped farmers in Romania to optimize resource use and reduce environmental impact. A report in the Journal of Sustainable Agriculture in 2020 stated that "precision agriculture has represented a sea change for Romanian agriculture, allowing farmers to increase their productivity while minimizing environmental impact".

Organic and sustainable production: Increased consumer awareness and preferences have led to greater demand for organic and sustainable agricultural products in Romania. According to a 2021 report by Romania's Ministry of Agriculture, "Romania's organic farming sector has seen significant growth in recent years as producers strive to meet growing consumer demand for organic food products".

Waste management and the circular economy: agri-food companies in Romania are striving to reduce waste, recycle by-products and follow the circular economy. A study published in the Journal of Cleaner Production in 2019 found that "innovative waste management practices and the integration of circular economy models have the potential to enhance sustainability and resource use efficiency in the Romanian agribusiness sector".

In the Romanian agri-food sector, the integration of sustainable practices and technologies is essential to ensure long-term viability and environmental protection.

Government Incentives and Programs

To support the growth and development of the country's agri-food sector, the Romanian government has implemented a number of policies and incentives. The programs aim to promote sustainable practices and increase the sector's competitiveness.

European Union funding and financing: as a member of the European Union, Romania has access to the Common Agricultural Policy (CAP) and the European Agricultural Fund for Rural Development (EAFRD). Investments in infrastructure, modernization and sustainability initiatives in the Romanian agro-industrial sector have been largely stimulated by these funding sources. A European Commission report in 2020 stated that "EU-level funding and support programs have played a crucial role in catalyzing the transformation and modernization of the Romanian agri-food industry".

Financing and tax benefits: The Romanian government stimulates investment and innovation in the agro-industrial sector through tax incentives such as reduced tax rates, investment tax credits and low-interest loans. These incentives primarily target agricultural and agribusiness enterprises that adopt sustainable practices or implement technological upgrades. Apparently, "the availability of government-backed financing and tax incentives has been a significant driver of the adoption of precision agriculture and other innovative technologies within the Romanian agribusiness sector," according to a study in the Journal of Agricultural Economics in 2021.

In addition, the government has invested in research and development programs aimed at increasing agricultural productivity, improving animal and crop resilience and developing new technologies for the agro-industrial sector. Romanian agriculture has received innovative solutions such as precision farming and smart irrigation as a result of these programs. According to a study published in 2019 in the International Journal of Agricultural Innovation, "The government's commitment to funding agricultural research and development has been instrumental in fostering a culture of innovation and technological progress within the Romanian agribusiness industry."

The Romanian agri-food industry is poised to continue to grow and develop in the coming years. The growth is fueled by government initiatives, the industry's natural strengths and the increasing focus on sustainability. 1. European Commission, 2019. EU publications on the impact of EU funding on Romanian agriculture.

Outlook and Future Prospects for Romanian Agribusiness

As a number of factors converge to stimulate the continued growth and evolution of the Romanian agro-industrial industry, it looks to have a promising future. A solid foundation for long-term success is provided by the sector's inherent strengths, such as skilled labor, a favorable climate and fertile soils.

Technological advances: The continued adoption of precision agriculture, smart technologies and data-driven decision-making tools will increase the productivity, efficiency and sustainability of the Romanian agribusiness sector. "The integration of advanced technologies will be a key driver of innovation and competitiveness in Romania's agribusiness industry," according to a study published in 2021 in the International Journal of Agricultural and Biological Engineering.

Due to changing consumer preferences and growing demand for organic, locally sourced and organic agricultural products, both nationally and globally, there is a promising market opportunity for Romanian agribusinesses. In

2020, the Romanian Ministry of Agriculture stated that “the growing consumer interest in organic and sustainable food products represents a valuable niche that Romanian producers can capitalize on to differentiate themselves and gain new market shares”.

Export potential is growing. Romania’s agribusiness industry is poised to take advantage of growing export opportunities on international markets and in the EU. According to a study in the Journal of Agricultural Policy in 2021, “improving the quality, consistency and traceability of Romanian agricultural exports has positioned the country’s agribusiness sector for greater integration into global supply chains”.

Government-backed policies: The Romanian government’s agreement to support the agro-industrial sector through funding, incentives and policy initiatives should continue to stimulate the sector’s growth and development. “The government’s proactive approach to promote innovation, sustainability and competitiveness within the Romanian agro-industrial sector has been a key factor in its recent successes and future potential,” says a 2020 European Commission report.

By leveraging these favorable trends and addressing the sector’s remaining challenges, the Romanian agribusiness industry is well-positioned to solidify its role as a crucial driver of the country’s economic prosperity and food security in the years to come.

Environmental influence and sustainability

The agro-industrial sector in Romania is paying increasing attention to sustainability and environmental protection. The industry is increasingly focused on adopting greener practices and mitigating its environmental impacts as it grows.

Organic Farming: In response to increased demand for organic and sustainable food, the adoption of organic farming techniques that avoid the use of pesticides and artificial fertilizers is on the rise. A 2021 report by the Romanian Ministry of Agriculture says: “The organic farming sector in Romania has seen significant growth in recent years as producers try to meet growing consumer demand for organic food products.”

Renewable energy: To power their operations and reduce their carbon footprint, agribusinesses are increasingly investing in renewable energy sources such as solar and wind power. A 2020 study in the Journal of Renewable Energy stated that “agribusinesses in Romania have been able to significantly reduce greenhouse gas emissions and energy costs by integrating on-site renewable energy generation.”

Water conservation: appropriate irrigation systems and water recycling initiatives are implemented to improve water use and reduce damage to local water resources. According to a 2021 report by the Romanian Academy of Agricultural and Forestry Sciences, Romanian farmers have been able to reduce water consumption by up to 30% by implementing smart irrigation technologies and water recycling techniques. This has helped manage water resources in the long term.

Waste management: Agricultural waste is recycled to produce biofuels, animal feed and raw materials for other industries in an effort to promote the circular economy. “The integration of circular economy principles has the potential to increase sustainability and resource use efficiency in the Romanian agro-industrial sector by reducing waste and creating new sources of income,” says a 2019 Journal of Cleaner Production study.

These sustainable practices help the Romanian agro-industrial sector to remain viable and competitive in the long term, as markets and consumers increasingly seek organic products and production methods. 1. Romanian Ministry of Agriculture.

Employment in the agricultural system: Romania versus the European Union

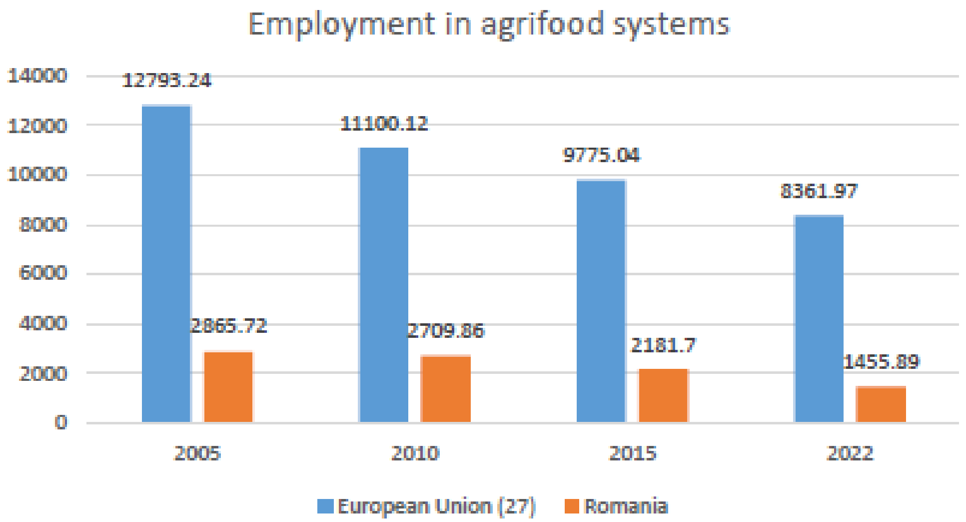
The majority of primary agricultural employees in Romania work on subsistence and small farms. Food distribution and the food industry are improving, but are less developed than other EU countries (FAO, 2020). Romania has a large number of informal jobs, leading to low social protection for workers (Eurostat, 2021).

In the European Union, jobs in the agri-food sector are much more diversified. In countries like France, Germany and the Netherlands, the agricultural sector has been partly replaced by distribution and processing. The automation and mechanization of agriculture has reduced the number of workers in primary production, while jobs in logistics, processing and agricultural technology are growing. In addition, sectors such as precision farming and food innovation are attracting more young people (European Commission, 2022).

In terms of the concentration of jobs in agriculture, there is a big difference between Romania and the European Union. Despite the fact that the EU controls and industrializes agriculture, Romania's economic structure is based on subsistence farming. In addition, jobs in processing and distribution have increased as a result of automation and the transition to sustainable practices in the EU, while these sectors are still developing in Romania.

Employment in agrifood systems

	2005	2010	2015	2022	2022/2005
European Union (27)	12793.24	11100.12	9775.04	8361.97	65.36241
Romania	2865.72	2709.86	2181.7	1455.89	50.80364
Gap	22.40027	24.41289	22.31909	17.41085	77.72608



The number of people employed in agri-food systems in the EU has continued to decline from 12,793.24 thousand in 2005 to 8,361.97 thousand in 2022.

This decrease demonstrates that the role of the agri-food industry in the EU economy has declined as it has transformed into more sophisticated and sophisticated sectors.

Between 2005 and 2022, there has been a decrease of about 65.36%, which shows a significant decrease in the labor force in this sector.

In addition, there is a decrease in the labor force in the agribusiness industry in Romania from 2,865.72 thousand in 2005 to 1,455.89 thousand in 2022.

Although this is a significant decrease, it is lower than the EU average of 50.8%. This shows that the agri-food industry in Romania is more dependent than other EU countries.

The reduction is significant but not steep, which could indicate a gradual modernization of the sector in Romania.

The gap between Romania and the EU has decreased from about 22.4% in 2005 to 17.4% in 2022.

Despite the fact that there is still a significant gap between the number of people working in the agri-food sector and the number of people working in the agri-food sector, the gap has narrowed, which could indicate a closer alignment of the Romanian economy with the EU economic structure and a greater diversification.

Conclusion

The study examines the agricultural industry in Romania, highlighting drivers, innovative technologies, challenges, opportunities and future prospects. The agricultural sector in Romania plays an important role in the domestic production of cereals and vegetables, but still relies on traditional methods and limited natural resources. Technological advances and precision applications have brought changes in this sector, but the widespread use of new technologies requires investment in digitization and workforce training.

Romania's agribusiness industry faces challenges such as inadequate infrastructure, limited access to capital and lack of coherent policy to improve efficiency, but the domestic market and global demand for premium food can boost the sector. Intensive agriculture can have a negative impact on the environment and sustainability, so it is essential to adopt sustainable farming methods to maintain an ecological balance.

Government and incentive programs contribute to the development of the sector, but policy implementation is still an obstacle. In conclusion, Romania has significant potential to become an important agri-food center in the future.

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ANALYSIS OF CRISIS SITUATIONS IN THE AGRI-FOOD SECTOR CASE STUDY – THE COVID-19 PANDEMIC

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Abstract

The following study analyzes the impact of the Covid-19 pandemic on the agri-food sector, a crucial domain for economic stability and public well-being. The goal is to understand how the pandemic has influenced food supply, consumption, and production, addressing both economic and social perspectives. The study is structured into three chapters: the first reviews theoretical concepts related to economic and agri-food crises; the second analyzes the pandemic's impact on demand, supply, foreign trade, and consumer price indices; and the third presents a case study based on statistical data, evaluating public perception of the crisis through a questionnaire. The results will provide a comprehensive perspective on the dynamics of the agri-food market in the context of the pandemic and the challenges faced by producers and retailers.

Key words: *Agri-food crises, COVID-19 pandemic, Case study.*

Introduction

The behavior of food purchasing and consumption represents the entirety of decisions made at an individual or group level regarding the purchase and consumption of agri-food products to satisfy current, as well as future, needs. This includes prior decisions as well as purchase/consumption decisions for product categories .

The main objective of the paper will be to analyze the current state of knowledge regarding specialized terms. This will be followed by an analysis of the impact of the pandemic on the dynamics of the agri-food products market, which will be substantiated through a case study aimed at investigating the population's perception of the crisis.

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In the field of agri-food products, whether they are intended for industrial consumption or sold directly to the public, the nature of the market for these products imposes certain specific marketing characteristics. In the structure of agriculture and food, agriculture is the primary supplier of agricultural products, food (eggs, milk, vegetables, fruits), and raw materials for processing into food.

The study will be structured around three chapters, each encompassing specific approaches to the analyzed topic. The first chapter will review key concepts from the specialized literature, providing theoretical perspectives on the crises addressed.

The second chapter aims to analyze the key elements of the economy, examining the direct impact of the Covid-19 pandemic on product demand and supply, as well as on foreign trade and consumer price indices. The influence of the pandemic period on the dynamics of the food market will be highlighted, revealing the main risks and challenges faced by producers and retailers.

The third chapter will be written based on the evaluation of a case study, which will outline the effects of the pandemic on the food sector.

In Romania, the development of a modern agri-food system will lead to a fairly high level of food self-sufficiency and the creation of competitive production structures, thus promoting exports and connecting them to the global market. The market is an economic category that produces goods in which all acts of buying and selling are expressed, considered as an organic unit with the relationships it creates and in relation to its space of performance.

Crises are multifaceted events that can affect entire societies or specific sectors such as the economy, politics, or international relations. They typically arise from the interaction of various factors and can result in a broad range of consequences. Often interconnected, crises in one area can impact other sectors. For instance, an economic crisis can alter the social structure and business environment, influencing the overall dynamics of society.

Crisis situations in the food sector can vary and involve a range of factors that affect production, distribution, and access to food (Duțu P, 2013).

The inflationary crisis in the food sector refers to a significant and persistent increase in food prices, which has notable consequences for the population's access to and security of food (Benedek J, 2016).

The overproduction crisis occurs when the excessive supply of goods or services significantly exceeds market demand, leading to a decrease in prices and adversely affecting producers and the economy as a whole (Kettell S, 2006).

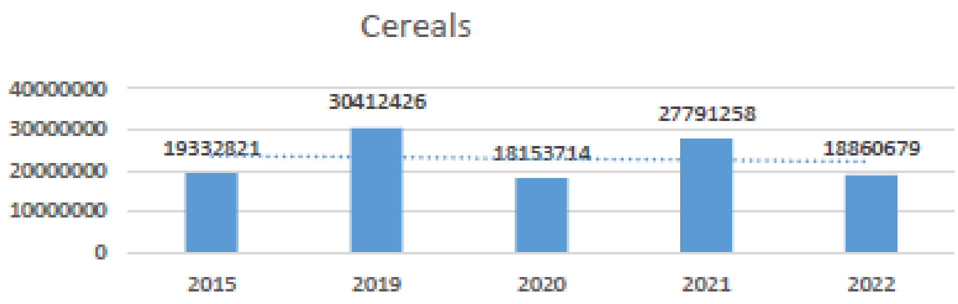
A crisis based on a lack of production arises when the quantity of goods and services produced is insufficient to meet existing market demand. This issue can have a significant impact on producers, consumers, and the economy as a whole (UCB din Tg-Jiu, 2017).

One of the most significant crisis situations in recent years is the pandemic crisis known as Covid-19, which has had devastating consequences for the global economy. Temporary suspensions of business activities, travel restrictions, and decreased demand have caused substantial losses in various sectors. To mitigate the economic impact, governments and organizations have implemented various support measures, such as unemployment benefits and loan facilities for businesses (Neacșu M, David DE, 2023).

The Covid-19 pandemic also adversely affected the food sector. Major disruptions in the supply chain forced food producers and distributors to adapt to challenging conditions regarding transportation and distribution. A decrease in demand, particularly in the restaurant and café sectors, created extensive financial pressures throughout the food production chain, testing both agricultural agents and food processors. Meanwhile, travel restrictions and social distancing measures generated labor shortages in the agricultural sector and processing units, impacting the quality of food products (Siminiuc R, Țurcanu D, 2020).

Agri-food products represent a fundamental pillar of the global economy, as they are essential in meeting the food needs of the world's population, which is constantly growing.

Graph 1. *Total Cereals Production*

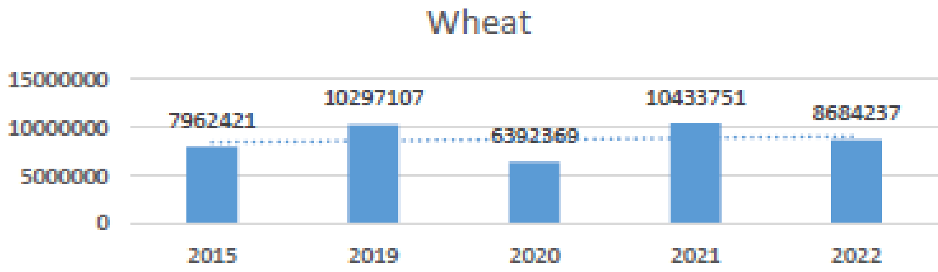


Source: Own processing

The graph presents data on total grain production. From the analysis, it is evident that values fluctuated between 2015 and 2022. Notably, the graph shows that the peak was recorded in 2019, with grain production reaching its highest point, approximately thirty million tons.

Additionally, it indicates a sharp decline in production in 2020, primarily due to the Covid-19 pandemic, which had a negative impact, causing disruptions in the supply chain and labor force.

Graph 2. *Total Wheat Production*

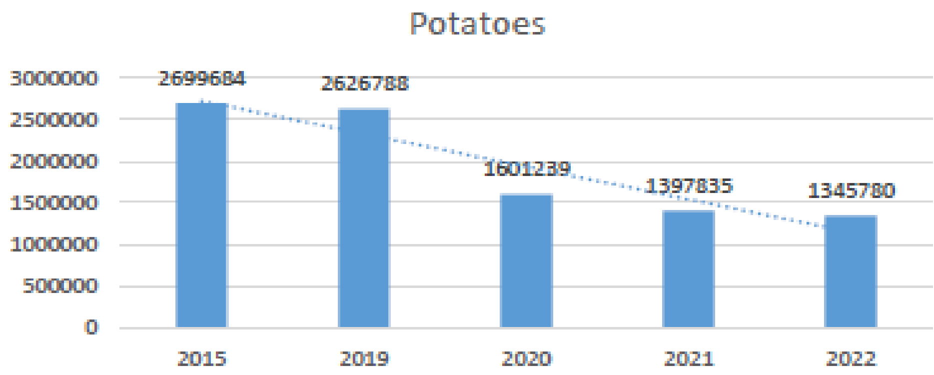


Source: Own processing

This graph illustrates total wheat production between 2015 and 2022. Analyzing the values, it can be observed that the indicator follows an upward trend from 2015 to 2019. However, 2020 shows a sharp decline of approximately 4 million tons, representing a 38% decrease compared to the previous year.

In 2021, the indicator recovers, as there is a significant increase compared to 2020, with wheat production reaching a peak and showing a growth rate of approximately 64%.

Graph 3. *Total Potatoes Production*



Source: Own processing

The graph represents the recorded values of total potato production from 2015 to 2022. It shows that the analyzed indicator follows a predominantly downward trend, with a significant decline in production starting in 2019.

Compared to 2019, 2020 saw a sharp decrease of approximately 40%, and this decline continued in the following years, with production reaching a low of 1,345,780 tons in 2022.

Tabel 1. *Trade Balance of Agri-food Products in Romania*

Trade Balance	Year 2018	Year 2019	Year 2020	Year 2021	Year 2022
Meat	-556980	-702655	-715303	-737774	-980759
Milk	-302658	-376998	-441783	-527577	-720902
Vegetables	-326988	-421535	-391085	-423299	-474788
Edible Fruits	-572992	-592116	-625475	-667014	-729721
Cereals	1851060	2187797	1466254	2948066	3337622

Source: Own processing

From the data presented above, it can be observed that the only product that recorded a surplus balance throughout the analyzed period was the category of „cereals." Over the five years, there was a fluctuating evolution in trade, with annual values oscillating and the impact of the pandemic being evident. From the beginning of this period, exports drastically decreased due to possible dysfunctions in supply chains and reduced demand. Contrary to expectations, values showed a recovery in the following years, indicating a strong market rebound.

Conversely, the product with the largest deficit was meat, which had a value of -980,759 euros in 2022. An annual increase in the deficit suggests Romania's dependency on imports from other countries, primarily from the United Kingdom, Italy, and France. Regarding 2020, the Covid-19 pandemic significantly impacted this category of products, leading to decreased demand and supply, which resulted in substantial price increases and significant declines in domestic meat production.

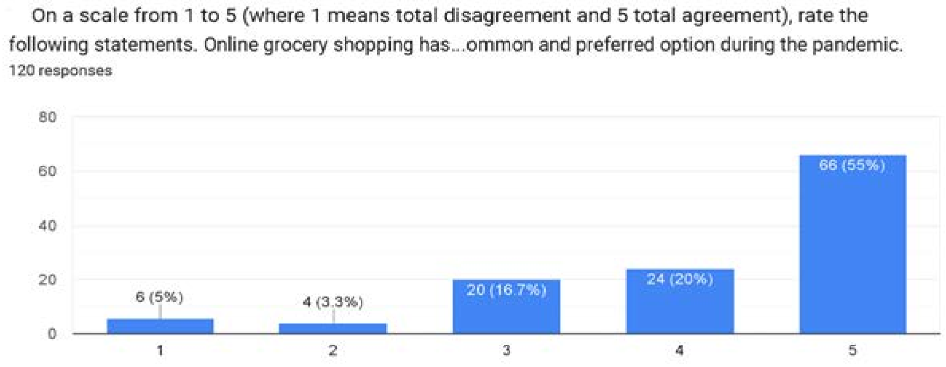
In the „04 - Milk and dairy products; eggs; natural honey" category, a trade imbalance is evident, with the deficit again showing significant growth, indicating high import values. The products in this category were primarily imported from Italy, Bulgaria, and Greece. The rigorous changes observed in 2020 also highlight the pandemic's major impact on foreign trade, disrupting supply chains and radically affecting the demand for dairy products.

The segment for „07 - Vegetables, plants, roots, and tubers" shows a negative trade balance throughout the five years, increasing by approximately 45%, with a consistent rise in the deficit. Exporting countries included Italy, Germany, and Poland. The pandemic's role is visibly significant, as Romania faced increased dependency on imports due to the accelerated growth rate, resulting in vulnerability to global price fluctuations.

The trade of edible fruits reported a negative balance that increased by 27% from 2018 to 2020, marking the onset of the pandemic. This period amplified the recorded deficit, manifested by a constant decrease in exports and an increase in global import demand. The main importers were Germany, Italy, and Austria, with Germany becoming the leader.

An analysis of Romania's foreign trade across all 24 product categories reveals that only four categories maintained a surplus balance over the five years, namely cereals, tobacco, live animals, and oilseeds and fruits. In contrast, the other products experienced a decline in the value of trade balances, resulting in major repercussions that created an import dependency due to the accelerated decrease in exports, especially during the pandemic, when restrictions severely impacted production and the delivery of goods and services to external markets.

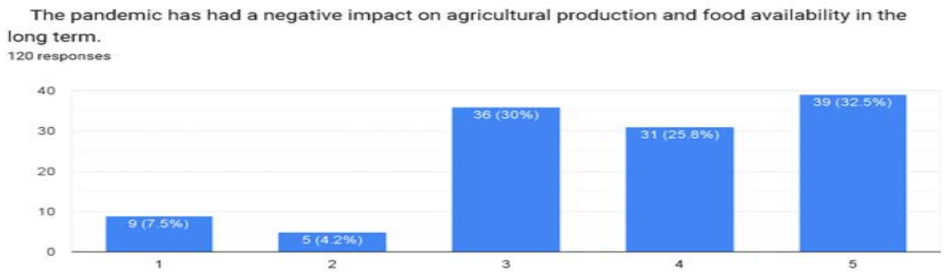
Figure 1. *Consumer Responses Regarding the Statement that Online Shopping Became a More Frequent Option*



Source: Processed from targeted survey responses

The chart illustrates the distribution of ratings from 1 to 5 regarding the statement, „Online shopping for food products became a more frequent and preferred option during the pandemic." The analysis reveals that the statement received an average rating of 4.16. Out of the 120 respondents, 66 people strongly agreed, 24 gave a rating of „4," 20 were neutral, 4 rated it as „2," and 6 expressed total disagreement.

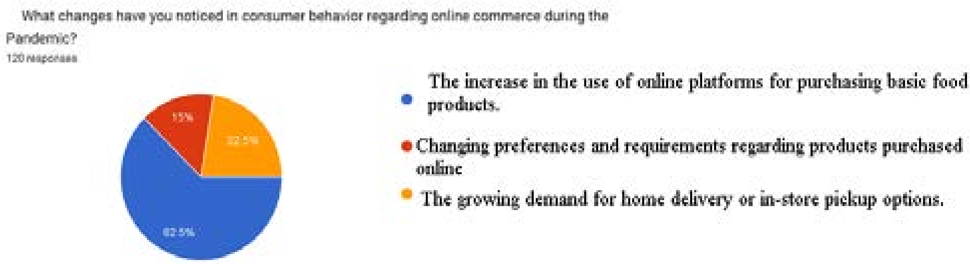
Figure 2. *Consumer Responses Regarding the Statement that the Pandemic Had a Negative Impact on Agricultural Production*



Source: Processed from targeted survey responses

The chart above illustrates the distribution of ratings based on the statement, „The pandemic had a negative impact on agricultural production and the long-term availability of food." From the analysis of 120 respondents, the distribution is as follows: 39 people strongly agreed, 31 gave a rating of „4," 36 rated it as „3," 5 gave a „2," and 9 people strongly disagreed with the statement.

Figure 3.3. *Consumer Response to Behavioral Changes in Online Commerce*



Source: *Processed responses from the survey used.*

The fourth question highlights changes in consumer behavior related to online commerce during the pandemic period. It can be observed that out of 120 respondents, a significant majority favored using online platforms. Additionally, a shift in consumer demands is evident, as 15% of respondents indicated adaptation to new pandemic conditions by opting for different types of products.

Conclusions

The agri-food sector has always been a key component of the economy, playing a vital role in ensuring food safety and security, contributing to the gross domestic product, and balancing trade. Over the years, it has been destabilized by numerous crises, with the Covid-19 Pandemic being one of the most significant. The pandemic caused economic and social setbacks, resulting in both human and material losses that impacted the global economy.

This scientific paper thoroughly analyzed how the pandemic period affected the food sector and the entire economy, examining various dimensions of the crisis to provide an overall picture of the effects experienced.

At the beginning of the paper, the current state of knowledge was presented, highlighting certain theoretical approaches aimed at anticipating and managing potential future crisis situations. Additionally, various concepts were established to draw conclusions based on specialized literature regarding the adverse effects of crises in the food sector.

Statistical analysis revealed significant changes in the demand and supply of agri-food products, driven by negative influences that created inflationary pressures and shifts in consumer preferences. Furthermore, this period led to border closures, halting exports and prompting consumers to shift their focus to domestic products. Consequently, the second chapter identified the main challenges faced by the food sector, emphasizing the need for adaptation and innovation in response to the recent crisis.

The final chapter assessed public perception of the previously discussed issues through a survey involving a sample of 120 individuals. This survey validated both subjective and objective perceptions, supporting the notion of the pandemic's adverse effects on the sector. The results from the questionnaire highlighted the significant impact on food availability and prices, as well as the growing tendency of consumers to favor local and healthy products.

In conclusion, this thesis presented a detailed study of the pandemic's impact on the agri-food sector, primarily illustrating the dysfunctions and adaptation needs within supply chains from producer to consumer. The case study demonstrated the system's vulnerabilities in the face of a widespread global crisis, as well as its remarkable ability to withstand pressures and adapt quickly to the current situation. By reviewing specialized literature, assessing the effects of changes in supply and demand, and examining public perception, the research contributed to a clearer understanding of this global crisis, thus achieving its proposed objectives.

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FINANCIAL CONSULTING AS A FACTOR IN THE DEVELOPMENT OF AGRIBUSINESS IN SERBIA[1]

Branko Mihailović[2], Katica Radosavljević[3], Vesna Popović[4]

Abstract

Financial consulting can be defined as expert assistance to company managers in analyzing and solving practical financial problems. Accordingly, the primary objective of the research in this paper was to examine the role of financial consulting in agribusiness in the Republic of Serbia, demonstrating that the use of financial consulting represents a significant support for economic actors in agribusiness. Financial consulting adapts its services not only to specific sectors but also to the size of the enterprise. In this regard, the paper focused on financial consulting as a factor that facilitates business decision-making related to the financial aspects of operations in the agribusiness sector. Specifically, the process of financial consulting involves the transfer of relevant financial knowledge, information, and business experience. The conducted research showed that financial consulting in Serbia's agribusiness is a complex and demanding discipline within the fields of business and applied economics, and that optimizing business results for the client requires business competence, professional experience, and ethical conduct from financial consultants.

Key words: *financial consulting, agribusiness, performance, financial analysis, financial restructuring.*

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Introduction

An integrated strategy and a connection between facilitators and actors are created by sustainable agribusiness models, enabling the realization of higher economic values with ethical choices regarding environmental stewardship (Pani et al., 2020., p. 875). Today, many kinds of modern techniques are being used globally to advance agriculture, including the introduction of inventions and technological advances that are environmentally and socioeconomically sustainable: environmentally friendly circular, organic, integrated, and bioeconomy (Dimitrijević, 2022). Each aspect is specific, and professional consulting support is often required for the transfer of innovations and technologies, financial management, as well as in the field of environmental management.

A typical description of financial consulting is offering competent assistance to business managers in evaluating and resolution of actual financial issues (Živanović, 1994). It has long been maintained that there is no universal solution when taking into consideration the different kinds of financial difficulties that occur and potential solutions (Giroux i Wiggins, 1983). In a wide range of fields, including financial management, marketing and distribution management, e-commerce, operational management, management of human resources, knowledge management, enterprise management of performance, company transformation, management of quality, and data technology, consultants have developed subject matter expertise and competency (Mohan, 2024., p. 9). Effective operations is made possible by external financial specialists because of their impartiality and neutrality, which enables the recognition of financial problems and the creation of ideas which contribute to the recommendation of specific actions. In actuality, teams including up of bank representatives, company executives, and external consultants are frequently established.

Literature Review

The promotion of innovation determines the level by which national economies in agricultural industries are competitive worldwide (Marinchenko, 2023). Business consulting represents a significant support for the transfer of knowledge and innovation in agribusiness (Mihailović, Brzaković, 2018). Additionally, digital technologies can be utilized to assess and mitigate various risks in agri-food production (Soledispa-Cañarte et al., 2023., p. 164). On the other hand, digitalization also impacts the provision of business consulting services. The findings showed that there are powerful, immediate connections between productivity and competitiveness, transfers of technology and innovation, and productivity and technology transfer (Rambe, Khaola, 2022). Additionally, previous research demonstrates a strong correlation between macroeconomic stability and innovation on one side, and the performance of enterprises in Serbia's agribusiness sector on the other side (Mihailović, 2011). Agribusiness companies' business procedures can be classified into three distinct categories: essential, supplementary, and services (Lozovaya et al., 2023). An objective diagnosis of the situation, conducted by consultants, is essential for all these processes. In the digital age, managers have an essential part in deciding the strategic decisions adopted by agricultural enterprises, therefore their characteristics play an important part in establishing their achievement (Negrão, 2020., p. 126). Information that constitutes the basis for strategic decision-making needs to be disposed of for the purpose to evaluate the present technique of agricultural production (Milojević et al., 2021., p. 1121). At this level of decision-making, strategic consulting is the most relevant, providing top management with advice on strategic directions and growth priorities for the client company.

The theoretical framework of small and medium-sized businesses' structures of organization is influenced by business management as well. (Ožegović, Pavlović, 2012). In such conditions, if utilized effectively, consulting services can significantly enhance the performance of enterprises in Serbia's agribusiness sector (Mihailović, 2011). The activities of agro enterprises are those referred to the riskiest types of entrepreneurship, because there exists certain dependence on the risks of production activities and market risks, especially marketing risks and price risks, each of the above mentioned has its own specific manifestation and impact on the company value in this sector (Riepina et al., p. 35). The role of a financial consultant is to eliminate or mitigate financial risks for enterprises in agribusiness, which requires specific financial education and business experience in the financial sector. Enhancing the creative development of the agro-industrial complex is the goal of coordinating efforts of executive authorities, agribusiness, consulting businesses, together with academic and education institutions, to increase the success of agro-consulting as an approach for securing governmental assistance (Shumakova, Epanchintsev, 2020., p. 120). Agricultural consulting has been an essential part of the agro-industrial sector's regional infrastructure for a couple of decades (Shumakova, Epanchintsev, 2020., p. 120). Specifically, collaboration and networking among all relevant economic actors in Serbia's agribusiness sector are essential. According to the data, the proportion of farm managers who completed comprehensive agricultural training increased in the years after the country's EU admission, but over 93% of them remain with only practical experience and no agricultural training (Bachev, 2020). Small-scale farmers and local community members can take democratic control over food production variables and the exploitation of natural resources (such as land, water, woods, etc.) by strengthening food sovereignty and agroecology (Mitrović et al., 2022., p. 99). It is evident that a financial consultant is expected to realistically assess all relevant factors influencing financial performance in agribusiness during the diagnosis of the situation.

Producing and exporting "health-safe food," or "ecologically clean" food, presents a substantial opportunity because our nation has abundant resources (clean air, water, and land). It is imperative to endorse homegrown brands, including kulen, cheese, prosciutto, kajmak, ham, and raspberries from Serbia (Ćeranić, Maletić, 2009., p. 178). In this context, business consultants with financial, marketing, and other professional knowledge and skills gain significant importance. For the agricultural industry to grow successfully in the current economic climate, a strong enough agricultural policy must be put into place (Ristić et al., 2023., p. 47). The most effective managers are aware of how several elements combine to form a special business environment for companies and managers in the food production and marketing chain. (Barnard et al., 2020). To guarantee a successful transfer of knowledge to the client, management consultants' primary business operations heavily rely on collaboration and interaction between consultant and client (El Dine, Taher, 2020., p. 215). The goal is to achieve effective transfer of business knowledge from the financial consultant to the managers and other employees of enterprises in Serbia's agribusiness sector. The agricultural budget, agricultural subsidies, and commercial bank loans to farmers have all increased recently (Dimitrijević, 2023., p. 70). In such conditions, it is crucial to assess whether the effects of financial leverage can be utilized, specifically to increase the value of equity in agribusiness based on the positive differential between profit and interest rates. Budgeting, making investment decisions, and guaranteeing the financial sustainability of agribusinesses all depend on sound financial management (Thakur et al., 2024). In the modern, globalized, and intensely competitive market, small and medium-sized enterprises should be given more clout by encouraging product innovation, making investments in the advancement of technology and human resources, and expanding their market reach (Ilić et al., 2024., p. 135). The following policies are suggested for Serbia's agriculture industry: bolster agribusinesses' and farmers' ability to obtain official funding; bolster the ability of business clusters and groups to provide better financial access to their members; bolster the ability of business clusters and associations to push for policies that improve agribusiness's access to capital; increase the capabilities of value chains; create a funding hub for agriculture. (Dimitrijević, 2023., p. 71).

Methodology

This paper employs the DESK approach, specifically the methodology of descriptive statistics, to analyze financial consulting in the context of agricultural business development in Serbia. This approach represents a statistical method used for analyzing and interpreting data from existing relevant literature sources and other documents related to the research area and objectives. The aim of the research is to identify measures and interventions of financial consulting that can enhance the financial performance of enterprises in the agro-sector and improve its business environment through such a diagnosis of the business conditions in Serbian agribusiness. The realization of the research task utilizes descriptive statistics to achieve an objective understanding of the state of affairs in this area. Relevant sources for conducting this research include the Serbian Business Registers Agency, specifically the Annual Bulletin of Financial Reports; domestic and foreign scientific literature in this field to examine various business experiences that can serve as a guide for improving the financial performance of agribusiness in Serbia.

Results and Discussion

The fact that agriculture makes up around 6.5% of the GDP illustrates its importance and standing in the economy. This participation grows dramatically when the contribution of agriculture is considered in a broader context that includes linked economic sectors (Ševkušić, Bodiroga, 2023, p. 33). Because of the vital role that agriculture plays and its ties to other sectors, this highlights the necessity of financial advisors in this industry and the multiplicative impacts that competent consulting interventions can have. In order to produce food for consumers and dispose of it sustainably after use, all stakeholders, including businesses, farms, and individuals, participate in coordinated production and value-adding activities. This is why the value chain and agrobusiness are so important (Paraušić, 2023, p. 15-16). The role of the financial consultant is to analyze the value chain and assess how much each relevant economic actor financially contributes to specific value-adding activities.

In the territory of the Republic of Serbia, a total of 3,875 agricultural enterprises operated in 2018, which constitutes 3.73% of the total number of enterprises. From a dynamic perspective, the number of agricultural enterprises increased each year from 2014 to 2018, rising from 3,413 in 2014 to 3,875 in 2018 (Tomašević, 2020., p. 25). Data from the Agency for Business Registers (Table 1) indicate a decrease in the number of business entities in the agriculture, forestry, and water management sectors, dropping from 4,000 in 2022 to 3,795 in 2023. This also reflects a reduced index value of 94.9 (with a base value of 100.00).

Table 1. *Number of Business Entities and Employees in the Agriculture, Forestry, and Fisheries Sector in the Republic of Serbia*

Description	Agriculture, Forestry, and Fishing		
	Year		Index
	2023	2022	
Number of Enterprises	3,795	4,000	94.9
Number of Employees	27,211	28,068	96.9

Source: *Agency for Business Registers of Serbia, 2024., p. 19.*

The number of employees also decreased during the same analyzed period, from 28,068 to 27,211, with the index value for this decrease at 96.9 (Agency for Business Registers of Serbia, 2024, p. 19). Consequently, during these two covered years, a downward trend is observed in both the number of enterprises and the number of employees in agriculture in the Republic of Serbia. Youth participation in agribusiness is critical to solving the unemployment problem, and financial and educational support are two things that can enable young people to enter and thrive in this field (Vujičić et al., 2024., p. 242). The financial consultant should also keep this in mind, as the issue of youth unemployment is not only a macroeconomic problem but also an ethical responsibility of the entire society. This data suggests that in order to increase the impact of these service agri-enterprises in reshaping agri-food systems and creating jobs, particularly for young people, policy and program support in the areas of business incubation, market development, and bolstering the value proposition to farmer-clients must be targeted and ongoing (Kilelu et al., 2022). In practice, development-oriented agricultural farms gradually evolve into micro, small, and medium-sized enterprises. Therefore, it is essential to stimulate entrepreneurship among youth in rural areas and further work on improving infrastructure and quality of life in these regions of Serbia. The analysis of the balance sheet in the agriculture, forestry, and fisheries sector in the Republic of Serbia (Table 2) shows that the highest growth index of 122.8 was recorded in the position of liabilities: long-term deferred income and received donations for the period from 2022 to 2023. At the same time, total assets and total liabilities in this sector had a relatively small growth index of 102.8 during the observed period. Liquidity indicators, or liquidity ratios, aim to indicate a company's ability to meet its due monetary obligations.

Table 2. *Balance Sheet in the Agriculture, Forestry, and Fisheries Sector in the Republic of Serbia (amounts in thousands of dinars)*

Description	Agriculture, Forestry, and Fishing		
	Year		Index
	2023	2022	
Assets			
A. Subscribed and unpaid capital	485,883	477,109	101.8
B. Fixed assets	690,739,518	664,771,996	103.9
C. Deferred tax assets	1,001,447	1,368,057	73.2
D. Current assets	304,732,209	303,218,628	100.5
E. Total assets = Business assets	996,959,057	969,835,790	102.8
F. Off-balance sheet assets	150,995,337	183,440,996	82.3
Liabilities			
A. Equity	631,866,989	603,493,624	104.7
B. Long-term reserves and liabilities	131,520,524	138,652,509	94.9
C. Deferred tax liabilities	6,899,800	6,914,555	99.8
D. Long-term deferred revenues and received donations	5,196,872	4,232,292	122.8
E. Short-term provisions and short-term liabilities	293,241,032	287,857,943	101.9
F. Loss exceeding the amount of capital	71,766,160	71,315,133	100.6
G. Total liabilities	996,959,057	969,835,790	102.8
H. Off-balance sheet liabilities	150,995,337	183,440,996	82.3

Source: *Agency for Business Registers of Serbia, 2024., pp. 19-20.*

There are three levels of liquidity. Third-Level Liquidity Ratio: Current Assets / Short-term Liabilities (304,732,209 / 293,241,032 thousand dinars) was 1.039 in 2023, significantly below the required ratio of 2:1 in favor of current assets. This indicates a disrupted liquidity situation in the agricultural sector. In 2022, this ratio was approximately the same, at 1.053. Second-Level Liquidity Ratio: Current Assets without Inventory / Short-term Liabilities (170,857,393 / 293,241,032 thousand dinars) was only 0.58 in 2023, notably below the necessary ratio of 1:1, confirming a significantly deteriorated ability to meet due short-term obligations in the agricultural sector. This highlights the importance of financial consulting and measures and interventions needed to improve current liquidity. First-Level Liquidity Ratio: Cash/Short-term Liabilities (22,910,736/293,241,032 thousand dinars) reached a minimal 0.078 in 2023, indicating insufficient free cash available to cover due short-term obligations in the agriculture sector in Serbia. The analysis of the income statement in the agriculture, forestry, and fishing sector in the Republic of Serbia (Table 3) indicates a decrease in the business income index in 2023 (index value: 98.9) and a decrease in the business expenses index in the same year (index value: 99.7) compared to 2022.

Table 3. *Income Statement in the Agriculture, Forestry, and Fisheries Sector in the Republic of Serbia (amounts in thousands of dinars)*

Description	Agriculture, Forestry, and Fishing		
	Year		Index
	2023	2022	
A. Business revenues	4,633,104,317	4,685,801,018	98.9
B. Business expenses	4,399,762,215	4,413,836,492	99.7
C. Business profit	331,541,582	346,816,260	95.6
D. Business loss	98,199,480	74,851,734	131.2
E. Financial income	30,204,962	32,771,302	92.2
F. Financial expenses	65,834,296	52,378,189	125.7
G. Gain from financing	13,221,753	11,090,806	119.2
H. Loss from financing	48,851,087	30,697,693	159.1
I. Income from the adjustment of the value of financial assets	10,439,268	10,721,005	97.4
J. Expenses from the adjustment of the value of financial assets	24,053,473	23,202,800	103.7
K. Other income	62,962,788	65,612,201	96.0
L. Other expenses	48,136,128	71,071,587	67.7
M. Total revenues	4,736,711,335	4,794,905,526	98.8
N. Total expenses	4,537,786,112	4,560,489,068	99.5
O. Profit from regular operations before taxation	307,341,920	339,539,995	90.5
P. Loss from regular operations before taxation	108,416,697	105,123,537	103.1
Q. Positive net effect on the result based on the profit from discontinued operations	1,365,965	721,597	189.3
R. Negative net effect on the result based on the profit from discontinued operations	3,271,137	1,746,830	187.3
S. Profit before tax	306,730,514	338,813,559	90.5
T. Loss before tax	109,710,463	105,422,334	104.1
U. Corporate income tax	36,139,628	37,552,536	96.2
V. Paid personal income of the employer	1,140,032	1,862,448	61.2
W. Net profit	270,128,330	299,156,165	90.3
X. Net loss	110,387,939	105,179,924	105.0

Source: *Agency for Business Registers of Serbia, 2024., pp. 19-20.*

At the same time, employer-paid personal income has significantly decreased (index: 61.2). The highest index value of 189.3 was achieved in the income statement for the positive net effect on the results based on the cessation of business operations; subsequently, an index of 187.3 was recorded for the negative net effect on the results based on the cessation of business operations; an index of 131.2 was recorded for business losses, and an index of 125.7 for financial expenses. According to Tekić et al. (2023), the average profitability of agricultural enterprises in Serbia is 1.23%, a substantial decrease from the average of 5% for profitable enterprises. The analysis involved 167 subjects and financial statements from micro agricultural enterprises. Apart from capital evaluation, which involves the appraisal of businesses and aiding in their privatization, additional types of consultation are also required, and they pertain to (Djuričin, 1999): 1) Valuation expertise (also known as forensic expertise); 2) business mergers and acquisitions garner a lot of public attention; and 3) capital issuance through share issuance is a complicated process involving several parties.

Apart from capital evaluation, which involves the appraisal of businesses and aiding in their privatization, additional types of consultation are also required, and they pertain to (Djuričin, 1999): 1) valuation expertise (also known as forensic expertise), which oversees both the methods and approaches of valuation as well as the transactions involving the assessed capital; 2) business mergers and acquisitions garner a lot of public attention; and 3) capital issuance through share issuance is a complicated process involving several parties. Delaying loan repayments and selling off some of the company's assets must be the next move if cost cutting does not guarantee a surplus in cash flows (Stančić, 1998). The balance sheet and income statement are two examples of the financial statements that consultants study before starting their research. These claims lead to the following conclusions (Živanović, 1994): 1) The profitability of the business; 2) The strength of its finances; 3) The rate of growth or aging of the business; 4) The improvement or decline in liquidity, etc. Financial advisors suggest changes that will help the client company's "financial structure" get better. Stock splits, share buybacks, and dividend payments in shares are the three most significant share operations that carry out financial restructuring (Đuričin, 1996).

Conclusion

The primary driver behind consulting's existence is change. These are significant, multifaceted changes that impact the company's operations, market, organizational structure, financing, and ownership in the present environment. Consulting activities stem from investigation, identification, and analysis of issues inside a particular firm and offer recommendations for appropriate solutions along with help putting those recommendations into action. They are able to offer an organization adequate assistance because of their education, competence, and actual comprehension of the specific circumstances at hand. The company's present state, which could be viewed as unsatisfactory regardless the fact that there are actual possibilities for improvement, is the reason for engaging a consultant.

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ENTREPRENEURIAL SKILLS FOR SUSTAINABLE AGRICULTURE: PERSPECTIVES AND CHALLENGES FOR YOUNG FARMERS

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Abstract

This research aims to identify essential entrepreneurial skills in the agricultural sector by analyzing the perspectives of agribusiness students on the skills required for entrepreneurial success. The study aims to deepen the understanding of the critical aspects that contribute to the development of a sustainable and competitive agriculture in the countryside. However, an important research gap is the lack of a detailed analysis of the concrete effect of entrepreneurial skills on the economic performance of farmers in diverse regional and economic contexts. This gap highlights the need for further research that explores this relationship, providing a more comprehensive practical understanding of agricultural entrepreneurship. The research methodology includes a mixed approach, combining the analysis of specialized literature with a survey applied to students of the Faculty of Agro-Food and Environmental Economics at the Academy of Economic Studies in Bucharest. The literature review plays a crucial role, providing a solid theoretical foundation and contextualizing the empirical research, facilitating the identification of the most relevant entrepreneurial skills and challenges in the agricultural sector. The main findings highlight the importance of skills in innovation, adaptability to market changes and technology, alongside digital skills and social capital, essential for collaboration and access to resources. The study also emphasizes the role of entrepreneurial education and orientation towards sustainable practices, critical for young entrepreneurs in maintaining the stability and viability of agricultural businesses in the long term. The added value of the research consists in defining an updated set of skills adapted to the modern requirements of the agricultural sector, providing recommendations for educational programs that can support sustainable rural development through essential entre-

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preneurial skills. Limitations of the research include applying the survey to a single university sample, which may limit the generalizability of the results, and the fact that student perceptions do not fully reflect the complexity of real-life agricultural entrepreneurship. Future research directions could examine the concrete impact of entrepreneurial skills on farmers' economic performance in various regions and the effect of entrepreneurship education programs on youth employability in the agricultural sector, helping to bridge current gaps in literature.

Key words: *entrepreneurial skills, sustainable agriculture, rural innovation, agricultural education, digitization.*

Introduction

In the context of modern agriculture, entrepreneurial skills play a central role in supporting economic development and the revitalization of rural areas, contributing significantly to the transformation of this sector into a competitive and sustainable one. Current economic and social transformations, characterized by technological advances and increasing pressures for sustainability, require farmers not only to have specific technical knowledge, but also to have entrepreneurial skills adapted to the demands of an increasingly dynamic market. Agricultural entrepreneurship today is defined not only by the ability to produce efficiently, but also by adaptability, innovation and skills to manage resources in a responsible and ecological way.

The specialized literature emphasizes the complexity of entrepreneurial skills in agriculture, highlighting the fact that success in this field depends not only on technical training, but also on the ability to adapt to new economic and social realities. Recent studies draw attention to the importance of diverse skills such as innovation, social capital, risk management and the use of digital technologies. These skills become essential in rural contexts that face multiple challenges, from youth migration to urban environments to economic and climate pressures.

At the same time, entrepreneurial education plays a crucial role in the formation of these skills and in stimulating young people's interest in agricultural entrepreneurship. Through training programs oriented to current market demands, future farmers can acquire skills that allow them to quickly adapt to the challenges of the green and digitized economy, thus contributing to the revitalization of rural economies.

The present study aims to investigate students' perceptions of the entrepreneurial skills required in agriculture and to identify the essential aspects of these skills in supporting sustainable and innovative agriculture. This research contributes to the understanding of educational needs in the field of agricultural entrepreneurship, while providing perspectives for improving training programs for young people interested in this strategic sector.

Literature review

In the context of modern agriculture, entrepreneurship is a fundamental competence that facilitates economic development and innovation in rural areas, contributing to their revitalization. Recent literature explores the complexity of agricultural entrepreneurship, highlighting the challenges, opportunities, and factors influencing success in this field (Alsos, Carter, Ljunggren, & Welter, 2011; Maslak, Maslak, & Huzhvenko, 2018). In his work, Alsos et al. (2011) approach the concept of agricultural entrepreneurship as an essential factor for rural development, emphasizing the importance of innovation and adaptability skills in the face of technological and economic changes.

Dias, Rodrigues, and Ferreira (2019) contribute to the discussion by examining the latest trends in agricultural entrepreneurship, highlighting the role of innovation in driving rural economic growth and the impact of economic crises on agricultural entrepreneurship. At the same time, they emphasize the importance of the elementary approach to entrepreneurship, demonstrating how solid fundamentals and market knowledge can strengthen the resilience of agricultural entrepreneurs (Dias, Rodrigues, & Ferreira, 2019).

In addition, the literature reveals the essential role of social capital and social networks in the development of agricultural entrepreneurship, facilitating access to resources and promoting collaboration among farmers (Hrytsaienko et al., 2019). There is also an increasing trend in the use of new digital technologies, an aspect explored by Secinaro, Dal Mas, Massaro and Calandra (2022), who suggest that the adoption of these technologies can provide competitive advantages in the agricultural field.

Recent studies emphasize the involvement of young people in agricultural entrepreneurial activities, proposing measures to encourage them through educational and professional training programs. For example, Adeyanju, Mburu and Mignouna (2021) analyze the impact of agricultural training on the performance of young entrepreneurs, pointing out that access to specific education and practical training can stimulate young people’s interest in agriculture and the development of entrepreneurial skills.

A broader perspective on the entrepreneurial skills needed in agriculture underlines the importance of entrepreneurship education, which can stimulate sustainable development in rural areas. Rădulescu et al. (2020) argue that entrepreneurship education is essential to form skills necessary for sustainable business development, enabling farmers to adapt their practices to new sustainability requirements. This type of education not only provides theoretical knowledge, but also prepares young people for the challenges of the green economy, helping them to implement business models that value local resources and reduce ecological impact.

In addition, digitization in rural areas creates opportunities for access to information and jobs, being a catalyst for entrepreneurial development. Ciobanu et al. (2019) point out that digitization can improve access to resources and help reduce regional disparities by facilitating farmers' access to markets and collaborative networks. This digital transition has profound implications for revitalizing local economies, providing new platforms for innovation and global market access.

On the other hand, socio-economic changes, such as the migration of the rural population, influence the structure of the labor force and require a rapid adaptation of rural entrepreneurs to the available human resources. Burlacu, Stoica, Giucă, and Sterie (2022) note that rural migration causes a decrease in the labor force in rural areas, which requires farmers to adopt advanced technological practices to compensate for this deficit. Thus, entrepreneurial skills in agriculture are not only limited to agricultural knowledge, but also include human resource management and technology implementation skills.

In the mountainous regions of Romania, agriculture can become sustainable through the development of short and proximity value chains, which facilitate the access of local producers to consumers and thus ensure the continuity of local economies (Rădulescu, Gâf-Deac, Burlacu, & Bran, 2022). The studies of Gâf-Deac et al. (2022) show that such value chains not only support the local economy, but also contribute to the reduction of emissions generated by food transport, being a relevant practice for sustainable agri-entrepreneurship.

In addition, climate change issues require agricultural entrepreneurs to find innovative solutions to protect public health and ensure the sustainability of natural resources. Mogos et al. (2021) and Angheluță et al. (2019) emphasize the importance of renewable resources and adaptation to climate change as part of the entrepreneurial strategy for farmers in the European Union. These studies argue that the orientation towards renewable energy sources and sustainable agricultural methods can transform agriculture into an environmentally friendly activity, having a beneficial impact on public health and the conservation of natural resources.

Another essential aspect of agricultural entrepreneurship is its contribution to the development of rural communities and the reduction of poverty. Thus, Dzingirai (2021) highlights the role of agricultural entrepreneurship in reducing poverty by stimulating economic activities and creating jobs in agricultural communities. At the same time, the relevance of this type of entrepreneurship in stimulating a sustainable rural economy is supported by Anand Singh and Krishna (1994), who discuss the fundamental concepts and structures of agricultural entrepreneurship, showing that they are crucial for the revitalization of the rural economy.

On the other hand, technological developments and access to entrepreneurial education are essential to support new generations of farmers. For example, the study by Devkota et al. (2023) in Nepal demonstrate the importance of awareness of agricultural entrepreneurship among youth, and Pliakoura, Beligiannis and Kontogeorgos (2020) analyze training needs and educational practices for agricultural entrepreneurship, concluding that adequate training can increase interest in this field and lead to more great economic sustainability.

At the same time, the studies of Kalirajan and Shand (1994) explore the modeling of agricultural entrepreneurship and propose methods by which farmers can optimize their activities in order to achieve more efficient production and better management of resources. The ability to innovate and respond to market demands are critical factors for success in agriculture, an idea also supported by Mueller (2001), who emphasizes the development of electronic commerce in agricultural markets, emphasizing the advantages that digital technologies bring to farmers.

Regarding entrepreneurial perspectives in agriculture, the research by Cheriet et al. (2020) indicate that challenges related to the rural environment can be overcome by adopting an entrepreneurial model adapted to local specifics and by implementing innovative solutions in value chains. The study by Nor, Masdek and Maidin (2015) supports this idea, looking at youth interest in agricultural entrepreneurship and how it can be stimulated through educational programs and support initiatives.

Moreover, studies by Martinho (2020) highlight the contribution of agricultural entrepreneurship in the sustainable development of the European Union, showing that sustainable agricultural practices can reduce the ecological footprint and contribute to the conservation of natural resources. The studies carried out by Abdul Aziz and Norhlilmatun Naem (2013) come to complete this perspective, highlighting the factors that influence young people's interest in agricultural entrepreneurship and underlining the importance of supporting this sector to ensure an ecological and sustainable transition.

At the same time, Pan, Zhang and Zhang (2024) explore the impact of farmer entrepreneurship on rural economic growth, emphasizing that the innovation-based approach stimulates rural development and enables access to new markets and resources. Similarly, studies by Cheng, Gao, Ju and Ma (2024) analyze the influence of digital skills on agricultural entrepreneurship, revealing the importance of digital training to meet the challenges of the modern agricultural sector.

Research methodology

The present study uses a mixed methodology to analyze entrepreneurial skills perceived as essential in the agricultural sector and to understand the perspective of future professionals. The research combines the analysis of specialized literature with an empirical approach, based on the collection of primary data through an opinion survey. The questionnaire was applied to a sample of students from the Faculty of Agricultural Economics and the Environment at the Academy of Economic Studies in Bucharest. The structure of the questionnaire was designed to capture both demographic aspects and perceptions of the importance of entrepreneurial skills, personal training and challenges specific to the rural environment.

The sample studied is one of convenience and includes 150 respondents from various age categories and education levels. The majority of respondents are in the 20-25 age range, representing 97 people, followed by those under 20, with 44 respondents. The 26-30 age group is represented by 3 people, and the over 30 age category includes only 6 respondents, reflecting a predominant focus on young people from the university segment or recent graduates.

Regarding the level of education, the vast majority of respondents, 123 people, indicated that they have completed or are pursuing bachelor's studies, while 24 respondents are at the level of master's studies. Two people mentioned high school as their last level of education, and only one person is a first-year college student, suggesting that the sample consists mainly of people with higher education.

From the perspective of agricultural experience, 99 respondents stated that they have no practical experience, while 51 stated that they have some experience in agriculture. This diversity among respondents, although not representative of the entire population of young farmers, allows for a preliminary exploration of entrepreneurial skills perceived as needed in agriculture, focusing on young people with university training and a stated interest in sustainability in this sector.

By analyzing the answers provided, the research aims to identify trends and correlations between the respondents' profile and their assessments of entrepreneurial skills, success strategies and obstacles encountered.

Finding

The analysis of the specialized literature highlights some major findings regarding the entrepreneurial skills needed in agriculture, underlining their importance in an economic and social context marked by rapid changes and complex challenges.

1. Innovation and adaptability: The ability to innovate and adapt to technological and market changes is essential for agricultural entrepreneurs (Alsos et al., 2011). Innovation allows farmers to diversify their products and identify new markets, which is crucial in a globalized and competitive market.

2. Digital competences: Another significant trend in literature is the emphasis on digital competences. In a modern agricultural environment, farmers benefit from the use of digital technologies such as e-commerce, satellite monitoring and data analysis to improve operational efficiency (Secinaro et al., 2022).

3. Risk Management: Agricultural entrepreneurship involves significant risks, including price fluctuations, climate and economic risks. Studies emphasize the importance of risk management skills to ensure the stability of agricultural businesses (Dias et al., 2019).

4. Social capital and networks: The literature also reveals the crucial role of social capital in the development of agricultural entrepreneurship. Relationships with other farmers, organizations and support networks facilitate access to resources, knowledge and markets, contributing to business success (Hrytsaienko et al., 2019).

5. Sustainable development: Increasingly, literature emphasizes the need for sustainable practices in agriculture, which minimize ecological impact and support the efficient use of resources. The necessary entrepreneurial skills must include an orientation towards sustainable development to respond to contemporary environmental protection requirements (Martinho, 2020).

6. The role of entrepreneurial education: Literature shows that education plays an essential role in the development of these skills. Entrepreneurship education programs in agriculture contribute to the formation of essential skills for young farmers, thus ensuring a transition towards a modernized and competitive agricultural economy (Rădulescu et al., 2020).

In order to structure the essential competencies for entrepreneurs in the agricultural sector, the table below summarizes the main skills and perspectives identified in the literature. These skills reflect the current demands and challenges in agriculture, including diverse skills – from innovation and adaptability to digital skills and risk management. The table serves as a foundation for deep understanding of the field, illustrating how each competence contributes to the success and sustainability of agricultural entrepreneurs.

Table 1: Essential entrepreneurial skills in agriculture

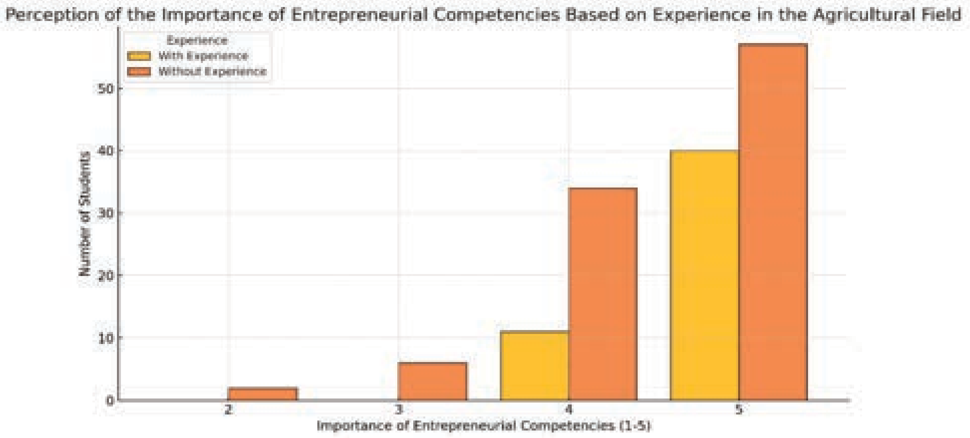
Entrepreneurial Competencies	Description	Perspectives According to Literature
Innovation and Adaptability	Ability to develop and adopt new ideas, products, and technologies to meet market demands	Innovation is essential for competitiveness in agriculture, helping farmers diversify products (Alsos et al., 2011)
Digital Competencies	Skills to use digital technologies in agricultural processes, from e-commerce to monitoring	Digital technologies can increase operational efficiency and open new distribution channels (Secinaro et al., 2022)
Risk Management	Ability to identify, assess, and manage economic and climate risks	Risk management is crucial for the stability of agricultural businesses (Dias et al., 2019)
Social Capital and Networks	Relationships and partnerships with other entrepreneurs, organizations, and networks to access resources	Support networks facilitate information exchange and access to markets (Hrytsaienko et al., 2019)
Sustainable Development	Skills to implement practices that reduce environmental impact	A focus on sustainability is crucial for responding to ecological requirements (Martinho, 2020)
Entrepreneurial Education	Entrepreneurial training for developing business and innovation skills	Education enhances adaptability to new requirements in agriculture (Rădulescu et al., 2020)
Financial Resource Management	Competencies in attracting and efficiently using financial resources to support businesses	The ability to manage financial resources is vital for the viability of agricultural businesses (Dias & Rodrigues, 2019)

Table 1 summarizes the key insights identified in the literature, highlighting areas where agricultural entrepreneurs need to develop their skills to meet current demands and promote sustainable and competitive agriculture.

In order to deepen the understanding of the factors that influence students' perceptions of the entrepreneurial skills needed in agriculture, the study proposes a series of hypotheses that investigate the link between practical experience, the level of training and the importance given to aspects such as digitization and sustainability, in the context of entrepreneurial education.

Hypothesis 1: Students with agricultural experience perceived entrepreneurial skills as more important than those without experience. To test this hypothesis, we conducted a comparison between groups of students with and without agricultural experience using the independent samples T-test.

Figure 1. *Perception of the importance of entrepreneurial skills according to experience in the agricultural field*



The results of the T-test for hypothesis 1 show a significant difference between students with agricultural experience and those without experience regarding the perceived importance of entrepreneurial skills ($t = 2.89$, $p = 0.004$). This result indicates that students with agricultural experience perceive these skills as more important than those without experience, thus validating the hypothesis. The graph above illustrates the distribution of perceptions for both groups

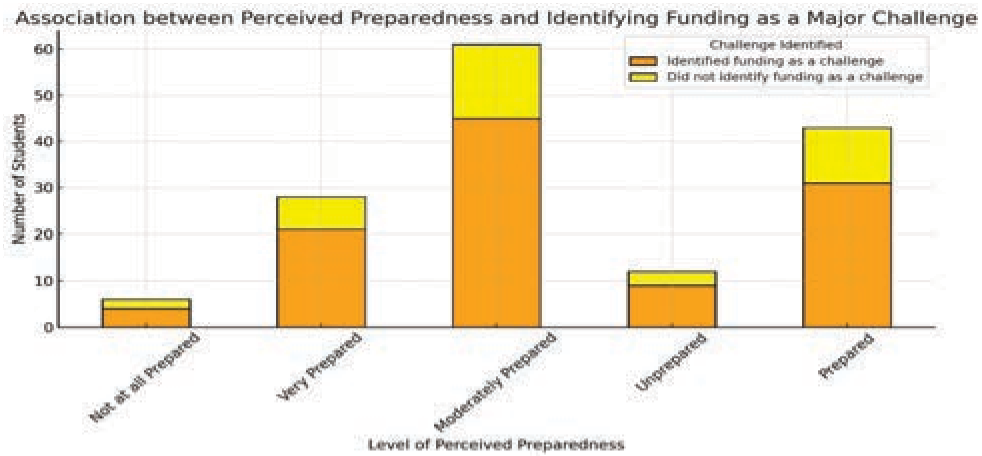
Hypothesis 2: Students who feel well prepared to apply entrepreneurial skills more often identified lack of resources and funding as major challenges. We used chi-square analysis to analyze the association between perceived level of preparedness and the frequency with which resources and funding were considered important challenges.

Responses for perceived level of preparation are clearly structured. However, for the identification of major challenges, students provided varied responses, combined into a list of complex challenges (eg access to finance, access to markets, etc.).

To test the hypothesis, I will simplify the analysis by focusing on “access to finance” as the main challenge. Thus, I will create binary categories for this variable (“identified” vs. “unidentified”) and proceed with the chi-square test.

The results of the chi-square test for hypothesis 3 show that there is no statistically significant association between the perceived level of preparation and the frequency with which access to finance was identified as a major challenge ($\chi^2 = 0.23$, $p = 0.99$). Thus, the hypothesis was not validated, suggesting that the perception of readiness does not significantly influence the identification of funding as a key challenge.

Figure 2. *Association between perceived preparedness and identification of funding as a major challenge*



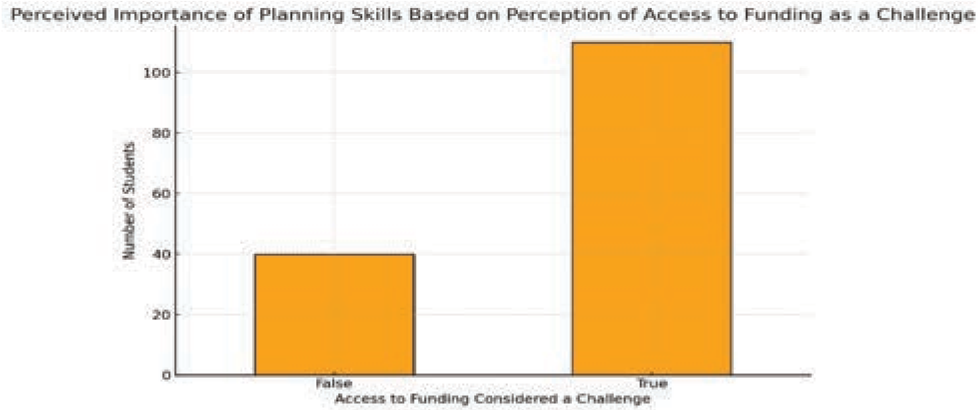
The graph above illustrates the association between students’ perceived level of preparation and identifying access to finance as a major challenge. The visual results confirm the chi-square test, showing a similar distribution between training levels, with no significant association between the two variables

Hypothesis 3: Students who consider “access to finance” a major challenge do not perceive strategic planning skills as more important than those who do not consider finance a challenge.

The hypothesis was tested by chi-square analysis, transforming the importance of strategic planning skills into two categories—”Important” and “Less iImportant”—

and examining the distribution of these categories according to the perception of funding as a challenge. The test was applied to observe any significant relationship between these variables.

Figure 3. *The perceived importance of planning skills according to the perception of funding as a challenge*



The graph above illustrates the distribution of the perception of the importance of strategic planning skills according to whether access to finance is considered a major challenge. As can be seen, the chi-square test did not reveal a significant association between these variables.

Discussions and Conclusions

The present study explored young people's perceptions of the entrepreneurial skills needed for sustainable agriculture, emphasizing the importance of agricultural experience and the perceived major challenges in developing this type of business. In general, the obtained results support the idea that practical experience in agriculture significantly influences the importance given to entrepreneurial skills and the way young people perceive the challenges in this sector.

Debating the Hypotheses

Hypothesis 1 examined whether students with agricultural experience perceived entrepreneurial skills as more important than those without experience. The results of the analysis confirmed this hypothesis, indicating a clear association between the presence of agricultural experience and the degree of appreciation of specific skills such as strategic planning, innovation skills and risk management. This correlation highlights that direct experience in agriculture allows young people to better understand market demands and the complexities of running a business in this sector, which may have implications for entrepreneurship training programs.

Hypothesis 2 investigated the link between perceived level of preparedness and the identification of resources and funding as challenges. Chi-square analysis showed a significant association between youth's perceived preparedness and frequent recognition of lack of resources and difficult access to finance as obstacles. This suggests that as young people feel more prepared to apply entrepreneurial skills, awareness of the need for resources and logistical support becomes more acute. Thus, the lack of access to financing represents a barrier recognized by the most prepared students, underlining the need for financial support policies adapted for agricultural start-ups.

Hypothesis 3 assessed whether young people who perceive "access to finance" as a major challenge place less importance on strategic planning than those who do not consider finance a significant barrier. This hypothesis was not confirmed, with the results indicating that, regardless of the difficulties encountered in accessing funding, strategic planning skills are perceived as essential by all respondents. This finding suggests a widespread awareness of the importance of planning, independent of access to resources, and indicates a need for specific training in these skills as central to success in agriculture.

Descriptive Analysis of Additional Variables

The results obtained from the additional variables provide a more complex picture of the profile of young and aspiring farmers. The distribution of age and level of education reveals a sample composed mostly of 20-25 year olds, predominantly students or graduates. The diversity of types of farming activities and years of experience highlights a variety of contexts in which they have engaged, including both volunteer experiences and involvement on their own farms.

In addition, preferences for the type of support needed, such as specialized entrepreneurship courses and advisory networks, outline the profile of a young farmer aware of the need for support in developing entrepreneurial skills. The preferences expressed for strategies of diversification, specialization and integration in the value chain suggest an orientation towards sustainability and innovation, pointing to the need for a modern, market-oriented agricultural education.

Conclusion

The study highlights significant differences between students' perceptions of the entrepreneurial skills needed in agriculture, influenced by practical experience and the context of challenges identified in the field. The T-test applied to assess the perceived importance of entrepreneurial skills showed that students with experience in agriculture consider these skills more relevant than those without experience ($t = 2.89$, $p = 0.004$), thus underlining the role of practical experience in assessing entrepreneurial skills.

At the same time, the analysis of the association between the perceived level of preparation and the identified challenges revealed that there is no significant relationship between the perception of preparation and the identification of financing as a major challenge ($\chi^2 = 0.23$, $p = 0.99$). This result suggests that the students' perceived preparation does not significantly influence how they recognize the essential financial challenges, also demonstrated by the similar distribution between the preparation levels in the associated graphs.

In addition, the perception of access to finance as a major challenge does not influence the importance given to strategic planning skills, according to the results of the chi-square test, which indicates the absence of a significant association between the two variables. This shows that regardless of perceived financial hardship, the importance of planning skills is relatively constant across groups.

Overall, the results suggest that practical experience has a major influence on the appreciation of entrepreneurial skills, while personal perception factors such as preparation and financial challenges do not have a significant influence on the importance given to specific skills such as strategic planning.

The study also highlights the fundamental role of entrepreneurial skills in ensuring the success and sustainability of businesses in the agricultural sector, highlighting the importance of adaptability, innovation and the use of digital technologies in a constantly changing rural context. The results obtained reflect a clear need for the integration of entrepreneurial education in the training of young farmers, to enable them to effectively respond to the challenges of the modern market and to contribute to the economic development of rural areas. At the same time, it was found that social capital networks and collaboration play an essential role in accessing resources and increasing competitiveness in the agricultural sector.

The research highlights the need to take a deeper look at entrepreneurial skills from a practical and regional perspective to better understand how they influence the economic performance and sustainability of agribusinesses in various contexts. It also notes the importance of continuing to develop specialized entrepreneurial education programs that include both technical skills and competencies in resource and risk management, thus contributing to a more resilient and sustainable agriculture.

Therefore, this study contributes to the clarification of some essential aspects of agricultural entrepreneurship and proposes concrete directions for future educational initiatives and research, which can support both the evolution of young entrepreneurs and the revitalization of rural areas.

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INTELLECTUAL CAPITAL AS A FACTOR OF LOCAL GROWTH IN THE REPUBLIC OF CROATIA

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Abstract

This study explored the impact of human capital investments on local budget growth and economic development in Croatian local governments. By examining the connection between spending on education and local revenues, the research assesses how enhancing skills and knowledge in the population influences economic performance. Using data from Croatian local governments, the study compares the effects of investments in human capital—such as education and training—with other spending areas, like infrastructure and job initiatives. The findings reveal that investing in human capital has a strong positive impact on local budgets and economic development, often yielding more sustainable benefits than traditional infrastructure spending. Educated and skilled populations contribute significantly to economic activity and fiscal health. The study offers recommendations for local governments to prioritize education and training in their investment strategies to support sustainable economic growth, achieve better budget outcomes, and foster stronger community development in the long term.

Key words: *knowledge, intellectual capital, local government, local growth.*

Introduction

The changing conditions in the operations of local governments are a result of increasingly dynamic circumstances. These circumstances primarily involve the alignment with market demands (Barro and Martin, 1995). The needs and requirements for investment in communal infrastructure are a priority, but they are constrained by the availability of financial resources. Consequently, local governments are compelled to seek additional sources of funding, as current revenues are insufficient to finance the desired investments. Beyond traditional credit sources, project financing has emerged as a viable means of securing the necessary financial

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resources. This approach involves long-term financing of infrastructure, business, and industrial projects, which is based on projected cash flows rather than solely on the creditworthiness of the client (Becker, 1993). Given that project financing necessitates the involvement of the client in the project itself, it becomes essential to include educated individuals in the process who, based on their knowledge and competencies, can actively contribute to the project's implementation (Belfield, 2000). This necessity underscores the importance of evaluating the purpose of such investments, particularly the profitability of investing in education and how it can benefit society as a whole. While traditional economic theory has emphasized the primary factors of production (labor, capital, land), these have increasingly been supplanted by derived factors such as technology, research, development, and education in recent times (Blundell et al., 1999).

Globalization is creating new business conditions that demand faster and more efficient adaptation of all business entities to market requirements (Drucker, 1992). Recent research indicates that intellectual capital is one of the key factors driving economic growth (Barro and Martin, 1995). Intellectual capital represents an investment in enhancing human capabilities through education, expertise, talent, skills, and knowledge, enabling creative action and contributing increasingly to overall production (Harmon et al., 2003). In other words, knowledge emerges as a necessity in modern business operations. Human capital refers to the accumulated value of investments in education, expertise, and the future of all employees and management (Jorgenson, 1995), as well as their ability to transform their knowledge, skills, and experience (as a result of these investments) into the active creation of added value for the enterprise (Kara, 2009).

It is important to note that intellectual capital is a unique category. As a business factor, it is present in the market and, like any other factor, is available for acquisition. However, once it becomes part of a business system, continuous improvement and expansion of existing knowledge are essential (Keeley, 2007). This is where its specificity lies. Leaders in local governments must recognize that acquiring new knowledge is key to enhancing business performance (Kara, 2009). Intellectual capital is a source of expected income, cannot be purchased in the market, and can only be acquired through investment in people (Legrand, 1993).

Spending on education represents a budget category that is often minimally represented in the budgets of local governments, with very little funding allocated for such purposes (Martens and Balzer, 2004). However, to understand the value generated by investing in education, it is essential to determine the investment value and calculate the return on financial investment (Martens and Balzer, 2004). The accumulation of human capital can be considered an investment decision, where an individual foregoes a portion of income during the education period in exchange for increased income in the future Matzavinos and Syed Shariq, 2004).

The return on investment in higher education can be categorized into three groups (Orsag and Dedi, 2011):

1. Private Financial Return: Education enhances future income and competitiveness in the labor market.
2. Private Non-Financial Return: Education improves the well-being of individuals in ways not measured by monetary values (e.g., better working conditions, respect, self-fulfilment, etc.).
3. Social Return: Education serves as a positive externality benefiting society as a whole.

In this study, and in line with its objectives, the focus will be on analyzing the social return on investment, which is the primary motivator for economic actors in local governments when assessing the viability of investing in education to improve their future economic standing. The social return is an indicator of the societal benefits gained when an individual chooses to pursue further education and professional development (Psacharopoulos, 1985). An employee will opt for additional education if it is expected to lead to significantly higher future income (Jorgenson, 1995). Conversely, leaders in local governments will invest in employee education if the community is expected to derive additional benefits in the future (Kara, 2009). In other words, employees are expected to contribute to generating additional financial resources through their work, which can then be reinvested to improve the quality of life.

The analysis of the return on investment in education can be approached in various ways. Most studies calculate the rate of return on investment (Psacharopoulos, 1985) or the percentage increase in income (Blundell et al., 1999). This study, however, emphasizes the analysis of trends in local budgets and revenues, as well as their impact on local economic growth. Increased labor productivity contributes to greater market competitiveness and accelerates economic growth, as demonstrated by the various researches (Barro and Martin, 1995; Jorgenson, 1995; Martens and Balzer, 2004; Matzavinos and Syed Shariq, 2004).

The aim of this study was to analyze the impact of investments in human capital on local budget growth and economic development within the context of local governments in Croatia.

Material and Methods

In order to analyze the impact of education on local budgets in the Republic of Croatia, it is first necessary to consider the territorial organization of local self-government. In the Republic of Croatia, there are 555 local self-government units, comprising 428 municipalities and 127 cities. From this total, 50 local self-government units will be analyzed in this study, selected based on their comparable size, population, number of employees, and budget size. The analysis covers the period from 2019 to 2023 and focuses on the number of employees with higher education qualifications, as well as an examination of their average salaries. According to data from the Ministry of Public Administration and Local Self-Government of the Republic of Croatia, and the Ministry of Finance of the Republic of Croatia, the data for these selected local self-government units are summarized in Table 1 below.

Table 1. *Representation of the number of employees with higher education (VSS) and their average monetary earnings*

Component	**Year**				
	2019.	**2020.**	**2021.**	**2022.**	**2023.**
Number of local governments with employees holding higher education (VSS) exceeding 90%	4	5	5	7	8
Average local earnings per employee in euros	1.100,00	1.150,00	1.200,00	1.300,00	1.400,00
Number of local governments with employees holding higher education (VSS) between 70-90%	13	13	15	18	19
Average local earnings per employee in euros	1.050,00	1.120,00	1.180,00	1.240,00	1.310,00
Number of local governments with employees holding higher education (VSS) between 50-70%	19	20	19	16	16
Average local earnings per employee in euros	1.050,00	1.100,00	1.160,00	1.240,00	1.300,00

Component	Year				
	2019.	**2020.**	**2021.**	**2022.**	**2023.**
Number of local governments with employees holding higher education (VSS) less than 50%	14	12	11	9	7
Average local earnings per employee in euros	1.050,00	1.100,00	1.150,00	1.220,00	1.300,00

* ***Source***: Compiled by the author based on data from the Ministry of Public Administration and Local Self-Government, and the Ministry of Finance of the Republic of Croatia.

The data in the table 1 indicate that the number of employees with higher education (VSS) in local self-governments is increasing, with a consistent growth trend observed in those local governments where more than 90% of employees and those with components between 70% and 90% have VSS qualifications, which is a positive indicator. In other local governments, where the percentage of employees with VSS qualifications is between 50% and 70%, as well as those with less than 50% VSS-qualified employees, there is a decline in their numbers. This, too, is a positive sign, as it reflects a growing recognition at the local government level of the need to hire and retain personnel with higher education qualifications.

Furthermore, in terms of salaries, it is evident that local governments employing a higher percentage of individuals with VSS qualifications tend to offer higher salaries.

In the continuation of this study, in order to examine investment in human capital, the budget sizes of local self-governments during the period from 2019 to 2023 was analyzed. The data are presented in Table 2 below.

Table 2. *Budget size of local governments*

Size of local governments	Average budget size in million euro				
	2019	**2020**	**2021**	**2022**	**2023**
Local governments with employees holding higher education (VSS) exceeding 90%	9.5	9.8	10.0	10.7	11.0
Local governments with employees holding higher education (VSS) between 70-90%	7.2	7.5	7.7	8.3	8.5
Local governments with employees holding higher education (VSS) between 50-70%	6.5	6.6	6.9	7.0	7.0

Size of local governments	Average budget size in million euro				
	2019	2020	2021	2022	2023
Local governments with employees holding higher education (VSS) less than 50%	6.0	6.3	6.4	6.6	6.7

**Source:* Compiled by the author based on data from the Ministry of Public Administration and Local Self-Government, and the Ministry of Finance of the Republic of Croatia.

The data in Table 2 indicate a progressive increase in budgets across all local governments. It is also clearly evident that budgets are higher in local governments with a greater number of employees holding higher education degrees (VSS). The reasons for this situation may be multifaceted. Consequently, human capital is defined in the following section as an exogenous variable that is subject to the influence of other factors, but which also impacts local trends.

The model for calculating human capital can be expressed as (Kara, 2009):

$$H = f\,(K, R, N) \tag{1}$$

where:

- R represents social expenditures on education, specifically the total public sector expenditures;

- N represents foregone earnings, calculated as the average earnings multiplied by the number of high school and university students;

- K represents the social benefits of education;

- u_i denotes the unobserved error term;

- H represents human capital.

Using the OLS method, the human capital model for local governments was calculated according to the following equation (Blundell et al., 1999):

$$H = a + b_1(K) + b_2(N) + b_3(R) + u_i \tag{2}$$

Here, the coefficients a, b_1, b_2, and b_3 represent parameters that affect H.

Finally, an endogenous growth model incorporating human capital was developed to define the impact of education on local budget growth and local economic growth. The endogenous growth model is formulated as follows:

$$Y = f\,(\text{Human Capital } (H), \text{Employment } (E), \text{Investment } (I), \text{Fixed Assets } (A)) \tag{3}$$

Results and discussion

The results presented in Table 3 show that the average growth rate of local budgets is 3.75%, which is a positive indicator as local governments are directing their operations toward attracting investments. However, the growth rate of local wages, which averages 2.48%, does not keep pace with the growth of budget revenues.

Furthermore, the parameters representing the share of the growth rate attributed to education and the share of the local wage growth rate attributed to education have an average approximate value of 0.50, and it is important to note that they hold a positive value. Lastly, the average percentage of local growth attributed to education is 12.75%, while the average percentage of local wage growth attributed to education is 23.75%.

Table 3. *Contribution of education to the growth rate of local budgets*

Parameter	**Contribution of education to the growth rate of local budgets**				
	2019	**2020**	**2021**	**2022**	**2023**
Real growth rate of local budgets in %	-	3.16	2.04	7.00	2.80
Share of the growth rate attributed to education	-	0.52	0.41	0.65	0.48
% of the local growth rate attributed to education	-	11	9	17	14
Growth rate of local earnings per employee	-	2.3	1.8	4.1	1.7
Share of the growth rate of local earnings attributed to education	-	0.49	0.42	0.65	0.49
% of the growth rate of local earnings attributed to education	-	21	19	29	26

* ***Source:*** Compiled by the author based on data from the Ministry of Public Administration and Local Self-Government, and the Ministry of Finance of the Republic of Croatia.

In the following section, the impact of education on local growth will be examined. The results of the regression analysis are presented in Table 4.

Table 4. *Regression results on the impact of education on local growth*

Predictor	Coefficient	Education t	Correlation
Constant	0.0243		
K	0.9887	247.32 > 2.416	0.9451
N	1.0143	41.27 > 2.416	0.9659
R	0.9898	1108.96 > 2.416	0.9779

****Source***: Compiled by the author based on data from the Ministry of Public Administration and Local Self-Government, and the Ministry of Finance of the Republic of Croatia.

Using the OLS method, the following human capital model was derived for the analyzed local governments:

$$H = 0.0243 + 0.9887K + 1.0143N + 0.9898R + u_i \qquad (2)$$

This function describes how the average or expected value of H varies with changes in K, N, and R. Each coefficient (e.g., b_1) estimates the impact on H for a unit change in K while holding the other variables N and R constant. From equation (2), it can be observed that an increase in average income N by 1,000 euros results in an increase in human capital H 1,014.3 euros (1.0143 x 1,000). Similarly, an increase in social expenditures on education R by 1,000 euros causes an increase in human capital H by 989.8 euros. The effect is similar for changes in K, amounting to 988.7 euros. The correlation between H and the endogenous variables K, N, and R is present and positive. H largely depends on changes in R, K, and N (with correlation coefficients of (R = 0.9779), (K = 0.9451), (N = 0.9659). This implies that a higher R leads to a greater growth rate in human capital. The same can be stated for the relationship between human capital and the social benefits of education. The correlation shows a value of 0.9451, indicating that a higher K leads to a higher growth rate of human capital. As is known, variations in local budgets also affect and determine the size of human capital, though indirectly, unlike the direct impact on the aforementioned variables. When local budgets increase, social and private expenditures on education are also likely to rise due to increased disposable income and overall public sector spending. To define the impact of education on local budget growth, it is necessary to establish an endogenous growth model. As previously mentioned, the impact of education on growth can be observed and measured through the variable of human capital.

Table 5. *Regression results of the growth model*

Predictor	Coefficient	Education t	Correlation
Constant	- 486		
H	1.2888	2.24 > 2.08	0.9136
A	0.1004	3.97 > 2.08	0.9559
E	0.0021	4.11 > 2.08	0.9633
I	0.7137	6.37 > 2.08	0.9741

**Source:* Compiled by the author based on data from the Ministry of Public Administration and Local Self-Government, and the Ministry of Finance of the Republic of Croatia.

According to equation (3), the endogenous growth model is expressed as follows:

$$Y = -486 + 1.2888(H) + 0.1004(A) + 0.0021(E) + 0.7137(I) + ui \qquad (3)$$

From the regression model (3), returns on education, investment, fixed assets, and employment are expressed in terms of real local growth. The return on education, through the human capital variable, is significantly higher compared to returns on investment, fixed assets, and employment (coefficients shown in Table 4). The variables in the regression (3) are expressed in euros. An increase in the level of human capital by approximately 1,000 euros would result in an increase in the local budget by about 1,288 euros. However, the coefficients from (3) strongly indicate that higher rates of local budget growth can be achieved through investment in human capital. The correlation between local growth and the observed variables H, A, E, and I is strongly positive and significant, ranging from 0.9136 to 0.9741. This suggests that as the value of the observed variables increases, so do the revenues of the local budget.

The analysis of the impact of human capital investment on local budget growth, as presented in the results, aligns with the broader theoretical context outlined in the introduction. This discussion interprets the findings in relation to the dynamic conditions of local governance, the increasing emphasis on derived factors such as education, and the role of intellectual capital in driving economic growth.

The results indicate a significant impact of human capital on local budget growth. Specifically, the model (3) shows that an increase in human capital by 1,000 euros results in a local budget increase of approximately 1,288 euros. This finding underscores the importance of investing in education and skill development as a means to enhance local economic performance. This is consistent with the notion discussed in the introduction that human capital—comprising education, expertise, and skills—is a crucial driver of productivity and economic growth (Harmon et al., 2003).

The positive correlation between human capital and local budget growth corroborates the idea that investment in education yields substantial economic benefits, both for individuals and for local governments. This supports the shift from traditional economic factors of production, such as labor and capital, to derived factors like education and technological advancement (Blundell et al., 1999).

The results show that the return on human capital significantly exceeds that of investments in fixed assets, employment, and other traditional variables. For instance, the coefficients for investment (0.7137), fixed assets (0.1004), and employment (0.0021) are substantially lower than the coefficient for human capital (1.2888). This highlights the superior impact of human capital investment compared to other forms of expenditure. This finding aligns with the assertion in the introduction that derived factors, particularly education, play an increasingly important role in economic development (Blundell et al., 1999).

This differential emphasizes that while traditional investments contribute to local budget growth, their impact is less direct and less significant compared to the investment in human capital. The results suggest that local governments could achieve more substantial economic growth by prioritizing education and skill development.

The high positive correlations observed between local budget growth and the variables of human capital, fixed assets, employment, and investment (ranging from 0.9136 to 0.9741) further substantiate the importance of these factors. The strong correlation indicates that higher investments in these areas are associated with increased local budget revenues, reinforcing the idea that strategic investments in these variables are crucial for local economic growth.

This positive relationship supports the notion that enhanced human capital, through improved education and skill development, contributes significantly to economic performance, as suggested by the references (Barro and Martin, 1995; Jorgenson, 1995; Matzavinos and Syed Shariq, 2004). Moreover, the high correlation between human capital and budget growth underscores the effectiveness of investing in education as a means to boost local economic conditions. Given the substantial returns on investment in human capital, local governments are encouraged to prioritize education and training programs. The findings suggest that investing in human capital not only benefits individuals by enhancing their future income but also provides significant societal benefits through improved local budget growth and economic performance (Kara, 2009). This is particularly relevant in the context of increasingly dynamic market conditions that demand effective adaptation and strategic investment in derived factors (Drucker, 1992).

Based on the findings, it is advisable for local governments to reallocate resources to enhance educational programs and training initiatives. The substantial impact of human capital on local budget growth demonstrates that such investments are not merely beneficial but essential for achieving sustainable economic development. This approach aligns with the broader economic theory that emphasizes the importance of education and intellectual capital in driving growth and competitiveness (Harmon et al., 2023; Martens and Balzer, 2004). In summary, the results confirm the significant role of human capital in driving local budget growth and economic development. They align with the theoretical framework that highlights the increasing importance of education and derived factors in modern economic conditions. The findings advocate for a strategic focus on education and skill development as a means to enhance local economic performance and achieve long-term growth.

Conclusion

In conclusion, this study underscores the pivotal role of human capital in driving local economic growth and enhancing budgetary performance. The empirical analysis reveals a strong positive correlation between investments in human capital and increases in local budgets, demonstrating that enhancing educational and professional skills leads to substantial economic benefits. Specifically, the return on investment in human capital significantly surpasses that of investments in fixed assets, employment, and other financial inputs. These findings align with contemporary economic theories that prioritize derived factors such as education, technology, and research over traditional production factors. The data suggests that local governments can achieve more substantial and sustainable economic growth by focusing on education and skill development. This investment not only boosts individual income and well-being but also contributes to broader societal benefits, including improved local budget revenues and economic competitiveness. Therefore, it is recommended that local governments prioritize funding for educational initiatives and professional training. By doing so, they can leverage human capital to stimulate economic growth, enhance the quality of life for their residents, and ensure a more robust and dynamic local economy. The positive impact of investing in human capital emphasizes its critical importance as a driver of economic progress in the modern, globalized business environment.

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FARM MANAGERS IN AGRIBUSINESS OF THE EUROPEAN UNION AND THE REPUBLIC OF SERBIA - COMPARATIVE APPROACH[1]

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Abstract

Managers represent the most important human capital and play a driving role in the efficient development of economic entities and agricultural holdings in rural development. Research in the paper aims to analyze and identify positive and negative trends, similarities and differences in the farm managers structure in the European Union and the Republic of Serbia. Research has confirmed the basic hypotheses. The comparative analysis confirmed that the EU and Serbia share similar characteristics, challenges and problems when it comes to the degree of engagement of professional managers on farms. The involvement of professional managers is directly related to the size and income of the farm. Large farms, due to the volume of operations, to a greater extent hire professional managers in business management. Medium and small farms are faced with numerous challenges in terms of unfavorable age structure, migration, inadequate educational level, gender structure, legal status of employment. This indicates the need for further research in encouraging and giving stronger support to the role of professional management on farms with the aim of sustainable, efficient, effective and profitable business in agribusiness.

Key words: *farm managers, professional management, structure, agribusiness, agricultural holding*

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Introduction

Business-specific practices and culturally dependent management philosophies indicate that managers are the driving force in the efficient development of economic entities in agribusiness and rural development. That is why the term “human capital” in contemporary management is used more and more often (Nedeljković & all, 2023). The term human capital in management means educational capital, labor managers capital, cultural and behavioral capital, as well as intellectual capital (Yakimova & Streltsova, 2019). According to a large number of authors, managers as a human capital occupy a central place and have a special importance for the development of agribusiness in rural areas (Ognjanović & all, 2023; Vukoje, 2022). In addition to technology, natural resources, state and agrarian policy and legislation in agribusiness, managers directly affect the increase in productivity in agriculture, amongst other things, because it has the ability to adapt to technological, innovative changes and modern challenges (Zepeda, 2001; Fikhtner & Shrediva 2019; Diebolt & Hippe, 2019).

Human resources, land and capital represent the already well-known “trilogy of factors of production in agriculture” according to the theory of economic analysis (Popesku & all, 2021; Schumpeter, 1987). Farm managers have a key role in harmonizing these factors in order to ensure the sustainability and development of farms. Managers of agricultural holdings perform specific roles (interpersonal, informational, operational), functions (planning, organizing, personnel, management, control) and use a range of skills (technical, humane, conceptual) in order to run an efficient, effective and profitable business (Zečević & all, 2023; Zečević & all, 2022). They play a key role in management activities that include business initiation, risk reduction, management and direction of all farm activities.

Also, managers are initiators of change and introduce new ideas and effective solutions with the application of modern scientific and information technologies in business practice (Nedeljković & Tomić, 2023). In addition to the fact that they represent the basic drivers of successful business, the special role of farm managers is in the introduction and application of innovative approaches in the decision- making process (Arnautović & all, 2022; Radović & all, 2019).

Agricultural holding managers are responsible for daily supervision of operations and strategic management (Gardašević & all, 2022). This role entails a diverse range of responsibilities including yield monitoring, financial planning, production sustainability. Their role, apart from production, includes interactions with suppliers, customers and ensuring compliance with agricultural standards and regulations (Carić & all, 2022). For these reasons, an efficient and successful farm manager must possess broad agricultural knowledge, leadership qualities and business skills in managing the complex operations of a modern farm.

In the modern environment of Europe, and more and more often here in Serbia, there is an increasingly present tendency to recognize the role and importance of professional management and the necessity of hiring managers as professional management personnel who represent the main drivers in the development of farms and agricultural production.

In the rural areas of the European Union, and also in Serbia, the population is relatively high, and agricultural production is the main source of income and affects the living standard of the local population (Popescu & all, 2021; Pavlak & Pocztaw, 2020; Erokhin & Tianming, 2021). One of the basic problems in the management of agribusiness in the European Union, as well as in Serbia, is the general trend of the decline of professional staff engaged in management activities in agriculture. The negative aspect is caused by the structure of management staff (owners of agricultural holdings are also managers in the largest number of farms), the age structure and the migration of young professional staff to urban areas and abroad looking for better-paid jobs (Georghe & all, 2022). For these reasons, it is evident the necessity of engaging expert, professional managerial staff in management and managerial tasks with the aim of increasing labor productivity, improving the farm structure and ensuring the sustainability, growth and development of the farm (Pavlak & all, 2021).

In agribusiness in the European Union, and also in Serbia, managers of agricultural holdings are characterized by an unfavorable age and gender structure, form of employment, and educational level. It is characteristic that these parameters are constantly changing and vary from country to country but also between different regions within the country (Ćurčić & all, 2022).

In this context, the aim of the work is to analyze the existing structure of management and management staff at agricultural holdings in the European Union and Serbia in relation to key parameters such as age structure, gender, level of education, training and experience.

Based on the available literature, the research in the paper is based on two hypotheses:

- Unfavorable age structure, migration of younger professional staff to urban areas, inadequate educational level of management staff are limiting factors for more efficient operations in the agribusiness of the European Union and Serbia.

- In Serbia and the European Union, the engagement of trained, professional managerial staff is directly conditioned by the size of the agricultural holding and the amount of income it generates. Professional managerial personnel are engaged in leading and managing large farms, while in smaller agricultural holdings, the owners or family members are the bearers of managerial roles.

Methodology

During the research in this paper, in order to observe and analyze the selected data and the comparative and deductive method, the method of induction, analysis and synthesis were used. The methodological framework and comparative analyses used an overview of the current state of situation in farm managers structure in agricultural sector in EU and Serbia. That supports the acceptation and adaptation of adequate conclusions that would be a key mechanism for the development of sustainability, efficiency and profitability in agribusiness. The structure of the work and the conducted research are aligned with the use of relevant data from the Statistical Office of the Republic of Serbia (SORS) and Eurostat as well as with the use of current scientific and professional domestic and foreign literature. For better understanding, all monitored indicators are presented in tables.

Results and discussion

Farm Managers in the EU: the situation in the agricultural sector

The European Union represents one of the world's most important players in agribusiness. Agriculture is the main sector of the economies of the European Union countries where employment is still at a high level. The structure of the management staff is conditioned by various parameters such as the organizational form and size of the farms, the amount of income generated on the farms, the form of employment of the managers, their level of education, gender and age structure. In relation to the ownership and organizational form (family and non- family) farms, the data indicate that the percentage of managers employed in family agricultural holdings is much higher (95.3%) (Table 1). In terms of age structure, the highest percentage of managers is in the age group between 40 and 64 years (of which 55.7% in family and even 69.5% in non-family agricultural holdings). Also, a high percentage of managers in family agricultural holdings are managers in the age group over 65 (33.9%). An unfavorable trend is expressed in the age structure of younger managers under the age of 40. This is especially pronounced in family agricultural holdings, where the percentage is 10.4. In the European Union, there are differences in the representation of farm managers and their age structure by country. So, for example, the countries with more prominent younger farm managers under the age of 40 are Poland (282 thousand) and Romania (250 thousand). The countries with the largest number of family agricultural holdings whose managers are between 40 and 64 years old are Poland (394 thousand), Spain (489 thousand), Greece (394 thousand). The European Union countries with the oldest population of managers on family farms, over 65 years old, are Romania (1514 thousand), Italy (459 thousand), Hungary (130 thousand),

Portugal (130 thousand) (EUROSTAT, 2018).

Table 1. *Farm managers in the EU by type of farm and age group (EU- 28)*

Age group	Family farms		Non-family farms	
	Numbers in thousands	Percent	Number in thousands	Percent
65 years and over	3325	33,9	66	13,8
40 – 64 years	5474	55,7	336	69,5
Less than 40 years	1022	10,4	81	16,7
Total	9823	95,3	483	4,7

Source: Eurostat, 2018.

The data indicate the necessity of including younger human resources in the management structure of family agricultural holdings in order to facilitate adaptation to modern challenges, productivity, efficiency, growth and development of family agricultural holdings. In the structure of farm managers in the European Union, there are pronounced differences in terms of gender and age structure. This is particularly reflected in the data that about two-thirds (70.7%) of farm managers in the European Union are men (Table 2).

Table 2. *Age and gender structure of EU farm managers (%)*

Age group	Male farm manager	Female farm manager
65 and over	21,0	12,5
55 - 64	18,5	7,0
45 - 54	17,5	5,3
40 - 44	6,0	2,0
35 - 39	4,0	1,5
25 - 34	3,5	1,0
Less than 25	0.2	0
Total	70,7	29,3

Source: Eurostat, 2020.

Data from Table 2 show that farm managers belonging to the older age group dominate in the European Union. In the structure of both sexes, the largest number of managers belongs to the age group over 55 (59%), while this level is extremely unfavorable in the structure of younger managers under 25 (4.7% of both sexes in total). A significant percentage is in the age structure of 40 to 54 years, in which 25.5% of managers are men, and only 7.3% are women (Table 2). In the countries of the European Union, there are also regional differences with regard to this parameter. Thus, for example, a low percentage of participation of women farm managers is characteristic in Germany (9.6%), Denmark (7.7%), Malta (6%), the Netherlands (5.2%). A high percentage of female farm managers is characteristic of the Baltic states of Latvia, Lithuania, and Estonia, where women are represented as managers in about 45% of farms (Eurostat, 2021).

The structure of management staff in agricultural holdings in the EU is characterized by a much higher representation of men (nearly two thirds, 70.7%) compared to female farm managers (close to a third, 29.3%) (Eurostat, 2020).

Data related to the gender structure of farm managers depending on the size of the agricultural holding show the dominant role of men as farm managers (Table 3). It is especially pronounced on smaller family agricultural holdings, but also on medium and larger farms (below 50 ha) and amounts to 90 percent or more.

Table 3. *Gender structure of managers on EU farms by size, 2020 (%)*

Farm size	Female	Male
< 2 ha	4,12	95,80
2 – 5 ha	7,74	92,96

Farm size	Female	Male
5 – 10 ha	8,63	91,37
10 – 20 ha	10,34	89,66
20 – 30 ha	6,85	93,15
50 – 50 ha	9,92	90,08
50 – 100 ha	14,42	85,58
> 100 ha	37,87	62,13

Source: Eurostat, 2021

The significant participation of women farm managers increases with the increase in the size of the land available to the farms. On farms over 100 ha, more than one third (37.87%) are managers (Eurostat, 2021). Through various development programs, the EU encourages and supports the development of female entrepreneurship in rural areas. The aim of these incentives is not only to establish a balance in the gender structure of farm managers, but also to emphasize greater competitiveness, reduce migration and sustainable development of rural areas for future generations (Babić & all, 2023).

One of the important parameters of the sustainability of human resources in rural areas is the educated structure of farm managers.

Table 4. *Educational structure of farm managers in the EU (%)*

	2018	2020
% with practical experience	68,3	72,3
% with basic training	22,6	17,5
% with high school education	9,1	10,2

Source: Eurostat, 2020

Based on the data from Table 4, most farm managers in the European Union have only practical experience. That percentage in 2020 is 72.3 and has increased by 4% compared to 2018. A particularly unsatisfactory trend is in the structure of highly educated farm managers. The fact that only one out of ten farm managers has complete agricultural education and training (10.2%) is worrying, while the remaining percentage of 17.5 in 2020 consists of managers with basic training in agriculture (Eurostat, 2020). Regional differences within the European Union are also expressed in this parameter. A small number of EU member states have a high percentage of farm manager training, such as the Netherlands (62.6%), Luxembourg (53.1%), France (38.4%), the Czech Republic (35.8%). The lowest level of training of farm managers who have full training is in Romania (0.4%) and Greece (0.6%). It is characteristic that these are also the countries (Romania 96.7%, Greece 93.2%) in which the largest share of farm managers whose educational structure is based exclusively on practical experience (Eurostat, 2020). These regional differences are expressed due to differences in national laws, education systems, employment systems and personnel policies of states and regions in the EU (Zečević & Nedeljković, 2014).

Farm managers in the Republic of Serbia: the situation in agribusiness

Farms represent the basic organizational form of business in Serbian agribusiness. The role of the farm manager is to ensure the sustainable and profitable development of the agricultural holding as well as to support the welfare of the wider community (advances the image of the local community, employs local labor, affects the reduction of the migration process, especially of youth and female population, empowers the local budget, etc.) (Jeločnik & all, 2020).

In the structure of family agricultural holdings according to agricultural holding holders and managers and according to gender in the Republic of Serbia, male participation is dominant according to all parameters. The participation of women among managers of agricultural holdings is lower than their participation among holders of agricultural holdings (15.3%), while the participation of men among managers is far more pronounced and amounts to 84.7% (SORS, 2018).

The data from Table 5 indicate that the managers of agricultural holdings are predominantly older persons and that the number of agricultural holdings whose managers belong to the oldest category is increasing. More than 39% of agricultural holding managers in the age category are over 65 years old. An extremely worrying fact is that only 3% of managers belong to the younger category between 25 and 34 years old.

Table 5. *Farm managers by age and gender in the Republic of Serbia, 2018.*

Age	Female	Male	Total
over 65 year	51,1	36,9	39,1
55 – 64 year	26,9	29,5	29,1
45 – 54 year	15,0	20,1	19,3

Age	Female	Male	Total
35 – 44 year	5,3	10.0	9,3
25 – 34 god.	1,6	3,2	3,0

Source: SORS, 2018

There are also pronounced differences when it comes to the gender structure. The share of women performing the role of farm manager is much higher in the age group over 65 and amounts to more than half, 51%, while it is markedly low (1.6%) in the younger category. A balanced ratio is only present in the 55 to 64 age group category (26.9% of female and 29.5% of male managers) (SORS, 2018). The age structure of managers in the Republic of Serbia is deteriorating. This is indicated by the fact that the share of managers in the oldest group in 2020 compared to 2012 increased by 6.1%, while the share of farm managers under the age of 35 decreased by 1.4% (SORS, 2020).

The size of farms affects the engagement of professional management staff in the harmonious development of specific agricultural activities (Dobre & all, 2021). Table 6 shows the gender structure of farm managers in relation to the size of the agricultural holding. Based on the data from Table 6, it can be concluded that the share of women among farm managers decreases with the increase in the size of the agricultural holding.

Table 6. *Structure of managers by gender and size of agricultural holding in RS, (%)*

Farm size	Female	Male
< 1 ha	19,3	80,7
1 – 2 ha	18,4	81,6
2 – 5 ha	14,7	85,3
5 – 10 ha	12,2	87,8
10 – 20 ha	9,9	90,1
20 – 50 ha	7,3	92,7
50 – 100 ha	4,6	95,4
> 100 ha	5,8	94,2

Source: SORS, 2018.

The largest share of women among farm managers (19.3%) is in farms smaller than 1 ha. With the increase in farm size, the share of male manager’s increases, while the share of female managers of the largest agricultural holdings over 100 ha is only 5.8% (SORS, 2018).

Table 7. *Structure of farm managers according to gender and economic size of agricultural holding in the Republic of Serbia (%)*

Income in EUR	Female managers	Male managers
0 - 2000	21,1	78,9
2000 - 4000	16,8	83,2
4000 - 8000	13,3	86,7
8000 - 15000	10,6	89.4
15000 - 25000	8,4	91,6
25000 - 50000	7,3	92,7
50000 - 100000	6,5	93,5
> 100000	6,2	93,7

Source: SORS, 2018

Depending on the economic size of the farms based on the data from Table 7, a higher share of male managers is evident and it increases with the increase in the economic size of the farms. The share of women among managers decreases with the increase in the economic size of the farm. The largest share of women among farm managers is present in agricultural holdings up to 2,000 eur (21%), and the lowest among farm managers with over 100,000 eur (6.2%).

An important parameter is the legal status of the workforce and management on farms. Data from Table 8 indicate that over 90% of agricultural holding holders are also managers and main decision makers on farms.

Differences are evident on medium-sized farms (from 5 to 20 ha). On farms of this size, there is a slightly higher percentage (6.4%) of family members who are in the position of manager. The highest percentage of employed professional managers is on farms of 10-50 ha and amounts to 5.1%. However, it is characteristic that the largest agricultural holding, over 100 ha, also has the highest share of agricultural holding holders who also perform the function of manager.

Table 8. *Agricultural holding managers according to legal status and size of agricultural holding in the Republic of Serbia, 2018 (%)*

Farm size	Farm holder manager	Family member manager	Employed manager
< 1 ha	92,6	4,5	2,9
1 - 2 ha	90,9	6,0	3,1
2 - 5 ha	90,2	6,5	3,3
5 -10 ha	89,3	6,4	4,3
10 - 20 ha	88,9	6,0	5,1
20 -50 ha	90,6	4,3	5,1
50 - 100 ha	93,2	3,6	3,1
> 100 ha	94,5	3,2	2,1

Source: SORS, 2018

The educational profile of farm managers in Serbia in terms of specialized knowledge and professional training is extremely unfavorable (Table 9).

Table 9. *Agricultural holding managers by level of education in the Republic of Serbia (%)*

Type of training and education	Serbia	Belgrade region	Vojvodina	Šumadija Western Serbia	Southern & Eastern Serbia
Practical experience	95,3	96,4	89,9	96,9	96,8
Basic training	3,4	2,2	7,8	2,2	2,1
High education	1,3	1,5	2,2	0,9	1,1

Source: SORS, 2020.

The largest number of managers belong to the structure that performs its function on the basis of practical experience. An extremely low percentage is among managers who possess specialized knowledge (1.3%) or have attended specialized professional courses and trainings. Observed according to the regions in Serbia, this percentage is somewhat more favorable in Vojvodina (2.2%), and the lowest in the region of Western Serbia and Šumadija, amounting to only 0.9%. A more favorable percentage in the educational structure of farm managers is in larger agricultural holdings, especially in those that generate large revenues. This is the result of the more favorable age structure of the managers of larger agricultural holdings and the need to hire professional managers with specialized knowledge due to the greater volume of work and the application of innovative solutions.

Conclusion

The development of management and entrepreneurship in the agribusiness of Europe and Serbia is the basic assumption of further development, sustainability and improvement of competitiveness in this sector. Managers have a central role in the efficient performance of entrepreneurial functions that influence the development of economic entities and agricultural holdings in rural areas.

Through a comparative analysis of the situation in the European Union and Serbia, the research in the work aimed to identify key problems in the management structure of agricultural holdings, which has an impact on the understanding of roles and the need for greater involvement of professional management staff on farms.

Research in the work based on a comparative analysis in the EU and Serbia confirmed the initial hypotheses. European agriculture and Serbian agriculture have similar characteristics in terms of the management structure and the involvement of managerial staff at agricultural holdings.

In relation to the ownership and organizational form of the farm, it is evident that in both the EU and Serbia, the percentage of managers employed in family agricultural holdings of which they are the owners is very high (95.3% in the EU, and over 90% in Serbia). The age structure of managers in EU and Serbian agribusiness is very unfavorable. Research has shown that in the agribusiness of the EU and Serbia, farm managers who belong to the older age group dominate (33.5% of managers in the EU are over 65 years old, while in Serbia that percentage is 39.1%).

A common problem in agribusiness in the EU and Serbia is depopulation and internal and external migration of managerial resources. This is particularly pronounced in Serbia, where the share of farm managers younger than 35 in 2020 is 1.4% lower than in the previous period. In the EU, this trend is particularly pronounced in the countries of our geographical region, such as Romania, Hungary and Bulgaria.

The role of women farm managers in the development of entrepreneurship and the development of agriculture is significant in the EU, and it is also recognized in Serbia. However, the share of female farm managers in the EU and Serbia differs. The share of women managers of agricultural holdings in the EU is 29.3%, while in Serbia this percentage is almost twice as low and is 15.3%). Also, in Serbia compared to the EU, the share of women in the management structures of small agricultural holdings is higher and amounts to 19.3%. In the EU, the participation of women managers on large farms (over 100 ha) is more pronounced and it amounts to more than 1/3 (37.87%). These parameters point to the need to take more effective support measures and strengthen incentives for women's participation in the management structure of farms.

One of the important parameters that needs to be emphasized in order to strengthen the abilities and skills of farm managers is the educational level, training and training. The educational structure of farm managers in the EU and in Serbia is largely unfavorable. This is indicated by the fact that the largest number of farm managers in the EU perform their management activities based on practical experience and basic training (72.3%). That percentage is even more pronounced in Serbia and amounts to 95.3%. Unlike the EU (where 9.1% of farm managers are highly educated), the percentage of professional managers with formal higher education in Serbia is extremely low and amounts to only 1.3%. This indicates the need to strengthen the motivation and inclusion of young staff in various formal and informal forms of education, greater availability of information and monitoring of modern trends through special management training and training.

Research has also confirmed the second hypothesis that the engagement of professional managerial staff on farms, both in the EU and in Serbia, is conditioned by the size of the farm and the amount of income it realizes. Due to the complexity and scope of operations, professional management is engaged in a far greater percentage in the management of large farms. Small farm owners are also managers, often with less professional skills and education, and perform their management activities and operations based on experience. In order to sustain and develop family farms, it is necessary to constantly raise the educational level and introduce professional management.

Research in the work aimed at identifying key indicators that point to the necessity of a more significant involvement of professional managerial staff on farms, both in the EU and in Serbia. This indicates the need for further research in the area of encouraging and strengthening the role of professional management with the aim of developing efficient, effective and profitable business in agribusiness.

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COMPARATIVE STUDY ON THE COMPETITIVENESS OF ROMANIA'S AGRI-FOOD SECTOR IN THE EUROPEAN CONTEXT

Gabriel Mazilu Alexandru[1]

Abstract

This thesis addresses the competitiveness of Romania's agri-food sector within the context of the European economy, focusing on aligning Romanian agriculture with EU standards. It aims to analyze the current European framework and propose concrete measures to improve competitiveness. The study investigates how Romania's agri-food sector can achieve economic performance comparable to other EU countries. The main objective is to explore opportunities for enhancing competitiveness by adapting to new EU policies and increasing innovation. Chapter I provides a theoretical analysis of competitiveness and the agri-food sector, highlighting the impact of the post-2020 Common Agricultural Policy. Chapter II evaluates Romania's trade balance in the agri-food sector relative to other EU states. Chapter III proposes specific measures to improve competitiveness across various sub-sectors. Conclusions summarize key findings and offer recommendations for boosting competitiveness. The study is based on European and national statistics, presenting a development model suited to current economic realities.

Key wrods: *competitiveness, agriculture, innovation.*

Introduction

In today's economy, competitiveness is fundamental to sustainable growth and the effective integration of national economies into the global marketplace. The agri-food sector is especially important, not only for ensuring food security but also for generating added value through complex production and distribution chains. Assessing the competitiveness of this sector in Europe requires a comprehensive approach that considers internal factors, such as technological innovation, operational efficiency, and external influences, including the Common Agricultural Policy (CAP) and global market dynamics.

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This sector faces substantial challenges, including ongoing climate change, price volatility, and increasingly strict food safety regulations. As a result, competitiveness hinges on the capacity of farmers and food processors to adapt and innovate, with critical support from public policies. CAP, along with European strategies for bioeconomy and sustainability, plays a significant role in this context, influencing both production practices and market access. These policies are designed to support sustainable practices, promote ecological transitions, and open international market opportunities, all of which are vital to strengthening the sector's long-term performance and resilience in a rapidly changing global economy.

Analyzing the competitiveness of Romania's agri-food sector within the European context is essential for understanding the country's position in the common market, identifying new opportunities, and addressing challenges faced by this crucial sector. With European standards for production and quality increasing each year, it's vital for Romania's agricultural and food industries to continuously improve to remain competitive within the EU. This analysis provides an overview of productivity, efficiency, and innovation in Romania's agri-food sector, highlighting both strengths and areas needing improvement.

Comparing Romania with other EU countries reveals differences influenced by factors such as land quality, infrastructure, labor conditions, and the use of advanced technologies. Insights gained from this comparison can help Romania adapt and apply agricultural and support policies from other countries to improve low-performance areas or enhance competitive advantages where they already exist.

Conceptual Approaches to Competitiveness and the Agri-Food Sector in the European Context

Competitiveness and international trade, facilitated by various exchange mechanisms and innovations, are essential for a dynamic global economy. International trade provides access to new resources, larger markets, and advanced technologies, allowing nations to overcome the constraints of domestic markets. This expanded access creates numerous opportunities that foster innovation, enhance production efficiency, and contribute positively to standards of living and employment.

Competitiveness is defined by an economy or company's ability to produce and deliver goods and services that meet global market demands. Achieving competitiveness can be a result of high-quality offerings, lower production costs, or an optimal blend of both. Innovation, infrastructure, advanced technology, education levels, and supportive national policies are key determinants of competitiveness.

Trade theory sheds light on the mechanisms and benefits of international trade, forming a cornerstone of international economics. Adam Smith's theory of absolute advantage and David Ricardo's theory of comparative advantage underscore the benefits of nations specializing in goods they produce most efficiently, driving global prosperity through trade. The Heckscher-Ohlin model later expanded on this by focusing on a nation's abundance of production factors, such as labor, capital, and natural resources, as determinants of trade patterns. Paul Krugman's concept of economic geography added another dimension, emphasizing the role of economies of scale and transportation costs in the formation of economic hubs, which often evolve into major centers of trade and industry.

In conclusion, these foundational theories illustrate the ways in which international trade and specialization lead to increased economic efficiency and shared global prosperity. They offer insights into why nations engage in trade and how they can leverage its benefits to optimize their growth and development.

Determinants of Competitiveness: Competitiveness Theories

Economic competitiveness represents a country's, regions, or company's capability to compete effectively in international markets. A variety of interrelated factors influence competitiveness, each contributing uniquely to its complex and dynamic nature.

Human capital is one of the fundamental determinants of competitiveness. The education, skills, and health of a workforce are vital in enhancing productivity and fostering innovation. Investments in human capital, such as vocational training and higher education, bolster long-term production and competitiveness by creating a workforce capable of adopting new technologies and optimizing current processes.

Robust physical and digital infrastructure is also crucial. Developed infrastructure in transportation, energy, and telecommunications reduces transaction costs, increases market access, and enhances the mobility of labor and goods, thus supporting a competitive business environment. In addition, the continuous advancement of technology and its swift adoption are necessary for maintaining a competitive edge. Research and development drive this progression by fostering a business environment that adapts quickly to change, ensuring sustained competitiveness.

Government policies and economic regulations are another determinant of competitiveness. Fiscal policies, labor laws, intellectual property protections, and trade policies can significantly impact the business climate. Supportive policies create a stable and predictable environment for business, attract investment, and facilitate infrastructure, education, and innovation. For instance, tax incentives for research and development encourage investment in new technologies, further enhancing competitiveness.

Cultural and social factors, including entrepreneurial culture, attitudes toward risk, and societal norms, also play a role in shaping competitiveness. Cultural values influence economic behaviors, as noted by Geert Hofstede. Societies that value independence and embrace risk-taking tend to be more innovative and competitive in global markets, fostering leaders and entrepreneurs who drive economic growth.

In sum, these elements collectively define the intricate landscape of economic competitiveness, highlighting how a strategic mix of education, infrastructure, policy, technology, and cultural openness can propel a nation or organization to success in the global market.

Specifics of Competitiveness in the Agri-Food Sector: The European Single Market and Competitiveness Prospects in the New Post-2020 Common Agricultural Policy

The agri-food sector is a key contributor to the European Union's economy, playing a crucial role in GDP, employment, and food security. Its competitiveness is shaped by factors such as diverse climates, farm structures, technological levels, and EU policies. The establishment of the European Single Market in 1993 marked a turning point, allowing free movement of goods, services, capital, and labor. By eliminating trade barriers and harmonizing health and safety standards, it opened new markets for agricultural producers, helping boost competitiveness through economies of scale and innovation.

The Common Agricultural Policy (CAP), which has evolved since its creation in 1962, supports a more sustainable and resilient agricultural sector. The post-2020 CAP reform emphasizes sustainability and climate goals by encouraging eco-friendly farming practices, such as crop rotation, the use of organic fertilizers, and preserving biodiversity. These practices aim to meet consumer demand for environmentally conscious products while improving soil health and reducing greenhouse gas emissions.

Innovation and digitalization are also central to the sector's competitiveness. Tools like the Internet of Things (IoT) enable precision agriculture, allowing farmers to monitor soil and weather conditions, reduce water usage, and manage resources more efficiently. Drones and artificial intelligence further enhance productivity by enabling remote field monitoring and optimized planning.

Additionally, CAP prioritizes support for young farmers and small local producers. Through grants, mentorship, and training programs, young farmers under 40 can more easily access financing and overcome entry barriers. This approach not only encourages a new generation to join agriculture but also promotes knowledge transfer and long-term sector stability.

In summary, CAP's focus on sustainability, technology, and youth support aims to strengthen the EU's agri-food sector, ensuring it remains competitive, resilient, and capable of adapting to global challenges.

Analysis of the Competitiveness Level of the Romanian Food Sector

According to the data presented in Table 1, there are five categories contributing to a surplus in Romania's trade balance, while nineteen other categories show a deficit. It can be observed that the trade surplus is primarily generated by raw materials such as cereals, seeds, oilseeds, and live animals. On the other hand, the deficit is driven by imported finished products with higher added value, such as processed cereals, animal-derived products (dairy, eggs, honey, etc.), and meat and edible offal.

Table 1: *Trade Balance of Agro-Food Products in Romania (2011-2022)*

Romania	2011	2016	2022	Media	Dev.S	Coef de V.	2022/2011
Cereale	1017689	1666460	3575183	2093563.4	799129.1	38.17%	3.51
Semințe și fructe oleaginoase; boabe, semințe și fructe diverse; industriale s	777649	912898	979612	794022.5	227830.6	28.69%	1.26
Animale vii	196947	229013	306126	241242	55040.93	22.82%	1.55
Tutun și înlocuitori de tutun prelucrați; produse, cu sau fără nicotină, ...	336876	494540	1139786	635843.17	325487.3	51.19%	3.38
Grăsimi și uleiuri animale, vegetale sau microbiene și produsele disocierii ac	-1001	4399	192165	42664.417	64908.34	152.14%	191.97
Materiale pentru împletituri vegetale; produse vegetale nedenumite și necu	102	968	-2264	-51.16667	831.3078	-1624.71%	-22.20
lac; gume, rășini și alte seve și extracte vegetale	-23338	-29805	-36558	-29174	4691.65	-16.08%	1.57
Produse de origine animală, nedenumite și necuprinse în altă parte	-28245	-29054	-53518	-32532.75	11630.13	-35.75%	1.89
Produse ale industriei morăritului; malț; Amidon; Inulină; gluten de grâu	-117672	-87075	-102893	-107139.1	12309.26	-11.49%	0.87
Preparate din carne, din pește, din crustacee, din moluște sau din alte never	-1523	-13931	-142467	-47933.25	51505.77	-107.45%	93.54
Arbori și alte plante vii; bulbi, rădăcini și altele asemenea; flori tăiate și frun	-112178	-124582	-237756	-149361.6	45428.24	-30.41%	2.12
Pești și crustacee, moluște și alte nevertebrate acvatice	-113781	-171408	-288655	-185302.3	54601.67	-29.47%	2.54
Cacao și preparate din cacao	-144366	-210290	-293647	-216855.4	55398	-25.55%	2.03
Cafea, ceai, maté și condimente	-200169	-240893	-358360	-248640.6	49532.63	-19.92%	1.79
Reziduuri și deșeuri din industria alimentară; furaje preparate pentru animal	-242534	-236551	-415593	-313634.8	78692.18	-25.09%	1.71
Preparate din legume, din fructe, din fructe cu coajă lemnoasă sau din alte pă	-145130	-248832	-421435	-267837.9	97254.75	-36.31%	2.90
Zaharuri și produse zaharoase	-319658	-242145	-422877	-285701	64422.48	-22.55%	1.32
Preparate din cereale, din făină, din amidon, din fecule sau din lapte; Produs	-178132	-277086	-497210	-310641.8	107443.9	-34.59%	2.79
Legume comestibile și anumite rădăcini și tuberculi	-134184	-307826	-512418	-310142.9	148823.3	-47.99%	3.82
Preparate comestibile diverse	-233227	-265648	-535885	-337253.1	111099.5	-32.94%	2.30
Băuturi, băuturi spirtoase și oțet	-166097	-225765	-613840	-292337.2	161250.6	-55.16%	3.70
Produse lactate; ouă de păsări; miere naturală; produse comestibile de origir	-234132	-271344	-754764	-352285.1	191030	-54.23%	3.22
Fructe comestibile și fructe cu coajă lemnoasă; coji de citrice sau pepeni	-158343	-564553	-773468	-520210.8	226667	-43.57%	4.88
Carne și organe comestibile	-316386	-450032	-1024424	-574089.9	249555.4	-43.47%	3.24
TOTAL	701303	1216428	2550759	1519473.5	625231.5	41.15%	3.64

The trade balance has remained positive, with a cumulative increase of 3.64 times from 2011 to 2022, rising from $701,303 thousand to $2,550,759 thousand, with an average of $1,519,473 thousand. This demonstrates the importance of surplus-generating categories, especially cereals, which have become the main contributor to the positive trade balance. The surplus from cereal exports grew significantly by 351% from 2011 to 2022, rising from $1,017,689 thousand to $3,575,183 thousand, with an average of $2,093,563 thousand.

Romania's Position within the EU from the Perspective of the Competitiveness Level of the Agri-Food Sector – A Comparative Approach

To determine Romania's position in terms of the competitiveness of its agri-food sector, I chose to analyze the trade balance results over three different time periods to observe its evolution and current standing. The analysis was conducted for six subcategories of the agri-food sector, as discussed in the previous subsection, and was compared with other EU member states in order to assess Romania's competitiveness.

Tara/produs	Cereale	Oleaginoase	Animale vii	Prep. Cereale	Carne și organe	P. origine animală
Austria	-59367	-206891	-40187	2381	288571	467217
Belgia	-1555266	-1593909	-223634	1507296	2453517	-494
Bulgaria	883951	962856	-758	88769	-307566	-44733
Croaţia	38723	30022	-108151	-110060	-195012	-91146
Cipru	-167496	-9913	-366	-104418	-50927	-6731
Republica Cehă	569989	59835	220993	-201853	-830421	202850
Danemarca	329186	103074	862092	227185	3814823	1942155
Estonia	28476	47060	60311	-36768	-73844	151042
Finlanda	242347	-139265	921	-320204	-102148	210990
Franţa	9775286	488762	2332852	693418	-933306	4066473
Germania	-45270	-3989718	-353985	2550063	1996913	2318376
Grecia	-355569	-198664	-78306	-195293	-1406359	-659743
Ungaria	1714497	672399	230045	-108212	761842	-58618
Irlanda	-150191	-57558	218804	816201	2581284	1836362
Italia	-2942045	-870172	-2101617	3187803	-3856245	-2299856
Letonia	100642	38090	54704	-26053	-120190	106334
Lituania	252765	94968	62643	5413	44040	414913
Luxemburg	-29457	5618	43213	-82739	-140415	-32073
Malta	-34157	-6510	-325	-53278	-69124	-57275
Olanda	-2659159	-2085444	1235757	1772772	5134541	5147893
Polonia	-165736	-420084	-127508	584412	1833005	1339004
Portugalia	-1096077	-698140	-202188	-297969	-936219	-301054
România	1017689	777649	196947	-178132	-316386	-234132
Slovacia	201900	290933	125259	-191572	-365856	-24861
Slovenia	-92967	-9643	30415	-122553	-149348	196
Spania	-2846667	-2001768	77702	-85124	3141285	-1154312
Suedia	87758	-115065	-2748	91422	-1104655	-614082

Cereals: Romania had $1,017,689,000, with France leading at $9,775,286,000
Seeds and oilseeds: Romania ranked 7th with $777,649,000, behind Bulgaria, Hungary, and France
Live animals: Romania was 7th with $196,947,000, with the Netherlands, France, and Denmark leading
Cereal preparations: Romania ranked 19th with a deficit of -$178,132,000
Meat and organs: Romania ranked 16th with a deficit of -$316,386,000
Animal products: Romania ranked 15th with a deficit of -$234,132,000

Conclusions

The competitiveness of the agri-food sector within the European context is an ever-evolving topic that plays a crucial role in shaping the economy of countries, including Romania. As global demands for food and agricultural products grow, it is essential for countries to continuously adapt, innovate, and improve their agricultural practices to stay competitive. In particular, the ability to meet consumer needs and market demands requires ongoing changes and innovations in production methods, technology, and sustainability practices. Without these efforts, countries risk losing their competitive edge in an increasingly globalized market.

In recent years, European countries have faced significant challenges and transformations due to the reforms introduced by the Common Agricultural Policy (CAP) in 2020. These reforms emphasize sustainability, environmental protection, and the long-term health of the planet over short-term economic profits. As part of these changes, Romania, like other European nations, has had to adopt new strategies and policies focused on innovation, modernization, and ecological farming methods. This shift is critical for Romania to remain competitive within the European Union, especially as the agri-food sector continues to play a key role in both national and international markets.

Romania has made notable progress in certain areas, such as the production of raw materials like cereals and oilseeds. These sectors have allowed Romania to position itself as a key player on the European stage, with the country ranking highly in the production and export of such commodities. However, despite these successes, Romania faces significant challenges in the production and export of finished products, such as meat and cereal-based processed goods. The country's competitiveness in these areas remains weaker compared to other EU countries, highlighting the need for further investment in value-added processing and product diversification to improve its overall standing in the European agri-food sector.

Overall, while Romania is making strides in key areas, the country's ability to maintain and grow its competitiveness in the European agri-food sector will depend heavily on its ability to embrace innovation, improve production efficiency, and adapt to the ever-changing demands of the global market. These efforts will be essential in ensuring Romania's place as a competitive player within the EU in the years to come.

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SUSTAINABILITY REPORTING IN TRANSITION: COMPARING EU AND WESTERN BALKAN PRACTICES

Gligorija Rnjak Punos[1]*, Goranka Knezevic*[2]

Abstract

This paper examines the development of sustainability reporting, focusing on the European Union's (EU) regulatory framework, including the Corporate Sustainability Reporting Directive (CSRD) and European Sustainability Reporting Standards (ESRS) which mandate detailed reporting on environmental, social, and governance (ESG). It explores how these regulations enhance corporate transparency and accountability while assessing their impact on the Western Balkans, which are in various stages of alignment with EU standards as part of the accession process. The study highlights specific challenges faced by the Western Balkans, such as limited regulatory capacity, technical expertise gaps, and implementation costs. It contrasts mandatory reporting in EU countries with the predominantly voluntary approach in the Western Balkans, identifying opportunities for improvement.

By analyzing corporate reports and conferences, the paper identifies barriers and opportunities for alignment with EU standards, emphasizing capacity building. The goal is to evaluate sustainability reporting across regions and propose strategies to bridge the gap between EU and Western Balkan practices.

Key words: *CSRD, ESRS, Taxonomy Regulation, Environmental, Social, and Governance (ESG), Western Balkans.*

Introduction

The 2015 Paris Agreement and UN 2030 Agenda elevated global awareness of climate change and sustainability. The EU responded with initiatives like the European Green Deal and CSRD, integrating environmental, social, and governance (ESG) factors into corporate reporting, influencing both EU member states and neighboring regions like the Western Balkans.

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One major milestone was the European Commission's 2018 *Action Plan for Financing Sustainable Growth*, which outlined ten key actions to reorient capital flows toward sustainable economies, integrate sustainability into risk management, and foster transparency in corporate governance (European Commission, 2018). Subsequently, the European Green Deal of 2019 set the ambitious target of achieving climate neutrality across Europe by 2050 (European Commission, 2019a).

The foundation of EU sustainability reporting legislation began with the 2014 Non-Financial Reporting Directive (NFRD), which required large public-interest companies with more than 500 employees to disclose non-financial information, including diversity data (The European Parliament and the Council of the European Union, 2014). Although the NFRD marked a significant step, it faced criticism for limited comparability, consistency, and reliability in reported information.

To address these gaps, the Corporate Sustainability Reporting Directive (CSRD) entered into force on January 05, 2023, significantly expanding the scope and depth of reporting requirements. The CSRD mandates detailed disclosures on environmental, social, and governance (ESG) matters, integrates the concept of double materiality, and requires external assurance and digital tagging of reported information. Implementation is phased, beginning with companies already under the NFRD in 2025 (for FY 2024), other large companies in 2026 (for FY 2025), and listed SMEs in 2027 (for FY 2026). By 2028, certain non-EU entities operating in the EU will also need to comply based on revenue thresholds (The European Parliament and the Council of the EU, 2022).

In addition to the NFRD and CSRD, the EU has introduced complementary regulations such as the Taxonomy Regulation and the Sustainable Finance Disclosure Regulation (SFDR). The Taxonomy Regulation provides a classification system for environmentally sustainable activities, offering guidance to companies and financial institutions (The European Parliament and the Council of the EU, 2020). Meanwhile, the Sustainable Finance Disclosure Regulation (SFDR) focuses on transparency in financial products, helping investors assess the sustainability of their investments (The European Parliament and the Council of the EU, 2019a). Together, these frameworks aim to align financial and corporate activities with broader EU sustainability objectives and prevent greenwashing.

During the 2021 UN Climate Change Conference (COP26), the IFRS Foundation launched the International Sustainability Standards Board (ISSB) to create global sustainability disclosure standards. By June 2023, the ISSB had introduced frameworks for climate-related disclosures and general sustainability-related financial reporting (IFRS Foundation, 2023).

The Western Balkans, closely tied to the EU through trade and investments, are progressively adopting EU sustainability standards as part of the accession process. Serbia, for example, has incorporated elements of the EU's Non-Financial Reporting Directive (NFRD) into its legislation. However, challenges such as limited regulatory capacity, technical expertise, and high implementation costs hinder progress. Despite these barriers, alignment offers significant benefits, including attracting investments and enhancing competitiveness. This paper underscores the importance of addressing these challenges to bridge regulatory gaps, fostering harmonized sustainability practices and advancing EU integration efforts. This study employs a content analysis with highlights how Croatia's EU membership and Serbia's EU candidate status influence their reporting strategies, using their sustainability reports.

Literature review

Climate change is increasingly impacting corporate financial performance, prompting investors, shareholders, asset managers, and other stakeholders-such as regulators and civil society-to demand enhanced transparency and disclosure of climate-related risks (Diwan & Amarayil Sreeraman, 2023). This has made it crucial for organizations to assess and disclose environmental risks related to their operations and supply chains. Consequently, mandatory corporate reporting has been adopted in many countries, aligning with the Sustainable Development Goals (SDGs) and endorsing environmental, social, and governance (ESG) principles as a framework for sustainability.

The CSRD extends reporting obligations to non-EU companies operating in the EU, setting a benchmark for the Western Balkans, where reporting remains largely voluntary. Companies should assess whether and when any of their subsidiaries and/or their entire consolidated group will become subject to the CSRD requirements (Meyner, Mishkin, Triggs, & Sullivan & Cromwell LLP, 2023). Environmental performance mapping and resilience assessments, involving disclosures and capital investments, are increasingly essential for understanding future financial flows. As climate change advances, resilience will become an even more significant topic in the science and policy circles that influence future urban development (Sharifi & Yamagata, 2016).

The 2030 Agenda for Sustainable Development presents several challenges, encompassing issues such as climate change, education, gender equality, health, hunger, peace, poverty, and social justice. With a wide range of indicators spanning different Sustainable Development Goals (SDGs), determining which goals should take priority can be a complex and challenging task (Lomborg, 2018).

While global initiatives such as the Paris Agreement emphasize universal goals, the Western Balkans face distinct challenges due to their geographic and economic vulnerability to climate change. According to the Two Representative Concentration Pathways RCP scenarios, the region is projected to experience higher-than-average temperature increases and significant reductions in precipitation, particularly in summer months. These changes intensify risks for key sectors such as agriculture and energy, which form the backbone of the Western Balkan economies (Knez, Strbac, & Podbregar, 2022).

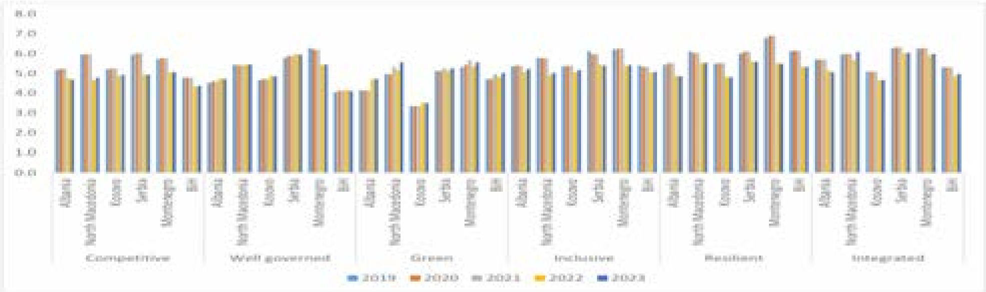
The Western Balkan (WB) region comprises six countries in Southeast Europe: Albania, Bosnia and Herzegovina (BiH), Kosovo, Montenegro, North Macedonia, and Serbia. These states are part of the EU Enlargement Policy, with all except Kosovo holding candidate status, while Kosovo is considered a potential candidate. Monitoring their progress on Sustainable Development Goals (SDGs) and comparing it to the EU's performance is essential for evaluating alignment and readiness for integration.

Membership in the European Union remains a key strategic objective for Western Balkan countries, serving as a major driver for reforms in candidate nations. Montenegro and Serbia began EU accession negotiations in 2012 and 2014, respectively. To date, Montenegro had opened 33 negotiation chapters, of which three have been provisionally closed (science, education, and culture) (European Commision, 2024), while Serbia had opened 22 chapters from 35 and temporarily closed two (European Commission, 2024).

Albania, which gained candidate status in 2014, began EU membership negotiations in 2022, alongside North Macedonia, which has been a candidate since 2005. Bosnia and Herzegovina's Stabilization and Association Agreement entered into force in June 2015, while Kosovo's agreement as a potential candidate followed in April 2016.

Reports from the EBRD highlight consistent progress by Western Balkan countries toward meeting EU membership criteria, reflecting their ongoing efforts to align with EU standards and policies. These steps underscore the region's commitment to EU integration (Sanfey & Milatovic, 2018).

Figure 1. *Evaluation of transition indicators for Western Balkan EU candidate countries*



Source: *EBRD Transition Reports*

According to OECD the Western Balkans faces a common set of environmental challenges, intensified by the growing impacts of climate change, posing significant risks to economic and social well-being. At the same time, the environment plays a critical role in the region, underpinning key sectors such as agriculture, tourism, and energy, which are essential for economic stability and growth. Addressing pressing environmental issues is crucial not only for achieving sustainable and resilient development but also for bolstering the region's competitiveness (OECD, 2024).

As the example of the good practice there is an initiative of the Centre for Financial Reporting Reform CFRR part of the World Bank Group, that organized the conference in Belgrade on May 11th, 2023 "Strengthening Corporate Governance in Serbia: Sustainability Reporting and the Increasing Role of Audit Committees". The conference reflects the European Union's broader intention to integrate the Western Balkans into its regulatory and governance frameworks. As part of the *REPARIS for SMEs* program (The Road to Europe Program of Accounting Reform and Institutional Strengthening for Small and Medium Enterprises), the initiative aims to align corporate financial reporting and governance practices in Albania, Bosnia and Herzegovina, Kosovo, Montenegro, North Macedonia, and Serbia with EU standards, fostering regional readiness for EU membership: further improving access of SMEs in the Western Balkans to professional accounting and financial management services; and alignment of Western Balkans corporate financial reporting frameworks with relevant directives and regulations of the European Union (EU) (Reform, 2023).

A central focus was on the EU's Corporate Sustainability Reporting Directive (CSRD) and European Sustainability Reporting Standards (ESRS), which require enhanced social and environmental disclosures. The conference emphasized Serbia's progress in adopting these measures, such as incorporating non-financial reporting into national legislation, showcasing steps toward harmonizing with EU requirements. The Republic of Serbia has already introduced environmental, social, and governance (ESG) non-financial reporting through its 2019 Law on Accounting which reflects main features of the Non-Financial Reporting Directive. Since 2019, companies with 500+ employees are required by law to report certain non-financial information (Reform, 2023).

Methodology

This study utilizes content analysis to compare the sustainability reports of selected EU and Western Balkan companies, emphasizing their compliance with GRI standards and alignment with regional strategies.

Comparative Analysis: Sustainability Reports of INA d.d. Croatia (EU) and NIS a.d. Serbia (non-EU) (INA Annual Report 2022, 2023) (NIS Sustainabilty Report 2022, 2023)

Similarities in Reporting

International Standards: Both INA and NIS adhere to GRI standards, ensuring global comparability. INA uses sector-specific GRI 11, while NIS is in the early stages of adoption.

Sustainability Goals: Both companies prioritize environmental protection, energy transition, and corporate social responsibility (CSR).

Stakeholder Engagement: Both utilize materiality assessments and involve local communities in their processes.

Differences in Approaches

Regulatory Framework: INA follows stringent EU Directive 2014/95 and TCFD guidelines, while NIS relies on Serbian legislation, focusing more on local interests.

Climate Change: INA's advanced decarbonization plans include renewable energy and circular economy projects. NIS is in the early stages, concentrating on Serbia's national energy goals.

Social Engagement: INA engages in EU-aligned regional projects, whereas NIS focuses on local programs like healthcare and youth support.

Comparative Analysis: Sustainability Reports of Lidl Croatia (EU) and Lidl Serbia (non-EU) (Lidl d.o.o., Croatia, 2024) (Lidl Srbija KD, 2023)

Similarities (Group-Level Affiliation)

Unified Sustainability Strategy: Both companies adopt the Schwarz Group's global vision, emphasizing circular economy, environmental conservation, and community engagement. Initiatives like "REset Plastic" and GRI-aligned reporting showcase shared approaches to sustainability.

Standardized Practices: Both firms benefit from group-wide supplier codes, employee welfare policies, and resources that ensure consistent quality and sustainable operations.

Brand Identity: A focus on product quality, affordability, and transparency aligns both Lidl Croatia and Lidl Serbia with the group's overarching mission to provide value responsibly.

Differences (Regional Context)

Regulatory Environment: Lidl Croatia (EU): Complies with strict EU directives (e.g., EU Taxonomy), driving detailed reporting, advanced climate initiatives, and biodiversity projects / Lidl Serbia (non-EU): Aligns with Serbian legislation, focusing on localized, achievable sustainability goals like food waste reduction and green energy use.

Social Impact: Croatia emphasizes EU-aligned initiatives like inclusive retail and regional biodiversity projects / Serbia targets grassroots campaigns, such as disability rights and local entrepreneurship support.

Stage of Climate Action: Croatia's efforts reflect advanced renewable energy integration and robust decarbonization / Serbia focuses on foundational measures like energy efficiency and waste management, tailored to national priorities.

Figure 2. *Comparative Analysis Table: EU vs. Western Balkan companies*

Aspect	INA (EU)	NIS (Non-EU)	Lidl Croatia (EU)	Lidl Serbia (Non-EU)
Regulatory Framework	Fully complies with EU Directives (e.g., CSRD, EU Taxonomy) and TCFD guidelines.	Relies on Serbian legislation, aligned with basic GRI standards.	Follows strict EU regulations for sustainability reporting, including EU Taxonomy compliance.	Aligns with Serbian laws, adopting localized sustainability measures.
Climate Initiatives	Advanced decarbonization projects, including renewable energy and circular economy models.	Focuses on national energy priorities such as natural gas development and CO_2 storage.	Integrates advanced renewable energy practices and biodiversity protection projects.	Primarily targets foundational measures like energy efficiency and food waste reduction.
Social Engagement	Engages in EU-driven regional projects (e.g., retail networks, community renewables).	Supports local initiatives such as healthcare and youth programs.	Implements EU-aligned regional social programs and diversity policies.	Emphasizes grassroots campaigns for local entrepreneurship and disability rights.
Sustainability Goals	Long-term strategies for energy transition and corporate social responsibility (CSR).	Focuses on meeting national goals with incremental adoption of global sustainability practices.	Reflects group-wide sustainability strategies with EU compliance.	Adapts group strategies to local challenges, emphasizing affordability and practicality.

Aspect	INA (EU)	NIS (Non-EU)	Lidl Croatia (EU)	Lidl Serbia (Non-EU)
Stakeholder Engagement	Conducts comprehensive materiality assessments and collaborates extensively with EU stakeholders.	Focuses on community-level engagement within Serbia.	Implements sophisticated stakeholder management driven by EU policies.	Prioritizes community-driven stakeholder activities tailored to local contexts.

Source: *Author*

Key Observations and Implications

Regulatory Influence: EU-based companies (INA, Lidl Croatia) demonstrate robust adherence to advanced sustainability standards, reflecting the strict regulatory environment. Non-EU counterparts (NIS, Lidl Serbia) adopt localized approaches, often constrained by national frameworks and resources.

Climate Action: EU companies are significantly ahead in renewable energy and circular economy projects, positioning themselves as leaders in climate resilience. Western Balkan companies are in the earlier stages, focusing on cost-effective and region-specific initiatives.

Social Responsibility: EU-driven projects emphasize regional integration and inclusivity, while Western Balkan companies prioritize immediate local community needs, reflecting their developmental stage.

Alignment Challenges: Western Balkan companies face difficulties aligning with complex EU requirements due to regulatory gaps, limited expertise, and high implementation costs.

Conclusion

This study explores the evolving landscape of sustainability reporting in the EU and its influence on the Western Balkans. The EU's regulatory frameworks, including the CSRD and Taxonomy Regulation, set benchmarks for transparency and alignment with global goals. While EU member states progress under mandatory frameworks, the Western Balkans face voluntary adoption, capacity-building challenges, and resource constraints.

Despite these obstacles, the region is advancing, driven by EU accession goals and the need to attract investment through transparency. Case studies reveal the importance of tailored strategies that balance local contexts with global standards.

Harmonization requires bridging knowledge gaps, enhancing regulatory capacity, and fostering cooperation. Initiatives like capacity-building programs and EU collaboration can accelerate progress. By addressing barriers, sustainability reporting can transform from compliance into a strategic tool for economic growth and environmental resilience, highlighting the Western Balkans' commitment to sustainable development and readiness for EU integration.

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ANALYSIS OF THE POSSIBILITY OF FINANCING AGRICULTURE FROM THE IPARD III PROGRAM IN THE REPUBLIC OF SERBIA[1]

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Abstract

Financial instrument for pre-accession assistance – IPARD III program, for the 2021-2027 period, was adopted by the Decision of the Government of the Republic of Serbia on December 14, 2023. The total financial value of the IPARD III program amounts to 588 million euros, of which the contribution of the European Union is 280 million euros. The main goals of the IPARD III program are the following: increasing the competitiveness, efficiency and sustainability of agricultural production, improving the economic position of agricultural farms, rural development, stimulating the employment of young people in rural areas, contribution to the mitigating of the climate changes' negative effects, as well as building efficient public administration in the field of agriculture and rural development in the Republic of Serbia. As of October 2024, four out of a total of eight measures have been accredited. The aim of the paper is to present the current financing possibilities from the IPARD III program in the Republic of Serbia, as well as to compare them with the financing possibilities from the IPARD II program. In the paper there have been used the following methods: the method of analysis and synthesis, comparative method and desk research method. The authors conclude that additional opportunities for financing agriculture and rural development in the Republic of Serbia are available within the IPARD III program compared to the IPARD II program.

Key words: *Financing, agriculture, rural development, IPARD III program, accredited measures, Republic of Serbia.*

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Introduction

Financing of agriculture is the biggest and most complex problem of domestic agriculture (Radović, 2009; Radović, 2014). Agriculture is characterized by biological and socio-economic specificities, and that is why the financing of this economic activity is very complex (Vasiljević, 1998). Very often, the problem is also the insufficiency of sources for financing agricultural production (Jovanović & Zubović, 2019). The lack of financial resources for the simple reproduction, as well as for the extended one, is one of the most significant causes of the crisis in which agriculture in the Republic of Serbia has been for more than three decades (Pejanović, 2016).

Financing of agriculture and rural development in the Republic of Serbia in recent years has also been realized from pre-accession funds of the European Union. Before acquiring the status of a candidate for membership in the European Union, the Republic of Serbia was entitled to financing from the component IPA CBC (Instruments for Pre-accession Assistance Cross – border Cooperation Programme). By acquiring the candidate status on March 1, 2012, the Republic of Serbia gained the right to use funds from the IPARD pre-accession component.

The essence of the Instrument for Pre-Accession Assistance for Rural Development (IPARD) is in providing financial support to the future members of the European Union with the aim of sustainable development of agriculture and rural development. The IPARD program defines measures to support rural development in accordance with the rules of the European Union, which are applied under the conditions and criteria for the use of these financial resources, as well as the way of conducting control.

Concerning the IPARD II program in the Republic of Serbia, which was implemented in the 2014-2020 period, it has been available 175 million euros, or 230 million euros in total, if funds from national sources are taken into account.

When analyzing the realization of funds from the IPARD II program, as of June 30, 2024, 80 million euros or 46% of the total available funds from the European Union were realized. With the mentioned date, 1,151 projects were paid out, the total value of which is EUR 106.7 million, when taking into account the disbursed funds from national funds (Semi-annual report on the implementation of the IPARD II program RS, 2024).

The Republic of Serbia has 280 million euros available from European Union funds within the IPARD III program, which is planned to be implemented in the 2021-2027 period. Combined with the funds from national sources, which need to be invested considering that the financing is realized according to the principle of co-financing, the total financial support of the IPARD III program amounts to 588 million euros.

Table 1. The measures of the IPARD III program

Measure name	Accredited/ Unaccredited (ends October 2024)	Participation in the total financial resources of the IPARD III program
Measure 1 – Investments in physical assets of agricultural holdings	Accredited	30%
Measure 3 – Investments in physical assets, processing and marketing of agricultural and fishery products	Accredited	21%
Measure 4 – Agro-ecological-climatic measure and organic production	Unaccredited	18%
Measure 5 – Implementation of local rural development strategies – LEADER approach	Unaccredited	3%
Measure 6 – Investments in rural public infrastructure	Unaccredited	5%
Measure 7 – Diversification of agricultural holdings and business development	Accredited	5%
Measure 9 – Technical assistance	Accredited	18%

Source: *https://ipard.gov.rs/ипард -iii-мере/; Prezentacija, PKV, 2024.*

The measures of the IPARD III program are shown in Table 1. The subject of analysis in this paper is the accredited measures of the IPARD III program (Measure 1, Measure 3 and Measure 7) and their comparison with the implemented, listed measures within the IPARD II program. Regarding the implementation of the mentioned measures, within the IPARD II program, there was a great interest of the users, measured by the number of projects submitted to the announced competitions. However, a large number of projects did not meet the required criteria. Precisely: " (a) for Measure 1, 46.5% of the total number of submitted projects met the criteria; (b) for Measure 3, 48.2% of the total number of submitted projects met the set criteria; (c) for Measure

7, only 28.9% of the total number of projects that participated in the published calls met the set criteria “(Radović, Subić, Pejanović, 2024, p. 1027).

Methodology and data sources

The aim of the paper is to present the current possibilities for financing agriculture and rural development in the Republic of Serbia from the IPARD III program, as well as to compare them with the financing possibilities from the IPARD II program. The paper uses: the method of analysis and synthesis, comparative method, as well as the method of research at the table (desk research). The data sources are the website of the Management Body for the IPARD program of the Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia, as well as available publications and brochures in which funding opportunities from the IPARD III and IPARD II programs are presented.

Research results

The subjects of the research and analysis are the financing possibilities that are available within: Measure 1, Measure 3 and Measure 7 of the IPARD III program, as well as the financing possibilities that were available within the same measures in the IPARD II program. More precisely, the subject of analysis in the mentioned measures of the IPARD III and IPARD II programs are the following: (a) sectors within which the realization of investments is possible; (b) potential beneficiaries of investments; (c) intensity of grant support; (d) types of potential investments; (e) incentive amounts.

Measure 1

Measure 1 of the IPARD III program includes investments in the physical assets of agricultural farms, and its main goal is to increase the competitiveness, efficiency and sustainability of agricultural production. More precisely, the aim of this measure is to bring agricultural farms into line with the standards of the European Union in the field of environmental protection, health and protection of plants and animal welfare. The goal of implementing this measure is to mitigate the negative effects of climate change, production of energy from renewable sources, sustainably management of natural resources (water, soil and air), as well as strengthening the position of farmers in the food chain and provision of support to the young farmers (https://ipard.gov.rs/projects/mera-1/).

Table 2. Basic characteristics of Measure 1 of the IPARD III program

Sectors: (a) milk; (b) meat; (c) eggs; (d) fisheries; (e) fruit; (f) vegetables; (g) grapes; (h) cereals; (i) industrial plants.	
Potential users: legal entities – owners of commercial family farms, entrepreneurs, agricultural cooperatives and business companies.	
Intensity of grant support	Up to 60% of the total eligible investment costs. Up to 65% of the total eligible costs for investments in mountainous areas. Up to 70% for investments made by young agricultural producers and producers of certified organic products in primary agricultural production. An additional 10% for investments related to waste and wastewater management. The total amount of support cannot exceed 75% of the investment value.
Potential investments	Investments in the construction and equipping of facilities, the establishment of perennial production and parent plantations, the acquisition of new equipment, machines and mechanization, computer software and hardware.
Incentive amounts	Eligible investment costs in the amount of 20,000 to 1,000,000 euros. The total support to which the user can exercise the right is 2,000,000 euros, during the implementation of the IPARD III program.

***Source**: https://ipard.gov.rs/projects/mera-1/Prezentacija, PKV, 2024.*

The basic characteristics of Measure 1 of the IPARD III program are shown in Table 2. The comparative analysis of financing possibilities within Measure 1 of the IPARD III program in relation to financing possibilities within Measure 1 of the IPARD II program led to the following conclusions:

(a) There are differences in the intensity of non-refundable support. In the IPARD II program, the intensity of grant support for investments made by young agricultural producers (under 40 years old) was up to 65%, and in the IPARD III program it was up to 70%. There is also a difference in the intensity of non-refundable support for investments that are realized in mountainous areas, in the IPARD II program the support was up to 70%, and in the IPARD III program it was up to 65% of the value of the investment;

(b) Potential users of funds are the same in both programs;

(c) The difference exists in the amount of the total sum of incentives per user during the program period. That amount was 1.5 million euros in the IPARD II program, and 2.0 million euros in the IPARD III;

(d) There is also a difference in the amount of the minimum investment sum. The minimum investment amount in the IPARD II program was 5,000 euros, and in the IPARD III program it was 20,000 euros (Guide for Measure 1 IPARD II, 2021; Guidance for Measure 1 IPARD III, 2024);

(e) The new sector in Measure 1 of the IPARD III program is the Fisheries Sector. Agricultural farms that will produce at least 10 tons of fish per year at the end of the investment can apply for this support (Presentation, CCIV, 2024).

Measure 3

Measure 3 of the IPARD III program includes investments in physical assets related to the processing and marketing of agricultural and fishery products. The aim of this measure is to increase the competitiveness of the agricultural and food sector and improve the efficiency and sustainability of the food industry. This process needs to be implemented while respecting ecological standards, overcoming the challenges imposed by climate change, encouraging the production of energy from renewable sources, as well as the development of the circular economy (https://ipard.gov.rs/projects/mera-3/).

The basic characteristics of Measure 3 of the IPARD III program are shown in Table 3. A comparative analysis of financing possibilities within Measure 3 of the IPARD III program in relation to financing possibilities within Measure 3 of the IPARD II program led to the following conclusions:

(a) Within Measure 3 of the IPARD III program, a new sector was introduced – The Fisheries Sector. Users who, after the realization of this investment, will have a daily production capacity for fish processing of more than 200 kg, can apply for this support (Presentation, CCIV, 2024);

(b) The difference exists in the amount of the incentives. In Measure 3 of the IPARD II program, the minimum amount of incentives was 10,000 euros, and the maximum amount was 2,000,000 euros, while in Measure 3 of the IPARD III program, the minimum amount of incentives was 20,000 euros, and the maximum amount was 1,300,000 euros;

(c) The potential beneficiaries and potential types of investments under Measure 3 are the same in both IPARD II and IPARD III programs (Guide for Measure 3 IPARD II, 2021; Guidelines for Measure 3 IPARD III, 2024).

Table 3. Basic characteristics of Measure 3 of the IPARD III program

Processing and marketing sectors: (a) milk; (b) meat; (c) eggs; (d) fish; (e) fruit; (f) vegetables; (g) grapes; (h) cereals; (i) industrial plants.	
Potential users: agricultural cooperatives, entrepreneurs and commercial companies.	
Intensity of grant support	Up to 50% of the total eligible investment costs. Support is increased by 10% for investments related to waste water management, circular economy and renewable energy sources.
Potential investments	Investments in: (a) building and equipping facilities; (b) acquisition of new equipment, machines and mechanization; (c) procurement of computer software and hardware.
Incentive amounts	The amount of eligible expenses is from 20,000 euros to 1,300,000 euros. Total support per user can amount to 2,500,000 euros during the entire period of realization of the IPARD III program.

Source: *https://ipard.gov.rs/projects/mera-3/Prezentacija, PKV, 2024.*

The intensity of grant support in Measure 3 is the same both in the IPARD II program and the IPARD III program (Table 3).

Measure 7

Measure 7 of the IPARD III program includes investments in the diversification of agricultural holdings and business development. This measure aims at the development of non-agricultural activities, the development of the service sector, and the creation of new opportunities for employment, rural development, as well as improving the quality of life in rural areas (https://ipard.gov.rs/projects/mera-7/).

Table 4. Basic characteristics of Measure 7 of the IPARD III program

Sectors: (a) the sector of direct marketing of agricultural and food products and home-made products; (b) rural tourism sector; (c) the small-scale service sector.	
Potential users: natural persons – owners of commercial family agricultural farms, entrepreneurs and companies (micro and small legal entities).	
Intensity of grant support	Up to 60% of the total eligible investment costs. An additional 10% for investments made by young farmers and producers of certified organic products. An additional 10% for investments related to waste and wastewater management, use of energy from renewable sources or investments in the circular economy. The total amount of support cannot exceed 75% of the investment value.
Potential investments	Construction and equipping of facilities for non-agricultural activities (rural tourism and small-scale services), energy production from renewable sources.
Incentive amounts	Sector of direct product placement: (a) construction/reconstruction with facility equipment – minimum amount of 5,000 euros, and maximum amount of 300,000 euros; (b) for equipping buildings, the minimum amount is 5,000 euros, and the maximum amount is 100,000 euros. Rural tourism sector: construction/reconstruction/equipment of buildings – minimum amount 20,000 euros, and maximum amount 300,000 euros. Sector of small-scale services: (a) construction/reconstruction with facility equipment – minimum amount 5,000 euros, and maximum amount 300,000 euros; (b) equipping buildings, the minimum amount is 5,000 euros, and the maximum amount is 200,000 euros. If the project includes investments in more than one sector, the minimum amount is 200,000 euros, und maximum amount is 300,000 euros. The maximum amount of incentives per beneficiary for Measure 7 of the IPARD III program is 600,000 euros.

Source: *https://ipard.gov.rs/projects/mera-7/*

The basic characteristics of Measure 7 of the IPARD III program are shown in Table 4. A comparative analysis of financing possibilities within Measure 7 of the IPARD III program in relation to financing possibilities within Measure 7 of the IPARD II program led to the following conclusions:

(a) Within Measure 7 of the IPARD III program, two new sectors were introduced: The Sector of direct marketing of agricultural and food products and home-made products and the Sector of small-scale services;

(b) Within Measure 7 of the IPARD III program, the intensity of non-reimbursed support is higher (up to 75% of the investment value), while in the IPARD II program it was up to 65% of the investment value;

(c) In the IPARD III program there are greater financing possibilities (type of investments) compared to the IPARD II program;

(d) The maximum amount of incentives per beneficiary for Measure 7 in the IPARD III program is EUR 600,000, and in the IPARD II program it was EUR 400,000 (Guide for Measure 3 IPARD II, 2021; Guidelines for Measure 3 IPARD III, 2024).

The potential beneficiaries of this funding source are the same under Measure 7 both in the IPARD II and IPARD III programs (Table 4).

Conclusion

Based on the conducted research, it can be concluded that within the framework of the IPARD III program there are greater opportunities for financing agriculture and rural development in the Republic of Serbia compared to the IPARD II program.

Within Measure 1 of the IPARD III program, the intensity of support for investments made by young agricultural producers (under 40 years of age) is greater, the minimum amount of investment is also higher, as well as the amount of the total incentive per user during the program period compared to Measure 1 of IPARD II program. As part of Measure 1 of the IPARD III program, a new sector was introduced – The Fisheries Sector.

Within Measure 3 of the IPARD III program, the minimum amount of incentives is higher compared to Measure 3 of the IPARD II program. Within this measure, a new sector was introduced in the IPARD III program – The Fisheries Sector.

As part of Measure 7 of the IPARD III program, two new sectors were introduced: the Sector of direct marketing of agricultural and food products and home-made products and the Sector of small-scale services. Within Measure 7 of the IPARD III program, financing opportunities (types of investments) are greater, the intensity of non-reimbursed support is greater, and the maximum amount of incentives per beneficiary during the program period is greater compared to Measure 7 of the IPARD II program.

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ANALYSIS OF CRISIS SITUATIONS IN THE AGRI-FOOD SECTOR: CASE STUDY OF THE RUSSIA-UKRAINE WAR

Ioana Cristina Neagu[1]

Abstract

The Analysis of Crisis Situations in the Agri-Food Sector. Case Study: Russia-Ukraine war" is a topic that includes current events, events that affect us in a negative or positive way every day, often without us realizing it. Romania is clearly undergoing continuous change, just like most other countries, in every aspect: economic, social, and medical. For these changes to occur, a strong factor is always needed. Currently, Romania is struggling with inflation, a phenomenon that is evidently affecting the population. An important factor underlying the current inflation is the military conflict between Russia and Ukraine. Through their analysis, clear signs of the impact of the military conflict at the country's borders can be observed, such as the increase in prices of agri-food products, the reduction of areas cultivated with wheat and vegetables, and the decrease in demand for vegetables that have seen price increases.

Key-word: *agri-food sector, crisis, Russia-Ukraine war.*

Introduction

The Analysis of Crisis Situations in the Agri-Food Sector. Case Study: Russia-Ukraine war" is a topic that includes current events, events that affect us in a negative or positive way every day, often without us realizing it.

Romania is clearly undergoing continuous change, just like most other countries, in every aspect: economic, social, and medical. For these changes to occur, a strong factor is always needed.

Currently, Romania is struggling with inflation, a phenomenon that is evidently affecting the population. An important factor underlying the current inflation is the military conflict between Russia and Ukraine. A crisis is a phenomenon characterized by the diversification of ways in which it unfolds.

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It signifies an imbalance in the area where it emerges and does not affect just one sector; rather, it creates a chain of losses and fragmentations. A crisis can take many forms: social, economic, medical, military, political, religious, ethnic, or environmental.

Crisis situations in the agri-food sector are fundamentally rooted in food safety and security, which are, at times, put at risk.

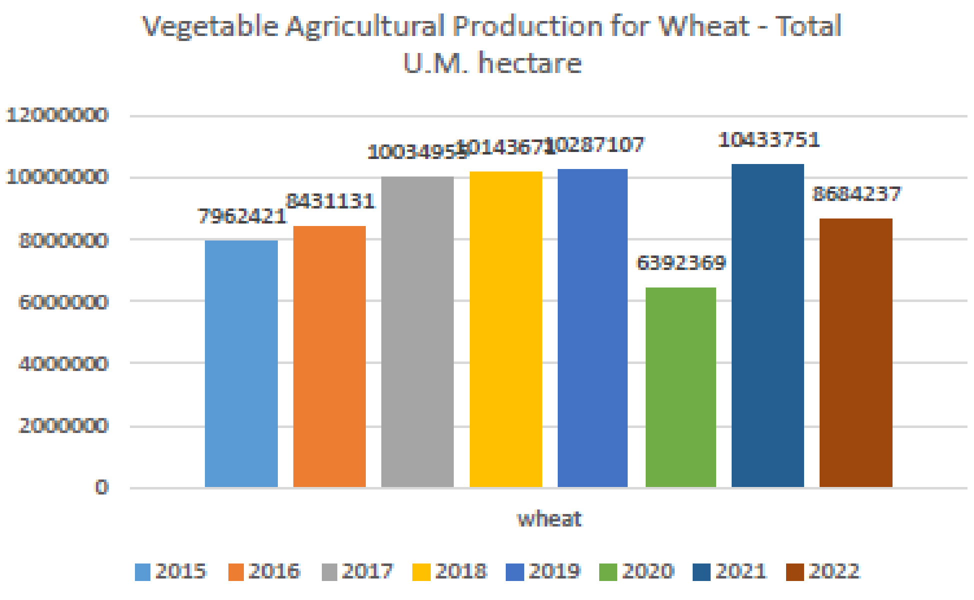
This paper analyses key indicators to determine whether the military conflict impacts Romania. Through their analysis, clear signs of the conflict's effects on the country's borders can be observed, such as rising prices for agri-food products, a reduction in areas cultivated with wheat and vegetables, and a decrease in demand for vegetables that have seen price increases.

The paper will also highlight the sudden rise in Romania's imports from Ukraine, a development that has impacted Romanian agriculture and product prices.

Analysis of the Food Sector

Analysis of the foreign trade in Romania

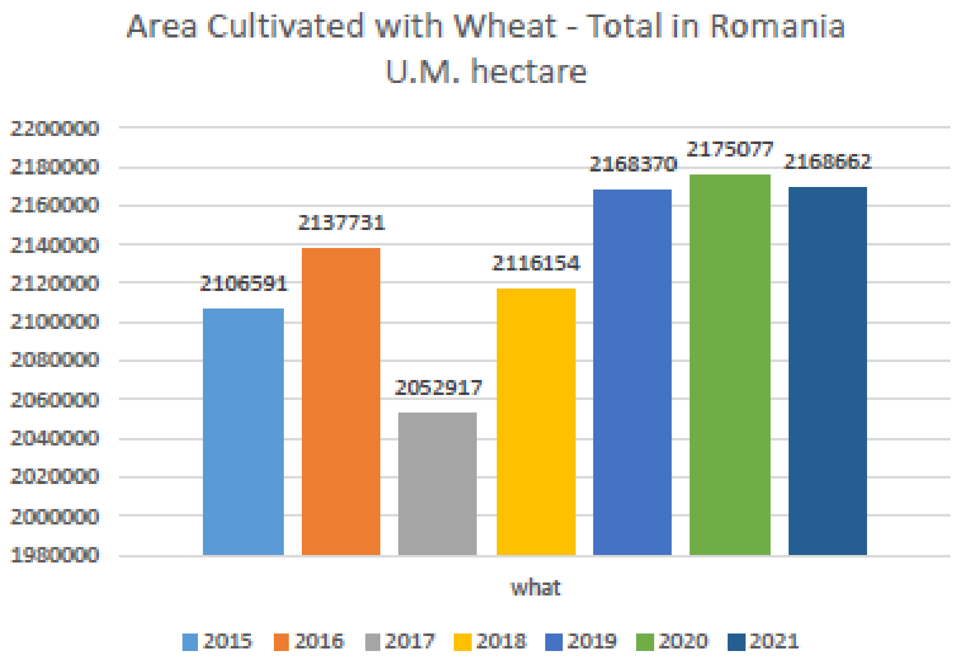
Chart 1: *Vegetable Agricultural Production for Wheat - Total*



Source: *Tempo*

In the years 2018 and 2019, wheat production continued to increase, with the indicator differing from 2015 by 29.20% more wheat production. The lowest value on the graph is marked by the year 2020, when, in a single year, wheat production decreased by as much as 37.86%. Farmers quickly got back on their feet after this difficult year and managed to double wheat production in 2021 compared to the previous year, thus the indicator evolved by 63.24%. In 2022, another decrease in the indicator is recorded, this time by 16.76%.

Chart 2. *Area Cultivated with Wheat - Total in Romania*

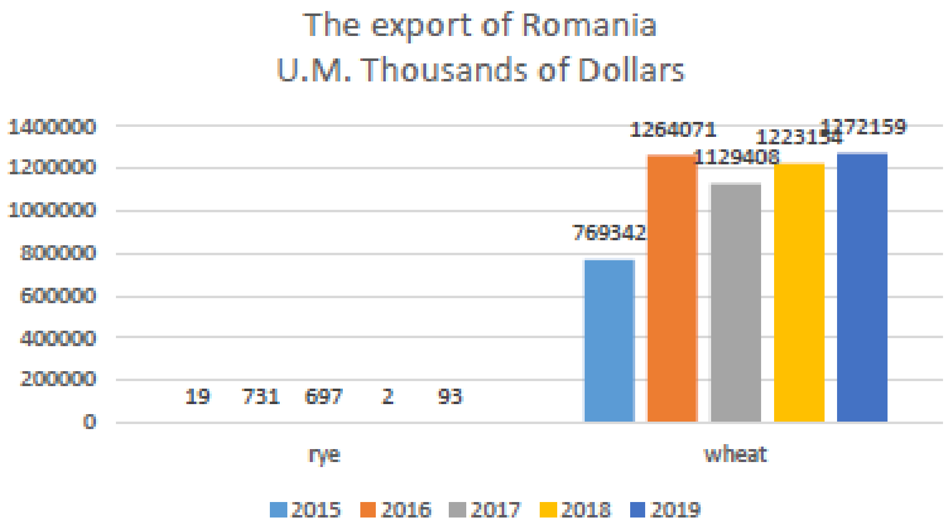


Source: *Tempo*

In 2017, the value recorded a decrease of 3.97%, thus marking the lowest value on the graph. Such a low value of the indicator can jeopardize the country's food security. The low level of area cultivated with wheat can generate risks regarding food supply, influencing costs and market accessibility.

The area cultivated with wheat continued to grow over the next two years but decreased in 2020. In 2021, it increased by 0.92% compared to 2020. In 2022, there was a decrease in value of 0.29%

Chart3: *The export of Romania*

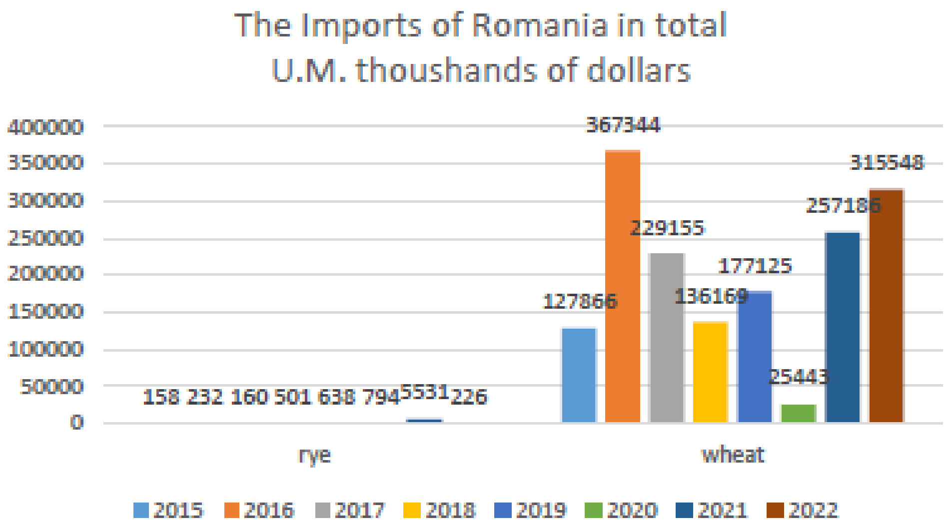


Source: *TradeMap.org*

In Romania, rye exports are small compared to other grains such as wheat. The lowest export value was recorded in 2015. In 2018, exports increased by up to 789.47% compared to 2015. This indicates a low production of rye. Romania has managed to increase its wheat exports over the analysed years. There have been slight fluctuations in the value of these exports, but a sharper decline occurred in 2020.

A possible cause for this immediate drop is the political changes in Romania that year. The year 2020 was marked by a medical crisis, which led to the decision to prohibit exports to countries outside the European Union. (Source: Agroinfo)

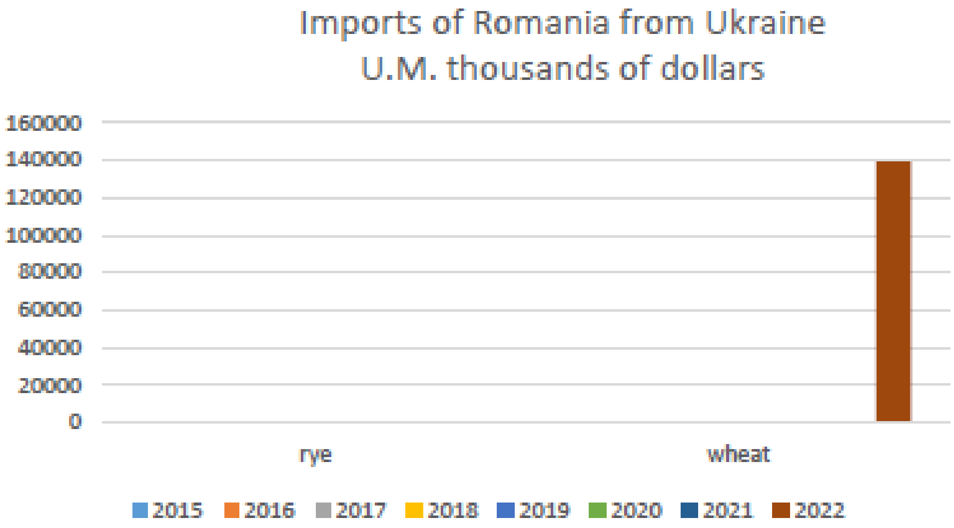
Chart 4: *The Imports of Romania in total*



Source: *TradeMap.org*

The fact that Romania imports a small amount of rye can be seen as a positive aspect, indicative of an internal production that is sufficient to meet domestic demand. The value of wheat imports increased from 2015 to 2022 by 146.71%, but 2022 does not represent the highest figure in the chart. The year 2016 marks a record year for wheat imports in Romania, rising from 2015 to 2016 by 239,478 thousand dollars, which is an increase of 187.19%. This may be attributed to low domestic production and increasing demand.

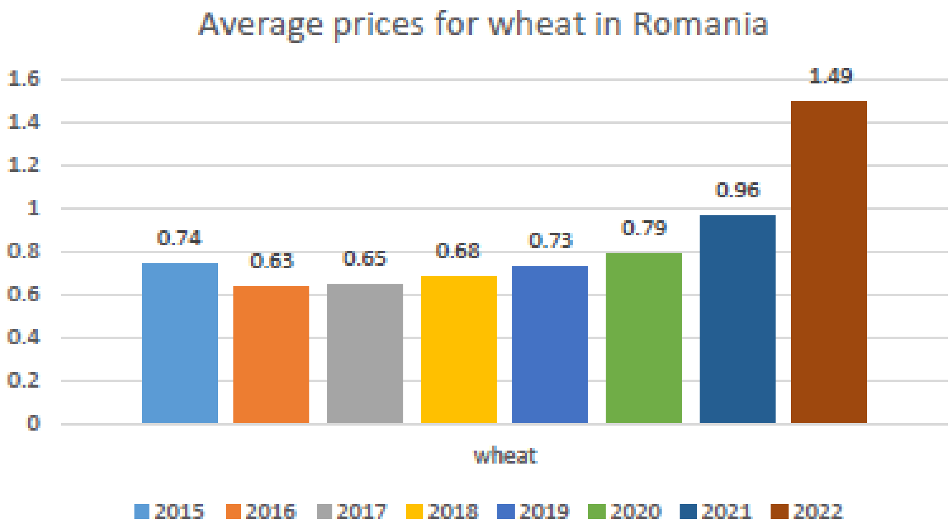
Chart 5: *Imports of Romania from Ukraine*



Source: *TradeMap.org*

Romania did not import rye and wheat from Ukraine until 2022. The year 2022 was marked by the outbreak of the Russia-Ukraine military conflict and was also the only year in which Romania imported rye and wheat from Ukraine. This negatively affected farmers in Romania, as excessive wheat imports for unfounded reasons led to a decrease in domestic wheat prices and, simultaneously, a drop in demand. As observed in Chart 1, wheat production in Romania began to decline in order to adapt to the conditions created by the unnecessary imports. Imports of wheat from Ukraine account for almost half of Romania's total wheat imports (44.06%). Imports of rye from Ukraine represent 2.45% of Romania's total rye imports.

Chart 6: *Average Prices for Wheat in Romania*



Source: *Tempo*

Average prices began to rise in Romania starting in 2017, but the most significant increase, a sudden surge, occurred in 2022. From 2019 to 2022, in just one year, the average prices for wheat doubled (increased by 55.2%). This fact was a consequence of the Russia-Ukraine military conflict. This military crisis affected Romania by doubling wheat prices. The doubling of prices is due to another consequence of the conflict, namely the imports from Ukraine that were not necessary. Thus, the demand for wheat decreased, and the internal production of Romanian farmers fell.

Conclusions

The Russia-Ukraine military conflict has affected Romania's agri-food sector. The area and production of wheat crops felt the negative effects of the military conflict, thus reducing the value of the indicator in 2022, the same year the war began.

The decrease in wheat production was sudden, as 2021 was a productive year with the highest value in the last 8 years, signaling a recovery after the medical crisis of 2020. Another crisis, this time a military one, caused another decline in wheat agricultural production. This was due to the wave of cereal imports from Ukraine, an action that was necessary to support farmers affected by this tragic event. Thus, with the increase in excessive imports, the demand for wheat in Romania decreased, leading to a decline in production.

Another effect of the military conflict is the increase in wheat imports. The year 2022 is the only year in which Romania imported wheat from Ukraine as a sign of support for Ukrainian farmers affected by the tragic incident. Thus, Romania's wheat imports increased by up to 5.44% compared to 2021.

Acknowledgments

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INVESTIGATING SOME POSSIBLE IMPACTS OF ENERGY USE ON AGRICULTURAL SECTOR DEVELOPMENT

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

Abstract

The impact of energy use and prices on the development of a sustainable agricultural sector has been highlighted by recent developments and changes in the modern 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 corresponding increase 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

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including in the European Union (EU). The utilization of energy in agriculture 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 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 multifaceted 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 the structure and volume of renewable energy production, the impact of agricultural practices on natural resources, and energy consumption patterns within the EU. 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's (2011) study examined the relationship between energy prices and biofuel expansion trajectories, suggesting that rising energy prices may lead to biofuel use beyond specific energy targets, resulting in higher agricultural commodity prices. 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. 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 categorise EU countries into groups based on the structure and volume of their energy production from renewable energy sources (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.

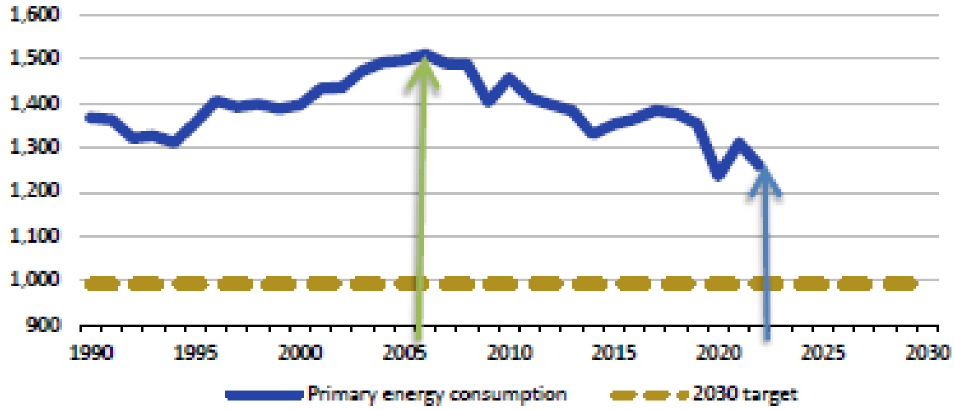
The review highlights a gap in studies on energy use in greenhouse production, pointing out the scarcity and fragmentation of reliable data. In order to improve the understanding of energy dynamics in greenhouses and to contribute to the green transition in agriculture, Paris et al. (2022) propose a framework for measuring energy use in greenhouse 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 has a high concentration of energy consumption, particularly in countries with a significant agricultural industry, such as France and Poland. Simionescu et al. (2022) assess the impact of renewable energy use on economic growth in 23 EU Member States from 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 a comprehensive view of the relationship between energy use in agriculture and its broader economic implications by examining a range of indicators related to the consumption of energy and the use of renewable sources in the EU.

EU distance and target for primary energy consumption

An impact analysis highlights the consequences of these energy targets on the agricultural sector, particularly in terms of energy efficiency. This aspect is 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. The European Union (EU) has set ambitious targets to reduce primary energy consumption by 2030 as part of its broader sustainability and climate change initiatives. 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.

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



Source: Eurostat, (2023)

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.

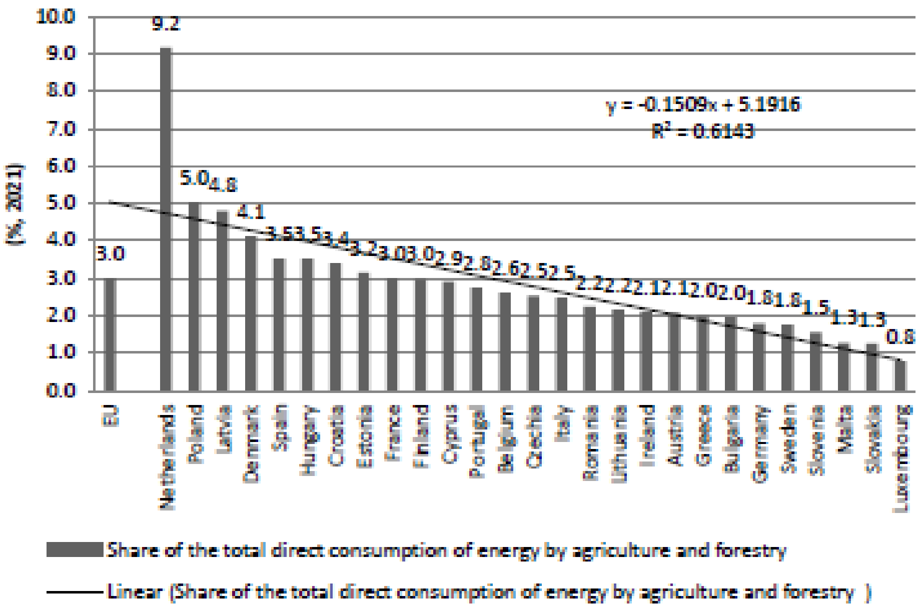
The peak of consumption appears around the mid-2000s, which may correlate with periods of economic growth and industrial expansion. However, post-peak, there is a noticeable trend towards reduced consumption, which aligns with increased efficiency, the adoption of renewable energy sources, and heightened 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.

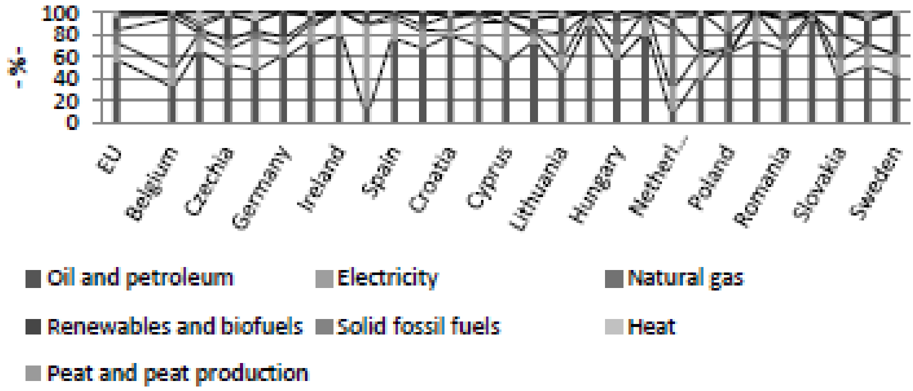
The Netherlands leads significantly with a 9.2% share. This high percentage could be attributed to the country's intensive agriculture practices, including large-scale greenhouse farming that requires substantial energy for heating and lighting. The Dutch agricultural sector is known for its high productivity 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.

The trend line indicates a general decline in the share of energy consumption as we proceed through the list of countries. 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 use of renewables and biofuels is a positive trend observed in countries like Austria and Romania. This shift is crucial for the long-term sustainability of the sectors, as it indicates progress towards reducing dependence on non-renewable resources and mitigating climate change impacts.

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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THE ROLE OF INTERNAL AUDIT IN PROMOTING SUSTAINABLE DEVELOPMENT IN AGRICULTURAL ENTERPRISES

Jelena Gruslav[1]*, Miroslav Perić*[2]

Abstract

This paper explores the role of internal audit in supporting the promotion of sustainable business development of agricultural enterprises, examining how the work of internal auditors and the timely identification of business risks helps the management and employees of these enterprises in achieving defined and sustainable business goals. The paper is based on a survey conducted among agricultural enterprises through a questionnaire, aimed at determining the efficiency and usefulness of the internal audit function in improving environmental, social, and management standards. This research emphasizes the importance of internal audit as a corrective mechanism in assessing compliance and implementation of regulations and the quality of established processes in achieving sustainable development of agricultural enterprises, with the aim of improving their commitment to implementing sustainable practices in their operations. The results of the research highlight the need for internal audit, as an advisory activity, to be included in the definition of sustainability strategies in agricultural enterprises, in order to encourage long-term value creation in the agricultural sector.

Key words: *internal audit, sustainable development, agricultural enterprises.*

Introduction

Internal audits promote sustainable development within agricultural enterprises by ensuring transparency, accountability, and risk management in sustainability initiatives. In the current research, it is noted that all companies, including agriculture companies, must align their business operation with sustainability demands (Vrabcová & Urbancová, 2023). One of the reasons why sustainability is so important in the agriculture sector is because the ag-

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riculture supply chain, which includes farmers, food producers, merchants, and input suppliers, is worth $5 trillion globally (Topp-Becker & Ellis, 2017). Stakeholders have begun to voice concerns about how businesses affect the environment. In response, companies can solve these issues and gain stakeholders' trust by releasing sustainability reports. For companies of great importance is important to take into account the potential impact that sustainability actions may have when it comes to their reputation and reduction of costs (Topp-Becker & Ellis, 2017). The great impact that agriculture companies have on sustainability is one of the reasons why this issue is of great importance.

One of the ways that should be discussed is what is the role of internal audit in achieving sustainability goals. First of all, it is important to note that according to the findings by Alzeban (2021), economic growth is influenced by the internal audit department's maturity (measured in years) and compliance with internal audit standards. Thanasas and Lampropoulos (2023) explain how internal audits can have an important role in value creation for the company. By evaluating environmental, social, and governance practices, internal auditors help organizations align their operations with sustainable development goals (SDG) and mitigate environmental risks. This enhances also the stakeholders' trust but also long-term business resilience.

Importance of internal audit for agriculture companies

An essential tool for evaluating production efficiency, controlling production resources, analyzing financial performance, and spotting possible dangers is internal auditing in agribusiness organizations. Additionally, this kind of audit increases company profitability, boosts market competitiveness, and ensures adherence to legal and legislative requirements. Given how quickly technology and regulatory markets are evolving, agribusiness internal auditing is unquestionably relevant (Danchikov et al., 2023). By applying internal audits, companies have the opportunity to determine opportunities and potential risks. Internal control encompasses all aspects of the business and is primarily focused on increasing liquidity, business efficiency, and the success of elements like productivity, efficiency, and effectiveness. It also aims to maximize corporate efficiency (Arnautović et al., 2023). It is noted that internal audits can have a great impact on customer satisfaction and other strategic goals (Chiarini et al., 2020). Arnautović et al. (2023) explain that when it comes to supporting the decisions taken by the company's top management, internal control in agricultural production organization increasingly plays the function of an assistant.

Application on sustainability issues

The use of synthetic chemicals to treat diseases and pests, artificial fertilization, the release of plant and animal waste, crop treatments that pollute the air, intensive systems that deplete the soil, the lack of correlation between plant requirements and land favorability level, and other practices are the main ways that agricultural activities produce different kinds of pollution. An environmental management system must be put in place, and the financial accounting framework must be improved, as the current financial reporting requirements do not fully account for the consequences that economic activity has on society and the environment (Burja, 2012). Carrillo-Labella et al. (2020) explain that benefits are present for employees and that they can learn how to act more sustainably. So it can be claimed that the benefits of adapting the business to sustainable factors are present across the wide range of companies' aspects. Adherence to reporting standards refers to the fact that internal auditors can evaluate how accurately and consistently a business discloses and reports on the SDGs. Auditors assist in ensuring continuous compliance by contrasting the organization's procedures with industry guidelines, global standards, and legal obligations. By comparing reported data with internal records and other sources, internal auditors can confirm the precision and dependability of an organization's SDG reporting. This verification procedure shows the company's dedication to transparency, fosters confidence, and empowers stakeholders to make knowledgeable decisions (Malyzhenkov & Associate, 2023). SDG-related risks can be found by internal audit, which can also help firms better understand how these risks affect their operations, finances, and reputation. This information enables businesses to reduce risks, manage their effects, and proactively address possible weaknesses (Malyzhenkov & Associate, 2023).

It is important to note some of the challenges that internal audit may face when it comes to sustainable goals. One of them are diverse expectations of stakeholders. As it can lead to significant variation when it comes to the estimation if the company is doing business sustainably or not. Due to the dynamic nature of the SDG metrics, regulations, and standards, internal auditors must remain up to date on the most recent advancements and industry best practices in order to assess their organization's SDG indicators (Malyzhenkov & Associate, 2023).

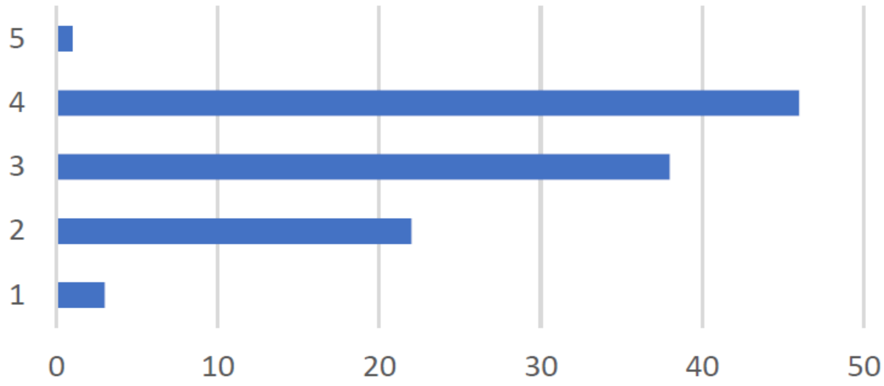
Methodology

This study used a quantitative survey approach to investigate how internal audit contributes to agricultural firms' attainment of the Sustainable Development Goals (SDGs). 110 employees from different agricultural enterprises were given a structured questionnaire with 12 questions. Eleven closed-ended questions were included in the survey to collect opinions about the importance that internal audit has in the aspect of sustainability in agricultural companies. Furthermore, one open-ended question gave participants the chance to share qualitative information about the actions that they perceive as important for internal audit to include so that sustainable development goals are achieved. Anonymity of the participants was assured and it is stated at the beginning of the questionnaire what is the purpose of the research. The close-ended questions were analyzed using descriptive statistics to identify trends and patterns, while qualitative responses were thematically analyzed to complement and deepen the quantitative findings.

Results

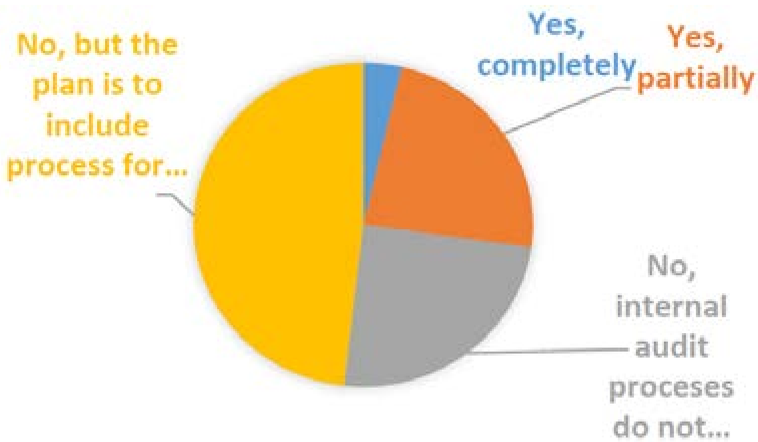
The research included 42 participants in the position of managers. In the position of internal auditor works 32 participants. 21 participants work in a sector that is related to sustainable development. At other positions in the company 15 participants. 50 out of 110 participants shared that their companies' internal audit is conducted. 46 out of 110 participants shared that in their companies, internal audit is not conducted. 14 participants shared that in their companies, internal audits are in the process of establishing. The following question addressed the estimated impact that agriculture companies have on the fulfillment of sustainable development goals. This question provides insight into the level of acknowledgment of the importance that agriculture has in the context of sustainability. Participants shared their attitudes on a scale from 1 (very much) to 5 (not at all). 46 participants shared that they believe that agriculture has a low impact on achieving sustainable development goals by selecting option 4 on the scale. Indecisive responses shared 38 participants who selected option 3 which shows that they have a neutral attitude. That agriculture has a huge impact on sustainability stated 22 participants (who selected option 2). Option 5 and the attitude that agriculture companies impact very much the sustainability goals achievement were selected by three participants. Only one participant shared that agriculture companies have no impact at all.

Chart 1. *Agriculture companies and sustainable goals*



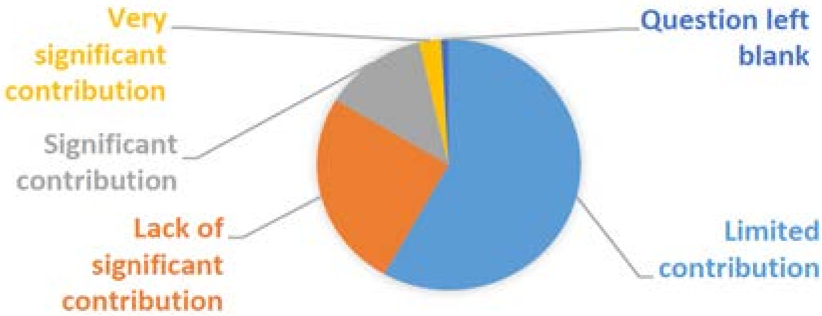
The focus of agricultural enterprises' internal audit processes on sustainable development issues is covered in the following question. According to 53 respondents, the company where they work is now implementing sustainable development initiatives, but the internal audit process is not currently centered on them. 27 out of 110 participants shared that the internal audit in companies in which they work is not focused on sustainable development. 26 participants shared that in their company internal audit processes are partially directed toward sustainable goals. Only four participants in the research said that the internal audit process is directed to sustainable processes.

Chart 2. *Internal audits and sustainable development*



The next question is directed to determine the level of the contribution of internal audit for economic efficiency and long-term of company's sustainability. 64 out of 110 participants estimate that contribution is limited. A lack of significant contribution is estimated by 28 participants. Significant contribution is estimated by 14 participants. A very significant contribution is estimated by 3 participants. One participant left this question blank.

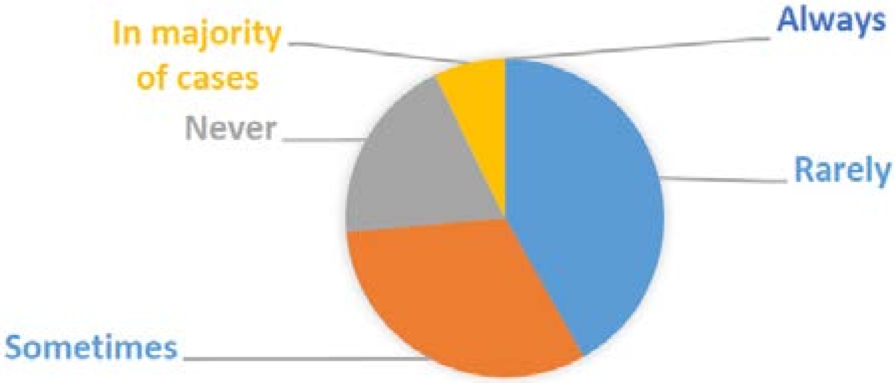
Chart 3. *Internal audit and economic efficiency*



The following question asked participants to select areas of internal audit that are considered most important within the company of participants' employment. The overall response among participants is that cost control and resource efficiency, as well as management of risks related to sustainability, are the most important areas that internal audit addresses should have the greatest impact on. Other areas also acknowledged as important by participants are legislative compliance, social responsibility, and relations with the local community.

The following question addressed the issue of the frequency of opportunities identified by internal audits for the improvement of business processes that are related to sustainability. 46 respondents believed that internal audit rarely has an impact on improving business processes. 35 participants believe that internal audit sometimes makes these suggestions. 21 participants stated that internal audit never identifies opportunities that are related to sustainability. 8 participants believe that these opportunities are identified in the majority of cases. None of the participants selected the option "always". The results of the responses of the surveyed respondents point to the conclusion that in this segment internal audit has a lot of room for improvement, because it is through the work of internal audit in improving the system of internal controls in business processes and the impact on the improvement of business processes in the company that the added value of internal audit would be added.

Chart 4. *Internal audit and improvement of business processes*

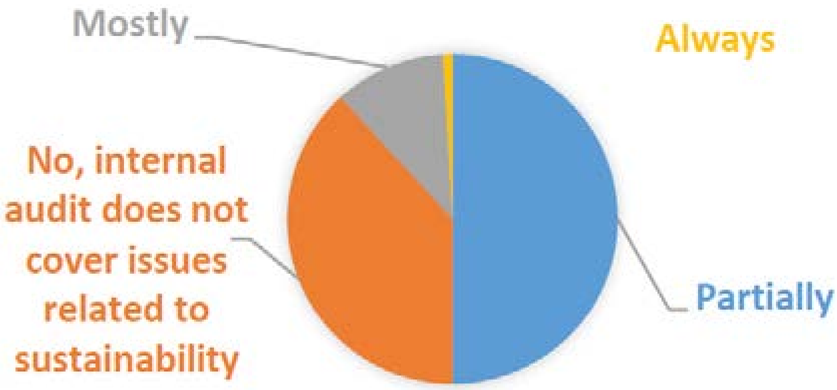


The focus of the research also was on the most important recommendations of internal audit by the opinion of participants for improvement of social development. Among selected responses of that include: legislative compliance, strengthening social responsibility, reduction of negative ecological influences, and resource optimization, resource optimization, and reduction of negative environmental influences are the most frequently selected options. Reduction of negative ecological influences was selected by 60 participants (54. 5%) and resource optimization was selected 59 times (5.6%). Legislative compliance was selected 35 times (31.8%). Strengthening social responsibility is selected 31 times (28.2%). It is important to point out that 27 out of 110 respondents (24.5%) stated that the internal audit does not make recommendations in the field of sustainability of any kind and therefore cannot answer this question.

Chart 5. *Recommendations of internal audit for sustainable development*

The following question addressed if internal audit is successful in identifying key risks related to sustainable development in their company. 55 participants out of 110 stated that key risks are identified partially by internal audit. 42 out of 110 participants stated that internal audit does not cover issues related to sustainability. That internal audit in most cases is successful in identifying key risks related to sustainable development in the company thinks 12 participants. Only one participant said that risks are always identified successfully by participants.

Chart 6. *Identification of key risks*

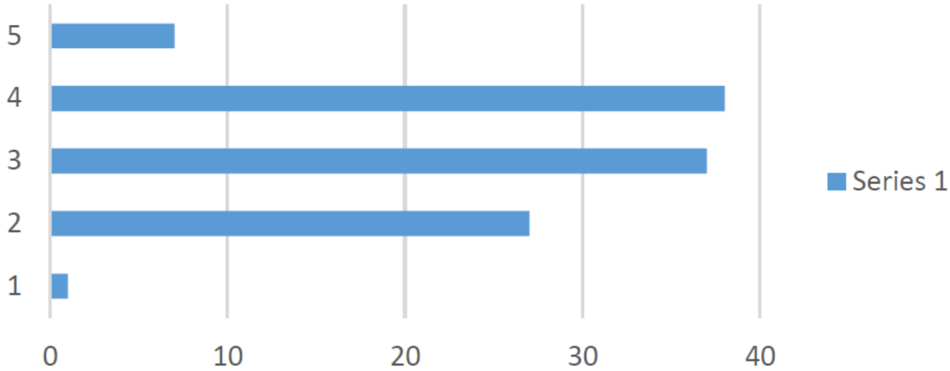


Participants were asked to determine the most important challenges in conducting internal audits about sustainable development in agriculture companies. Participants were encouraged to select all challenges that they consider that be of that importance. The majority of participants responded that insufficient awareness of the importance of sustainability is the major challenge. 83 participants selected this option which makes 75.5% of participants who believe that this challenge is of the ultimate importance. Management resistance to change was selected by 55 participants which makes up 50% of the total number of participants. Limited expertise in auditing sustainable practices marked by 25 participants which makes 22.7%. Lack of resources for adequate audit processes is an option that was selected the lowest number of times (it makes 20%).

Chart 7. *Important challenges*

Awareness of the management about the role of internal audit in the achievement of business goals was the topic addressed in this research. Participants responded using a scale from 1 (very much aware) to 5 (not at all). One participant selected option 1 and said that management is very much aware of the role of internal audit of business goals. Option 2 was selected by 27 participants which means that the manager to a great extent is aware of that role. The neutral option was selected by 37 participants. Option 4 is selected by 38 participants. 7 participants selected option 5 and shared the opinion that managers are not aware of that role at all.

Chart 8. *Awareness of management.*



The last question referred to the suggestion that participants think would help improve sustainable development in the company. An audit of waste management was one of the suggestions made by participants in this research. Suggestions made also are verification of objectives and indicators of sustainability, resource optimization, monitoring and evaluation of resource use, climate change risk assessment, developing programs for employee education and awareness, improving the sustainability reporting system, and monitoring of energy and resource consumption.

Conclusion

It can be concluded that it is necessary to increase the awareness of the role of internal audit and its application in agricultural enterprises. Research shows that employees in agricultural companies are aware of the potential benefits and aspects that can be improved if the internal audit is focused on sustainable development. Considering the increasing importance of sustainability and protection of national resources, it is of great importance to further explore the potential that supports and develops the issue of long-term sustainability. This imposes the need to devote significant attention to this area from the internal audit and to include it in the annual work plans of the internal audit, as a continuous task. In this way, the internal audit will make its concrete and essential contribution to the implementation of the strategy of sustainable development in agricultural enterprises.

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THE EFFECTS OF SUBSIDIES FROM THE AGRICULTURAL BUDGET OF THE AUTONOMOUS PROVINCE OF VOJVODINA ON INVESTMENTS IN AGRICULTURAL COOPERATIVES

Jelena Nestorov Bizonj[1]

Abstract

Agricultural cooperatives that have property and continuously invest in new capacities have the ability to provide a greater scope and quality of services to their members and cooperants in comparison to agricultural cooperatives that do not have property and investment conditions.

The majority of agricultural cooperatives in Autonomous Province of Vojvodina do not have the ability to finance major investments in material assets from personal sources, and obtaining credit for investments is extremely unfavourable. Therefore, agricultural cooperatives require subsidies to undertake new investments.

This paper will present the effects of past subsidies from the agricultural budget of the Autonomous Province of Vojvodina on investments in agricultural cooperatives, starting from the analysis of the availability of subsidies for cooperatives, concluding with the definitions for proposals for future incentives of better quality.

Key words: *agricultural cooperatives, subsidies, investments, property.*

Introduction

The long production process in agriculture, with the seasonal nature of production with a slow capital turnover, contributes significantly to a slow accumulation of internal capital for investments in agricultural production. Providing external financial sources in agriculture in terms of credit funds is not favorable in relation to the rate of capital turnover in primary agricultural production, especially in recent years, due to rising interest rates and the decreasing creditworthiness of producers and agricultural cooperatives. Various disturbances on the agricultural and food product markets in recent years, along with pre-

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dominantly low prices for primary agricultural products and high production costs over the past two years, have led many farmers and cooperatives to face liquidity issues, as well as difficulties in repaying existing loan obligations. At the same time, their creditworthiness for the future borrowing has come into question, as has the economic justification of further indebtedness.

The aforementioned issues are even more prominent with a large number of agricultural cooperatives whose members and cooperates have not managed to settle their debt for acquired raw materials in due time, due to the lack of yields or insufficient yields as a consequence of this year's draught. In accordance with the above, conditions for undertaking new investments in agriculture from internal or credit funds are not favorable. By obtaining a portion of grants for investments in agriculture, the potential for agricultural cooperatives to make new investments under current business conditions increases. However, a question emerges regarding the possibilities agricultural cooperatives have to obtain portionsof grants for investments.

The greatest opportunities for obtaining a portion of grants for investments come from national and provincial agricultural budgets, specifically through calls for proposals issued by the Ministry of Agriculture, Forestry, and Water Management, and the Provincial Secretariat for Agriculture, Water Management, and Forestry. A portion of grants for investments is possible to obtain through IPARD calls, and to a lesser extent from other sources (calls issued by other ministries of the Republic of Serbia and provincial bodies, calls from local governments, funds, special programs and others).

Although there are programs and calls for proposals at republic and provincial levels agricultural cooperatives can apply to in order to secure a part of grant for investments, the question arises as to what extent cooperative use these sources of funding and how successfully. Searching for the answers to these questions, in January 2024 the Cooperative Union of Vojvodina from Novi Sad in collaboration with the Provincial Secretariat for Agriculture, Water Management, and Forestry created TheStudy of the Effects the Provincial Secretariat of Agriculture, Water Management and Forestry's Open Competitions Have Had on Farmer Cooperatives in the Autonomous Province of Vojvodina in the Period 2018-2023 (hereinafter: The Study). Through this document, data on the participation and funds secured by agricultural cooperatives from the Autonomous Province of Vojvodina in the calls issued by the Provincial Secretariat for Agriculture, Water Management, and Forestry during the period 2018-2023 have been analyzed. Based on this analysis, conclusionshave been drawn, along with proposals and recommendations for future calls for proposals. Accordingly, certain conclusions and recommendations from the Study will be used in this paper to evaluate theeffects of subsidies from the agricultural budget of the AutonomousProvince of Vojvodina on investments in agricultural cooperatives. It should be noted that this paper does not include an analysis of the participation of agricultural cooperatives in securing grants for investments from other sources and from other authorities at the local, provincial, and national levels.

The analysis of the effects of subsidies from the agricultural budgetof the Autonomous Province of Vojvodina on investments in agricultural cooperatives

According to the data obtained from the register of cooperatives of The Cooperative Union of Vojvodina, at the end of 2023, the institution had in its membership 462 agricultural cooperatives and 20 cooperatives of othertype, which operated actively. Of the specified number of agricultural cooperatives, based on the data from Serbian Business Registers Agency about publicly disclosed financial statements, it was ascertained that the Annual Financial Statement for 2022 was submitted on time by 321 agricultural cooperatives. According to the aforementioned, the number of321 agricultural cooperatives that operate actively and meet the eligibilitycriteria according to this standard was used in the Study for the analysis of participation and received subsidies through the calls of the Provincial Secretariat for Agriculture, Water Management, and Forestry in the periodfrom 2018 to 2023.

Agricultural cooperatives that operate actively have a great need for new investments in movable and immovable property. That was identified via a survey conducted in 2021 by The Cooperative Union of Vojvodina, in which 165 cooperatives in the Autonomous Province of Vojvodina participated, and which showed that as many as 78% had the need to investin fixed assets. The high level of interest for securing subsidies for investments can be observed from other sources. For example, through the calls of the Ministry for Rural Welfare (formerly the Ministry without Portfolio for Regional Development) for the reception of subsidies by cooperatives, during the period from 2017 to 2021, as many as 1,048 cooperatives submitted applications for the annual calls. The success of the realization of these grants in the observed period could also be reflected inthe fact that grants were received by 207 agricultural cooperatives, so almost 20% of the total number of applied cooperatives (selection threshold)won the grant, or around 32,2% of cooperatives with proper application, as noted by Jeločnik, M., Subić, J., and Vasiljević, Z., (2023). From the total number of cooperatives that applied for the calls issued by the Ministry for Rural Welfare, it can be concluded that agricultural cooperatives have significant needs for receiving subsidies for investments.

Based on the analysis of participation of cooperatives on all calls of the Provincial Secretariat for Agriculture, Water Management, and Forestry for the period from 2018 to 2023, in the continuation of the paper, the part of the results and conclusions from the Study significant for this research will be presented in detail. It was deduced that agricultural cooperates from the Autonomous Province of Vojvodina had the right to apply to all calls of the Provincial Secretariat for Agriculture, Water Management, and Forestry. Out of 81 published calls in the period from 2018 to 2023, agricultural cooperatives applied for 32 calls (specifically 39% of calls). Out of the total number of agricultural cooperative that operate actively, only 51 cooperatives (16%) applied for the calls, and only 34 cooperatives(11%) managed to receive subsidies. Total amount of received subsides from all the calls of the Provincial Secretariat for Agriculture, Water Management, and Forestry was 83.572.059 dinars, which is 1,57% of the total allocated amount in all calls, whose total budget was 5.333.116.228 dinars.

Several reasons were identified as to why the majority of agricultural cooperatives that operate actively in the Autonomous Province of Vojvodina did not apply for the calls from the Provincial Secretariat for Agriculture, Water Management, and Forestry during the period from 2018 to 2023. The main reasons why agricultural cooperatives did not apply for calls are grouped into several categories, and the most significant are: the failure to submit application due to not meeting the prescribed criteria for calls, the failure to submit applications due to a lack of interest in the intended purposes of the funds provided by the calls; and due to the failure to provide a part of personal funding for investments.

Within the group of reasons related to the failure to submit application dueto not meeting the prescribed criteria for calls, the most significant and prevalent reasons were related to registered agricultural holdings(hereinafter: RAH) of agricultural cooperatives, and are based on two grounds. In the first group of agricultural cooperatives that did not meet the criteria were 63 agricultural cooperatives that had RAH with larger areas under field or other crops than the maximum areas allowed, as defined by the calls (which is over 100 hectares of field crops). In the second group of agricultural cooperatives that did not meet the call criteriawere 203 agricultural cooperatives that did not have agricultural land and did not have RAH, which was one of the conditions for applying. In accordance with the above, the total of 266 agricultural cooperatives (83%of the total number of agricultural cooperatives that operate actively) did not meet the criteria for calls either due to larger areas under specific cropson RAH, or due to the lack of RAH, which led to the identification of mainreasons for low participation of agricultural cooperatives on provincial calls. In addition to the aforementioned, other reasons for not applying on calls due to the prescribed conditions were identified, including: unfinished procedures for registering cooperative ownership of cooperative property or unfinished land consolidation processes; cases when the size of agricultural cooperative exceeds the one prescribed by calls (a cooperative is categorized as medium or large legal entity), and other reasons.

The lack of interest in the intended purposes of the funds provided by the calls is the second group of reasons as to which cooperatives did not submit application on provincial calls in the period from 2018 to 2023. It is important to emphasize that as many as 78% of agricultural cooperatives in the survey conducted by the Cooperative Union of Vojvodina reported that they have a need for investments, as well as a need to receive subsidiesfor investing. On the other hand, via survey was determined that they lackinterest in the intended purposes of the funds provided by the provincial calls, from which it can be concluded that there is a mismatch between theinvestment needs of agricultural cooperatives and the intended use of fundsin provincial calls. Conversely, there are specific provincial calls where theinterests of cooperatives in investing align with the purposes of the calls. An example of this case is the provincial call for which agricultural cooperatives expressed the biggest interest, i.e. The Call for Co-financingthe Purchase of Equipment and Systems for Irrigation, as well as Equipment for Improving the Water, Air, and Thermal Conditions of Plants in The Autonomous Province of Vojvodina.

Another significant group of reasons why cooperatives did not apply for provincial (and likely other) calls during the period from 2018 to 2023 is related to their inability to secure a portion of their own funding for investments.

Within the Study, an analysis of the criteria for receiving subsidies prescribed by individual rulebook for the calls, was conducted. It was concluded that the criteria were to a great extent adapted to the evaluation of natural persons, as well as that it cannot be determined from the rulebook if and how agricultural cooperatives were evaluated (and all otherlegal entities) according to a specific criterion (e.g. a criterion of gender and age of the applicant). It was also observed that there is a lack of definedcriteria by which legal entities would receive additional points based on their business success, as well as other indicators such as the number of employees. A more detailed analysis was conducted on the criteria relatedto additional scoring of applicants which have the status of a cooperative member or a cooperative. Under this criterion applicant received additional points due to their status of a cooperative member (10 points) ora cooperative (also 10 points). It was ascertained that the additional scoringfor the status of a cooperative member had positive effects in terms of increasing possibilities for natural persons who are cooperative members to obtain grants, while in regard to agricultural cooperatives, the same effects were not achieved under the criterion.

In relation to the results of participation and received subsidies by agricultural cooperatives from the Autonomous Province of Vojvodina incalls of the Provincial Secretariat for Agriculture, Water Management, andForestry during the period from 2018 to 2023, as well as other conclusionspresented, suggestions and recommendations for future calls were made, to increase the participation of agricultural cooperatives in future provincial calls, as well as to increase their opportunity to obtain subsidies.

It was proposed that the changes be done to the eligibility criteria for applications that agricultural cooperatives did not meet during the period from 2018 to 2023. Within this group of suggestions, the most significantones were connected to the removal of restrictions in terms of number of hectares under a specific crop for agricultural cooperatives that have RAH in calls, and enabling agricultural cooperatives without RAH to apply under specific condition in future calls.

Within the group of suggestions for expanding the purpose of subsidies in future calls and/or introducing new calls which would align with the expressed investment needs of agricultural cooperatives, it was suggested that new calls with new purpose be introduced, specifically subsidies for building and equipping storage capacities (warehouses and silos). It was also proposed to introduce a call for physical assets whose users would beexclusively agricultural cooperatives.

A reassessment of the criterion for grants was suggested, while asking for special status and conditions for agricultural cooperatives, that would be in line with the specificities of the cooperative model of organization. It was also suggested that amendments and additions be made regarding the additional scoring based on the status of a cooperative member or a cooperative, to positively affect individual cooperative members and agricultural cooperatives.

Considering that agricultural cooperatives (and other natural persons and legal entities) showed the biggest interest in the calls for allocating funds through the co-financing of the purchase of equipment and systems for irrigation, as well as equipment for improving the water, air, and thermal conditions of plants in the Autonomous Province of Vojvodina during the observed period, it was proposed that in the future the overall funding forthis type of call be increased.

Based on the conclusions, proposals and suggestion from The Study created by the Cooperative Union of Vojvodina in January 2024, the Provincial secretariat for Agriculture, Water Management, and Forestry accepted and implemented a certain number of suggestions within The Call for Co-financing the Purchase of Equipment and Systems for Irrigation, as well as Equipment for Improving the Water, Air, and Thermal Conditions of Plants in the Autonomous Province of Vojvodina. The most important suggestions that were accepted are related to the removal of restrictions on eligibility to apply based on the number of hectares under a certain crop for agricultural cooperatives that have RAH (the previous limit was up to 100 hectares of field crops); and enabling agricultural cooperatives considered as medium-sized legal entities to apply. The result of removing the aforementioned restriction was that through this call in 2024 more agricultural cooperatives applied than for each year during the period from 2018 to 2023, where 2/3 of agricultural cooperatives which applied managed to receive the grant. The total nominal amount that agricultural cooperatives received through this call during the period from 2018 to 2023 was 46.760.689 dinars, while in 2024 agricultural cooperatives received a total of 29.701.902 dinars through the same call. According to previous announcements on the part of the Provincial Secretariat for Agriculture, Water Management, and Forestry, the acceptance ofadditional proposals and recommendations from the Study is planned, provided the conditions for their implementation are met.

Conclusion

It is a fact that agricultural cooperatives in The Autonomous Province of Vojvodina received only 1,57% of the total amount of allocated funding inall calls issued by the Provincial Secretariat of Agriculture, Water Management and Forestry from the provincial agricultural budget for investment incentives. This clearly illustrates extremely low participationof cooperatives in provincial incentive measures. Extremely low percentage of agricultural cooperatives' participation in the observed period, along with the identified reasons for that, leads to the conclusion that incentives and conditions for their realization were inconsistent with the characteristics and needs of cooperatives.

One of the significant restrictions for improvement of competitiveness of agricultural cooperatives is the lack of adequate subsidies for cooperativemodel of organization and the implementation of development projects within cooperatives (Nestorov, J., Tomić, D., Puškarić A., 2015). Declarative support for cooperative model of organization exists, with agricultural cooperatives being most often identified as potential users of grants from the agricultural budget. However, through the analysis of theirparticipation and results in calls it could be deducted that the specificities of cooperative model of organization have not been recognized in regardsto the conditions for applying for calls. It can be concluded that the true role and significance of agricultural cooperatives for improvement of economic position of farmers has not been recognized by the creators of measures of agricultural policy.

According to the presented data in this paper, it can be concluded that in the period from 2018 to 2023, the effects of the subsidies from the agricultural budget of the Autonomous Province of Vojvodina on the encouraging and achieving investments in agricultural cooperative were marginal. However, a progress was made through the creation of The Study in which the reasons of the low participation of cooperatives withinthe provincial subsidies policy were identified, and were given the suggestions for change in the current negative trend, which was positivelyreflected in the first call issued by the Provincial Secretariat for Agriculture, Water Management, and Forestry in 2024, where some of therestrictive conditions for cooperatives were changed. As a result, cooperatives participated in larger numbers and secured significantly higher subsidies through this call compared to previous periods.

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ECONOMIC ASSESSMENT OF INVESTMENTS IN RURAL INFRASTRUCTURE IN HILLY-MOUNTAIN AREAS [1]

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Abstract

As one of the important elements of rural infrastructure, water supply represents the major precondition of modern lifestyle. However, in hilly mountainous regions of Serbian rural areas, water supply still does not have the treatment it deserves, while is not in line with the concept of sustainable development. Due to mentioned, there is a need for prompt attention to the issue of fresh water supply, while approach has to be in a planned manner, respecting both professional aspects, and all three pillars of sustainable development (economic, environmental and social). Considering that in hilly mountainous areas there are still local communities that have existed for many years without centralized or public water supply system, rural settlements are usually forced to rely on individual water supply solutions. Simultaneously with social progress, as well as towards the general increase in "urbanization" of villages, this issue is indispensably linked to overall development.

Author's research is focused on finding quality (technical) alternatives that secures the quality of fresh water, with special emphasis on economic assessment of investment in establishment of centralized water supply system. Preset economic model assumes overall investment of 1,843,589.74 EUR, or investment in fixed assets of 1,691,025.64 EUR, and investment in permanent working capital of 152,564.10 EUR. Applying the dynamic methods for evaluation of economic effectiveness of investments, there were derived next results: Net Present Value of 4,129,742.47

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EUR, Internal Rate of Return of 87.59%, and Payback Period of 10 years and 1.53 months. Considering planned exploitation period of investment (30 years) and occurred discount rate (7%), there could be concluded that in economic sense the investment is fully justified, while the local rural community could expect achieving of significant profit by its further utilization.

Key words: *rural areas, hilly-mountainous areas, water supply system, sustainable development, economic effectiveness of investment, Serbia.*

Introduction

Living in rural space could bring many benefits, but also several aggravating circumstances to local population, as are implementation of physical and social infrastructure elements in extent that meets the local needs (Barrios, 2008; Chakraborty et al., 2012; Atkociuniene, 2014).

Level of infrastructure development usually is the magnet for humans to settle some area. It prevents migrations, while brings newcomers to rural space opening the new entrepreneurial options and perspectives. It makes life in rural areas as decent alternative to this found in settlements (Munzwa, Wellington, 2010; Li et al., 2019). As a concept and policy platform, rural development has important role in systematic equipping of rural areas with basic and advanced infrastructures elements (electricity and IT systems, roads and traffic, water supply and sewage system, medical and social care, or education, sport and culture centers, etc.), (Jeločnik et al., 2011a; Jelocnik et al., 2011b; Surowka et al., 2021).

Coming from the fact that water supply represents one of the key developmental factors for any society, the municipality of Mali Zvornik (Serbia) serves as a positive example where this issue is given due attention. According to this, strategic approach and focus to all professional aspects in addressing the water supply problems of rural areas within the municipality of Mali Zvornik are the true example of good practice in the hilly and mountainous regions of Serbia.

As an essential link in sustainable development, social life strives to initiate and guide the social progress, or higher level of living quality, provoking the intensified transformation of rural areas into the urban environments. In this way, the issue of water supply becomes an indispensable aspect of social development, emphasizing the need for greater attention to this problem (Hoggart, Paniagua, 2001; Friedmann, 2005; Group of authors, 2006).

Initiative to perform the research for detailed study of hydrological conditions and the state of water supply served as the starting base for development of water supply system project turned to rural areas at the territory of Mali Zvornik municipality (Lazić et al., 2008).

Mentioned project for equipping rural areas within the municipality of Mali Zvornik includes two conceptual solutions. First alternative is based on construction of new water supply network, designed for thirty-year calculation (depreciation) period. The second technical solution is based on utilizing the existing system, while integrating new water supply system into it. For the purposes of this research, authors have selected the first solution, upon which they defined derived economic effects of investment in implementation of mentioned infrastructural element.

Materials and Methods

Focusing to assessment of economic effects derived from investment in water supply system implemented in rural areas of Mali Zvornik municipality, research is in line to principles towards ensuring the maximum level of financial benefits per unit of invested assets. According to that investment analysis relies both on quantitative and qualitative methods, securing investment in the most optimal (most cost-effective) business idea (Rajnović et al., 2016).

Investment analysis linked to water supply system implementation imply the use of methods for evaluating the economic efficiency of investments in agriculture. These include static and dynamic methods, as well as methods for evaluating the economic efficiency of investment under the conditions of risk and uncertainty (Gittinger Price, 1972; Românu, Vasilescu, 1993; Vasiljević, 2006; Subić, 2010; Subić et al., 2016; Subić et al., 2020; Jeločnik et al., 2022).

Research Results

The basic assumptions made in investment analysis include elements such are: overall investment (Table 1.), sources of financing (Table 2.), planned production value (Table 3.), planned costs of system running (Table 4.), profit and loss statement (Table 5.), and economic flow (Table 6.).

Table 1. Total investment (in EUR)

No.	Description	New investment	Total investment	Share in total investment (%)
I	**Fixed assets**	**1,691,025.64**	**1,691,025.64**	**91.72**
1.	Buildings and structures	1,551,086.80	**1,551,086.80**	84.13
2.	Other	139,938.84	**139,938.84**	7.59
II	**PWC**	**152,564.10**	**152,564.10**	**8.28**
TOTAL (I+II)		**1,843,589.74**	**1,843,589.74**	**100.00**

Source: Authors' calculation based on Subić, 2008.

Table 2. Sources of financing (in EUR)

No.	Description	New investments	Total Investments	Share in total investments (%)
I	**Internal financial resources**	**152,564.10**	**152,564.10**	**8.28**
1.	Fixed assets	0.00	0.00	0.00
2.	Current assets	152,564.10	152,564.10	8.28
II	**External financial resources**	**1,691,025.64**	**1,691,025.64**	**91.72**
1.	Fixed assets	1,691,025.64	1,691,025.64	91.72
TOTAL (I+II)			**1,843,589.74**	**100.00**

Source: Authors' calculation based on Subić, 2008.

Table 3. Planned production (in EUR)

No.	Description	Phases of work			Phases of project utilization			
		I (Year 2)	II (Year 3)	III (Year 5)	I (Year 5)	II (Year 5)	III (Year 5)	IV (Year 5)
1.	Water (Legal Entities)	166,343.04	398,242.58	544,553.66	544,553.66	544,553.66	544,553.66	544,553.66
2.	Water (Natural Persons)	252,694.73	604,977.51	1,432,218.83	1,432,218.83	1,432,218.83	1,432,218.83	1,432,218.83
3.	**Total income**	**419,037.78**	**1,003,220.09**	**1,976,772.49**	**1,976,772.49**	**1,976,772.49**	**1,976,772.49**	**1,976,772.49**

Source: *Authors' calculation based on Subić, 2008.*

Table 4. Planned production costs (in EUR)

No.	Cost description	Work phases			Phases of project utilization			
		I (Year 2	II (Year 3	III (Year 5)	I (Year 5)	II (Year 5)	III (Year 5)	IV (Year 5)
I	**Material costs**	**113,941.71**	**209,290.89**	**256,494.17**	**256,494.17**	**256,494.17**	**256,494.17**	**256,494.17**
1.	Raw materials and supplies	24,994.93	52,076.33	67,352.70	67,352.70	67,352.70	67,352.70	67,352.70
2.	Energy and fuel	31,505.96	69,734.84	92,527.09	92,527.09	92,527.09	92,527.09	92,527.09
3.	Other material costs	57,440.82	87,479.72	96,614.39	96,614.39	96,614.39	96,614.39	96,614.39
II	**Non-material costs**	**194,637.70**	**529,480.38**	**753,695.65**	**753,695.65**	**753,695.65**	**753,695.65**	**753,695.65**
1.	Depreciation	20,307.69	187,719.23	355,130.77	355,130.77	355,130.77	355,130.77	355,130.77
2.	Labor	117,784.76	245,401.68	284,210.74	284,210.74	284,210.74	284,210.74	284,210.74
3.	Services	20,878.76	43,513.46	56,281.49	56,281.49	56,281.49	56,281.49	56,281.49
4.	Other non-material costs	35,666.49	52,846.01	58,072.65	58,072.65	58,072.65	58,072.65	58,072.65
Total (I+II)		**308,579.42**	**738,771.27**	**1,010,189.82**	**1,010,189.82**	**1,010,189.82**	**1,010,189.82**	**1,010,189.82**

Source: *Authors' calculation based on Subić, 2008.*

Table 5. Profit and loss statement (in EUR)

No.	Description	Work phases			Phases of project utilization			
		I (Year 2)	II (Year 3)	III (Year 5)	I (Year 5)	II (Year 5)	III (Year 5)	IV (Year 5)
I	**TOTAL INCOME**	**419,037.78**	**1,003,220.09**	**1,976,772.49**	**1,976,772.49**	**1,976,772.49**	**1,976,772.49**	**1,976,772.49**
1.	Sales incomes	419,037.78	1,003,220.09	1,976,772.49	1,976,772.49	1,976,772.49	1,976,772.49	1,976,772.49
II	**TOTAL EXPENSES (1+2)**	**308,579.42**	**738,771.27**	**1,010,189.82**	**1,010,189.82**	**1,010,189.82**	**1,010,189.82**	**1,010,189.82**
1.	Operating expenses	308,579.42	738,771.27	1,010,189.82	1,010,189.82	1,010,189.82	1,010,189.82	1,010,189.82
1.1.	Material costs	113,941.71	209,290.89	256,494.17	256,494.17	256,494.17	256,494.17	256,494.17
1.2.	Non-material costs excluding depreciation and interest on loans	174,330.01	341,761.15	398,564.88	398,564.88	398,564.88	398,564.88	398,564.88
1.3.	Depreciation	20,307.69	187,719.23	355,130.77	355,130.77	355,130.77	355,130.77	355,130.77
2.	Financial expenses	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.1.	Interest on loans	0.00	0.00	0.00	0.00	0.00	0.00	0.00
III	**GROSS PROFIT (I-II)**	**110,458.36**	**264,448.82**	**966,582.67**	**966,582.67**	**966,582.67**	**966,582.67**	**966,582.67**
IV	**INCOME TAX ***	16,568.75	39,667.32	144,987.40	144,987.40	144,987.40	144,987.40	144,987.40
V	**NET PROFIT (III-IV)**	**93,889.60**	**224,781.49**	**821,595.27**	**821,595.27**	**821,595.27**	**821,595.27**	**821,595.27**

** The corporate income tax rate in this particular case is 15%.*

Source: *Authors' calculation based on Subić, 2008.*

Table 6. Economic flow (in EUR)

No.	Description	Work phases			Phases of project utilization			
		I (Year 2)	II (Year 3)	III (Year 5)	I (Year 5)	II (Year 5)	III (Year 5)	IV (Year 5)
I	**TOTAL CASH INFLOW (1+2)**	**419,037.78**	**1,003,220.09**	**1,976,772.49**	**1,976,772.49**	**1,976,772.49**	**1,976,772.49**	**2,349,154.54**
1.	Total income	419,037.78	1,003,220.09	1,976,772.49	1,976,772.49	1,976,772.49	1,976,772.49	1,976,772.49
2.	Remaining value of the project	0.00	0.00	0.00	0.00	0.00		372,382.05
	2.1. Fixed assets					0.00		219,817.95
	2.2. Permanent working capital					0.00		152,564.10
II	**TOTAL CASH OUTFLOW (3+4)**	**611,196.85**	**1,734,859.46**	**1,193,139.73**	**800,046.45**	**800,046.45**	**800,046.45**	**800,046.45**
3.	Investment value	306,356.37	1,144,140.09	393,093.28				
	3.1. In fixed assets	279,625.00	1,052,607.03	358,793.61				
	3.2. In permanent working capital	26,731.37	91,533.06	34,299.67				
4.	Costs excluding depreciation and interest on loans	288,271.73	551,052.04	655,059.05	655,059.05	655,059.05	655,059.05	655,059.05
5.	Corporate income tax	16,568.75	39,667.32	144,987.40	144,987.40	144,987.40	144,987.40	144,987.40
III	**NET CASH FLOW (I-II)**	**-192,159.08**	**-731,639.37**	**783,632.76**	**1,176,726.04**	**1,176,726.04**	**1,176,726.04**	**1,549,108.09**

Source: *Authors' calculation based on Subić, 2008.*

In line to research goal, static methods were used, such are (Tables 7-10.): Economic-efficiency coefficient, Net profit margin ratio, Accounting rate of return, and Payback period.

Table 7. Economic-efficiency coefficient (in EUR), (Ee > 1)

Years of investment realization	Total Income	Total Expenses	Economic-efficiency coefficient
0	1	2	3 = 1/2
I-II	419,037.78	308,579.42	1.36
III-V	1,003,220.09	738,771.27	1.36
VI-X	1,976,772.49	1,010,189.82	1.96
XI-XV	1,976,772.49	1,010,189.82	1.96
XVI-XX	1,976,772.49	1,010,189.82	1.96
XXI-XXV	1,976,772.49	1,010,189.82	1.96
XXVI-XXX	1,976,772.49	1,010,189.82	1.96

***Source**: Authors' calculation based on Subić, 2008.*

Table 8. Net profit margin ratio (in EUR), (NPMR > i)

Year of investment realization	Profit	Total Income	NPMR
0	1	2	3 = 1/2*100
I-II	93,889.60	419,037.78	22.41
III-V	224,781.49	1,003,220.09	22.41
VI-X	821,595.27	1,976,772.49	41.56
XI-XV	821,595.27	1,976,772.49	41.56
XVI-XX	821,595.27	1,976,772.49	41.56
XXI-XXV	821,595.27	1,976,772.49	41.56
XXVI-XXX	821,595.27	1,976,772.49	41.56

***Source**: Authors' calculation based on Subić, 2008.*

Table 9. Accounting rate of return (in EUR), (ARR > i)

Year of investment realization	Profit	Initial outlay	ARR
0	1	2	3 = 1/2*100
I-II	93,889.60	1,843,589.74	5.09
III-V	224,781.49	1,843,589.74	12.19
VI-X	821,595.27	1,843,589.74	44.56
XI-XV	821,595.27	1,843,589.74	44.56
XVI-XX	821,595.27	1,843,589.74	44.56
XXI-XXV	821,595.27	1,843,589.74	44.56
XXVI-XXX	821,595.27	1,843,589.74	44.56

***Source**: Authors' calculation based on Subić, 2008.*

Table 10. Simple payback period (in EUR), (SPP < n)

Year of investment Realization	Net cash flow from economic flow	Cumulative net cash flow
I-II	-192,159.08	-192,159.08
III-V	-731,639.37	-923,798.44
VI-X	783,632.76	-140,165.69
XI-XV	1,176,726.04	1,036,560.35
XVI-XX	1,176,726.04	2,213,286.39
XXI-XXV	1,176,726.04	3,390,012.42
XXVI-XXX	1,549,108.09	4,939,120.51

***Source**: Authors' calculation based on Subić, 2008.*

The calculation of the payback period is as follows:

$|-140{,}165.69|/1{,}176{,}726.04 = 0{,}12$

[(that is 10,12 years or 10 years and 1,43 months (12*0,12)].

In addition to static methods, dynamic methods were also used in this research, namely (Tables 11-12.): Net present value, Internal rate of return, and Dynamic payback period. Unlike static methods, dynamic methods are based on the discounting technique, which is a way of bringing all revenues and expenses, incurred at different time periods, to their present value (Vasiljević, 2006). Using discounting technique, there could be brought all future revenues and expenditures to their present value (Gittinger Price, 1972).

Table 11. Net present value (NPV) and Internal rate of return (IRR), (in EUR)

No.	Description	Work phases			Phases of project utilization				Cumulative
		I (Year 2)	II (Year 3)	III (Year 5)	I (Year 5)	II (Year 5)	III (Year 5)	IV (Year 5)	
0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1.	Net cash flow from economic flow (columns 3 to 8)	-192,159.08	-731,639.37	783,632.76	1,176,726.04	1,176,726.04	1,176,726.04	1,549,108.09	5,079,286.20
2.	Discount rate (%)	7.00	7.00	7.00	7.00	7.00	7.00	7.00	
3.	Discount factor $(1+i)^{-n}$ where i = discount rate; n = year of investment life cycle	1.0000	1.0000	1.0000	0.9346	0.8734	0.8163	0.7629	
4.	Present value of net cash flow from economic flow (columns 3 to 8)	-192,159.08	-731,639.37	783,632.76	1,099,743.96	1,027,798.09	960,558.97	1,181,807.14	4,269,908.16
5.	**Net present value of investment (columns 2 to 8)**	**4,129,742.47**							
6.	**Relative net present value of investment [(columns 2 to 8) / |column 2|]*100 > i**	**44.70%**							
7.	**Internal rate of return (IRR > i)**	**87.59%**							

***Source**: Authors' calculation based on Subić, 2008.*

Table 12. Dynamic payback period (in EUR), (DPP < n)

Year of investment Realization	Present value of net cash flow from economic flow	Cumulative net cash flow
I-II	-192,159.08	-192,159.08
III-V	-731,639.37	-923,798.44
VI-X	783,632.76	-140,165.69
XI-XV	1,099,743.96	959,578.27
XVI-XX	1,027,798.09	1,987,376.37
XXI-XXV	960,558.97	2,947,935.33

***Source**: Authors' calculation based on Subić, 2008.*

The payback period is calculated as follows: $|-140,165.69|/1,099,743.96 = 0,13$

[(that is 10,13 years or 10 years and 1,53 months (12*0,13)].

The inability to predict future events (incomes, expenses, economic lifespan of the investment project) significantly impacts the justification for investment and reduces the real possibility of making the right decision. In line to this, decision-making is often faced with the problem of uncertainty and the need to reduce business risks. The assessment of the economic effectiveness of investment under conditions of uncertainty can be performed using various methods and techniques (Subić, 2010). For the purpose of research, there are considered two methods (Table 13.), specifically: Break-even point, and Margin of safety.

Table 13. Break-even point of investment exploitation (in EUR)

No.	Description	Work phases			Phases of project utilization			
		I (Year 2)	**II (Year 3)**	**III (Year 5)**	**I (Year 5)**	**II (Year 5)**	**III (Year 5)**	**IV (Year 5)**
1.	Incomes (I)	419,037.78	1,003,220.09	1,976,772.49	1,976,772.49	1,976,772.49	1,976,772.49	1,976,772.49
2.	Variable costs (VC)	231,726.48	454,692.58	540,704.91	540,704.91	540,704.91	540,704.91	540,704.91
3.	Fixed costs (FC)	76,852.94	284,078.70	469,484.91	469,484.91	469,484.91	469,484.91	469,484.91
4.	Gross margin (GM = I - VC)	187,311.30	548,527.51	1,436,067.58	1,436,067.58	1,436,067.58	1,436,067.58	1,436,067.58
5.	Break-even point (relative) (BEPr = (FC / GM) * 100), in %	41.03	51.79	32.69	32.69	32.69	32.69	32.69
6.	Break-even point (value) (BEPv = (I * BEPr) / 100), in EUR	171,929.22	519,560.91	646,254.30	646,254.30	646,254.30	646,254.30	646,254.30
7.	Margin of safety (relative) (MSr = ((1 - (BEPv / I)) * 100), in %	58.97	48.21	67.31	67.31	67.31	67.31	67.31
8.	Margin of safety (value) (MSv = (I*MSr/100)), in EUR	247,108.56	483,659.18	1,330,518.18	1,330,518.18	1,330,518.18	1,330,518.18	1,330,518.18

Source: *Authors' calculation based on Subić, 2008.*

Conclusion

According to static assessment of investment economic efficiency (investment in implementation of water supply system for rural areas in the municipality of Mali Zvornik), the following conclusions can be drawn:

- The **economic-efficiency coefficient** is over than one, indicating that total income exceeds total expenses. Consequently, it can be concluded that the investment is economically viable, i.e. investment is profitable.
- The **net profit margin ratio** is higher than 7% (assumed weighted cost of capital). Therefore, it can be stated that investment project is accumulative (meaning that during the project's exploitation, the costs of financing sources are covered, and additionally profit is generated).
- Except in the first two years, **accounting rate of return** exceeds 7% (assumed weighted cost of capital). Thus, it can be concluded that the investment project is profitable (indicating that the financing costs are covered, and additional earnings are generated).
- The **payback period** of investment is 10.12 years, so investment will be repaid in 10 years and 1.43 months (0.12 x 12 months).

Considering dynamic assessment of economic efficiency of realized investment in water supply system, following conclusions can be drawn:

- Investment in over five-years utilization period (project lifespan) would enable investor to achieve a total profit increase, by the use of discount rate (i = 7%) at the starting moment of exploitation (n = 0), amounting to 4,129,742.47 EUR (NPV).
- Investment is profitable, as Internal rate of return (IRR) during the project implementation exceeds discount rate (87.59% > 7%).
- Investment project will be paid back in 10.13 years, what corresponds to 10 years and 1.53 months (0.13 x 12 months).

Considering investment analysis under conditions of risk and uncertainty, the following conclusions can be drawn:

- During the project utilization, i.e. in one of observed phases, production volume must not fall below 32.69%, or achieved sales revenues must not drop below 646,254.30 EUR.

- During the project utilization, i.e. in one of observed phases, decrease in production volume could come up to 67.31%, or revenues could drop up to 1,330,518.18 EUR.

Based on mentioned above, general conclusion is that investment in water supply system implemented in rural areas of municipality of Mali Zvornik is profitable, while it generates income, or it is fully justifiable.

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IMPACT OF ENVIRONMENTALLY RELATED TAXES ON REDUCING POLLUTION IN AGRICULTURAL SECTOR

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Abstract

The authors analyze an impact of the environmentally related (ERL) taxes on reducing pollution in the agriculture sector in Serbia. The obtained results show a strong positive correlation between carbon dioxide emissions and ERL taxes implying that these taxes are not effective in case of carbon dioxide emissions. A strong negative correlations exist between non-methane volatile organic compounds emissions and ERL taxes, between sulfur oxides emissions and ERL taxes, between particulate matter <10 μm emissions and ERL taxes, and between carbon monoxide emissions show and ERL taxes, further indicating that the observed variables move in opposite directions with a strong association. Bearing in mind the obtained findings, the authors may conclude that the ERL taxes in the agriculture sector are relatively effective.

Key words: *Environmentally Related Taxes, Air Pollution, Greenhouse Gases Emission, Correlation, Agricultural sector.*

Introduction

As global environmental and climate challenges continue to intensify, environmental policies and taxes are increasingly seen as fundamental pillars for achieving a sustainable environment. The positive effect of environmentally related taxes on boosting environmental standards may prompt policymakers to raise these taxes, as the current level is considered too low to achieve climate change objectives and falls short in relation to the social cost of carbon and the prices of taxed fuels. In post-transition countries, environmentally related taxes are essential for driving sustainable development (Andrei et al.,

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2016). Agriculture can be affected by environmentally related taxes. As agro-ecosystem productivity improves, the resulting shifts in agricultural practices have contributed significantly to the growing environmental pollution (Miceikiene et. al, 2022).

Literature Review

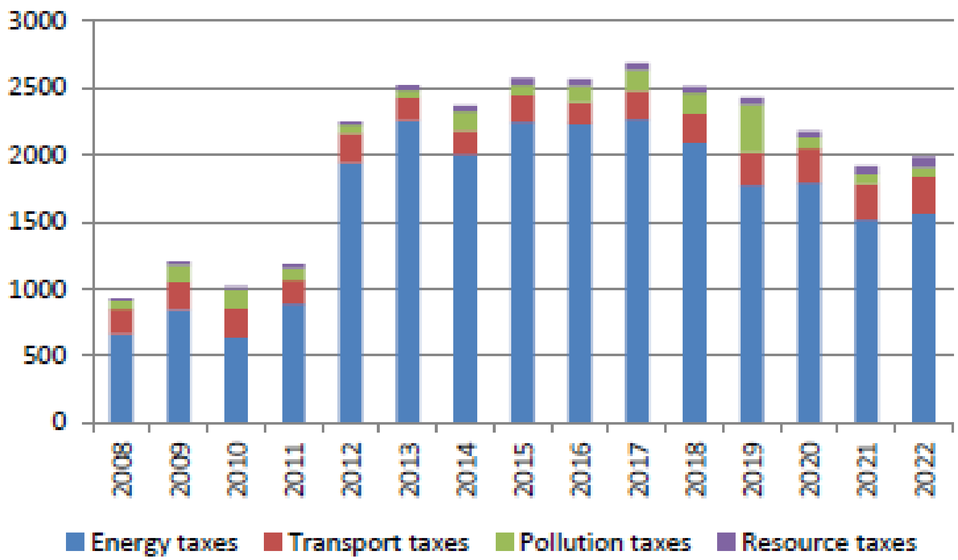
Wang and Tang (2023) conclude that the environmentally related taxes offers two advantages: it may regulate air pollution and foster sustainable development, while also enhancing social harmony and improving the well-being of residents. Using the ARDL model Arltová and Kot (2023) show that environmentally related taxes have an impact on air pollution in 37 OECD member countries in the period from 2004 to 2018. Similarly, Youssef et al. (2023) find a negative and statistically significant correlation between environmentally related taxes and CO_2 emission in the countries within the European Economic Area. Using the panel cointegration tests Wolde-Rufael and Mulat-Weldemeskel (2023) show a negative impact of environmentally related taxes on CO_2 emissions in 20 European countries covering the period from 1995 to 2012. Tang and Yang (2023) assess the impact of environmentally related taxes on air pollution in China. Their heterogeneity analysis reveals that the reform is more impactful in cities with higher levels of taxes. The study confirm that environmentally related taxes can be an effective tool for reducing pollution in developing economies. Utilizing FE panel model Balaban and Stoiljković (2023) show that the environmentally related taxes had an impact on emission of carbon oxides and ammonia in Serbia during the period from 2008 to 2020. The authors also reveals that the emission of particulates <2.5 μm grows along with the environmentally related taxes increase. Using the panel smooth transition regression model Esen et al. (2021) find that environmentally related taxes lower the ecological deficits after exceeding a certain threshold level in the EU-15 countries cover the period from 1995 to 2016. Thus, the authors conclude that if taxes are at the optimal level, this can have a positive impact on the environment.

Jansson et al. (2024) show that a global tax may lead to a reduction in global agricultural emissions, although it may also threaten food security in certain EU regions. Borrego et al. (2023) believe that the implementation of environmentally related taxes would be beneficial for achieving sustainable development in agricultural sector in Portugal. Using Method of Moments Quantile Regression Alola et al (2023) show that the environmentally related taxes enhance environmental well-being and gross value added from agricultural sector in France, Germany, Italy, and Spain during the period from 1995 to 2020. Most importantly, the obtain results offer timely policy insight that align with both the environmental quality and food security framework of the EU. Utilizing multiple regression analysis, correlation coefficient and cluster analysis Inkábová et al. (2021) show that environmentally related taxes in agricultural sector had an impact on reducing pollution in Slovakia covering the period from 2009 to 2018. Mardones and Lipski (2020) emphasize that the environmentally related taxes applied solely to agricultural sector does not lead to a significant reduction in emissions.

Data and Methodology

Due to the lack of a sufficiently long time series, the correlation method was applied in this study. Data for the agricultural sector in Serbia were observed on an annual basis from 2008 to 2022. Figure 1 shows environmental tax revenue in agricultural sector in Serbia.

Figure 1: *Environmental tax revenue in agricultural sector in Serbia (million RSD)*

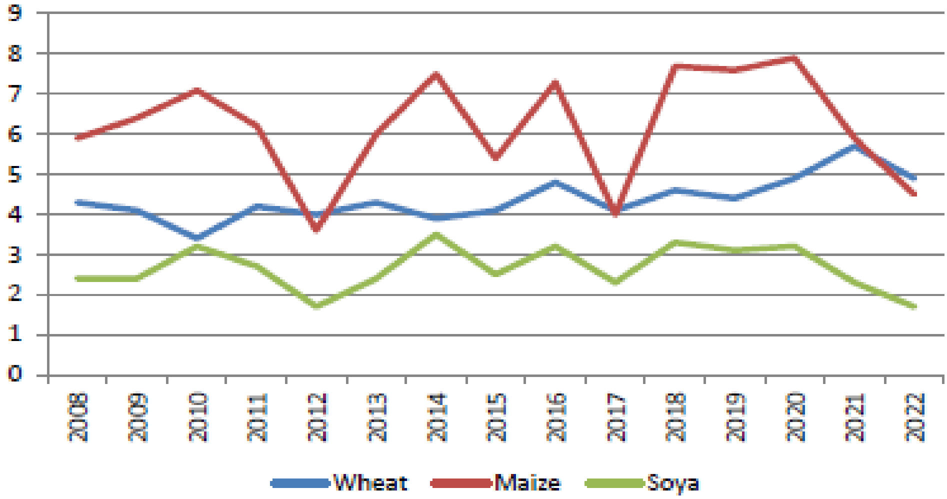


Source: *SORS and Statistical Office of the Republic of Serbia*

Figure 1 shows that taxes increased by 30% in 2009 compared to 2008, while in 2010, a 12% decrease was recorded compared to 2009. In 2011, total ERL taxes rose by 11% compared to 2010, and in 2012, there was a record increase of 90% in ERL taxes compared to 2011. The upward trend continued in 2013, with a 12% increase compared to 2012. A single-digit decrease of 6% in ERL taxes was observed in 2014 compared to 2013, followed by a renewed growth in 2015. After 2015, ERL taxes remained relatively stable, with a 10% increase in 2020 compared to 2019, and an 11% decrease in 2021 compared to 2020.

Figure 2 shows Crop production and gross value added in agricultural sector in Serbia. As can be seen the yield of crops has varied over time.

Figure 2: *Crop production and gross value added in agricultural sector*



Source: *SORS and Statistical Office of the Republic of Serbia*

Table 1. *Greenhouse gases emissions in agricultural sector in Serbia*

Year	Carbon dioxide, kt (Gg)	Methane, t (Mg)	Nitrous oxide, t (Mg)	Carbon dioxide from biomass used as a fuel, kt (Gg)	Hydrofluo-rocarbons, t(Mg)
2010	300,308	95773,186	8435,265	2,123	0,064
2011	313,624	94992,359	8945,389	7,910	0,056
2012	482,493	94189,796	10809,053	10,707	0,085
2013	484,688	92633,120	10403,143	8,116	0,080
2014	453,557	94795,179	8625,391	14,127	0,096

Year	Carbon dioxide, kt (Gg)	Methane, t (Mg)	Nitrous oxide, t (Mg)	Carbon dioxide from biomass used as a fuel, kt (Gg)	Hydrofluo-rocarbons, t(Mg)
2015	478,860	94433,433	8481,829	10,145	0,072
2016	641,350	91410,406	10010,735	6,516	0,053
2017	588,593	91874,963	8992,925	6,060	0,046
2018	396,124	90341,469	7499,580	5,610	0,047
2019	443,582	90799,957	7323,210	6,066	0,036
2020	482,581	90814,393	8868,846	5,889	0,033
2021	354,870	88726,296	6162,413	6,188	0,025
2022	461,263	84049,126	6850,167	6,228	0,026

Source: Environmental Protection Agency and Statistical Office of the Republic of Serbia

Table 1 shows greenhouse gases emissions in agricultural sector in Serbia during the period from 2010 to 2020. As can be seen from the table the emission of carbon dioxide and carbon dioxide from biomass used as a fuel have been increased during the observed period, while methane, nitrous oxides and hydrofluorocarbons emissions have decreased in the observed period.

Table 2. *All pollutants emissions in agricultural sector in Serbia*

Year	*Nitrogen oxides, t(Mg)*	*Non-methane volatile organic compounds, t(Mg)*	*Sulphur oxides, t(Mg)*	*Particulates < 2.5µm, t(Mg)*	*Particulates < 10µm, t(Mg)*	*Carbon monoxide, t(Mg)*	*Ammonia, t(Mg)*
2008	12505,188	5940,844	63,100	382,742	6108,448	1822,434	23604,006
2009	16655,869	6155,199	47,461	420,598	6065,045	2009,987	27931,578
2010	9875,650	5893,760	82,279	377,130	5995,334	3662,466	20171,973
2011	11454,237	5862,450	42,862	392,778	6010,553	2961,227	21238,592
2012	17214,422	5810,545	53,431	479,290	5976,183	2167,628	25984,512
2013	15959,575	5885,845	45,730	485,251	6037,041	1500,030	24206,085
2014	9761,333	5761,970	19,405	365,226	5958,354	764,466	19791,153
2015	10277,585	5742,431	19,984	365,519	5904,556	771,273	20376,477
2016	12688,974	5637,834	31,270	364,839	5851,977	774,920	22772,805
2017	11987,572	5577,933	42,664	375,641	5844,884	848,295	21475,452
2018	8116,166	5676,954	38,254	371,036	5930,738	781,522	16775,242
2019	7723,905	5631,706	37,420	357,888	5903,716	701,535	16432,382
2020	10775,401	5687,427	43,317	379,038	5957,543	820,623	20016,575
2021	6556,264	5600,814	47,261	392,870	5958,164	914,332	13999,286
2022	8865,989	5506,354	52,482	404,422	5934,324	990,993	16038,976

Source: Environmental Protection Agency and Statistical Office of the Republic of Serbia

Table 2 shows all pollutants emissions in agricultural sector in Serbia during the period from 2010 to 2020. As can be seen from the table the emission of particulates < 2.5μm have been increased during the observed period, while emission of nitrogen oxides, non-methane volatile organic compounds, sulphur oxides, particulates < 10μm, carbon monoxide and ammonia have decreased during the observed period.

Results and discussion

What is clearly evident from the available data is a strong positive correlation (0.734051) between the level of GDA and environmentally related (ERL) taxes from the agricultural sector during the period from 2008 to 2022. This indicates that as GDA increases, the collection of environmental taxes also rises. The productivity of agricultural activity was measured based on the most widely produced crops: wheat, maize, and soya (yield, t/ha). There is a very weak positive correlation (0.221674) between wheat productivity and environmentally related taxes, suggesting a weak relationship between the two variables. Similarly, the correlation between maize productivity and environmentally related taxes is very weak and negative (-0.04785), also indicating a weak connection. An identical situation is observed when examining the correlation between soya production and environmentally related taxes, where a very weak positive correlation (0.102745) is noted. The general conclusion that can be drawn is that the yields of the observed crops are not significantly related to environmentally related taxes.

When examining individual greenhouse gas emissions in the agricultural sector in Serbia, there is a strong positive correlation (0.787839) between carbon dioxide emissions and ERL taxes, indicating that the two variables move in the same direction. This suggests that as the collection of environmentally related taxes increases, carbon dioxide emissions also rise, implying that the observed taxes are not effective in reducing carbon dioxide emissions. A weak negative correlation (-0.40777) is observed between ERL taxes and methane emissions, suggesting that these variables move in opposite directions, but the relationship is weak. A very weak positive correlation (0.168499) is found between ERL taxes and nitrous oxide emissions, indicating that the variables move in the same direction, though the connection between them is very weak. A moderate positive correlation (0.587306) is observed between ERL taxes and carbon dioxide emissions from biomass used as fuel, suggesting that these variables move in the same direction, with a moderate strength of association. Finally, a very weak negative correlation (-0.00967) is found between environmentally related taxes and hydrofluorocarbon emissions, indicating that the two variables move in opposite directions, but the relationship between them is extremely weak.

When examining individual pollutant emissions in the agricultural sector in Serbia, a variety of correlations with ERL taxes are observed. There is a very weak negative correlation (-0.11478) between nitrogen oxides emissions and ERL taxes, suggesting the two variables move in opposite directions, but with a weak relationship. Similarly, a strong negative correlation (-0.63541) is found between non-methane volatile organic compounds emissions and ERL taxes, indicating a strong inverse relationship. A similar strong negative correlation (-0.67822) is observed for sulfur oxides emissions, showing a strong inverse trend with ERL taxes. In contrast, particulate matter <2.5μm emissions exhibit a very weak negative correlation (-0.02828) with ERL taxes, implying a minimal inverse relationship. However, a stronger negative correlation is found between particulate matter <10μm emissions and ERL taxes (-0.75924), suggesting a significant inverse association. Carbon monoxide emissions also show a strong negative correlation (-0.76562) with ERL taxes, indicating the variables move in opposite directions with a robust relationship. Finally, ammonia emissions display a very weak negative correlation (-0.23501) with ERL taxes, indicating a weak inverse relationship. These correlations are assessed according to the guidelines of Hinkle et al. (2003) and Evans (1996).

Conclusion

When examining individual greenhouse gas emissions in the agricultural sector in Serbia, a strong positive correlation (0.787839) is observed between carbon dioxide emissions and ERL taxes, indicating that both variables move in the same direction. This suggests that as the collection of environmentally related taxes increases, carbon dioxide emissions also rise, implying that these taxes are not effective in addressing carbon dioxide emissions.

When considering the emissions of all pollutants in the agricultural sector, a strong negative correlation (-0.63541) is found between non-methane volatile organic compounds emissions and ERL taxes, indicating that these variables move in opposite directions, with a strong inverse relationship. A similar strong negative correlation (-0.67822) exists between sulfur oxides emissions and ERL taxes, suggesting an inverse relationship between the two variables. A strong negative correlation (-0.75924) is also observed between particulate matter <10 μm emissions and ERL taxes, indicating a significant inverse relationship. Likewise, carbon monoxide emissions show a strong negative correlation (-0.76562) with ERL taxes, further indicating that the two variables move in opposite directions with a strong association.

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AUTONOMYOF WILL AND DISPOSAL OF AGRICULTURAL LAND[1]

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Abstract

Autonomy of the will is the basic principle of the law governing the matter of contract law. The autonomy of the will is a confirmation of the existence of subjective civil rights, but also a guarantee of the position and role of the will of the individual in the establishment, change and termination of subjective civil rights. This would mean that the contracting parties conclude, change and terminate their contractual relations of their own free will. The widest freedom of contract exists when the object of disposal is private property. However, this freedom is not limitless, but must be within the limits of coercive regulations, public order and good customs, which limits are quite wide depending on the subject of the contract. Certain restrictions exist in the disposal of agricultural land. The paper analyzes the influence of autonomy of will on the disposal of agricultural land in private ownership. On the one hand, agricultural land is an asset of general interest in the Republic of Serbia, and on the other hand, there are general rules of freedom of disposal of private property, but this freedom is limited in specific cases, considering the status of an asset of general interest. Autors believe that the state benefits from goods of general interest and the owner bears the risk. That is why the state should make an additional contribution, by reducing the risk of agricultural land owners with safe subsidies so that both parties benefit.

Key words: *autonomy of will, agricultural land, good of general interest, restrictions on disposal, natural law.*

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Introduction

Regulation of obligation relations in any social system, depending on the nature of the system and the interest that is to be achieved, gives the legislator two possibilities. If it concerns interests and relationships that can only be protected by a specific legal solution and its strict application, the legislator opts for imperative coercive norms, which the contracting parties must respect. But, if the interests and relationships are not such that they need to be protected by an imperative legal norm, then the contracting of the business relationship is completely left to the interested parties (legal vacuum) or is regulated by dispositive norms of the law that only substitute the will of the contracting parties if it is not expressed otherwise in the mutual contract. Therefore, in this case, the primary importance is the will of the contracting parties in relation to the will of the legislator prescribed by laws (Perović, S., 1995). Such norms are mostly contained in the Law on Obligations of the Republic of Serbia (ZOO).

Every legal system in the field of obligations allows the contracting parties a greater possibility to regulate their relations themselves, of their own free will, but always within the limits established by law. The principle of the dispositive nature of the provisions of the law regulating this area is accepted in the modern world as ruling, where the will of the contracting parties, as a rule, has a dominant character. The agreement of the contracting parties on the content of their relationship is the law for the parties that concluded it.

In accordance with that principle, the law of Serbia expressly prescribed that the provisions of that law are complementary in nature. This means that the dispositive legal norms are applied only if the contracting parties, within the permissible limit of autonomy of will, have not determined otherwise (ZOO).

Every legal system allows the freedom of contractual regulation of business relations, but also foresees a limit to which the freedom of the contracting parties can extend. This means that this freedom is never absolute and unconditional, so we can only talk about its broader or narrower frameworks of application. Freedom of contract is opposed by the general rules of the social order, the nature and framework of which depend on the nature and character of the basic principles on which a social system rests (Marković, R., 2014). The principle of freedom to regulate contractual relationships in Serbia is limited by one traditional provision according to which contractual parties in contractual relationships are free to regulate their business relationships in accordance with their will within the limits of compulsory regulations, public order and good customs (Perović, S., 1995).

When it comes to limiting the freedom of contract, through a generally accepted norm, it can be said that it is a theory of public order, which first appeared and developed in the French doctrine. This theory can be understood as a general theory about the limits of freedom of contract, regardless of the term used to denote that limit in the codes of individual countries (Marković, R., 2014).

In Serbia as well, public order and its protection are in the foreground. Public order can be described as a set of institutions and certain regulations, whose role is primarily to protect the general interest of a society. It is necessary to point out that the institution of public order is of a relative nature and therefore subject to invisible changes in every society, including Serbian society. Namely, on the question, what is public order, different legal systems give different answers, depending on special circumstances and relationships (Gounot, E., 1912). Closely related to the institutions of public order are the rules of business ethics and good behavior.

Finally, the autonomy of the will is also limited in relation to the inviolability of concluded contracts. The courts, recognizing the occurrence of a change of circumstances (clausula rebus sic stantibus), allow, in addition to his compensation, the termination of the contract. The injured party is not obliged to remain with the contractual relationship (pacta sunt servanda), but may request termination of such contractual relationship.

The problem raised in this paper is the relationship between the state and business entities (legal or natural persons) in the field of agriculture, interested in achieving business goals with their own property, using their property, agricultural land and agricultural products. The goal of every business entity is to use and dispose of its assets in order to gain profit (Penner, J. E., 1997). The goal of the state, as one of the constituents, is also to realize the profit of economic entities so that it, the state, would realize its benefit in a sociological sense from public revenues from the operations of economic entities. In this regard, the owner of the property and/or capital participates in all business results - he receives the realized profit or, unlike all other constituents, he bears the only risk. The fact that the economic results of a business entity's operations are reflected directly in its assets is one of the key levers of entrepreneurship and motivation for investing capital in business: viewed in the relationship between the state on the one hand and the owners of agricultural land and products as means of labor on the other, there is no socialization losses and participation in profits. Success in business is shared by all constituents, and failure "happens" only to the owner of agricultural land, i.e. capital.

The main goal of this paper is to show the possibilities of well-regulated relations between the state and the owner of agricultural land as goods of general interest and/or agricultural products whose disposal, as well as the free disposal of certain agricultural products, is limited by imperative norms, against the general principle of autonomy of will prescribed by the ZOO.

Methodology

In order to collect and evaluate relevant information, the following methods were used:

- analysis of several cases in practice - agricultural producers in the territory of Srem,
- the synthesis method was used to summarize the conclusions, while giving recommendations for the application of good rules in this area.

The research was conceived as a theoretical-empirical one, which decided to apply basic analytical and synthetic methods in the theoretical part, and in the empirical part, the survey method.

During the preparation of the theoretical part, numerous modern scientific and professional literature, as well as practical experiences, were consulted through the research of foreign and domestic literature that deals with the issues of autonomy of will, property rights and the state as a person interested in the sustainable operation of economic entities and the management of goods of general interest.

The authors conducted a survey in which ten representatives of companies and larger agricultural holdings in the territory of Srem, who have 3 or more employees and have been in business for more than ten years, participated, which implies that they have sufficient knowledge about the activity they are engaged in. The goal of the survey was to determine the position of farmers and processors of agricultural products in the situation of restrictions on the distribution of their property by the state.

All properties that have been reached through research have been classified, in order to point out important connections and relationships, and by the method of comparison, we have learned about the desired goals, ways and directions of cooperation between the owners of goods of general interest and the state.

Bearing in mind the strategic importance of agriculture in the RS and the fact that the relationship between the state and the owner of agricultural land as a good of general interest synergistically connects several components - economic, political, social, legal and environmental issues, the main hypothesis of this work is based on the assumption that the relationship between of the state and owners of goods of general interest can be arranged in such a way that they serve to increase the competitiveness of agriculture in the Republic of Serbia and, in particular, to redistribute risks.

Research results

The interest of the property owner of agricultural land

Analyzing data obtained from representatives of companies and larger agricultural holdings in the territory of Srem, it can be concluded that they are not satisfied with compensation from the state in a situation where, due to certain circumstances, it limits the prices of their goods and services. Compensation is not paid in an adequate amount, it is not paid in a timely manner, nor can they affect the amount of compensation. They believe that in such cases the risk of working on their own property is borne only by the owners of the property.

The right to property is considered both a natural and a personal right, guaranteed by the Constitution of the Republic of Serbia and other regulations. Property rights aim to achieve human dignity by ensuring the economic independence of individuals (Paunović, Krivokapić, Krstić, 2018; Kuljić, T., 2016). In order to exercise economic rights, the state has the right 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.

When it comes to the autonomy of the will, in recent times the maxim "the individual acts, and the right commands" is increasingly present. This means that, compared to the long history when the autonomy of the will was much more dominant, something is still changing, in terms of the circumstances and the extent of the autonomy of the will. The limitations of the autonomy of the will are numerous and constantly increasing.

It is true that the individual will must necessarily give way to somewhat higher social values that would be in the interest of all, but not to the detriment of the individual, the owner of his own property, but the state is obliged to provide means in order to completely eliminate the risk of the owner of private property (Penner, J. E., 1997). The dogma of absolute independence and independent limitation of the human will will experience new blows and will be increasingly endangered. The opinion that the will is in the service of the law, and not the law in the service of the will (thering), will easily penetrate. The will is also increasingly attributed a social function, and is even considered as an instrument for the realization of a social function.

Every business, regardless of whether it is carried out by a natural or legal person, is only at first glance an idyllic system that has one interest, the interest of the property owner. However, the fact is that every business is full of conflicts and different interests towards the internal and external world (Vasiljević, M., 2013). It is inevitable that there are multiple interests, and certainly the risks of the constituents: the interest of shareholders, creditors, employees, the interest of the management, the company itself, the interest of society in the sociological sense (of the state).

There is no doubt that the main interest of property owners is to secure profits, which, however, in most of the world in the last few decades has been limited by moral aspects. Therefore, it can be concluded that "the interest of business is the totality of all individual interests of all constituents." In this totality, the interest of the owner of the property (capital) is certainly primary, that is, in the first place, but in any case it is not the only interest.

Agriculture is extremely important for the Republic of Serbia and its citizens. Double requirements are constantly placed before it: it needs to find a way to produce quality food for the population, at the same time to take care of environmental protection, so that the fulfillment of these requirements by persons engaged in agriculture is constantly under scrutiny, users, the public and the state.

The state can implement extraordinary intervention measures in this area for the effective and timely prevention, i.e. elimination of market disturbances caused by a significant increase or decrease in prices on the domestic or foreign markets or other events and circumstances that lead to or threaten to lead to significant disturbances in the market, in order to protection of the living standard of the population. But he cannot implement the mentioned measures to the detriment of the owner of the property, but must compensate him.

In Serbia, the government's measures, such as the one banning the export of flour and wheat, have damaged millers and farmers. It happens that the state, due to the economic crisis and the low standard of living of citizens, passes regulations on limiting the prices of agricultural products or their products to the detriment of producers. That is why those business entities should receive adequate and timely compensation from the state that would provide them with sustainable business, not only so that they would have the interest and motive to produce what is expected of them and thereby fulfill the state's obligation to the citizens, but that the service realistically compensates so that they do not bear the business risk. We need to find a fair solution on compensation for farmers, millers and others in the same position, which will not suffer either the budget or the socially vulnerable categories.

Sustainable business and state responsibility

Globalization, as a process that marked the end of the twentieth century, helped the world to understand how business operations of economic entities affect not only the individual, but also the immediate environment and the global ecosystem. The day we realized that we operate in a global village, we also began to understand the complicated connections between customers, suppliers, local communities, the state, the environment and our own success.

Thanks to the media, and especially the development of the Internet, the planet has become aware of the challenges that stand in the way of its sustainable development and survival. Thus, today, a responsible attitude towards employees, citizens and the environment is demanded not only from governments but also from private companies.

The imperative of sustainable business is not just a question of altruism. It is primarily a question of the physical survival of individuals and companies in a world of limited resources. The adoption of a sustainable business model enables business entities not only to survive in conditions of limited resources and to develop continuously and in the long term (World Business Council for Sustainable Development, 1998), and the state's living income and the performance of its functions that the Constitution mandates.

Therefore, socially responsible business is actually a derivative of sustainable development. 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). Therefore, the state is obliged to assume the full risk that it imposes on other economic entities in the performance of its functions.

Acknowledgement

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Conclusion

A little less than a century ago, scientists correctly concluded 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 that the right to property has been deprived of its unlimitedness for a long time, primarily for the purpose of protecting the public interest. Due to such a changed understanding, property 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 or reduction of property rights. The authors believe that in numerous procedures to limit the disposal of the property of farmers and processors of agricultural products, the state crossed the limit of its powers in a negative sense and significantly damaged the rights of persons with inadequate compensation for their risk.

The importance of agriculture for the economy of Serbia, for people and the environment is undoubtedly great. The state should provide a safer environment for agricultural production and more intensive development of the agricultural sector.

Considering the obligation of socially responsible behavior in all, including in this case, 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 cases before above all, limiting the rights of the agricultural producer related to the disposal of their product, but also fair compensation up to the assumption of full risk.

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ANALYSIS OF ENVIRONMENTAL EXPENSES IN ROMANIA AND SERBIA

Maria Claudia Baicu[1]

Abstract

This discussion encompasses ”Analysis of environmental expenses in Romania and Serbia”, reduction of greenhouse gas emissions, and carbon footprint. The analysis of ecological spending in Romania focuses on assessing the costs associated with environmental protection and natural resource management, including government spending, private sector investments, and European funds allocated for ecological projects. Romania has implemented various policies to improve resource management in alignment with sustainable development objectives. Studies on these expenditures examine their impact on the economy and society, as well as the efficiency of fund utilization in environmental projects.

Key words: *emissions, environmental expenses, carbon footprint.*

Introductiom

The present study entitled „Analysis of environmental expenses in Romania and Serbia" looks at aspects such as Romania's expenses allocated to funds for environmental protection, the reduction of greenhouse gas emissions, and the carbon footprint. A detailed analysis of environmental spending is necessary to see the effect on the health of the population and the economy and also to find effective strategies to solve the problems facing the country. Reducing greenhouse gas emissions is an essential objective in combating climate change. From a climate point of view, Romania adopts a strategy to reduce greenhouse gas emissions, which aims to reduce them by 99% by 2050. (Ministry of Environment, Waters and Forests, 2023)

Serbia has addressed policies and regulations to protect the environment, such as the „National Strategy for Sustainable Development," which aims to protect the environment and promote more efficient resource use by integrating

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sustainable development principles in all economic sectors. These policies are essential to promoting a more sustainable future. (Ministry of Environment, Waters and Forests, 2024)

Strategies and measures applied to achieve sustainable development goals

Reducing greenhouse gas emissions is an essential objective for combating climate change. The following measures, combined with public awareness and education, can make a significant contribution to reducing greenhouse gas emissions. Some several strategies and measures that can be implemented to achieve this goal:

1. Energy efficiency: Improving energy efficiency in buildings, industry, and transport can significantly reduce energy consumption and, implicitly, gas emissions.

2. Renewable energy sources: Promoting the use of solar, wind and hydropower helps to replace fossil fuels, which are the main source of CO2 emissions.

3. Sustainable transport: Encouraging the use of public transport, bicycles, and electric vehicles helps reduce emissions from the transport sector.

4. Sustainable agriculture: Agricultural practices that reduce the use of chemical fertilizers and pesticides, as well as efficient management of agricultural waste, can decrease gas emissions.

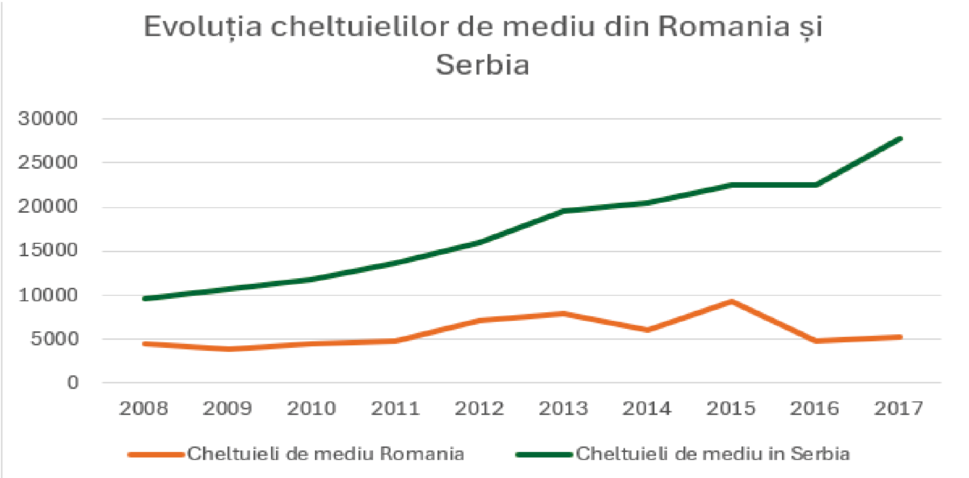
5. Forest Conservation: Forests play a crucial role in absorbing carbon dioxide. Protection and reforestation help reduce emissions.

6. Policies and Regulations: Implementation of strict environmental policies and regulations that limit industrial emissions is essential to ensure compliance with environmental standards.

Econometric analysis of environmental expenditures in Romania and Serbia

For the two countries we created an econometric model where we analyzed the environmental expenses from 2008 to 2022, except for Serbia where we found data up to 2017.

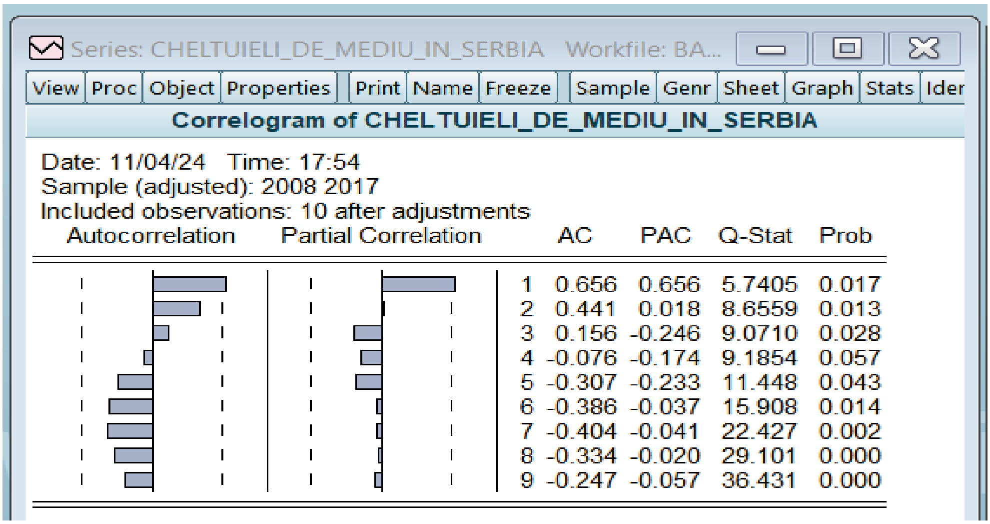
Figure 1. *Evolution of environmental expenses*



***Source*:** Own processing based on the data provided by Tempo Online

According to the analyzed data, the environmental expenses in Serbia are higher than those in Romania during the years 2008-2017.

Figure 2. *Correlogram of environmental expenditures in Serbia*

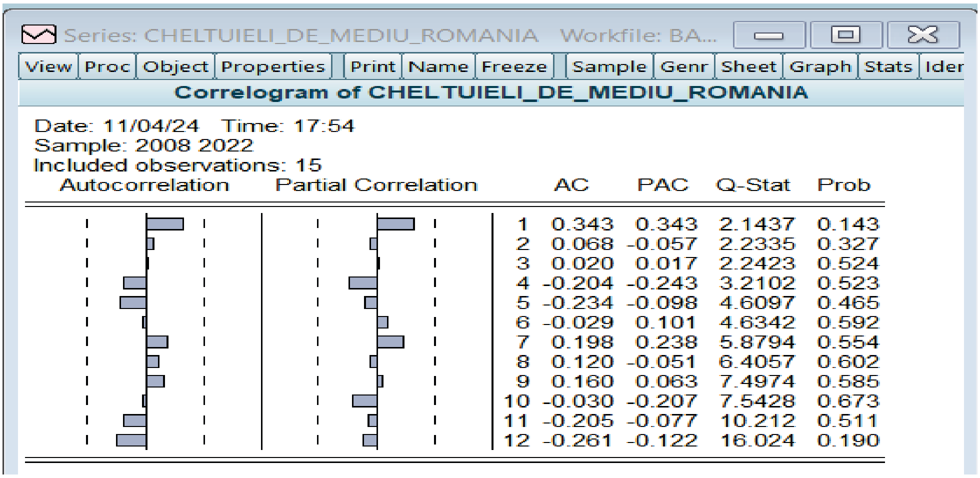


	AC	PAC	Q-Stat	Prob
1	0.656	0.656	5.7405	0.017
2	0.441	0.018	8.6559	0.013
3	0.156	-0.246	9.0710	0.028
4	-0.076	-0.174	9.1854	0.057
5	-0.307	-0.233	11.448	0.043
6	-0.386	-0.037	15.908	0.014
7	-0.404	-0.041	22.427	0.002
8	-0.334	-0.020	29.101	0.000
9	-0.247	-0.057	36.431	0.000

***Source*:** EViews

The correlogram indicates the trend and seasonality of the data evolution. For the correlogram made for the datasets, we have recorded seasonality because it does not fall within the limits imposed by the dotted lines.

Figure 3. *Correlogram of environmental expenditures in Romania*



Series: CHELTUIELI_DE_MEDIU_ROMANIA Workfile: BA...

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Correlogram of CHELTUIELI_DE_MEDIU_ROMANIA

Date: 11/04/24 Time: 17:54
Sample: 2008 2022
Included observations: 15

	AC	PAC	Q-Stat	Prob
1	0.343	0.343	2.1437	0.143
2	0.068	-0.057	2.2335	0.327
3	0.020	0.017	2.2423	0.524
4	-0.204	-0.243	3.2102	0.523
5	-0.234	-0.098	4.6097	0.465
6	-0.029	0.101	4.6342	0.592
7	0.198	0.238	5.8794	0.554
8	0.120	-0.051	6.4057	0.602
9	0.160	0.063	7.4974	0.585
10	-0.030	-0.207	7.5428	0.673
11	-0.205	-0.077	10.212	0.511
12	-0.261	-0.122	16.024	0.190

Source: Eviews

The correlogram indicates the trend and seasonality of the data evolution. For the correlogram made for the data sets, we have no seasonality recorded because it falls within the limits imposed by the dotted lines. In addition, the autocorrelation over 12 lags is shown.

Figure 4. *Stationarity testing with the Augmented Dickey-Fuller test in Romania*

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Augmented Dickey-Fuller Unit Root Test on D(CHELTUIELI_DE_MEDIU_ROM/

Null Hypothesis: D(CHELTUIELI_DE_MEDIU_ROMANIA) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=1)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.647196	0.0037
Test critical values:	1% level	-4.057910	
	5% level	-3.119910	
	10% level	-2.701103	

Source: Eviews

Figure 5. *Testing stationarity with the Augmented Dickey-Fuller test in Serbia*

Series: CHELTUIELI_DE_MEDIU_IN_SERBIA Workfile: BAZA DE DATE SERBI...

View | Proc | Object | Properties | Print | Name | Freeze | Sample | Genr | Sheet | Graph | Stats | Ident

Augmented Dickey-Fuller Unit Root Test on D(CHELTUIELI_DE_MEDIU_IN_SERBIA)

Null Hypothesis: D(CHELTUIELI_DE_MEDIU_IN_SERBIA) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=1)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.328199	0.0495
Test critical values:	1% level	-4.582648	
	5% level	-3.320969	
	10% level	-2.801384	

***Source*:** EViews

In Figures 4 and 5 we performed the test with the level of the first difference, we obtained a probability lower than 0.05 and demonstrated the stationarity of the data.

Figure 6. *Heteroscedasticity testing of residuals*

Equation: UNTITLED Workfile: BAZA DE DATE SERBIA::Untitled\

View | Proc | Object | Print | Name | Freeze | Estimate | Forecast | Stats | Resids

Heteroskedasticity Test: White
Null hypothesis: Homoskedasticity

F-statistic	2.753582	Prob. F(2,7)	0.1312
Obs*R-squared	4.403207	Prob. Chi-Square(2)	0.1106
Scaled explained SS	1.659976	Prob. Chi-Square(2)	0.4361

***Source*:** Eviews

The probability of the F-statistic of 0.1312 is > 0.05. Therefore, the homoscedastic character of the residuals appears, which is why, from the perspective of this test, the model is validated.

Homoscedasticity of residuals is required for model validation.

The homoscedastic character of the residuals indicates a constant variation of the errors, the appearance of the character validates the econometric model for the chosen variables.

Conclusion

The analysis of environmental expenditures in Romania and Serbia highlights the significant differences in the two countries' approaches to environmental management and resource allocation. Romania, with a better-defined legislative framework and a deeper integration of environmental policies in the national strategy, has demonstrated a tendency to increase investments in ecological projects. On the other hand, Serbia, although in a process of alignment with European standards, still faces challenges in mobilizing the financial resources necessary for the effective implementation of environmental policies. This comparison underlines the importance of a coherent and sustainable strategy in the management of environmental expenditures, which contributes not only to the protection of the environment but also to the sustainable economic development of both countries.

Following the analysis of the statistical data, we created an econometric model with two variables, namely the environmental expenses in Romania and the environmental expenses in Serbia. Following the analysis of the environmental expenses in the 2 countries from 2008 to 2017, respectively 2022, we found that the analyzed model is a valid one that can be applied in reality. We made this conclusion following the analysis of the White Test (Heteroscedasticity testing of residuals) where the probability of the F-statistic of 0.1312 is > 0.05.

Therefore, the homoscedastic nature of the residuals appears, which is why, from the perspective of this test, the model is validated. Homoscedasticity of residuals is required for model validation. Following the application of the model and in reality, Romania will achieve neutrality by 2050, and Serbia will achieve the goals of sustainable development.

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MARKETING RESEARCH ON CONSUMER'S PREFERENCES FOR CHOCOLATE

Maria Carina Grosu[1], *Bogdan Alexandru Rățeacă*[2], *Ionuț Ștefan Amuza*[3]

Abstract

The study explores various approaches to marketing research and their role in developing effective strategies. It analyzes how marketing research aids in understanding consumer needs and expectations within the dynamic chocolate market. Key marketing research frameworks are examined, highlighting their significance in uncovering both overt and latent consumer needs. Focusing specifically on the Romanian chocolate market, the research evaluates current supply and demand while investigating the economic, socio-cultural, and individual factors that influence consumer behavior. Additionally, a case study on consumer preferences delves into the impact of pricing, branding, packaging, and advertising on purchasing decisions. The findings provide valuable insights that can inform more effective marketing strategies and enhance alignment with evolving consumer expectations in this competitive landscape.

Key words: *marketing research, chocolate market, consumer preferences.*

Introduction

Marketing research aims to gather information about the desired customer profile and the broader market to guide the organization's strategy when launching products into the market. This investigation may involve gathering data from current or former customers, consumers in the target market segment, or even analyzing the marketing activities of competitors (Kolb Bonita, 2008).

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The marketing research involves a wide variety of objectives, including estimating the market potential for new or existing products, analyzing consumer reactions to existing products on the market, assessing market conditions and trends, identifying the causes of failure of products on the market, finding the most effective methods of distributing products to consumers, understanding the types of consumers and the factors influencing their purchases, obtaining feedback and suggestions for product improvement, assessing the strengths and weaknesses of competitors, analyzing marketing problems, identifying appropriate methods of product distribution, and analyzing how consumers react to product packaging (Beall Anne, 2022).

In marketing strategies, marketing research plays an essential role, offering multiple advantages. It helps to generate business ideas, providing insight into the target market and relevant factors for next steps. It also provides a wide range of concepts to choose from and facilitates the development of concepts for business, resolving common business obstacles. Marketing research provides up-to-date information on market trends, which are essential in the context of rapid change and provide valuable input for future marketing strategies. It can also be used to test the results of market research and to target marketing actions to generate sales (Hawkins, Del I.; Mothersbaugh, David L., 2010).

The characteristics and roles of marketing research include the following categories such as data collection which involves extensive research and obtaining relevant data related to different areas of marketing such as consumer behavior, products, sales, distribution channels, pricing, advertising and logistics. Another characteristic of marketing research is the systematic method, because marketing research must be conducted in an organized and planned way following a well-defined structure rather than random or chaotic action.This systematic method is also made up of two subcategories such as objectivity and structured process (Foxall, Gordon; Goldsmith, Ronald; Brown, Stephen, 2003).

There are two main categories of market research depending on the objectives of the organization. First, companies have to decide whether to conduct primary or secondary research. Second, the researcher has to choose between using quantitative or qualitative methods. The four types of market research are: primary market research, secondary market research, qualitative research as well as quantitative research (Kallol Das, 1994-2006).

Market Analysis

Chocolate market in Romania

According to available data in Romania there are 646 companies registered in the trade register, having as their activity the manufacture of chocolate, cocoa products and sugar products. The number of economic agents in this sector is 289, representing only 0.01% of the total number of economic agents in Romania. The total turnover recorded by the firms involved in chocolate manufacturing according to the statistical data provided is 874.5 million lei, representing 198.8 million euro, accounting for 0.04% of the total turnover in Romania (Table 1).

The average number of registered employees is 3,396 persons, which reflects a percentage of 0.08% of the total number of employees in Romania, and the total profit registered is 72.8 million RON, representing 16.5 million euro, the net percentage being 0.03% of the net profit realized in Romania.

Table 1. *Top 5 Romania chocolate companies in 2023*

No.	Company Name	Turnover (lei)	Profit (lei)	Income (lei)	Costs (lei)	Number of Employees
1.	KANDIA DULCE SA	195.753.061	12.484.044	201.069.005	185.705.545	413
2.	MONDELEZ ROMANIA S.A.	679.329.330	6.392.182	678.565.713	670.628.162	131
3.	HEIDI CHOCOLAT SA	104.336.973	3.177.151	106.357.486	102.566.496	264
4.	FERRERO ROMANIA SRL	1.214.041.058	16.971.441	1.217.070.818	1.195.966.175	75
5.	NESTLE ROMANIA SRL	1.225.899.179	91.465.170	1.240.388.187	1.130.466.220	552

Source: *https://www.topfirme.com/*

The analysis of the financial data expresses a semi-figurative diversity among the firms in the industry. Nestle Romania SRL stands out with the highest turnover, while Ferrero Romania SRL registers the highest profit. Mondelez Romania S.A. stands out for its considerable turnover, given that it has a smaller number of employees, while Kandia Dulce S.A., with a significant turnover, maintains a notable balance between income and expenses. Heidi Chocolat S.A. completes the top of the list, in an intermediate range, with a high turnover and a considerable profit. The data reveal not only the magnitude of operations, but also the diversified financial performance of firms within the Romanian chocolate industry.

Kandia Dulce Joint-stock Company

Kandia Dulce S.A., based in Bucharest and part of Mondelez International, is a leading chocolate manufacturer known for its long history of high-quality sweets and a diverse product portfolio featuring various chocolate flavors.

Mondelez Romania Joint-stock Company

Mondelez Romania S.A., a subsidiary of Mondelez International, offers a diverse range of products under brands like Milka, Toblerone, and Cadbury, continuing a legacy of quality since the early 1900s.

Heidi Chocolat Joint-stock Company

Heidi Chocolat S.A., part of Heidi Chocolat AG, is a leading Romanian chocolate producer known for its quality and diverse range, including milk and dark chocolate, pralines, and candies. Established in the 1990s, it has built a strong reputation for innovation and safety standards.

Marketing mix - product policy and pricing

Table 2. *Kandia's product range*

No.	Product name	Quantity (grams)	Price (lei)
1.	Rom - White chocolate bar with peanuts and salted caramel	44	2,79
2.	Kandia Chocolate bar with brandy and orange cream	46	2,29
3.	Laura praline filled with chocolate cream	138	7,69

Source: *https://www.cora.ro*

Table 3. *Mondelez product range*

No.	Product name	Quantity (grams)	Price (lei)
1.	Milka chocolate with Alpine milk and strawberry flavor	100	4,59
2.	Africana Peanut Chocolate	90	4,39
3.	Poiana Chocolate with strawberry cream	90	3,95

Source: *https://www.auchan.ro/*

Table 4. *Mondelez product range*

No.	Product name	Quantity (grams)	Price (lei)
1.	Heidi Milk chocolate whith strawberry flavore	80	8,09
2.	Heidi Hazelnut praline	100	16,39
3.	Heidi Fruits Lover Mix	315	50,46

Source: *https://www.mega-image.ro/*

Distribution policy

Kandia Dulce S.A. products are marketed through regional distributors, who buy the goods from the central warehouse and then distribute them to small shops and warehouses. It has chosen to adopt an intensive distribution strategy, which involves supplying products through as many outlets as possible. The company currently works with a total of 44 exclusive distributors and has plans to expand its distributor network.

Mondelez Romania S.A. distributes its wide range of products through a network of over 44 regional distributors, supplying small shops, local warehouses, and large hypermarkets like Carrefour, Metro, and Selgros. This intensive distribution strategy aims to maximize market coverage and ensure product availability across numerous retail locations. The company plans to expand its network of exclusive distributors to further enhance accessibility and meet the diverse preferences of Romanian consumers.

Heidi Chocolat S.A. ensures the availability of its chocolate products across a wide range of sales channels, including stores and supermarkets, aiming to reach a diverse consumer base. The company collaborates with distributors and partners to streamline product distribution nationwide, maintaining accessibility for customers. This extensive distribution model supports Heidi's market presence and leadership in Romania's chocolate industry, with a focus on timely delivery and consistent quality.

Promotion policy

Kandia Dulce S.A. has adopted a strategy to promote its products and image, which involved different options, such as market information strategy, strategy to stimulate demand, differentiation of the offer, but also to stabilize sales.

Over the years, Mondelez Romania S.A. has chosen to use various promotional strategies to make its products known to consumers. These strategies have involved marketing and advertising campaigns as well as online communication through the website (www.mondelez.ro).

Heidi Chocolat S.A. promotes its products through TV, radio, print ads, and online marketing on social media and its website. The company also offers regular promotions, like discounts and special packaging, to attract and retain customers. By participating in events and focusing on product innovation, Heidi Chocolat S.A. strengthens its position in Romania's chocolate market.

Financial Data

Table 5. *Financial data of Kandia in the last 5 years*

No.	Year	Turnover (lei)	Profit (lei)	Income (lei)	Costs (lei)	Number of Employees	Average work productivity (lei/employed)
1.	2018	138.470.674	6.780.818	140.449.184	133.668.366	445	311.170.05
2.	2019	153.568.327	7.277.510	154.870.467	147.592.957	456	336.772.65
3.	2020	141.443.629	6.309.308	160.829.405	154.130.316	432	327.415.81
4.	2021	160.626.530	7.591.678	159.336.596	150.259.942	396	405.622.55
5.	2022	195.753.061	12.484.044	201.069.005	185.705.545	413	473.978.36

Source: *https://www.topfirme.com/*

Between 2018 and 2022, the company experienced significant fluctuations in turnover and net profit. Turnover initially grew by approximately 41% in 2019, followed by a decline in 2020. 2021 saw a strong rebound with an increase of approximately 13%, accompanied by an increase of approximately 20% in net profit. In 2022, turnover increased significantly, by approximately 22%, and net profit increased by approximately 65%. The average number of employees varied slightly, with an initial decrease in 2020, followed by a slight increase in 2021 and 2022.

Table 6. *Financial data of Mondelez in the last 5 years*

No.	Year	Turnover (lei)	Profit (lei)	Income (lei)	Costs (lei)	Number of Employees	Average work productivity (lei/employed)
1.	2017	501.537.886	401.836	510.624.398	507.894.850	108	4.644.869
2.	2018	568.711.705	4.677.482	571.474.264	565.066.966	115	4.945.319
3.	2019	647.271.521	6.800.226	647.933.266	639.498.891	141	4.590.578
4.	2020	628.588.471	6.523.737	740.856.750	686.465.225	132	4.762.034
5.	2021	679.329.330	6.392.182	678.565.713	670.628.162	131	5.185.720

Source: *https://www.topfirme.com/*

Between 2017 and 2021, the company saw significant growth in its turnover, increasing from 501.5 million lei in 2017 to 679.3 million lei in 2021, representing an approximate 35% rise. Net profit peaked in 2020 at around 46.5 million lei, while total revenues surged to 740.9 million lei that same year, with expenses consistently ranging between 670 and 680 million lei. These figures indicate a positive financial evolution for the company, marked by substantial increases in turnover and revenue, alongside notable fluctuations in net profit in 2020.

Table 7. *Financial data of Heidi in the last 5 years*

No.	Year	Turnover (lei)	Profit (lei)	Income (lei)	Costs (lei)	Number of Employees	Average work productivity (lei/employed)
1.	2018	103.043.107	3.066.118	109.172.408	105.701.810	404	255.057
2.	2019	102.483.806	2.925.078	105.427.414	108.352.492	382	268.282
3.	2020	88.787.316	1.678.689	95.713.098	94.008.413	300	295.958
4.	2021	91.234.945	1.713.828	94.316.160	92.299.654	282	323.528
5.	2022	104.336.973	3.177.151	106.357.486	102.566.496	264	392.216

Source: *https://www.topfirme.com/*

Between 2018 and 2022, the company experienced significant fluctuations in its financial performance, with turnover increasing slightly from 103.04 million lei in 2018 to 104.34 million lei in 2022. Net profit saw considerable variation, dropping to a loss of -2.93 million lei in 2019 before recovering to 3.18 million lei in 2022, while total revenues decreased by 2.6% to 106.36 million lei that same year. Additionally, total expenses fell by approximately 3%, and the average number of employees declined by about 34%, reaching 264 in 2022.

Demand

Table 8. *Average monthly expenditure on chocolate products for the main social groups (lei)*

No.	Social categories	2018	2019	2020	2021	2022
1	Total	3,8	4,6	4,43	5,13	5,92
2	Employees	4,59	4,78	5,08	6,03	6,79
3	Self-employed in non-agricultural activities	2,64	3,16	3,37	3,57	4,51
4	Farmers	2,33	2,61	2,94	2,84	3,84
5	Unemployed	2,08	2,67	3,14	2,62	3,37
6	Retired	3,36	3,63	4,09	4,64	5,33

Source: https://insse.ro/cms/

Between 2018 and 2022, average annual expenses for chocolate products increased by approximately 55%, reaching 5.92 lei in 2022. Salaried employees saw a 48% increase in monthly spending, rising to 6.79 lei, while self-employed workers in non-agricultural activities experienced the highest percentage growth of about 71%, reaching 4.51 lei. Farmers also showed significant growth at around 65% to 3.84 lei, while unemployed individuals had a moderate increase of 62%, totaling 3.37 lei, and pensioners, with higher-than-average expenses, rose by approximately 59% to 5.33 lei in 2022.

Table 9. *Average monthly expenses on the purchase of chocolate products by residence (lei)*

No.	Of residence	2018	2019	2020	2021	2022
1	Total	3,8	4,06	4,43	5,13	5,92
2	Urban	4,46	4,65	4,95	6,15	7,01

Source: https://insse.ro/cms/

Annual spending on chocolate products grew by an average of 56% between 2018 and 2022. In urban areas, expenses increased by 57%, reaching 7.01 lei in 2022, while rural areas saw a 54% rise. This highlights a slightly higher growth rate in urban areas, reflecting differences in purchasing behavior between urban and rural residents.

Table 10. *Average monthly chocolate consumption*

Year	2018	2019	2020	2021	2022
Quantity(Kg)	0,197	0,2	0,206	0,216	0,216

Source: *https://insse.ro/cms/*

The evolution of the average monthly consumption of chocolate shows an increase of about 10% over the whole period 2018-2022.The consumption increased from 0.197 in 2018 to 0.216 in 2022, representing an increase of 9.6%. This modest but steady increase indicates an upward trend in chocolate consumption over the past few years.

Conclusions

The detailed study of the chocolate market in Romania opens wide perspectives for the expansion of this sector, highlighting a marked inclination of Romanian consumers towards chocolate consumption. This inclination is shaped by several essential criteria, including excellence in quality, brand reputation, an optimal balance between cost and value, as well as an attractive diversity of products offered. At the beginning of the analysis, a variety of theories and approaches in marketing research were examined, highlighting their fundamental importance in describing consumer behavior and precisely identifying the needs and desires of the target audience. Emphasis was placed on the critical role that market studies play in developing promotional strategies tailored to the food sectors, with a particular focus on the chocolate segment. These studies are essential in guiding strategic decisions in the industry, with the goal of achieving a higher level of customer satisfaction and commercial success for producers. The relationship between supply and demand for chocolate was analyzed in detail, examining aspects related to distribution, production, pricing structure, and consumer behavior. It was found that these elements are significantly influenced by buyer preferences, resource access, and the socio-economic context. It was deduced that a detailed and comprehensive perception of the market is indispensable for creating effective marketing strategies that respond to the dynamic needs of the chocolate sector.

Finally, to better detail consumer preferences and expectations, a comprehensive survey was conducted to evaluate various opinions regarding quality, price, and appearance. The responses collected provided a valuable perspective on how different population segments, distinguished by gender, age, personal preferences, and income level, choose chocolate. This research offered a more in-depth understanding of consumption trends and shaped a clearer picture of consumer behavior in their relationship with chocolate products, highlighting variations in preferences and expectations.

Acknowledgments

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THE ROLE OF NON-REFUNDABLE EUROPEAN FUNDS IN INCREASING THE EFFICIENCY OF THE AGRI-FOOD LOGISTICS SYSTEM

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Abstract

Logistics, originally a military concept, has evolved to become a fundamental aspect of many sectors, including agriculture and food production. This article will explore the historical roots and contemporary applications of logistics, pointing to its crucial role in increasing efficiency and competitiveness. Through a comprehensive analysis of military studies and academic papers, it examines the complex character of logistics and its impact on operational effectiveness. The article also analyzes the evolution of logistics from the military to the civilian domain, pointing out its importance in modern business operations, particularly in supply chain management. In addition, it addresses the challenges and opportunities related to logistics in the agri-food sector in Romania, underlining the crucial role of European Union funds in supporting its development. By clarifying key principles and strategies, this article provides insights into how logistics can be used to improve competitiveness and sustainability in the agri-food sector.

Key words: *logistics, EU non-reimbursable funds, agri-food.*

Introduction

The term "logistics" has its origins in the military context of strategic importance during the Second World War. It is now widely accepted that logistics is a key factor in the effectiveness of armed forces and has a significant influence on the outcome of global conflicts (Rear Admiral Henry E. Eccles (Retired), 1953). Colonel Cyrus Thorpe's contribution to the field defined pure logistics as the science of theory and its application in military training,

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emphasizing the importance of separating theory from practice (Rear Admiral Henry E. Eccles (Retired), 1953).

In the contemporary era, logistics plays a pivotal role in business operations, particularly within the manufacturing and trade sectors, where it is instrumental in the management of supply chain resources (Cameron Hashemi-Pour & David Essex, 2024). The effective management of logistics enables the procurement, storage, and transportation of resources in a manner that is both cost-effective and responsive to customer demands (Will Kenton, 2024). In the context of natural gas, logistics encompasses the administration of transportation infrastructure, which is vital for ensuring uninterrupted supply(Will Kenton, 2024).

In Romania, the agri-food sector contributes 10% of GDP and employs over 2 million people (Fooddrink Europe, 2023). The modernization of this sector is facilitated by European funds, which enable it to become competitive at the European level (Nedelcu et al., 2023).

Competitiveness assessment of the Romanian agri-food sector

The study, entitled "The Competitiveness of the Romanian Agri-Food Sector in Comparison with European Countries," employs a comparative analysis to examine the competitiveness of the Romanian agri-food sector vis-à-vis other European countries. It underscores the significant agricultural potential of Romania, which benefits from a favorable climate and fertile soils that allow for production diversification (Nedelcu et al., 2023). However, Romania has yet to fully capitalize on the factors needed to increase competitiveness, including investments in innovation, advanced technology, infrastructure, and penetration of international markets (Fooddrink Europe, 2023).

In 2020, Mintenica Mariana Ciuștea underscored the significance of European non-reimbursable funds in facilitating the modernization of agricultural operations through the provision of cutting-edge equipment and technologies, as well as enhancing access to international markets. From 2014 to 2020, Romania received €8.128 million from the European Fund for Agriculture and Rural Development, a sum that is nearly three times greater than that received by Bulgaria. These funds were allocated to support farmers in enhancing the quality and productivity of their products (Mintenica Mariana Ciuștea (Butnaru), 2020).

The benefits of non-reimbursable EU funds for the Romanian agri-food sector

European non-reimbursable funds confer several advantages upon the agri-food sector in Romania, facilitating the advancement of agricultural infrastructure, the modernization of farms and an enhancement in their efficiency and sustainability. The support provided by these funds for innovation and research projects facilitates the implementation of advanced technologies and modern agricultural practices, thereby enhancing the competitiveness of the sector at the European level (Fooddrink Europe, 2023) Concurrently, the funds facilitate Romanian farmers' access to international markets, supporting exports and the promotion of local products, which are pivotal elements for reinforcing the competitiveness of the Romanian agri-food sector within the European Union. It is imperative to continue capitalizing on the non-reimbursable funds to enhance Romania's standing within the European market and to guarantee a sustainable growth of the sector (Fooddrink Europe, 2023),

Table 1. *Money received per Operational Program (*billion EUR*)-reported on 01.04.2024*

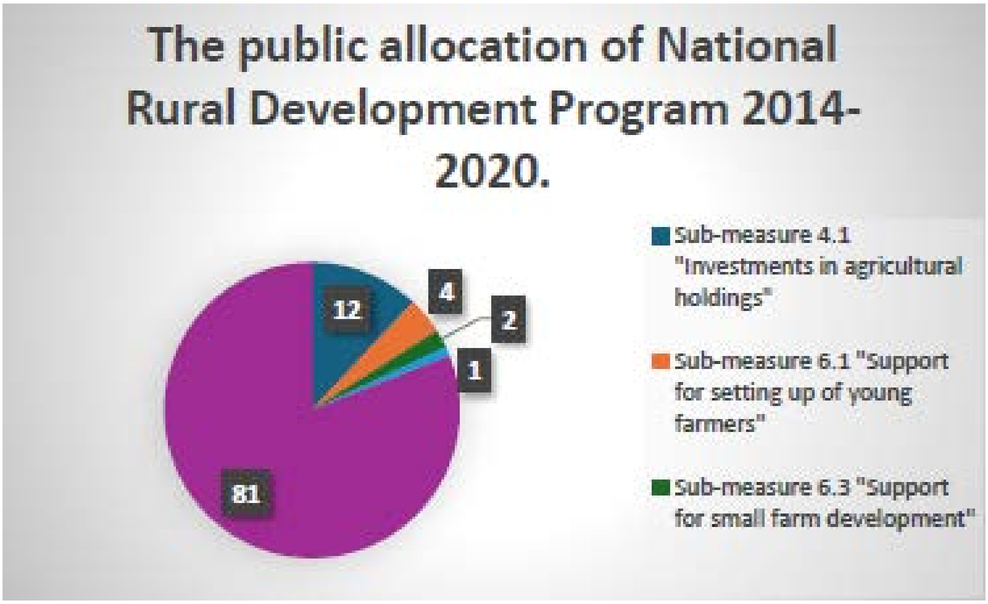
Program name	Total value (billion EUR)
Operational Program for Aid to Disadvantaged People (POAD)	0,46
Human Capital Operational Program (POCU)	4,62
Large Infrastructure Operational Program (POIM)	9,32
Regional Operational Program (POR)	6,37
Fisheries and Maritime Affairs Operational Program (POPAM)	0,09
National Rural Development Program (PNDR)	9,46
Administrative Capacity Operational Program (POCA)	0,56
Technical Assistance Operational Program (POAT)	0,31
Competitiveness Operational Program (POC)	2,14

***Source**: https://www.fonduri-ue.ro/statistici*

As evidenced by the table analysis, the National Rural Development Program received the largest amount, amounting to €9.46 billion, with the Large Infrastructure Operational Program receiving the second-largest allocation at €9.32 billion. In contrast, the Operational Program for Fisheries and Maritime Affairs received the smallest allocation, amounting to €0.09 billion.

The agri-food logistics system in Romania has been the recipient a series of measures introduced as part of the National Rural Development Program (PNDR). Among these, Measure 4.1 targets investments in agricultural holdings, facilitating the purchase and transportation of necessary equipment for modernization. Measure 6.1 provides support to young farmers through the organization of training and assistance programs, thereby ensuring their access to essential resources for business development. Measure 6.3 helps small farmers by optimizing the transportation and distribution of agricultural products, thereby reducing losses and enhancing market accessibility. Finally, Measure 6.4 concentrates on the infrastructure for non-agricultural activities in rural areas, supporting the transportation of materials and the distribution of non-agricultural services. An efficient logistics system is crucial for the implementation of these measures, contributing to sustainable development and rural prosperity.

Chart 1. *Public allocation of funds from PNDR 2014-2020*



Source: *Data processing AFIR*

The analysis of the graph demonstrates that sub-measure 4.1 (Investment in agricultural holdings) represents the largest proportion of the total allocation, accounting for 12%. This is followed by other sub-measures, which collectively account for 81% of the total allocation. Sub-measures 6.1, 6.3 and 6.4 account for a comparatively smaller share of the total allocation.

Table 2. *Analysis of funding applications and project selection*

Sub-measure	Submitted applications for funding			Selected applications for funding		
	No.	Value (EURO)	Average value of sub-mitted projects	No.	Value (EURO)	Average value of selected projects
Sub-measure 4.1 "Investments in agricultural holdings"	6.147	3.32 bn	541.669	3.265	1.81 bn	554.878
Sub-measure 6.1 "Support for setting up of young farmers"	15.143	0.62 bn	41.112	10.878	0.44 bn	41.039
Sub-measure 6.3 "Support for small farm development"	20.618	0.3 bn	14.999	13.916	0.2 bn	15.000
Sub-measure 6.4 "Investment in creation and development of non-agricultural activities"	2.518	0.42 bn	168.610	986	0.16 bn	164.999

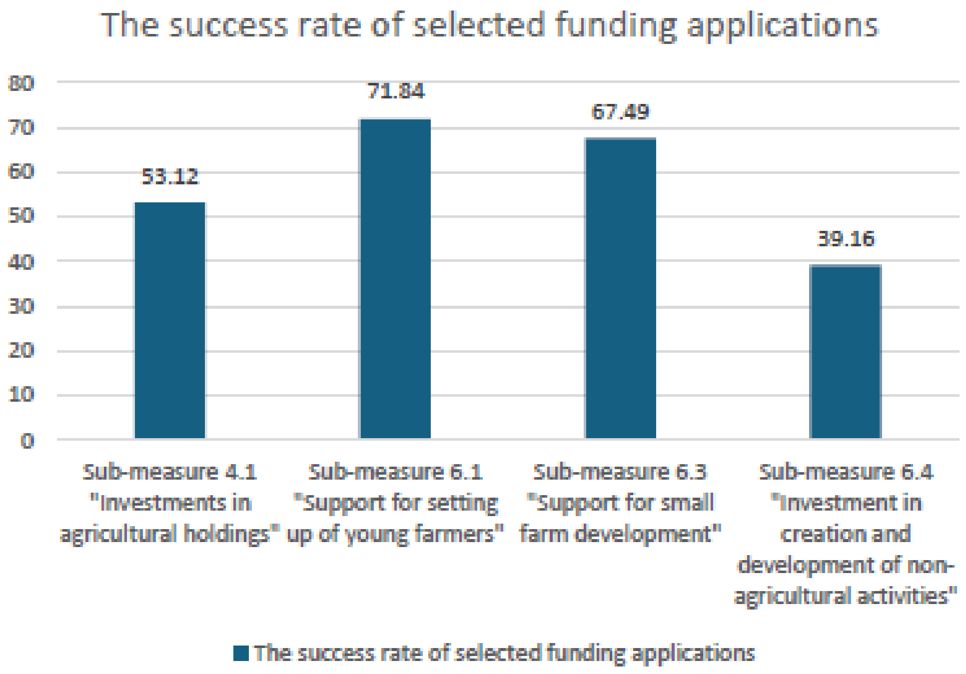
Source: *Data processing AFIR*

The following table presents a comparison between the funding applications submitted and those selected under the various sub-measures of the PNDR.

It is evident that the number and value of applications for funding submitted for each sub-measure are considerably higher than those selected. This signifies robust competition and a substantial interest from beneficiaries to access funding under the program.

In general, the mean value of selected projects is comparable to or slightly lower than the mean value of submitted projects. This suggests that the selection process may favor smaller projects or projects that are more realistic in terms of the resources required for implementation.

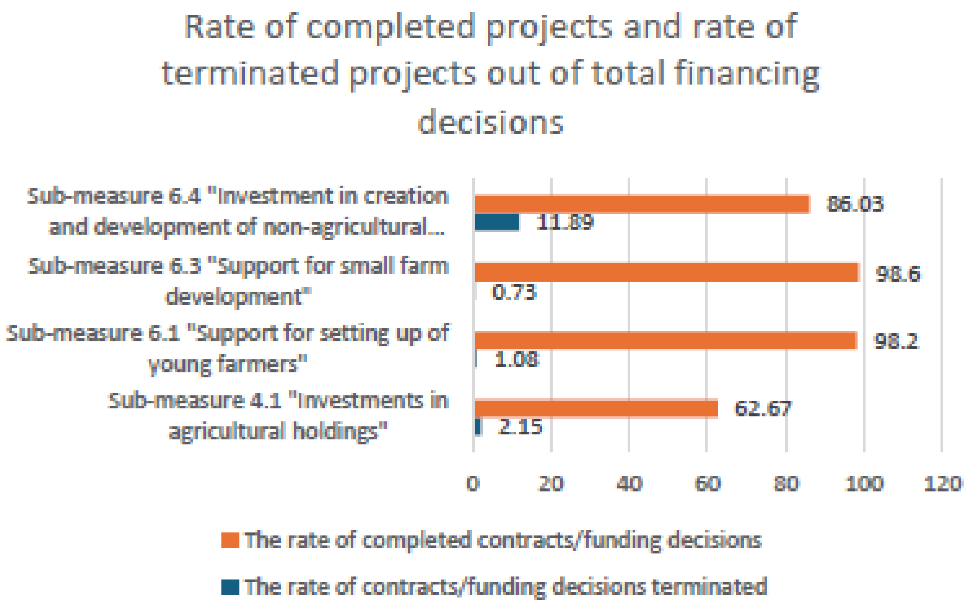
Chart 2. *Success rate of selected funding applications*



Source: Data processing AFIR

The success rates for each PNDR sub-measure reflect the disparate priorities and interests that inform the sub-measures. Sub-measure 4.1, with a success rate of 53.12%, indicates a focus on agricultural modernization. In contrast, sub-measures 6.1 and 6.3, with success rates of 71.84% and 67.49%, respectively, demonstrate a commitment to supporting young farmers and the development of small farms. In contrast, sub-measure 6.4's 39.16% rate indicates difficulties in accessing funds for non-agricultural projects and emphasizes the necessity of economic diversification in rural areas. These success rates highlight the requirement to adapt policies to the diverse needs of rural communities.

Chart 3. *Rate of completed projects and rate of terminated projects out of total financing decisions*



Source: *Data processing AFIR*

The ratio of completed and terminated projects to total funding decisions provides insight into the stability and effectiveness of projects under each sub-measure.

The completion rates for sub-measures 6.1 and 6.3 are notably high, at approximately 98%, which serves to indicate the success and sustainability of projects targeting young farmers and small farm development.

Sub-measure 4.1 also exhibits a commendable completion rate (62.67%), which suggests a certain degree of stability in the implementation of agricultural projects.

In contrast, sub-measure 6.4 has a lower rate of finalized contracts (86.03%) and a significantly higher rate of contract termination (11.89%), indicating potential challenges in the implementation of non-agricultural projects and a need for improvement in this area.

Conclusions

The deployment of non-reimbursable European funds has proved instrumental in improving the efficiency of the logistics system in the Romanian agri-food sector. This has facilitated the modernization of farms and the development of rural infrastructure. The transition from a military to a commercial context has underscored the strategic significance of logistics for operational efficiency and business competitiveness. Through targeted initiatives such as the National Rural Development Program, European funds provide support for investments in cutting-edge technologies and infrastructure, thereby fostering the growth of a competitive and sustainable agri-food sector at the European level. The analysis of the projects financed demonstrates a high level of interest in these funds and a notable success in the implementation of projects oriented towards agricultural modernization and support for young farmers. However, the lower completion rate of non-agricultural projects highlights the necessity to adopt policies in order to respond to the diversified needs of rural communities, ensuring sustainable growth and efficient distribution of resources. Therefore, continued investment in logistics and infrastructure is key to ensuring the sustainability and competitiveness of the Romanian agri-food sector in the long term. In addition, strengthening the logistics system will enable Romania to make more efficient use of local resources and reduce its dependency on imports. In this way, the agri-food sector becomes not only a significant economic contributor but also a guarantor of national food security.

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STRENGTHENING RESILIENCE IN AGRICULTURE: STRATEGIES FOR NATURAL, ECONOMIC, AND EMERGENCY DISASTERS

Mirjana Dejanović[1]

Abstract

Resilience in agriculture is increasingly vital due to the growing frequency of natural and economic disasters, as well as emergencies that threaten food production. Climate change, economic instability, and global crises like pandemics and political unrest pose significant risks to agricultural systems worldwide. This paper examines strategies to enhance agricultural resilience, including adaptation to droughts, floods, and extreme weather events. Key measures include using resilient plant and animal varieties, soil conservation methods such as cover cropping and crop rotation, and implementing smart irrigation systems. Economic challenges like price fluctuations and market shifts are addressed through income diversification and flexible supply chains, supported by governments and international organizations. In emergencies, innovations like satellite monitoring and drones aid in early risk detection and response. The paper stresses the importance of education, training, and networking among farmers, along with an integrated approach that combines innovation, policy, and education.

Key words: *resilience, agriculture, climate change, economic crisis, innovation, emergencies.*

Introduction

Agriculture is vital for global food security and economic stability but faces increasing threats from climate change, economic instability, and global crises. Extreme weather events, such as droughts, floods, and heatwaves, are more frequent and severe, while geopolitical tensions and market volatility exacerbate vulnerabilities. Strengthening agricultural resilience is crucial to maintaining food production and livelihoods. Collaboration among farmers, researchers, policymakers, and international organizations is needed to create a supportive framework for innovation, policy, and community resilience. The paper also includes a survey of Serbian farmers, assessing their adaptation to climate change, economic

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resilience, and use of technology. Findings highlight gaps in knowledge, training, and financial resources, underlining the need for targeted support. An integrated approach combining technological, economic, policy, and educational strategies is essential for building agricultural resilience to ensure long-term food security and sustainable livelihoods.

Methodology

This paper uses a qualitative research methodology to explore strategies for enhancing resilience in agriculture. The research is based on a thorough review of existing literature, case studies, and reports from international organizations, government agencies, and agricultural experts. The aim is to identify best practices, assess the effectiveness of various strategies, and provide recommendations for improving resilience in agricultural systems. To complement the literature, review a survey was conducted by sending an anonymous questionnaire to 2,500 email addresses of agricultural producers, covering the entire territory of Serbia. During the survey distribution process, it was found that 37% of the email addresses were incorrect, so the survey was delivered to 1,575 valid email addresses. Of this number, 316 agricultural producers responded to the survey. The survey covered a wide range of questions and also provided an opportunity for respondents to add their own opinions and comments that were not directly related to the questions asked.

Resilience in Agriculture

Resilience in agriculture refers to the ability of agricultural systems to absorb, recover, and adapt to disruptions caused by natural or economic crises, ensuring continued food production, income, and livelihoods. As global risks increase from climate change induced weather extremes to market shocks caused by pandemics or geopolitical instability the need for resilience has become more urgent. Building resilience requires a multi-faceted approach, combining sustainable resource management, climate adaptation, technological innovation, and diversification. Efficient land and water management, such as crop rotation and drip irrigation, helps mitigate climate challenges like droughts and floods. Biodiversity within farming systems supports ecosystem health, while resilient crop varieties and agroecological practices, like organic farming, protect against climate variability. Diversification of crops, markets, and digital tools, such as farm management software, improve decision-making and reduce risks from extreme weather, disease, and price fluctuations. Education, training, and financial support, including insurance, enable farmers to adopt resilient practices and recover from disasters. Supportive policies, climate-smart agriculture, disaster risk management, and local food systems are essential for long-term food security. Collaboration through farmer cooperatives and networks fosters resilience, and infrastructure development, such as storage and processing facilities, reduces dependence on global markets. A comprehensive approach that integrates sustainable practices, technology, policy, and community collaboration ensures agricultural systems can withstand future challenges, securing food production for generations to come.

Strategies for strengthening resilience

Strengthening resilience in agriculture is crucial for enabling the sector to withstand and recover from natural disasters, climate extremes, and economic pressures. A comprehensive approach is needed, combining sustainable practices, innovative technologies, and effective policies. This strategy focuses on three key areas: natural disaster resilience, climate adaptation, and economic resilience, each essential for maintaining robust and adaptable agricultural systems. The following sections will explore strategies to strengthen resilience in these critical areas.

Natural disaster resilience

Natural disasters such as floods, droughts, and extreme weather events pose direct threats to crop yields and livestock production. Strengthening resilience against these disasters requires a focus on adaptive agricultural practices that improve environmental sustainability and reduce vulnerability. Natural disasters are becoming more frequent, severe, and costly, causing over 79,000 deaths and affecting 200 million people annually. Experts predict these numbers will rise due to climate change and more people living in high-risk areas. Disaster risk management must be integrated into development policies to better protect vulnerable communities. The triple track approach to food security, which focuses on increasing food production, improving access to food for vulnerable populations, and enhancing nutritional quality, is recommended to address these interconnected challenges. Poor communities, particularly women and children, are most affected by disasters. Therefore, integrating disaster risk management into development strategies is essential to reduce future economic and social losses, especially in agriculture, which requires more investment in risk reduction. (Haen & Hemrich 2007).

India also is faced with increased risks from natural disasters due to climate change and a growing population. Effective decision-making in emergencies is crucial, and artificial intelligence (AI) and machine learning (ML) can significantly improve prediction processes, resource allocation, and aid coordination. These technologies enable faster data analysis and better crisis management, thereby enhancing community resilience to disasters (Singh & Manoharan, 2024).

Natural hazards are a global challenge, and improving resilience is crucial to minimizing their impacts. SDG 13.1 aims to reduce disaster risks from climate change, enhance resilience, and strengthen adaptation. A new disaster resilience index, developed using IMF methodology, evaluates 62 indicators across 24 developed and 67 developing countries from 1995 to 2019. Results show a significant disparity in resilience across income groups: high-income countries (0.674) have the highest resilience, followed by upper-middle (0.463), lower-middle (0.372), and low-income countries (0.314). Top performers include Switzerland, Germany, and France. In 2019, resilience scores were: (a) >0.7 for 9 countries, (b) 0.5-0.7 for 31 countries, (c) 0.3-0.5 for 44 countries, and (d) <0.3 for 7 countries. Recommendations for low-resilience countries include improving health systems, ensuring economic stability, enhancing social capital, and empowering women. Addressing these areas will strengthen disaster preparedness and support sustainable development. (Khan et al.,2022).

Adapting to Climate Extremes

Building resilience in agriculture involves adopting climate-resilient crops and livestock, designed to withstand droughts, floods, and extreme temperatures. Modern soil conservation methods, like cover cropping and crop rotation, preserve soil health and improve productivity. Smart irrigation systems, using technology to monitor moisture and weather, optimize water use and reduce waste, enhancing efficiency during droughts or irregular rainfall. Climate change is already underway due to greenhouse gases that have accumulated in the atmosphere, particularly since the 1950s. Even if emissions stopped today, global temperatures will continue to rise due to gases that remain for centuries. While reducing emissions is essential, it won't be fast enough to avoid many impacts, as the world still relies on fossil fuels. Climate change can cause irreversible damage, like species extinction and habitat loss, and negatively affect the economy, though some sectors may benefit. Proactive planning at local, regional, and national levels is crucial to reduce risks and costs, as waiting for perfect information or global agreements will lead to higher future challenges and costs. (Snover et. al, 2007). Climate change poses significant risks to food safety, including increased foodborne illnesses, crop contamination, and mycotoxin exposure. Addressing these challenges requires integrated policies, enhanced monitoring and early warning systems, and climate-resilient agricultural practices. These strategies help detect emerging risks and mitigate the effects of extreme weather. Additionally, updating food safety standards, training stakeholders, and fostering international cooperation are key to ensuring a safe and sustainable food supply in a changing climate (Eruaga, 2024).

In his doctoral dissertation Nnachi analysed projects by the World Food Programme (WFP) and the International Fund for Agricultural Development (IFAD) in Nepal, El Salvador, and Ethiopia, focusing on reducing food insecurity, improving climate resilience, and enhancing rural livelihoods. In Nepal, WFP targets hunger and food security for vulnerable groups, while IFAD works on increasing productivity and promoting climate adaptation. In El Salvador, WFP focuses on poverty reduction and climate adaptation, while IFAD supports small farmers through training and resilient value chains. In Ethiopia, WFP addresses urgent needs, and IFAD focuses on irrigation, markets, and financial services. Both organizations could improve collaboration, especially in climate data sharing and sustainable agriculture (Nnachi, U., 2019).

Based on an analysis of case studies and UNDP reports, the study assessed the effectiveness of UNDP's climate action initiatives at the local level, identifying key themes across regions. In Pacific Island nations, UNDP helped develop solar, wind, and hydropower projects to reduce fossil fuel use and improve energy access. In the Sahel, the Great Green Wall project, supported by UNDP, addresses land erosion and enhances food security. In Southeast Asia, UNDP assisted smallholder farmers in adopting climate-smart agricultural practices, while in Latin America, the organization contributed to climate-resilient urban planning to withstand extreme weather events. The analysis showed positive results, such as increased capacity for climate action and socio-economic development, though challenges like political instability, limited resources, and capacity-building issues hindered full implementation. Recommendations include greater stakeholder involvement, improved capacity-building, innovative financing, and solutions tailored to local communities. (Asad et al., 2024). Governments must integrate climate change adaptation into national agricultural policies, ensuring that resources are allocated to support the implementation of climate-smart agricultural practices. These policies should be aligned with global frameworks such as the Paris Agreement to ensure that agricultural resilience efforts are consistent with broader environmental goals.

Economic Resilience

Economic shocks, such as price fluctuations, market disruptions, and trade conflicts, can severely affect agricultural systems, especially in developing countries where agriculture is the primary livelihood. To build resilience, it is essential to reduce dependence on a single crop or market, as this increases vulnerability to sudden changes. Diversifying crops, exploring new markets, and creating flexible production and supply chains can help buffer against these shocks, ensuring farmers can adapt and thrive in uncertain economic conditions. Income diversification is also crucial, with strategies like growing multiple crops, engaging in agro-tourism, or integrating livestock and aquaculture, which stabilize household incomes and reduce dependence on one source of revenue.

Building resilient agricultural supply chains is key to adapting to economic shocks. Investments in infrastructure such as storage, transportation, and local processing can reduce reliance on international trade, enhancing resilience to disruptions caused by global events like pandemics or trade wars. Governments play a vital role by providing financial support through tools like crop insurance, disaster relief, and emergency loans. Policies promoting fair trade and market access, along with subsidies for sustainable farming, help stabilize incomes and strengthen long-term resilience. By ensuring farmers have access to credit, technology, and information, governments can foster innovation and support agricultural systems that are adaptable and economically stable.

Emergency Preparedness and Innovation

Building resilience to emergencies requires comprehensive disaster risk management, including early warning systems, recovery plans, and community preparedness, balancing short-term relief with long-term recovery. Emergencies, whether natural or human-made, can overwhelm vulnerable systems, but proactive approaches and innovative technologies can reduce damage. Nature-based Solutions (NbS), such as mangroves, wetlands, and agroforestry, are effective for disaster risk reduction and resilience, particularly in Latin America and the Caribbean. NbS offer sustainable, cost-effective alternatives to traditional infrastructure, improving biodiversity, water management, and livelihoods. However, integrating NbS into disaster risk management frameworks requires financial support, long-term monitoring, and collaboration among stakeholders, local knowledge, and alignment with climate adaptation and development goals. (Lucatello & Alcántara-Ayala, 2024).

The Twin Track Approach to food security combines immediate hunger relief with long-term development strategies for sustainable growth and resilience. It addresses urgent food needs through emergency assistance, including food aid, cash transfers, and safety nets, while simultaneously promoting long-term solutions like agricultural development, economic empowerment, and infrastructure improvements. By integrating both tracks, this approach ensures that both short-term crises and future vulnerabilities are addressed, providing a holistic strategy for food security. It is particularly effective in protracted crises and fragile states, where both immediate relief and long-term resilience are crucial to reducing vulnerability and improving food security. (Pingali et al., 2005).

AI in agriculture enhances crop monitoring, production planning, and resilience by analyzing data to predict yields, detect threats, and optimize resources. Beyond agriculture, AI can improve resilience in sectors like infrastructure, disaster response, climate adaptation, healthcare, business, cybersecurity, and environmental sustainability. To maximize its potential, careful implementation is needed, considering ethical, security, and social factors. This approach helps build a more resilient and sustainable future for individuals, communities, and systems (Rane et al., 2024). AI technologies have boosted agricultural production, enhancing food security and environmental sustainability. By optimizing farming processes and monitoring systems, AI increases crop yields, reduces environmental impacts, and addresses challenges like resource depletion, labor shortages, and high production costs. This leads to improved productivity, resilience to climate change, and greater food security. (Usigbe et.al, 2024).

Incorporating satellite monitoring and drones enhances agricultural resilience and disaster preparedness by providing real-time data on crop conditions, weather, and environmental changes. These tools enable early detection of threats like droughts, floods, and pest infestations, allowing for quicker, more efficient responses to both short-term and long-term challenges.

The COVID-19 pandemic exposed vulnerabilities in global agriculture, disrupting production and distribution due to supply chain breakdowns, labor shortages, and shifting consumer behavior. Small-scale farmers faced significant income losses, threatening food security. The crisis underscored the need for policies that build resilience, promote community-based marketing, and integrate smart technologies. Labor shortages and border closures highlighted the importance of resilience in agri-food systems. Governments must develop crisis management plans, support diverse agricultural systems, and encourage adaptive practices. By combining policy reform, community marketing, and technological innovation, agriculture can better withstand future crises (Lioutas & Charatsari, 2021). The world faces major challenges in securing an adequate food supply, influenced by factors like energy availability, fertilizers, climate conditions, and supply chain disruptions, worsened by rising transportation costs. Beyond the risk of food shortages, there is a threat to nutritional quality, as economic pressures may push consumers to cheaper, lower-quality products, potentially reducing overall food purchases. (Dejanović M., 2023).

The ongoing conflicts in Ukraine and the COVID-19 pandemic have worsened Serbia's agricultural situation, with exports, particularly apples to Russia, stagnating due to higher transportation costs and the ruble's devaluation. While Ukraine accounts for just 0.2% of Serbia's agricultural trade, disruptions from both crises have led to rising food prices and resource shortages. To address this, Serbia needs to improve its commodity reserves system, including better coordination of agricultural production, protective pricing, and more efficient import-export policies. Increasing stock levels of essential goods and ensuring regular inspections of commodity reserve warehouses are critical for food supply stability and crisis preparedness. (Mihajlović, M., Milunović, M., & Ćearmilac, U., 2024).

Corporate Social Responsibility (CSR) faces challenges, often neglecting the needs of future generations. To prevent irresponsibility, clear rules must be established for individuals and corporations, with laws regulating behavior. Industry 4.0 offers tools to monitor and enforce socially responsible practices, and sanctions should be imposed on violators to ensure sustainable development. (Dejanović, M. 2023).

Because of that Education and training are essential components of disaster preparedness. Farmers need to be equipped with the knowledge and skills to adapt to new technologies, manage risks, and respond to emergencies. Programs that focus on sustainable farming practices, disaster risk reduction, and the use of modern technologies can enhance overall resilience in agricultural communities.

Integrated Approach to Resilience

Building resilience in agriculture requires a coordinated approach that combines technological innovation, supportive policies, and community engagement. Agricultural systems are vulnerable to climate change, market fluctuations, and natural disasters, so governments, international organizations, NGOs, the private sector, and local communities must collaborate to create conditions that enable farmers to adapt and thrive. Technological advancements like precision agriculture, smart irrigation, and drought-resistant crops help farmers use resources more efficiently and adapt to changing conditions. Agroecological practices such as crop rotation and organic farming enhance long-term sustainability and resilience. However, technology alone is not enough. It is essential to invest more in the education and training of farmers, as well as to improve their access to information and resources, in order to enable the adoption of best practices and modern technologies. Addressing these challenges is crucial for enhancing the agricultural supply chain, optimizing resource use, and promoting sustainable agricultural practices (Dejanović, M., Popović-Pantić, S., & Kovačević, 2023).

Collaboration among stakeholders is key to building agricultural resilience. Farmer cooperatives and community organizations are vital for sharing information, supporting each other during crises, and ensuring tailored strategies. Networking between farmers, researchers, policymakers, and practitioners' fosters innovation and context-specific solutions. Integrating local knowledge with scientific research enhances resilience, making it more practical and culturally relevant. Digital platforms are crucial for sharing resources, and improving farmers' digital literacy helps them access vital information and adopt innovative solutions. A coordinated approach that combines technology, policy, education, and collaboration strengthens agricultural systems, ensuring long-term food security and sustainability amid climate change and other challenges.

A study in China examined the impact of agricultural insurance on rural households' economic resilience using data from the 2020 Guanzhong Plain Farm Household Survey. The research found that agricultural insurance significantly boosts resilience, improving it by 10.8%. It helps households by spreading risks, improving credit access, and increasing income, with stronger effects for cash crop growers and larger farmers. The findings highlight the key role agricultural insurance plays in helping rural households withstand economic shocks, offering insights for policies that support rural economic development (Xie et al., 2024).

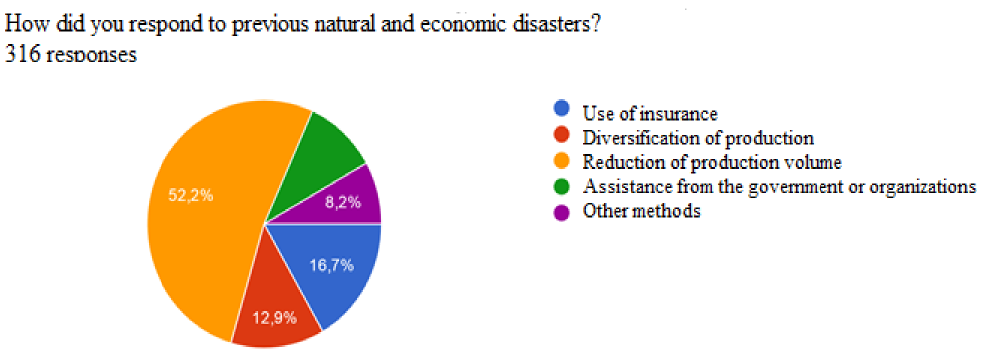
Food system resilience during crises, such as the COVID-19 pandemic, focused on the impact on vulnerable populations, especially children. The pandemic disrupted school meal programs, worsening food insecurity, prompting initiatives like Emergency Meals-to-You (eMTY) to deliver meals to rural areas. The research used workshops with experts to develop strategies for improving food access before, during, and after disasters. A resilience scorecard assessed food system strengths and weaknesses, revealing the need for better integration into local governance, enhanced disaster preparedness, and stronger local food systems. Key recommendations included sharing nutritional data, mapping farm-to-school resilience, and supporting local food providers. The findings emphasized the need for better coordination, early warning systems, and ecosystem preservation to improve food system resilience and ensure equitable food access during crises. (Ryan et al., 2024).

A study in Western Macedonia, Greece, examined the role of governance in economic sustainability and disaster resilience. Conducted through an online survey from September 18 to October 4, 2022, the research found that governance significantly impacts both areas. Key factors like disaster resilience education, early warning systems, and international relief were identified as essential. The study emphasized the importance of governance support and public involvement in strengthening resilience, confirming a strong link between governance efforts and improved economic sustainability. Recommendations include prioritizing public awareness, disaster education, and enhancing international relief capacity, with future research focusing on community-based approaches and technological innovations in governance (Kalogiannidis, et al., 2023).

An anonymous survey conducted in Serbia, with 316 respondents from 1,575 agricultural producers, found a consensus on the need for financial assistance for immediate recovery. Respondents also emphasized the importance of structural and infrastructural improvements to prevent future damage, particularly in sectors vulnerable to natural disasters.

Beyond immediate relief, there is a strong focus on long-term solutions to safeguard against future economic and infrastructural risks. In response to the question, "How have you responded to previous natural and economic disasters?", businesses reported using various strategies to mitigate losses and maintain stability.

Picture 1. Respond agricultural producer on previous natural and economic disasters



Source: Survey for agricultural producers: key factors influencing production outcomes conducted anonymously via email done by author

These included reducing production volumes, diversifying products and markets to spread risk, utilizing insurance for financial protection, and seeking external support through relief programs. These proactive and reactive measures help minimize the immediate impacts of disasters while ensuring long-term resilience.

In response to the question, “How do you assess the impact of weather conditions on your results over the last few years?”, the overwhelming negative feedback highlights the need for better adaptation strategies. These strategies should include developing resilient crop varieties, improving irrigation systems, and enhancing weather forecasting. The feedback also emphasizes the importance of policies that support climate resilience, such as financial support for farmers, sharing sustainable farming knowledge, and investing in infrastructure to reduce weather-related risks. Education and training programs are also critical, as they equip farmers with the knowledge and skills needed to adopt new technologies, improve practices, and respond to emerging risks.

The research question, “What measures would be most effective for protecting agriculture in case of emergencies?” focuses on identifying strategies to strengthen agricultural resilience in times of crisis. Essential measures include the establishment of early warning systems, the construction of resilient infrastructure, the provision of financial support, crop diversification, and comprehensive farmer education. These approaches are designed to minimize the impact of natural disasters, ensure a swift recovery, safeguard food security, and reduce losses.

Based on the survey question, “What strategies do you consider most important for enhancing resilience in agriculture?” respondents emphasized diversification, investment in modern technology, and sustainable practices like organic farming and crop rotation. Serbian farmers suggested strategies such as reestablishing cooperatives, reducing input costs, better disaster protection, anti-corruption efforts, and ensuring subsidies align with European standards. Key recommendations also include fair pricing, improved infrastructure, stronger cooperatives, and better financial support for modernization. Survey results highlighted the need for improved training, access to modern technologies, and stronger support systems. By integrating innovative solutions and ongoing capacity-building, farmers will be better prepared for challenges posed by climate change and economic instability. Building agricultural resilience requires a multi-dimensional approach, combining technological, economic, and policy solutions. This integrated strategy ensures long-term food security, adapts to changing conditions, and fosters resilience for future generations.

Conclusion

The increasing frequency of natural disasters, economic crises, and emergencies underscores the urgent need for agricultural resilience. A combination of innovative technologies, sustainable farming practices, diversification, and government support can help agricultural systems withstand shocks, ensuring food security and economic stability. Empowering farmers through education, training, and collaboration is key to adapting to these challenges. The role of stakeholders in building a resilient agricultural sector is essential for ensuring long-term sustainability. Resilience in agriculture is vital to address climate change, natural disasters, and economic instability. Effective strategies include adopting climate-resilient crops, sustainable land management, precision farming, smart irrigation, and crop diversification. Collaboration among governments, international organizations, and local communities is crucial to provide financial support, facilitate access to insurance, and promote climate-smart policies. Technologies like early warning systems, satellite monitoring, and drones are critical for timely responses.

Survey results in Serbia highlight that strategies such as crop diversification, investment in technology, sustainable farming, and stronger cooperation with local institutions are essential for enhancing resilience. Serbian farmers advocate for better infrastructure, disaster protection measures, reduced input costs, stronger cooperatives, and financial support for modernization. Their recommendations emphasize the importance of coordinated policies, fair pricing, and improved training for farmers. In summary, building agricultural resilience requires a coordinated, multi-dimensional approach that combines technological, economic, and policy solutions. By strengthening resilience, societies can ensure long-term food security, protect farmers' livelihoods, and adapt to changing climatic and economic conditions, safeguarding global food security for future generations.

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DEVELOPMENT OF LOGISTICS AND SUPPLY CHAIN IN AGRIBUSINESS[1]

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Abstract

The paper is based on the conceptual definition of logistics and supply chain in agribusiness. Recently, due to the complexity of the supply process, as well as the specifics of agricultural production, the analysis of the supply chain in agro business is gaining importance. The paper tries to use a descriptive method to explain the difference between logistics as a concept and the supply chain, and to explain their role in agribusiness. In their earlier research, many authors dealt with individual parts of the supply chain in agriculture and agribusiness, and presented their work with the difficulties and advantages that exist within it. The results show that logistics is a narrower concept than the supply chain, i.e. that it represents one part of it, and that the complexity of the process is due to the peculiarities of the agricultural products themselves as an indispensable part of agribusiness.

Key words: *supply chain, agribusiness, logistics, agriculture, suppliers, consumers.*

Introduction

Supply chain and logistics are disciplines that have flourished in application and study with the advent of globalization and technological and IT development. Logistics and supply chain management are relatively new areas in the scientific research of managerial practice.

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Supply chain and logistics cover diverse and complex tasks of business organizations and individual business functions. Their development has gone through many stages until today. The concept of logistics and supply chain has changed and evolved. The term logistics refers to the totality of tasks and measures that arise from the company's goals and are related to the optimal provision of material, information and value flows in adapting the company's processes (Segetlija, 2008). Supply chain refers to the process of planning, organizing and controlling the flow of materials-raw materials and services from suppliers to end users/customers. This integrated approach includes suppliers, procurement management, integrated logistics and operational (Bloomberg, et al., 2006). These definitions show that these concepts are related and deal with the study of the same processes in companies.

Chen and Paulraj (2004) emphasize that the popularity of supply chain and logistics is stimulated from many directions such as: quality, materials management and integrated logistics, industrial markets and networks, focus on competitiveness and influence of specific industries. The areas of study of these disciplines are diverse and include: studying the impact on strategic purchases, communications within the supply chain, reducing the number of suppliers, long-term partnerships, supplier selection, cross-functional teams, trust and attendance, internal integrations, external integrations, supply chain performance, etc.

Recently, the concept of agribusiness is often associated with the concepts of logistics and supply chain. All the more so since agribusiness represents a very diverse industry that includes activities related to food production, procurement and distribution of agricultural products. Agribusiness plays a key role in meeting the global demand for food, thus ensuring the acceleration of rural development, employment and economic growth of a territory. Precisely for this reason, it is necessary to conceptually look at logistics and the supply chain, as well as their relationship and role in agribusiness, and the obstacles that may appear on the way to final realization, using the method of analysis.

Some of the authors in their earlier research dealt with certain segments of the supply chain in agriculture and agribusiness. In some of them, the central place was occupied by the choice of suppliers as well as sales channels, i.e. distribution centers (Anand and Jeyaraj, 2018; Jha and Singh, 2018; Kumar and Khanna, 2018; Rehman et al., 2019; Swinnen, 2019; Constantin et al., 2021; Puška et al., 2021; Puška et al., 2023; Nedeljković, 2022; Kumar and Yadav, 2023).

Methodology

Given that the work is a partial review of logistics and supply chains in agribusiness, the method of content analysis as well as the method of synthesis was used. The first part of the work covers the origin and development of logistics as a skill, and supply chains as a necessary process of modern business. Also, the first part analyzes the relations between these two phenomena. The second part of the paper bases the analysis on supply chains in agribusiness, following its characteristics as well as the importance of management in them. In the continuation of the second part, a literary overview of the type of cooperation in supply chain management in agribusiness is given. For the purposes of writing the paper, available domestic and foreign scientific and professional literature related to the subject matter was used.

Origin and development of logistics and supply chain

Logistics is a unique field of business management and has been present in everyday life since the beginning of modern civilization (Božić and Aćimović, 2004). The term logistics has always been associated with the physical movement of goods from one place to another. As such, it has been used in all segments of life throughout history, but it has not received significant attention. It was only in the 19th century that the importance of procurement began to be studied. In 1832, Charles Babbage published a text entitled "On Economy, Machinery, and Production" (Bloomberg et al., 2006), where the importance of procurement for a company is mentioned for the first time. After that, the concept of logistics found its place in the army when the first definitions were presented. Logistics is the strategy of the art of handling soldiers on the battlefield, the tactics of how to handle them on the battlefield (Lummus et al., 2001). In addition to transporting soldiers to the battlefield, logistics included procurement, maintenance and transportation of military equipment, materials and soldiers. During the Second World War, American scientists perfected mathematical models of planning, optimization and simulation (Segetlija, 2008) in order to reduce costs and speed up the movement of military equipment and soldiers from one front to another.

After the Second World War, logistics began to be applied in companies. Until then, the emphasis was on operations and operational management, how to produce as many products as possible at a lower price. Since then, logistics has played an increasingly important strategic role for companies that strive to keep up with changes in the market.

The beginnings of the scientific study of the supply chain stem from the work of Forrester (1961) who showed that increased demand can be solved by reducing and eliminating delays in materials and raw materials through properly designed feedback loops. In the same year, he set five rules aimed at avoiding bankruptcy, and related to the management of material flows. After these rules, the movement of materials and goods in companies began to be scientifically investigated. Thus, in the 80s of the last century, the possibilities of reducing the costs of raw materials and materials were exhausted, business processes were optimized and perfected, which led to an increase in productivity and product quality. At that time, the scientific foundations of supply chain management had not yet been established, but it was studied within logistics. The concept of supply chain management began to be used in the 80s of the last century. Kraljic (1981) argued that procurement must become supply management, while Oliver and Webber (1982) advocated raising logistics to a higher level. From these initial works, the scientific discipline of supply chain management developed.

The study of logistics within companies began to appear in the 50s of the last century. At that time, the academic community began to actively study transport and procurement as separate disciplines, but did not focus on distribution and logistics. Not long after, warehousing and inventory management began to be studied. The first book dealing with business logistics was published in 1964 (Maslarić, 2014). Here, with the help of the business prefix, an attempt was made to distinguish this discipline from military logistics. Earlier works on this topic included the optimization of internal transport. The reason for this can be found in the technological and informational limits of the time (Ballou, 2007). With the development of technology and informatics in the 70s and 80s, more and more attention is being paid to the flow of information and materials in companies. At the beginning of the 80s, the foundations for the study of the supply chain were laid. The study of the supply chain diminished the study of logistics because the authors were divided. Some authors advocated that the study of logistics be expanded to include the supply chain (Oliver and Webber, 1982), while other authors considered that the supply chain is a broader concept that includes logistics.

The development of logistics and the supply chain went in parallel until the 80s of the last century, and the emphasis was on logistics, and the supply chain was studied within it. Only then does the supply chain begin to be separated from logistics and studied independently.

In addition to logistics, the supply chain also developed through procurement management through four phases. In the first phase, procurement management is subordinated to the more important functions of marketing, finance and operational management. As procurement costs increased, greater importance began to be attached to this term, and in the 1970s, procurement became part of materials management. Only in the fourth phase, which began in the 1980s, was the formation of the supply chain where materials and procurement management began to be studied. Bloomberg et al. (2006) emphasize that the first shift was in changing the point of view on procurement from an internal process, to procurement as a process that realizes added value. Another shift was in moving procurement management from tactical to strategic planning. Inventory management was no longer a tool to reduce costs, but a tool to improve the overall business.

At the beginning of the 80s, importance began to be attached to other segments such as: strategic planning, information support, marketing and finance. These segments, together with logistics, are integrated into supply chain management. In Europe, these segments have been added to logistics and are studied within the framework of an integrated approach to logistics. Differences between these terms exist, but they are not so significant because both terms include the same business processes that occur in companies. Based on the presented development path, it can be concluded that supply chain management is a much broader category than logistics management, "because it is primarily directed towards consumers." Likewise, it shows its marketing relevance because it represents a new business philosophy and strategy in which the planning of all segments of the movement of goods and information in the distribution process prevails" (Milovanović et al., 2011).

The relationship between logistics and the supply chain

The relationship between logistics and supply chain is intertwined because both terms study the movement of materials and products from suppliers to customers. Generally, two attitudes are present. Logistics and supply chain have the same meaning and there is a difference between these two terms. According to the first paragraph, logistics and supply chain have the same meaning because it is difficult to separate them because both terms promote the same ideas: delivery of products at the right time and at the right place through cost management, i.e. by eliminating all unnecessary costs that increase procurement and production and product distribution (Ballow, 2004).

Another point of view is that there is a clear difference between these two concepts, so some believe that logistics is a broader concept than supply chain, and others that supply chain is a broader concept than logistics. However, the best explanation of the difference between these two terms was given by Delfmann and Albers (2000), who determined that the difference between these two terms is primarily in the different understanding of their concept.

In continental European literature, logistics evolved and took on wider proportions, while in Anglo-Saxon literature, logistics stagnated, and a supply chain was created on its foundations. The basic differences between these two terms are in the way of optimizing the internal transport of goods and commodities. In logistics, it focuses on one company, while in the case of the supply chain, all companies that participate in those processes are included. Another difference is that logistics is more theoretically oriented towards solving problems, while supply chain is more oriented towards practical application. Orientation towards key partners is an important segment of the distinction between logistics and the supply chain and an important segment of the research in this work, which is why the focus in this research is on the supply chain and not on logistics.

Cooper et al. (1997) say that the modern understanding of supply chain management is not significantly different from the concept of integrated logistics management. Based on this, it can be concluded that the supply chain and logistics have gained greater meaning and that their field of study covers significantly more jobs that match each other. However, the same authors say that when defining the term supply chain management, elements are present that are not present when defining the term logistics. Based on this, it can be concluded that conceptual supply chain management is a broader concept than integrated logistics management.

Most authors advocate the opinion that the supply chain is a broader concept than logistics because it includes all activities from procurement, storage, production to distribution through the development of partner relationships. In this approach within the supply chain, logistics is represented, which deals with issues of optimizing the internal flow of materials and products in the company. Alvarado and Kotzab (2001) say that the supply chain is essentially the integration of logistics in marketing. Logistics is that part of the supply chain process that is concerned with planning the introduction and controlling the efficient flow of materials and supplies of products, services and information from the point of source to the point of consumption to meet customer requirements. Based on this definition, it can be concluded that logistics is part of the supply chain process, that is, it is a segment of the supply chain. From such approaches, it follows that the supply chain is viewed as a broader concept in relation to logistics, although it originally developed from logistics. This is confirmed by Lummus et al. (2001) who say that logistics is generally related to activities within one company, while the supply chain also includes the management of customer orders, production processes and information flows necessary for the coordination of activities within the supply chain.

In practice, the terms integrated supply chain and integrated logistics are used interchangeably. However, integrated supply chain is much more than integrated logistics because supply chain evolved from integrated logistics. Milovanović et al. (2011) say that the essence of integrated logistics is to integrate procurement, production and delivery to meet the needs of consumers. They are key in the marketing business concept. For the integrated supply chain, they say that in addition to the area covered by integrated logistics, it also includes relations with suppliers and consumers, which are a form of external supply chain. Based on this, it can be concluded that the supply chain includes some processes and relationships that are outside the field of logistics studies.

Segetlija (2008) states that supply chain management has its origins in central logistics problems and that supply chain management is in fact a qualitatively new development stage in the logistics life cycle. Russell (2008) states in his work that supply chain management is based on information systems and that it also includes production processes. Supply chain differs from logistics because it is more strategically important. However, it should be noted that although a distinction is made between supply chain and logistics, the importance of logistics in relation to supply chain management is not diminished, but it can be concluded that logistics is the basic element of the supply chain (Maslarić, 2014).

Agribusiness Supply Chain

Today's agribusiness represents the merging of traditional agriculture with increasingly modern technologies of procurement, production and distribution of agricultural products. Agribusiness through the entire value chain optimizes the use of resources with the aim of maximizing profits, while maintaining existing quality standards. Today, agribusiness ensures the supply of food in rather difficult economic conditions in the world, where to a large extent the supply chains have been interrupted in various ways. Also, agribusiness is directed to foreign markets and in this way has to a large extent connection with global trends in the supply of food and the necessary raw materials. For this reason, agribusiness as a huge industry meets global demand, with the aim of supporting rural development and economic growth.

According to Lehman et al. (2012) agro-food sector includes agriculture, food industry, distribution, and finally consumers, i.e. all members of society. The largest part of food sales and distribution is carried out by large conventional food supply chains, which represent a network of related organizations through which products move from producers to end customers, i.e. consumers. However, these are food systems that are organized in such a way as to "exclude" contact between producers and consumers (Gajdić, 2019).

Norton (2014) identifies the following problems in the value chain in the agricultural sector, namely: poor quality of seeds and varieties, poor quality of products in the harvest, inadequate threshing techniques, inadequate assessment of product quality, insufficient training of farmers and lack of financial resources for improved management of post-harvest activities. He also points out that agriculture in these countries is characterized by double value chains that exist simultaneously for the same product.

When we talk about the food supply chain, we mean a dynamic system that connects agricultural producers with consumers (Gajdić, 2019). Depending on the number of intermediaries involved in the processing and distribution of the final food product to the consumer, and the geographical distance between the farmer and the consumer, food supply chains can be distinguished in terms of spatial proximity (short or long), in terms of business relationships of the actors involved, and in terms of form (Renting et al., 2003; Parker, 2005; Wubben et al., 2013; Haas and Petz, 2017; Todorovic et al., 2018).

Kumar and Yadav (2023) highlight the following key stages in the agribusiness supply chain:

- **Input Supply** (seeds, fertilizers, pesticides, various types of machinery);
- **Production** (land preparation, planting, irrigation, crop maintenance, animal husbandry, other);
- **Harvesting and Post-Harvest Handling** (harvesting, sorting, cleaning, packing);

- **Processing** (grinding, cooking, canning, freezing, conservation, fermentation);
- **Packaging and Storage** (temperature and humidity control);
- **Distribution and Logistics** (warehousing, inventory management, warehouse logistics) and
- **Retail and Consumption** (traders, supermarkets, various types of stores).

The supply chain is extremely important in the efficient flow of products from producers to consumers, especially in circumstances where the world's population is expected to grow to 9.7 billion by 2050. In support of this, and based on earlier research by some authors, Kumar and Yadav (2023) issue some of the critical points in the supply chain in agribusiness, namely:

- The supply chain in agribusiness is a complex network of activities that includes a large number of interested parties such as farmers, suppliers, processors, distributors, wholesalers and retailers;
- The nature of many agricultural products requires caution in supply chain management. As Mollenkopf (2020) concludes, factors such as seasonality, variability in yield and quality, and the need for specialized handling and storage contribute to the complexity of supply chain operations;
- Additional problems in the transport and distribution of agricultural products are possible. This requires more efficient logistics and transport as well as more economical movement of products;
- Maintaining quality standards in the supply chain plays a very important role. According to Christopher (2016), the ability to monitor and maintain product quality throughout the supply chain is key to meeting regulatory requirements and consumer expectations;
- An important segment in the chain is represented by information systems and technology. Progress in this part is reflected in the application of various devices for monitoring and analyzing data in order to make decisions in a timely manner and in real time;
- Growing impact on the environment is a growing challenge. This requires the introduction of new acceptable methods in the production and distribution of products and

- Coping with new challenges imposed by new applied technologies such as blockchain, robotics, precision agriculture, etc.

Collaboration in agri-food supply chain management

Collaboration is needed in agri-food supply chain system in order to minimize cost, increase the profit, fulfil the quality assurance, and as the result is gaining the trust from consumers. Collaboration involves all activities such as production processes, sharing information and infrastructure, skills and knowledge among all stakeholders in the agri-food supply chain such as farmers, food manufacturers, distributors, retailers, consumers, government, NGOs, and finance providers. Each stakeholder has limitation that can be solved by conducting collaboration. This collaboration need strong commitment from all organization involved to achieve the common goal (Steele and Feyerherm, 2013).

Conclusion

By studying the concepts and their areas of research, it is concluded that these two concepts are interconnected and that it is not possible to observe them independently of each other. Through the study of the development of logistics and the supply chain, it can be said that although the supply chain originated from logistics, it has a wider field of study in relation to logistics. That is why it was necessary to explain the origin and development of these terms and their mutual relationship.

Based on the above statements, it is concluded that the supply chain is a broader term than logistics. Logistics principles are studied within the supply chain, and in addition, the supply chain also includes relations with external participants in the company's trade. Therefore, in this research, within the practice of the supply chain, partnership relations with customers and suppliers are included as an important segment of the study of the supply chain.

The supply chain in agribusiness, which represents a complex process that includes a wide range of activities, deserves a special role. Due to currently disrupted supply chains in certain parts of the world, food supply is a real challenge. By overcoming the previously mentioned obstacles, the supply chain in agribusiness becomes a sure pillar of rural development and economic growth, as well as a driver of sustainable development.

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ASSESSING THE MANAGERIAL CAPACITIES OF MILK PRODUCERS IN TITEL MUNICIPALITY

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Abstract

Farmer managerial capacities can be defined as "possessing appropriate personal characteristics and ability to cope with certain problems and opportunities, in the right way and at the right time." Considering the significance of managerial capacities and the problematic state of the milk production sector, and the pressing need to boost its competitiveness, this study investigates the managerial capacities of milk producers in the Titel municipality, located in AP Vojvodina. The decision to analyze milk producers in Titel municipality is based on its higher-than-average number of milking cows compared to the national average in Serbia, leading to a substantial level of milk production. The objective of this study is to assess their managerial capacities, focusing on personal traits, skill sets, and the decision-making process. Following the identification of the producers' managerial profiles, the study proposes specific recommendations aimed at enhancing these capacities to foster greater competitiveness in milk production. Data analysis indicates that in addition to implementing strategies for improving milk yield and adopting advanced biotechnologies, strengthening managerial capacities, particularly in decision-making, is essential.

Key words: *managerial capacities, milk production, Titel municipality.*

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Introduction

It is evident that significant differences in production and economic outcomes often exist between farms operating under more or less similar natural and socio-economic conditions. These disparities can be attributed, among other factors, to biological variables, the degree of specialization and intensity of production, farm size, and production practices employed on the farm. However, it is widely recognized that these differences can largely be explained by variations in farmers' abilities, specifically their managerial capacities (Vukelić, 2015). In countries with developed agriculture, increasing attention is being directed towards studying and improving the managerial capacities of producers across all sectors aimed at enhancing competitiveness. Farmer managerial capacities can be defined as the possession of appropriate personal traits and the ability to address specific challenges and opportunities effectively, at the right time, and in the right manner (Rougoor et al. 1998, Rougoor 1999). For successful and competitive production, modern farmers must allocate greater time and effort to developing their managerial capacities compared to their predecessors (Vukelic and Rodić, 2014). Numerous scholars have examined the managerial capacities of farmers and their impact on agricultural performance (Rougoor et al. 1998, Rougoor 1999, Vukelić 2015, Kay et al. 2008, Johansson 2007, Solano et al. 2006). These managerial skills, encompassing areas such as strategic planning, informed decision-making, risk management, and financial control, are increasingly recognized as pivotal factors influencing both productivity and profitability in farming operations. Researchers emphasize that farmers with advanced managerial competencies are more likely to adopt innovative technologies, optimize resource use, and achieve superior economic outcomes. Cattle breeding represents the cornerstone of livestock production and serves as a key indicator of the overall development of the agricultural and food sectors, both globally and within the Republic of Serbia (Radišić et al., 2021, Đorđević et al. 2023). In recent years, Serbia's milk production sector has faced substantial challenges and transformations, significantly impacting the economic, technological, and social dimensions of agriculture. While Serbia boasts a long-standing tradition in milk production, the current landscape reveals numerous issues requiring strategic intervention and resolution. Milk is predominantly produced on small- and medium-sized farms, which are characterized by extensive production practices. Larger farms, although fewer in number, achieve higher productivity levels and produce higher-quality products. The sector exhibits low levels of digitalization and limited adoption of modern technologies. A lack of education and restricted access to professional advisory services hinder the implementation of advanced technologies in livestock breeding and milk production. While there are examples of successful implementation of information technologies and automation, these remain largely confined to larger-scale farms. Serbia possesses highly favorable conditions for the development of cattle breeding. These conditions should be leveraged to enhance production capacities and foster greater interest among producers in this sector. Improving the managerial capacities of milk producers is a critical factor in addressing current challenges, enhancing efficiency, sustainability, and competitiveness within the sector. Although family-owned and operated farms dominate milk production, developing their managerial skills could significantly improve business outcomes and drive the modernization of production practices. This research centers on evaluating the managerial capacities of milk producers in the Municipality of Titel, AP Vojvodina. Considering that farmers often act as managers of their operations, the study aims to assess their personal attributes, abilities, and decision-making processes. Based on this assessment, specific recommendations will be proposed to enhance managerial capacities, ultimately contributing to the increased competitiveness of milk production in the region.

Material and method

For the purposes of the research, 60 cow's milk producers from the municipality of Titel, Vojvodina, were surveyed. The decision to analyze milk producers in Titel municipality is based on its higher-than-average number of milking cows compared to the national average in Serbia, leading to a substantial level of milk production. Data collection was conducted through direct, face-to-face interviews using a structured questionnaire. The questionnaire consisted of 12 sections: general information about the milk producer or manager (gender, age, and education level), experience in milk production, goals and motivations for engaging in production, risk-taking readiness, knowledge improvement, data and information acquisition, record-keeping, production planning, forecasting and assessing consequences, strategies employed to achieve goals, monitoring, evaluation, analysis, and discussion of achieved results. To identify the primary goals that milk producers aim to achieve, as well as the strategies they implement to mitigate risks and attain optimal production and economic outcomes, a five-point Likert scale was employed. Responses ranged from total disagreement to total agreement. The collected data were analyzed using the SPSS statistical package (Statistical Package for the Social Sciences). Histograms, graphs, and tables were generated within SPSS, while some additional visualizations were created using Microsoft Excel 2013

Results and discussion

The personal characteristics and abilities of the farmer, as a very important aspect of managerial capacity, consist of biographical data about the farmer (which includes gender, age, level of education and experience of the farmer), drivers and motives for engaging in a given production (goals that the farmer wants to achieve), and farmer's abilities and capabilities (cognitive power and intellectual skills). Of the 60 (sixty) milk producers included in this research, only 15 (fifteen) are female (25%), which means that even today, when it is mechanized, milk production is dominated by men, namely men aged 46 to 55 (table 1), therefore they make up over 50% of the total number of men. The average age of milk producers is 47.16 years, which indicates that they are mostly middle-aged experienced producers.

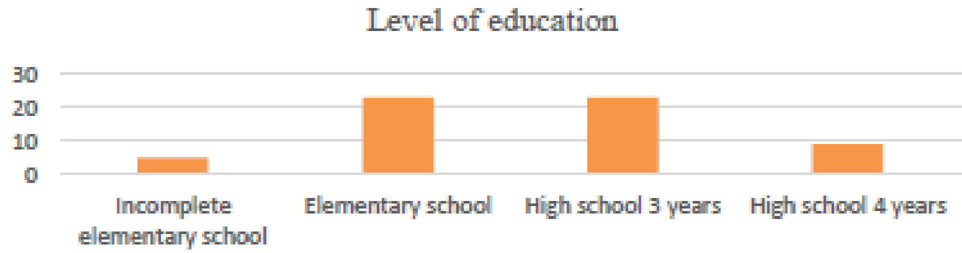
Table 1. *Ratio of milk producers by gender and age*

Gender	Age (years)						Total
	Less than 25	26-35	36-45	46-55	56-65	Over 65	
Male	3	3	7	23	8	1	**45**
Female	1	1	4	6	2	1	**15**
Total	**4**	**4**	**11**	**29**	**10**	**2**	**60**

Source: *Pavlović (2021)*

Graph 1. shows the educational structure of milk producers in Titel municipality, on the basis of which the dominance of primary and secondary three-year vocational education is clearly visible. Among the respondents, there are no milk producers with higher vocational education, higher vocational education and master's degree/doctorate, which indicates that the educational structure in Titel municipality is at the lowest level when it comes to this sector. The reason for this is the high average age of milk producers, which is 47.16 years, as well as the insufficiently developed awareness of how important education is in the field of agriculture. Among the respondents, those with primary and secondary education dominate, with a total participation of 77%. Respondents over the age of 56 have incomplete primary education.

Graph 1. *Educational structure of milk producers*



The current age and educational structure of the rural population in Serbia has a negative impact on the acceptance and application of new technologies in agriculture, innovation, entrepreneurship and all other segments that ensure the progress of agriculture and the rural environment in general. The level of professional education significantly affects the other variables in the model, especially when it comes to using computers, reading professional magazines, attending all events related to milk production and investing in new technologies as soon as they appear on the market (table 2).

Table 2. *The relationship between the level of professional education and the use of computers*

		Use of computer		Total	%
		Yes	No		
Level of education	Incomplete elementary school	0	5	5	9
	Elementary school	17	6	23	38
	High school 3 years	23	0	23	38
	High school 4 years	9	0	9	15
Total		49	11	60	100
%		82	18	-	100

Source: *Pavlović (2021)*

The experience of respondents in milk production in the municipality of Titel was observed on the basis of total work experience and experience by number of generations in this sector.

In the literature, the most frequently mentioned goal of farmers is profit maximization, which was also shown in this research (table 4). "Achieving maximum profit" is the most important goal when it comes to milk production, with an average score of 4.98, followed by "providing a comfortable life for yourself and your family" with an average score of 4.62 and "producing as low as possible expenses" and "being one's own boss" with a score of 4.50 (table 4).

Table 3. *The experience of milk producers in Titel municipality*

		Number of generations				Total	%
		2	3	4	5 and more		
Years of experi-ence	2-5	0	3	0	0	**3**	**5**
	5-10	0	3	1	1	**5**	**9**
	10-20	1	6	1	0	**8**	**13**
	over 20	0	26	16	2	**44**	**73**
Total		**1**	**38**	**18**	**3**	**60**	
%		**2**	**63**	**30**	**5**	**-**	**100**

Source: *Pavlović (2021)*

Table 4. *Goals that dairy farmers want to achieve*

Goals	Average
To achieve maximum profit	4.98
Expansion of production capacities	3.42
Achieving a higher degree of specialization	3.50
Reducing the risk in production to a minimum	3.98
To leave a stable production to someone as an inheritance	3.55
To produce at the lowest possible costs	4.50
To produce health-safe food	3.27
To provide a comfortable life for yourself and your family	4.62
To be a respected producer in your municipality	3.47
To do a job that I like	3.32
To be your own boss	4.50

Source: *Pavlović (2021)*

Making a quality decision also implies considering the consequences that could happen in the future. Difficulties in making business decisions are primarily related to those activities that have a high degree of influence from external factors, such activities include agriculture. The analysis of the risk-taking readiness rating of the producers included in this research and the strategies they apply to reduce risk are shown in Table 5. Based on the results of the research, the average rating of willingness to take risks is 2.87 (table 5).

The best ranked risk reduction strategy in this research was production at the lowest possible costs (table 5). Given that the survey also showed that most producers felt that milk production was not profitable, this was expectable. Based on the average scores (table 5), it can be concluded that a large number of milk producers consider that advance production planning is the most important risk reduction strategy.

Table 5. *Dairy producers' risk appetite and risk mitigation strategies*

Risk management	Average
Assessment of willingness to take risks	2.87
Risk reduction strategies	
Arranging the purchase of inputs and forward sales	3.62
Production at the lowest possible costs	4.35
Consulting with experts	2.27
Advance production planning	3.77
Strict compliance with hygiene and other regulations	3.05
Production insurence	1.08
Life insurance	1.07
Stocking up when the market situation is favorable	3.57
Having financial reserves	3.47
Monitoring work operations and adapting to production changes	3.22
Investing outside of milk production	3.70

Source: *Pavlović (2021)*

This result is expected, considering the necessity of planning when it comes to any production, especially milk production. The functioning of every business system takes place under conditions of a certain amount of risk and uncertainty. The existence of uncertainty makes planning necessary, because it aims to reduce that uncertainty and risk in functioning and development.

Decision-making is largely about handling information. It is necessary to collect and evaluate information, in order to choose alternatives of action and check the results. Differences in information sources and information processing, which reflect the degree of analytical thinking a farmer uses, can affect the quality of the decision-making process, which in turn can affect farm performance. The quality of the intuitive process largely depends on accurate feedback, that is, on responding to relevant information about the results. Table 12 shows the results of the research related to the sources of information, i.e. the method of collecting information that the surveyed milk producers in the municipality of Titel use. In the table 6, it can be seen that the most frequently used source of information is the experience of colleagues, i.e. other milk producers. This source of information is used by all the surveyed producers, which is expected considering that they can see for themselves their success and experience.

Table 6. *Way of gathering information for the decision making process*

Way of gathering information		Frequency	%
Internet	Yes	47	78.3
	No	13	21.7
	Total	**60**	**100.0**
By observing and copying other successful producers	Yes	60	100.0
	No	0	0
	Total	**60**	**100.0**
At professional and scientific events	Yes	5	8.3
	No	55	91.7
	Total	**60**	**100.0**
By reading professional literature	Yes	11	18.3
	No	49	81.7
	Total	**60**	**100.0**
Radio and TV program	Yes	59	98.3
	No	1	1.7
	Total	**60**	**100.0**
From short courses/lectures	Yes	0	0
	No	60	100.0
	Total	**60**	**100.0**
Agricultural advisory service	Yes	1	1.7
	No	59	98.3
	Total	**60**	**100.0**
Promotion of the comercial companies	Yes	0	0
	No	60	100.0
	Total	**60**	**100.0**

The Internet and radio and TV shows are also a common source of information because they are easily accessible these days, even to older dairy farmers. Other sources of information are mentioned much less often, which was expected, because they are sources of information that are quite inaccessible to producers. Namely, courses/lectures are very rarely organized, and even when they are organized, producers are rarely involved. As for scientific events, their target group is not producers, but the scientific community, so farmers are rarely informed about their holding.

In order to realize the planned business activities, it is necessary to create a plan of business activities that will coordinate and direct the entire activity of the company in the given time period. It represents a document on the future business and financial orientation of the business entity to achieve optimal regulations in business by determining goals, tasks and actions. The plan is a product of the planning process. A plan is a special planning decision on the basis of which a planning action immediately follows. The plan defines the action in a certain period of time (time plan) or in a certain segment of business activity (project plan) that should be implemented in order to realize the business goals. Plans serve to design actions and their development in the desired direction. The results of the research on the existence of the production plan of milk producers and the time period for which they are planning are shown in table 7. The research results show that milk producers attach great importance to production planning, and out of 60 respondents, only 1 milk producer does not have a production plan. However, only a quarter of respondents plan for a period of 5 years or more, while the vast majority decide to plan production only for the next year. The survey showed that all respondents who plan for a period of 5 years or more have more than 30 dairy cows, which entails a greater investment in production, thus a greater risk.

Table 7. *Existence of the production plan and the time period for which the producers plan*

Do you have plan your production?	**Frequency**	**%**
Yes	59	98.3
No	1	1.7
Total	**60**	**100.0**
Time horizont of prodaction planning	**Frequency**	**%**
5 years and more	14	23.3
1 year	46	76.7
I do not plan	0	0
Total	**60**	**100.0**

Source: *Pavlović (2021)*

Conclusion

The state of cow's milk production in Serbia remains unsatisfactory, despite significant state investments in premiums and subsidies. It is nearly impossible for a large number of small farmers to remain competitive in the face of excessive imports and low milk purchase prices. Regardless of their experience and knowledge, producers must continually improve and adapt to modern practices. Essential measures include enhancing livestock breeds, monitoring animal health, optimizing nutrition and care, and implementing new technologies in production processes. One of the key strategies for survival and competitiveness is improving farmers' managerial capacities. The research conducted in Titel Municipality highlights several critical insights about dairy producers and their operational challenges. Demographically, dairy farming is predominantly male-driven (75%), with a significant proportion of middle-aged farmers (46–55 years) and low educational attainment, as 76.7% possess only primary or vocational qualifications. Despite this, producers have extensive experience, with 73% having over 20 years of farm management experience. Their goals are primarily economic, focusing on maximizing profits, ensuring financial security, reducing costs, and maintaining independence in decision-making, while social goals such as generational succession are less prioritized. Risk-taking and innovation adoption remain conservative among these producers. They prefer strategies like minimizing production costs to mitigate risks, with an average risk-taking score of 2.87. While 95% participate in professional development activities, their reliance on the internet as the primary source of education limits exposure to advanced practices and expert advisory services. Collaboration with scientific institutions is limited, mostly confined to milk sample analyses with universities. Decision-making processes heavily rely on intuition and familial input, rather than systematic methodologies. Peer experience serves as the primary information source, followed by internet and media outlets. While many producers own computers, fewer than half use them for professional purposes, such as planning or record-keeping, and only 25% utilize them for detailed production planning. Production planning practices are widespread but often short-term, with most producers planning for just one year. Popular strategies include increasing productivity and reducing costs, although there is limited emphasis on improving product quality or diversifying outputs. Record-keeping is common but largely informal and independently managed, raising concerns about its accuracy and utility. Nonetheless, producers value result analysis, with 86.7% conducting thorough reviews of their decisions, underscoring an awareness of the importance of accountability. Despite their efforts, a majority of producers (68.4%) perceive milk production as unprofitable, citing low purchase prices as the primary challenge. To address these issues, recommendations include improving managerial skills through continuous education, enhanced collaboration with advisory services, and participation in professional gatherings. Producers are also encouraged to adopt modern technologies for planning, record-keeping, and decision-making, shift their focus from cost reduction to long-term quality improvement, and strengthen partnerships with scientific institutions for better access to innovations. Implementing these strategies could significantly enhance competitiveness and sustainability in the milk production sector amidst challenging economic conditions.

Prioritizing the enhancement of managerial skills among milk producers is vital for ensuring sustainable and competitive development in Serbia's milk production sector. Implementing targeted education programs, increasing access to modern technologies, and providing professional advisory support can empower farmers to optimize production and respond effectively to evolving market demands.

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IMPLEMENTATION OF THE HACCP STANDARD IN DOMESTIC DAIRY INDUSTRY

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Abstract

The aim of the research was to understand the nature and implementation of the HACCP standard and identify accompanying issues in domestic dairies. Interviews were conducted with representatives of HACCP working groups from five dairies, as well as with a representative from the Food Safety Council. The results showed that all dairies have HACCP working groups, product descriptions, and production schemes, which are significant for food safety. The dairies met the HACCP standard requirements in terms of hazard analysis. Dairy D's HACCP plan is not compliant with the standard's requirements, while other dairies have specified CCPs and critical limits. All dairies keep records, although Dairy D reported deficiencies in monitoring sheets. If there is a deviation from the critical limits, immediate action is taken, and the situation is brought under control. Internal audits of the HACCP system are conducted at least once a year, and any identified deficiencies are documented. All dairies have implemented prerequisite programs and developed food traceability systems. The problems faced by domestic dairies were identified, with the most significant being the lack of risk management software, inadequate training, the introduction of overly strict laboratory requirements, among others. In terms of prerequisite programs, dairies mainly faced structural and technical issues, as well as problems with health inspections. Dairy D had issues with product recalls. Problems with the implementation of the HACCP standard also arise during product export, where regulations are significantly stricter. The effective application of the HACCP standard depends on management commitment, prerequisite programs, and training.

Key words: *HACCP standard, food safety, dairy industry.*

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Introduction

Food safety is one of the most important aspects of public health. With globalization and increasingly complex supply chains, ensuring that food products are safe for consumption is crucial. Inadequate food safety management can lead to serious health risks, loss of consumer trust, and economic losses. Therefore, the implementation of effective food safety management systems is key to maintaining high standards of quality and protecting consumer health.

One of the most effective systems for ensuring food safety is HACCP (Hazard Analysis Critical Control Point), which identifies, evaluates, and controls hazards at all stages of the production process, from raw material sourcing to distribution and consumption (Dillon and Griffith, 2001). HACCP enables companies to identify hazards before they arise in the production process and apply control measures to maximize food safety (Cullor, 1997; Savanović et al., 2017).

Contaminated food causes health problems and severe economic consequences globally (Hussain and Dawson, 2013). Each year, around 600 million people become ill, and 420,000 die due to the consumption of contaminated food. Food containing harmful microorganisms and contaminants causes more than 200 diseases (WHO, 2022). Therefore, HACCP is an essential tool for protecting consumer health. Implementing control measures and updating food safety management systems allows for the timely detection, prevention, and elimination of hazards (Cusato et al., 2012). Rapid urbanization, disproportionate population growth, intensive international trade, and public health protection are the main global drivers pushing countries to strengthen their food safety management systems (Sandrou and Arvanitoyannis, 2000).

For the successful implementation of the HACCP standard, prerequisite programs[4] must function properly and be proven effective. The efficiency of HACCP implementation depends on the knowledge and skills of management and engaged personnel. The implementation of the HACCP standard must be revised as necessary (Wallace and Williams, 2001).

The implementation of the HACCP standard is not only a legal obligation in many countries but also a key element in achieving high standards of quality and competitiveness in the global market. The HACCP standard is applied and continually improved, and its implementation in the dairy industry is expected to increase consumer trust and facilitate international trade.

4 Prerequisite programs are measures necessary to maintain hygiene, which every company must implement to ensure food safety and establish a functional self-control plan.

This research aims to understand the nature and implementation of the HACCP standard and identify accompanying issues in domestic dairy companies. The research will focus on case studies, providing concrete examples and recommendations for the successful implementation of the HACCP standard in dairies, an important segment of the food industry.

Literature review

The food safety management system combines preventive measures, preparedness, and self-control to ensure food safety.

The food safety management system based on HACCP in the European Union is regulated by Regulation No. 852/2004 on food hygiene and Regulation No. 853/2004 on specific rules for food of animal origin. According to Regulation No. 852/2004, the primary responsibility for food safety lies with the food handler, who must establish and apply HACCP procedures. The general principles of food law, information exchange to ensure the effective functioning of the traceability and recall system for contaminated food, are outlined in Regulation No. 178/2002. EU legislation establishes high standards for the protection of human health, animal health, and the environment, with the European Food Safety Authority (EFSA) assessing risks. In cases of serious risks, the Rapid Alert System for Food and Feed (RASFF) allows for urgent responses and the withdrawal of dangerous food from the market[5] (Commission Notice..., 2016).

In the Republic of Serbia, the food safety management system is regulated by: the Food Safety Law, the Veterinary Law, the Law on the Health Safety of Foodstuffs and General Use Items, the Law on Organic Production, the Law on Genetically Modified Organisms (GMO), and the Consumer Protection Law, along with numerous regulations and decrees. These laws set requirements for hygiene control, traceability, and food labeling to ensure consumer protection and harmonization with international standards. Key institutions responsible for enforcing these laws include: the Ministry of Agriculture, Forestry and Water Management, the Ministry of Health, the Food Safety Council, the Veterinary Inspection, and others.

The HACCP standard identifies and analyzes risks that can endanger consumers and establishes control points where risks can be eliminated or reduced to an acceptable level (Dillon and Griffith, 2001). The essence of the HACCP standard is prevention, i.e., the identification of potential hazards before they occur (Cullor,

5 In 2020, 3,781 RASFF reports were made, of which 1,403 were threats (RASFF, 2024).

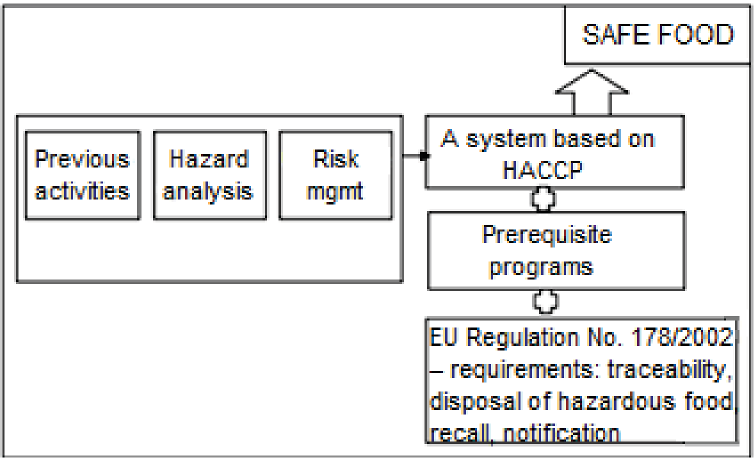
1997). Although end-product testing was once considered sufficient, it is clear that it cannot fully guarantee food safety. The most effective way to reduce the risk of contamination in the food industry is the HACCP standard, which offers stricter control than traditional methods (Borchers et al., 2010).

HACCP was developed in the 1960s at the request of the American space agency (NASA) to ensure food safety in the space program (Bauman, 1995). The reasons for implementing the HACCP standard include legal obligations, consumer health protection, economic benefits, and better corporate reputation.

A functional HACCP standard relies on prerequisites, such as hygiene and production practices. When properly applied, prerequisite programs define the principles of proper food handling, making the HACCP standard more efficient and easier to manage (Wallace and Williams, 2001). If prerequisites are not adequately applied, more complex HACCP plans with multiple critical control points (CCPs) are created, complicating management (Roberto et al., 2006). Prerequisites cover infrastructure requirements, employee hygiene, pest control, waste management, and other areas relevant to food safety (Commission Notice..., 2016).

Food safety is achieved through the application of the HACCP standard, prerequisite programs, and compliance with the requirements of Regulation No. 178/2002, which must be fully and correctly implemented (figure 1). By focusing on the core of the HACCP standard, achieving effectiveness depends on the design, implementation, control, and management of the HACCP system (Wallace et al., 2014).

Figure 1. Food safety management system based on HACCP



Source: Wallace et al. (2014); Commission Notice... (2016)

The traceability system enables the tracking of food through all stages of production, processing, and distribution, aiding in the rapid and precise withdrawal of unsafe food from the market (Badia-Melis et al., 2015). Traders are legally obligated to withdraw food that poses a health risk or is unfit for consumption (Regulation No. 178/2002).

The HACCP self-control system is based on 7 principles (Regulation No. 852/2004, Article 5):

1. Identification of hazards to be avoided, eliminated, or reduced;
2. Determination of critical control points;
3. Establishment of critical limits;
4. Implementation of monitoring;
5. Corrective actions;
6. Regular verification of effectiveness;
7. Documentation of the process.

The implementation of the HACCP system includes 12 steps, which relate to the preliminary activities of the HACCP system (1-5), hazard identification and analysis (6), and risk management (7-12):

1. Formation of the working group,
2. Preparation of product descriptions,
3. Determination of product purpose,
4. Development of technological schemes for products,
5. Approval of technological schemes,
6. Identification and analysis of hazards,
7. Identification of critical control points,
8. Definition of critical limits at critical control points,
9. Monitoring at critical control points,
10. Corrective actions,
11. Verification of system compliance,
12. Documentation and data retention.

The costs of the HACCP system include the preparation of the plan, training of employees, and procurement of equipment, while the benefits are harder to quantify (Maldonado et al., 2005). In the dairy sector, the largest cost is the time spent on documentation and equipment adjustments (Cusato et al., 2012). The implementation of HACCP can take anywhere from several months to several years, depending on the complexity of the processes and the number of control points (Donovan et al., 2001). The benefits include ensuring food safety, customer retention, regulatory compliance, and improved export opportunities. The system also contributes to a positive image and increases consumer trust (Bauman, 1995; Caswell, 2000; Maldonado et al., 2005; Cusato et al., 2012).

Research method and sample

In the empirical part of the study, the implementation of the HACCP standard in dairy enterprises was researched using a case study approach. Data were collected through semi-structured in-depth interviews. The sample consisted of three large and two small dairy enterprises. The questions were divided into thematic categories, such as: preliminary activities of the HACCP system; hazard analysis; risk management; prerequisite programs; traceability, control of non-conformity of products and processes; functioning of the monitoring system; and problems that arise during the implementation of HACCP. The interviews were conducted via Zoom from June 17 to June 30, 2024, lasted about an hour, and the enterprises were labeled A, B, C, D, and E due to anonymity requests. Additionally, a telephone interview was conducted on June 24, 2024, with a representative of the Food Safety Council to obtain further information. The analysis of the interviews is illustrated with quotes from the respondents.

RESULTS AND DISCUSSION

In order to analyze the nature of the HACCP-based food safety management system, information obtained from interviews with members of the HACCP working groups of the sampled dairies is used. This subsection formulates the research questions and focuses on the answers.

Previous activities of the HACCP system

Question 1: How are predetermined activities carried out?

All dairies have formed a HACCP working group composed of experts from different fields, with assigned responsibilities. Changes in working groups were recorded only in companies A, B and C. *"We have two dairies and in both the team leader is the quality manager. In addition, the HACCP working group includes a dairy manager, a laboratory manager, a technologist, a storekeeper and a technical engineer."* (A) *"Position changes in the HACCP team happen, simply a team member is replaced."* (B)

Product descriptions include chemical, physical and microbiological indicators, characteristics of raw materials and descriptions of finished products, as well as descriptions of consumer groups. *"We have prepared short product descriptions and, of course, a description of how to use the product. The main product is cheese. If consumer groups are not specified, the purpose of use of the product is general."* (B)

Dairies A and C have a specification for each product in the product description, and allergens are listed separately. *"We have created specifications for each product, they are reviewed every three years, if something changes with the product, then even sooner. Chemical, physical or microbiological parameters are analyzed daily. Some things may need to be added, eg. allergens. Also, we want this information from raw material suppliers. The origin of the raw material is important, because it affects the final product, so we inform the customer if, in addition to allergens, there are also substances that have entered the product through the line or through storage. The products are suitable for all consumer groups except those with milk intolerance."* (C)

The specification of dairy A will be supplemented as necessary. *"Our dairy has kept the product specification, which is first sent to the customer, it is simple, it is on one side of A4 format, and individual declarations can be added as attachments, e.g. we have an allergen declaration. We have such standard products that we first create a short description and, if necessary, supplement it with additional information."* (A)

The purpose of the product is determined, the product description is updated, if there is a special group, an overview of the consumer group for which the product is intended is given. *"We update according to what is available and as technology evolves. We have special groups, we make animal feed and substitutes for whole milk for calves, dried whey, skimmed milk powder, etc. "* (E)

All dairies have detailed technological schemes, which reflect the actual production processes, with key parameters (time, temperature, pH), which are revised annually or as needed. *"Each group of products has a technological scheme, and* *the descriptions are accurate, confirmed and correspond to reality”*. (A) *“The flow chart contains all the steps of the process, including the equipment, premises, temperature and time at each stage.” They are reviewed annually and revised if necessary* (D), *and any change in the technological process or control points is introduced and approved by the working group”*. (C)

Hazard identification and analysis

Question 2: On the basis of what is the identification of hazards in your dairy and how is hazard management carried out?

The HACCP working group analyzes all phases of the technological scheme for biological, chemical and physical hazards. All dairies pointed out food hazards, as well as their causes and control measures.

Prevention of microbiological risk is done by analyzing milk samples, and this risk can be controlled by pasteurization. *“In order to prevent micro-biological danger, milk samples are analyzed in the laboratory. Once a week, we also analyze samples from the truck. This danger can only be corrected by heat treatment, so pasteurization is a critical control point.”* (A)

Dairy Plant B emphasizes the cleanliness of equipment as a method for managing microbiological hazards. *“We control microbiological risk through the cleanliness of the equipment. We have our own laboratory, we analyze samples, pasteurize, and use personal protective equipment.”* (B)

In the case of Dairy Plant E, controlling packaging materials is important. “*In the case of microbiological hazards, when receiving packaging, a visual check is performed to ensure that the packages are not damaged or undergo microbiological analysis in the laboratory. At every stage, we check that the product is not contaminated.*” (E)

Antibiotics are a chemical hazard. If cows have been treated with antibiotics, their milk cannot be used for a certain period. To prevent or avoid antibiotic residues, milk is analyzed using a rapid test. “*In the case of chemical hazards, we monitor incoming raw materials, so the producer has a declaration of compliance regarding chemical hazards, and we request analyses from them as needed. Chemical risk also includes the risk of allergens, where their presence is checked.*” (C)

Dairy plants consider detergent residues a chemical hazard. *“In the case of chemical hazards, we provide training on the use of detergents to prevent risks.”* (E)

Dairy Plant B treats allergens as a special hazard. *"In the case of allergens, we consider this risk separately, as it can be introduced with certain raw materials, and there are potential opportunities for cross-contamination."* (B)

To prevent physical hazards, dairy plants have installed screens to prevent foreign objects from entering the product, and metal detectors have been placed on the lines. *"In the case of physical hazards, we look for any possibility of foreign objects being present somewhere and have additionally installed a screen on the line, a metal detector, and an X-ray machine."* (C)

Dairy plants have met the requirements of the HACCP system regarding hazard analysis. The purpose of this analysis is to define hazards that are important from a food safety perspective, determine preventive actions, and address them in the HACCP plan (ILSI, 1999).

Risk management

Question 3: What are CCPs and critical limits? How are CCPs determined?

HACCP teams in dairies B and C use structured risk assessment methods and probability matrices to identify CCPs, such as: milk reception, pasteurization and metal detection. These methods often include scorecards or matrices designed to measure the degree of likelihood and severity of a hazard, rating it as: 'high', 'medium', 'low' or 'insignificant' (Wallace et al., 2014). To determine the CCP, it is necessary to take into account the probability of occurrence of the hazard and the scale of the possible adverse effect. *"Through hazard analysis, the stage becomes CCP, when the deviation is no longer controllable."* (B)

CCPs in the dairy industry are milk reception (antibiotic testing), pasteurization and metal detection. Dairies A and B have the same CCP (antibiotics, pasteurization, metal). Dairy E adds sieve as CCP, and dairy C heats the water in the boiler, when doing pasteurization. *"When determining the CCP, we use a risk assessment method."* (C)

Dairies A and E use a decision tree to determine CCP. *"The basis is a decision tree with answers to yes and no questions."* (A) CCPs are also determined using a decision tree in dairy E. *"We define CCPs using a decision tree."* (E) Dairy D uses an adapted HACCP plan without establishing a CCP. *"The self-control plan is based on good hygiene and production practices, as well as on the proper implementation of preventive and corrective measures."* (D) In the case of dairy D, it would be important to set up pasteurization, as a CCP. The HACCP plan of dairy D does not comply with Article 5 (2) (b) of Regulation no. 852/2004, which states: "identification of the CCP, where the control is essential to prevent, eliminate or reduce the hazard to an acceptable level."

In the case of dairies A, B, C, E, after determining the CCP, the critical limits for each CCP are determined. The critical limit must have a measurable value and separate the acceptable from the unacceptable. *"Antibiotics must not be in milk, so zero tolerance. In the case of pasteurization, the milk must be heated for at least 15 seconds at 72 °C."* (A) CCPs must be based on evidence that the selected values provide process control (Commission Notice..., 2016). Food is safe as long as critical limits are not exceeded. *"When determining the critical limit, we use scientific articles."* (C)

Question 4: What CCP monitoring procedures exist and are they properly implemented?

In order to ensure that CCPs do not exceed critical limits, monitoring is carried out, the situation is assessed and the results are recorded. Dairy operators control the presence of antibiotics, pasteurization temperature and metal detection. *"Monitoring needs to be delegated to a specific position."* (A) *"Temperature monitoring is done once during the working day, and the presence of antibiotics in milk is read on the analyzer."* (B) During observation or measurement, it must be possible to notice an omission. The results are recorded in paper and/or digital form, with the possibility of corrective measures, if deviations occur. Dairies monitor critical limits every day, in order to react in a timely manner. In the case of dairy D, deviations from the norm are highlighted on the monitoring sheets, the monitoring sheets are not filled out daily. *"The principle is that we do not record everything, but what differs from the usual state."* (D) *"If there are antibiotics in milk, the product is reprocessed or disposed of."* (A)

In the case of dairy D, a digitized monitoring system is functioning. *"The pasteurizer itself monitors the temperature, and if for some reason it doesn't reach it, the milk goes into a new circuit and goes around until it finally reaches the temperature."* (D)

Dairies review the data of the monitoring sheets every day, so that they can react quickly. Also, they store data for two or three years, and even longer at the request of customers.

Question 5: When and what corrective measures are implemented?

Corrective measures are applied when monitoring reveals that the situation in the CCP is out of control (Schmidt and Newslow, 2007). If the critical limit is exceeded, the raw materials are rejected, the pasteurization is repeated, and the defective milk is disposed of. In the case of antibiotics in milk, it is destroyed. *"If we consider antibiotics in milk, then such milk is destroyed."* (B) When the metal detector does not work, the products are blocked and checked again, when the detector works. The causes of deviations are analyzed to prevent recurrence, and corrective measures are documented and recorded in the non-conformity register.

Question 6: What compliance verification procedures are in place and how are records kept?

Internal and external audit procedures have been established in dairies to verify compliance with the HACCP system. An internal audit is performed at least once a year, during which the HACCP plan, monitoring sheets, results of laboratory analyzes and technological schemes are reviewed. Observed deficiencies are recorded and the documentation is updated. *"At least once a year, an internal audit is carried out, then the HACCP system and results are reviewed to see if there are any suggestions for improvement or addition."* (A) *"We performed an analysis of products, hygiene conditions, documents and technological schemes together with an expert consultant. "* (B, C) The results of the audit are documented, and based on the collected information, necessary changes are made to the self-control plan and system (Schmidt and Newslow, 2007). The self-monitoring system of companies A, B, C, D is up-to-date, easy to find and covers all activities. *"Yes, it is updated, we have all the procedures and registers in digital form and we can find them quickly"*. (C)

External auditors can be representatives of the Food Safety Council and customers. Dairies keep documentation and the HACCP plan, while employee training on the HACCP system is conducted as part of regular hygiene training. *"There are trainings on food hygiene, where HACCP is included."* (C)

Question 7: How is the adequacy and fulfillment of the prerequisites of the program ensured?

Prerequisite programs were implemented in all sampled dairies. These include good hygiene and manufacturing practice, and updating documentation is necessary with any change in procedures, such as cleaning or pest control plans. *"In general, it is very good to complete the prerequisite programs, it helps a lot in* *preventing various dangers" (C) We must carefully keep records and implement the prerequisite programs."* (E)

Question 8: How does the traceability system, product and process non-conformity control work?

All dairies have a functional traceability system. Thanks to this system, product recalls have been carried out, helping to quickly recall potentially dangerous food. *"Each container and equipment has its own number. Raw milk is tracked from the tank to the finished product, and each product is given a serial number, which allows for traceability from production to market. The system is tested at least once a year, including a product recall exercise. Although there have been no major problems so far, in one case the product was recalled due to defective packaging."* (A)

Dairies regularly test product traceability and recall. In case of non-conformity, the products are recalled, evaluated and, if necessary, processed or disposed of. Dairies B, C, D and E had to withdraw the product from the market. Although Dairy D had problems with product recalls, the other dairies manage traceability successfully. Dairy D had an incident with a recall, because it was not fast and efficient enough. *"We had a case where the raw milk was analyzed and the product had to be recalled, we notified the distributors, but the product was sold out and we couldn't recall it."* (D)

Problems in implementation of HACCP system in the dairy industry

One of the main problems is the lack of a unified software solution for creating and managing HACCP plans. Companies are forced to develop their own documentation methods, which complicates data systematization and risk analysis implementation. Excel spreadsheets are used, but there is a pronounced need for specialized programs that would facilitate work and provide quick access to relevant information.

Another issue is insufficient employee training. Training often focuses on food hygiene, with HACCP included only as one segment. *"Regular training on food hygiene includes a part on HACCP"* (B). Although legislation is clear regarding operators' obligations to provide adequate employee training, including knowledge about CCPs and risks, in practice, this training is not comprehensive enough.

Identifying CCPs is also challenging, especially in smaller dairy companies, such as Dairy D. In some cases, it was not possible to identify CCPs, so risks were managed through prerequisite programs. While legislation allows flexibility in the application of HACCP, especially for small producers, it is essential to ensure that this flexibility does not compromise food safety. In the dairy industry, pasteurization is a critical CCP, but in cases where pasteurization is not performed, detailed inspections of the final product are necessary to ensure its safety.

Laboratory analysis is another problem, particularly for small enterprises that cannot afford expensive equipment. Stringent requirements for laboratory analyses, along with the obligation to use accredited methods, pose a financial challenge. Strict laboratory requirements are the main reason why Dairy E does not have a laboratory. *"This is now a problem that is causing HACCP to function poorly"* (E). As a result, most dairies rely on external analyses, which complicates control and increases costs.

Infrastructure problems and technical deficiencies in production facilities, such as damaged tiles, also hinder the implementation of prerequisite programs. *"It happens that tiles break."* (B). Health inspections of employees are another challenge, as general practitioners often do not want to conduct examinations as frequently as needed.

Finally, the compatibility of HACCP standards with the requirements of export markets is a problem for companies operating in the international market. Some foreign standards may be stricter than domestic ones, requiring additional food safety certifications. Companies are compelled to meet various standards, resulting in additional costs and difficulties in exporting.

These issues highlight the need for greater support in the form of specialized software solutions, better training, more accessible laboratories, and alignment with international standards to facilitate the implementation of HACCP standards in the dairy industry.

Conclusion

The HACCP standard establishes key control mechanisms in food production to ensure its safety. The system is based on risk assessment, hazard identification and their control. Its effective implementation depends on management commitment, good hygiene practices and employee training.

All dairies formed a working group for HACCP, established and managed previous activities based on HACCP principles. All dairies have identified hazards and control measures. The traceability system keeps the desired information about the product and its ingredients in the chain of production and use up to date. The verification of the reliability of the HACCP system consists of: audit of compliance of the self-control system, audit of documentation, analysis of corrective measures and audit of the results of laboratory analyses. Documents of the HACCP system are kept, and an internal audit is performed at least once a year.

The implementation of the HACCP standard has caused problems related to risk management and product recall, and the need for improvement of those processes and continuous training of employees has been emphasized. The study sample included Dairy D, which did not properly identify all relevant CCPs and respect all hazards that may occur in the production process. In the risk analysis, there were problems with the strict requirements, which are imposed on the laboratory, as well as with the health examination of the employees. Dairies also had problems with product recalls. Cooperation with supervisory authorities in ensuring food safety is important. Persons responsible for the development and management of the food safety system should be regularly trained in procedures based on HACCP principles.

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THE ANALYSIS OF THE TRADE BALANCE OF ROMANIA AND SERBIA

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Abstract

This paper offers a comparative analysis of the trade balance of Romania and Serbia, highlighting the main trends, differences, and economic challenges faced by both countries in the current global context. The study examines the evolution of exports, imports, trade deficits, and surpluses in recent years, with a focus on dominant economic sectors and the influence of trade policies. In addition, the paper includes a bibliometric analysis of the specialized literature on the trade balance, exploring the frequency, relevance, and trends in research on this topic. Thus, the main research directions and theoretical frameworks used to understand this subject in Romania and Serbia are identified. The paper also discusses the impact of the European Union on Romania's trade balance and the prospects for Serbia's regional integration. It provides an integrated perspective on the economic and academic factors contributing to the trade performance of both countries, highlighting future opportunities and risks.

Key words: *trade balance, Romania, Serbia, exchange, bibliometric analysis.*

Introduction

The economy of each country, regardless of its size or level of development, is connected to the international market through foreign trade. The volume of exports and imports influences domestic prices, the exchange rate, interest rates, aggregate demand, and GDP, thus affecting the overall macroeconomic equilibrium (Bălan, 2011).

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A country's international trade represents an exchange of goods and services with other nations. This type of trade arises because no country can produce everything it needs, thus requiring imports from abroad. This reliance on imports is due to both natural and artificial factors, such as geographical location and available human resources.

In today's globalized context, international trade plays an essential role in supporting the economies of many countries, increasingly influencing economic development. Thus, Purnomo (2020) argues that most countries rely on international trade to sustain their economies, aiming to improve living standards and stimulate economic growth. A country's trade performance is generally evaluated through its trade balance, whether surplus or deficit, which reflects the level of competitiveness in the international trade of goods and services (Cristanto and Bowo, 2021).

The motivation for writing this paper stems from several factors, such as:

The role of foreign trade in economic stability: Imports and exports have a direct impact on the economies of Serbia and Romania, influencing macroeconomic balance, exchange rates, and inflation. Since international trade is a key component for GDP growth and job creation, analyzing it helps in understanding how these economies function and develop within the regional context.

Identifying key trading partners and sectoral performance: Another motivation for this research is to determine the main import and export partners for each country, as well as the sectors in which each country excels. This analysis aids in identifying each country's competitive advantages and highlights sectors with greater development potential within their national economies.

Relevance for trade policy: The study can contribute to recommendations for improving the trade balance, including suggestions for market diversification and enhancing the competitiveness of local products.

Literature review

Trade is an economic concept that refers to the process of buying and selling goods, products, or services. This can involve a payment made by the buyer to the seller or can consist of the exchange of goods and services between two parties (Sanghoon, 2002). Transactions involving goods, services, or capital that cross national borders or occur between international territories are considered foreign trade. In many countries, international trade constitutes a significant component of gross domestic product (GDP). Factors such as industrialisation, advancements in transportation, globalisation, and the rise of multinational corporations have had a considerable impact on trade dynamics (Stoica et al., 2022).

Numerous studies have analysed countries' foreign trade balances (Rajković et al., 2020; Kuzman et al., 2016; Živković and Kostić, 2023; Jovičić et al., 2020; Pătărlăgeanu et al., 2020) or specific sectors (Zăpucioiu et al., 2023; Mocanu et al., 2023; Istudor et al., 2022; Ion et al., 2008) and the effects of structural changes in production.

Gherman et al. (2021) support the idea that the trade balance is an economic-statistical tool that systematically records and compares the total value, or by groups of goods, of a country's imports and exports. Through the trade balance, countries can monitor their participation in international trade, capitalising on the results of national economic activities in the global market.

Research methodology

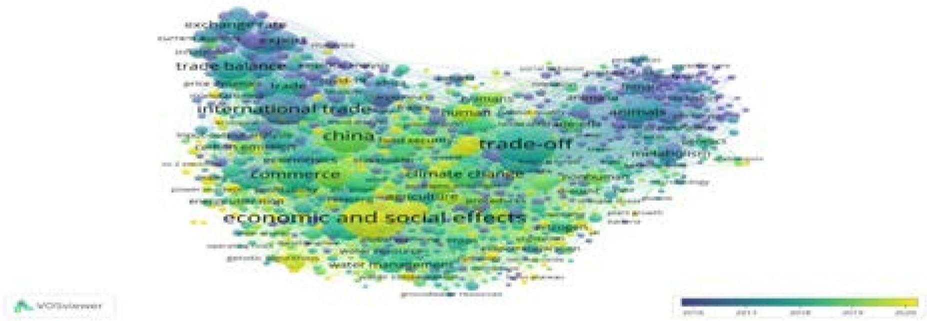
In this paper, a bibliometric analysis was initially conducted by mapping connections and the intensity between keywords searched in bibliometric databases, a method commonly used in the specialised literature (Zaharia et al., 2018; Pătărlăgeanu et al., 2020; Sterie et al., 2024; Zăpucioiu and Trică, 2022).

To assess the trade balance situation of Romania and Serbia between 2019 and 2023, a detailed analysis was performed on data available from the International Trade Centre. This analysis identified the main export and import markets for goods in Romania and Serbia, examined the trade balance of agricultural goods for both countries, and described potential products that could be exported from one country to the other.

Results and discussions

The Scopus bibliometric database was used to search for indexed articles containing the phrase "trade balance." This query resulted in 23,028 scientific documents, of which 15,779 are articles. Maps illustrating connections between the countries where these works were published will also be created. All bibliometric analyses will be conducted using VOSviewer software. Version 1.6.20 of VOSviewer allows for the analysis of bibliometric and sociometric networks in terms of the performance of articles or specialised works, authors, organisations, impact factor, and more. Additionally, it facilitates the identification of networks in close proximity, using methods to evaluate the link and association strength between them.

Figure 1. *Link between trade balance and other related terms*



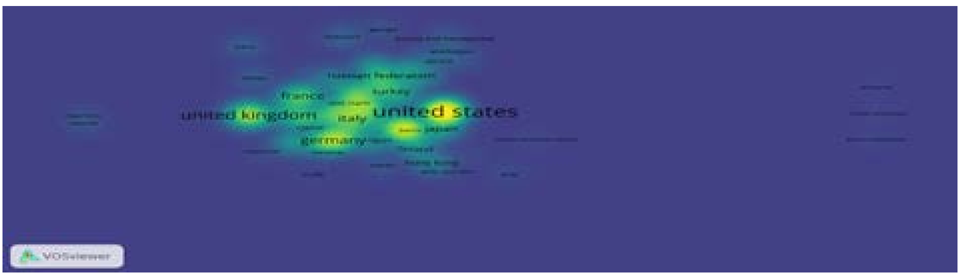
***Source**: Own processing using VOSviewer of information extracted from WoS*

The map shown in Figure 1 was created 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**: Ten

In the analysis of identified keywords, according to the criteria described above, notable clusters can be observed regarding theme and timeframe, as identified by the authors' research. In earlier periods, clusters (displayed in darker fonts) can be seen relating to *exports*, *exchange rate*, *price dynamics*, and so on. Subsequently, a more recent cluster was identified, linking terms such as *economic and social effect*, *climate change*, *human*, and *cereal*. The most recent keywords identified in current research refer to *agriculture*, *food security*, and *trade-off*, hinting at issues of national security.

Figure 2. *Link between coauthor countries*



***Source:** Own processing using VOSviewer of information extracted from WoS*

The map in Figure 2 was created with the following specifications:

- **Unit of analysis**: Co-authors
- **Counting method**: Full counting
- **Scientific documents with authors from more than 25 countries were excluded** from the map generation
- **Minimum number of scientific documents required for a country to appear on the map**: Ten

In terms of the interconnections between co-author frequencies by country, countries with interest in the researched topics were identified. Since the beginning of the last decade, this subject has been studied in countries such as the United States, the UK, and Germany, where the most scientific results have been produced. However, there are also countries where these topics have been researched to a lesser extent, such as Georgia, Peru, and Serbia.

Table 1. *Analysis of total imports and exports (thousand dollars)*

	2023			2019		
Country	Import Value	Export Value	Trade deficit	Import Value	Export Value	Trade deficit
Romania	131962913	100642463	-24%	96644319	77298748	-20,02%
Serbia	39644484	30790286	-22%	26548364	19557555	-26,33%

Source: *Edited by the authors based on ITC data*

The comparative table for 2023 and 2019 highlights that Romania recorded significant imports of $131.96 million in 2023, an increase from $96.64 million in 2019, alongside exports of $100.64 million, indicating improved external competitiveness. However, the trade deficit rose to -24%, compared to -20.02% in 2019, suggesting a challenge in maintaining trade balance. Conversely, Serbia recorded imports of $39.64 million and exports of $30.79 million in 2023, reflecting growth from $26.55 million and $19.56 million, respectively, in 2019. Although the trade deficit slightly improved, remaining at -22% in 2023 compared to -26.33% in 2019, this suggests more effective management of foreign trade. Thus, Romania faces a larger trade deficit than Serbia, which may reflect economic challenges in maintaining a balance in international trade.

For the methodology of selecting import sources and export destinations included in the analysis, the top 10 countries (trading partners) were selected for both imports and exports.

Table 2. *List of importing markets for a product exported by Romania*

Importers	Exported value in 2019	Exported value in 2020	Exported value in 2021	Exported value in 2022	Exported value in 2023	2023/2019
World	77298748	71046399	88389729	96829602	100642463	130%
Germany	17343320	16193180	18153087	19202057	20973002	121%
Italy	8722038	7645913	9251499	9761670	10244686	117%
France	5330921	4782411	5647386	5815442	6383473	120%
Hungary	3723309	3547298	5011873	7088133	5698841	153%
Bulgaria	2716467	2588939	3459541	3763155	4178331	154%
Poland	2725421	2654615	3522316	3685161	3703107	136%
Netherlands	2359442	2524251	3032007	3393629	3401445	144%
Türkiye	2504160	2391524	3103651	2987161	3307237	132%
Spain	2350447	2106522	2635064	3008297	3245855	138%
Czech Republic	2424797	2202246	2765963	2796274	3239113	134%

Source: *Edited by the authors based on ITC data*

The country to which Romania exports the most products and services is Germany, with exports valued at $100.64 million in 2023, representing a 21% increase compared to 2019. The largest growth in Romanian exports, however, is seen in Bulgaria, where exports increased by 54% in 2023 compared to 2019.

Table 3. *List of supplying markets for a product imported by Romania*

Exporters	Imported value in 2019	Imported value in 2020	Imported value in 2021	Imported value in 2022	Imported value in 2023	2023/2019
World	96644319	92056306	116401945	132699563	131962913	137%
Germany	19506528	19172183	23473826	23603647	25589884	131%
Italy	8830558	8231018	10362186	10885819	11438643	130%
Hungary	6808332	6748851	7991184	8650789	8542899	125%
Poland	5776424	5677445	7270509	7874275	8242665	143%
China	5094577	5744772	6378604	6819081	7309591	143%
Türkiye	4322273	3993704	5754001	7406969	6886968	159%
Bulgaria	2844971	2867501	4951213	9363211	6149108	216%
Netherlands	3811448	3569965	4619163	5323933	5662602	149%
France	4749916	4255037	4901951	5155453	5640135	119%
Austria	3017915	2939658	3706525	4225972	4616092	153%

Source: *Edited by the authors based on ITC data*

The value of imports in Romania was $131.96 million in 2023, representing a 37% increase compared to 2019. The country from which the most imports are sourced is Germany, followed by Italy and Hungary. Interestingly, there was also a 116% increase in imports from Bulgaria in 2023.

Table 4. *List of supplying markets for a product imported by Serbia*

Exporters	Imported value in 2019	Imported value in 2020	Imported value in 2021	Imported value in 2022	Imported value in 2023	2023/2019
World	26548364	26154982	33793017	39756632	39644484	149%
Germany	3445911	3559879	4457726	4676647	5204058	151%
China	2506052	3249389	4158724	5139502	4801499	192%
Italy	2320959	2197695	2726713	2716456	2897882	125%
Türkiye	1056194	1143921	1701794	2123582	1863718	176%
Russian Federation	2458188	1583857	1806057	3043390	1727227	70%
Hungary	1140437	1299508	1422716	2134012	1658683	145%
Poland	897834	872736	1107783	1221836	1273770	142%
Romania	815238	821613	1001048	1022820	1176217	144%
France	783802	728581	884464	1132975	1137543	145%
Austria	754748	670816	844908	1001159	1085332	144%

Source: *Edited by the authors based on ITC data*

The countries from which Serbia imports the most goods and services are Germany (with a 51% increase in 2023 compared to 2019), China (with a 92% increase), and Italy (with a 25% increase). Notably, imports from the Russian Federation decreased by 30% in 2023 compared to 2019.

Table 5. *List of importing markets for a product exported by Serbia*

Importers	Exported value in 2019	Exported value in 2020	Exported value in 2021	Exported value in 2022	Exported value in 2023	2023/2019
World	19557555	19384734	25566161	28565681	30790286	157%
Germany	2477551	2505956	3242866	3986785	4669325	188%
Bosnia and Herzegovina	1495549	1361235	1846745	2076842	2118904	142%
Italy	1979512	1627102	2177247	2098754	1915480	97%
Hungary	820222	911432	1289163	1463544	1681397	205%
Romania	1140931	1258899	1410719	1267280	1542463	135%
Montenegro	874521	807010	969809	1083283	1316789	151%
Russian Federation	976995	913960	996156	1201057	1196568	122%
Czech Republic	651667	724550	887709	902360	1174055	180%
China	318351	369166	944547	1186102	1159704	364%
Croatia	631081	648842	801607	1025032	1117928	177%

Source: *Edited by the authors based on ITC data*

The countries from which Serbia imports the most goods and services are Germany, Bosnia and Herzegovina, Italy, Hungary, and Romania. Serbian exports increased by 57% in 2023 compared to 2019.

The Combined Nomenclature consists of 19 sections and 96 chapters. The first 4 sections, which include the first 24 chapters, cover all exported agri-food products; therefore, these 24 chapters were included in this study.

The trade balance of Romania for agri-food products was initially analyzed for the years 2019 to 2023.

Table 6. *Trade balance for agri-food products Romania*

Product	2019	2020	2021	2022	2023
01 Live animals	283,63	252,46	365,15	306,126	323,929
02 Meat and edible meat offal	-783,376	-818,688	-868,223	-1,024,424	-1,310,682
03 Fish and crustaceans, molluscs and other aquatic invertebrates	-205,489	-201,212	-261,572	-288,655	-317,666
04 Dairy produce; birds' eggs; natural honey; edible products of animal origin	-414,489	-503,535	-621,492	-754,764	-738,686
05 Products of animal origin, not elsewhere specified or included	-41,565	-44,551	-43,599	-53,518	-61,499
06 Live trees and other plants; bulbs, roots and the like; cut flowers and ornamental foliage	-166,777	-168,549	-231,641	-237,756	-264,287
07 Edible vegetables and certain roots and tubers	-473,036	-439,05	-501,291	-512,418	-673,161
08 Edible fruit and nuts; peel of citrus fruit or melons	-664,657	-709,889	-788,68	-773,468	-916,569
09 Coffee, tea, maté and spices	-251,888	-277,276	-316,841	-358,36	-388,045
10 Cereals	2,452,030	1,642,238	3,522,536	3,575,183	3,702,537
11 Products of the milling industry; malt; starches; inulin; wheat gluten	-108,431	-107,668	-123,644	-102,893	-63,882
12 Oil seeds and oleaginous fruits; miscellaneous grains, seeds and fruit	763,473	583,653	1,160,206	979,612	1,594,468
13 Lac; gums, resins and other vegetable saps and extracts	-30,086	-34,661	-35,813	-36,558	-37,932
14 Vegetable plaiting materials; vegetable products not elsewhere specified or included	-536	-433	175	-2,264	-4,807
15 Animal, vegetable or microbial fats and oils and their cleavage products	56,638	-6,926	101,468	192,165	162,072
16 Preparations of meat, of fish, of crustaceans, molluscs or other aquatic invertebrates	-74,671	-87,665	-132,631	-142,467	-156,461
17 Sugars and sugar confectionery	-293,946	-260,795	-353,868	-422,877	-449,938
18 Cocoa and cocoa preparations	-260,395	-260,905	-296,988	-293,647	-360,226
19 Preparations of cereals, flour, starch or milk; pastrycooks' products	-369,896	-396,034	-465,386	-497,21	-556,868
20 Preparations of vegetables, fruit, nuts or other parts of plants	-344,497	-355,776	-395,858	-421,435	-530,391
21 Miscellaneous edible preparations	-405,561	-407,648	-524,635	-535,885	-532,212
22 Beverages, spirits and vinegar	-368,084	-393,453	-562,169	-613,84	-611,861
23 Residues and waste from the food industries; prepared animal fodder	-330,598	-389,438	-470,818	-415,593	-526,461
24 Tobacco and manufactured tobacco substitutes	652,518	1,161,313	1,183,738	1,139,786	1,318,366
TOTAL	**-4367,18**	**-5460,61**	**-6353,53**	**-4985,71**	**-6704,95**

Source: *Edited by the authors based on ITC data*

The table regarding Romania's agri-food trade balance illustrates a consistent deficit trend during the period from 2019 to 2023, with negative values in most product categories. The product categories where Romania has a surplus balance include: live animals, cereals, oilseeds, and oil-bearing fruits; various cereals, seeds, and fruits; animal, vegetable, or microbial fats and oils; and tobacco. This analysis highlights the challenges Romania faces in agri-food trade, suggesting the need for more effective strategies to improve the competitiveness of domestic products in international markets.

Table 7. *Trade balance for agri-food products Serbia*

Product	2019	2020	2021	2022	2023
01 Live animals	17,714	30,527	45,086	30,235	26,318
02 Meat and edible meat offal	-68,241	-80,584	-91,482	-161,013	-227,225
03 Fish and crustaceans, molluscs and other aquatic invertebrates	-45,17	-39,637	-49,983	-70,078	-69,425
04 Dairy produce; birds' eggs; natural honey; edible products of animal origin	-5,734	-10,482	-17,704	-82,202	-70,273
05 Products of animal origin, not elsewhere specified or included	590	-1,689	-2,524	-5,994	-7,164
06 Live trees and other plants; bulbs, roots and the like; cut flowers and ornamental foliage	7,081	8,005	868	5,453	-4,075
07 Edible vegetables and certain roots and tubers	17,326	-155	-8,021	-24,324	-56,626
08 Edible fruit and nuts; peel of citrus fruit or melons	373,891	434,931	636,092	583,802	456,987
09 Coffee, tea, maté and spices	-59,163	-57,568	-66,601	-103,149	-104,444
10 Cereals	565,603	720,645	873,733	657,125	365,815
11 Products of the milling industry; malt; starches; inulin; wheat gluten	61,842	51,614	70,322	96,534	82,037
12 Oil seeds and oleaginous fruits; miscellaneous grains, seeds and fruit	115,385	178,251	80,033	38,365	24,961
13 Lac; gums, resins and other vegetable saps and extracts	-4,172	-4,142	-2,9	-5,914	-5,664
14 Vegetable plaiting materials; vegetable products not elsewhere specified or included	-1,449	-888	-1,589	-3,457	-1,955
15 Animal, vegetable or microbial fats and oils and their cleavage products	168,454	151,537	197,942	193,614	169,826
16 Preparations of meat, of fish, of crustaceans, molluscs or other aquatic invertebrates	-34,056	-41,486	-50,302	-58,821	-58,729
17 Sugars and sugar confectionery	7,286	9,937	52,951	32,205	-17,476
18 Cocoa and cocoa preparations	-45,873	-66,282	-80,069	-51,362	-63,94
19 Preparations of cereals, flour, starch or milk; pastrycooks' products	20,855	23,694	15,653	44,208	57,736
20 Preparations of vegetables, fruit, nuts or other parts of plants	35,292	5,467	22,083	26,383	19,264
21 Miscellaneous edible preparations	45,705	28,638	45,005	62,96	72,226
22 Beverages, spirits and vinegar	135,805	113,164	164,96	219,152	302,077
23 Residues and waste from the food industries; prepared animal fodder	127,468	149,329	142,142	207,491	262,699
24 Tobacco and manufactured tobacco substitutes	61,133	205,541	196,379	180,244	283,288
TOTAL	2086,982	766,41	3039,206	1811,457	1436,238

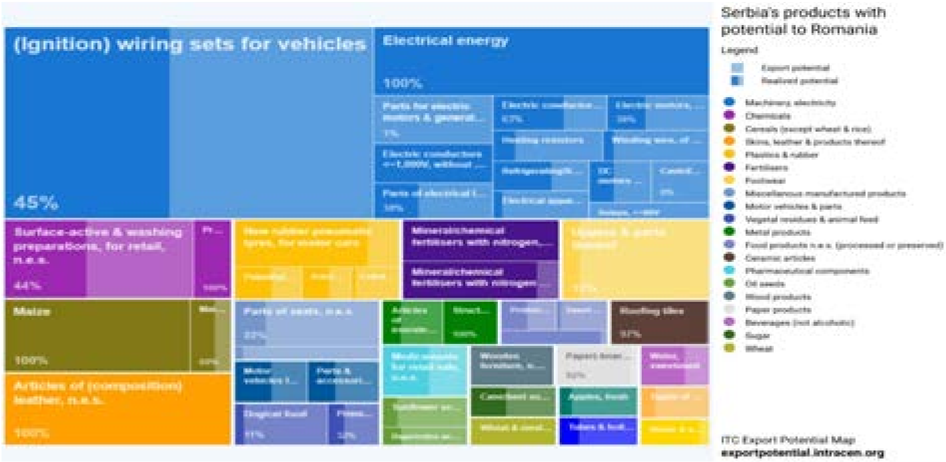
Source: *Edited by the authors based on ITC data*

The table regarding Serbia's agri-food trade balance for the period from 2019 to 2023 shows fluctuations in the values of exports and imports, with an overall surplus. In 2023, Serbia recorded a total surplus of approximately $1,436.238 million.

Plant-based products, such as cereals, had a positive impact on the trade balance, contributing significant exports during the analysed period. Additionally, processed food products, such as vegetable and fruit preparations, helped reduce the deficit. On the other hand, imports of meat, dairy products, and other animal-based products continue to generate considerable deficits, indicating a significant reliance on external products in these categories.

In comparison to Romania, which experienced a deficit in its agri-food trade balance, Serbia has managed to achieve a surplus in certain categories, highlighting better control over the trade balance in specific segments. This aspect suggests opportunities for developing a more effective trade strategy to support exports and reduce dependency on imports in the agri-food sector.

Figure 3. *Serbia's products with potential to Romania*

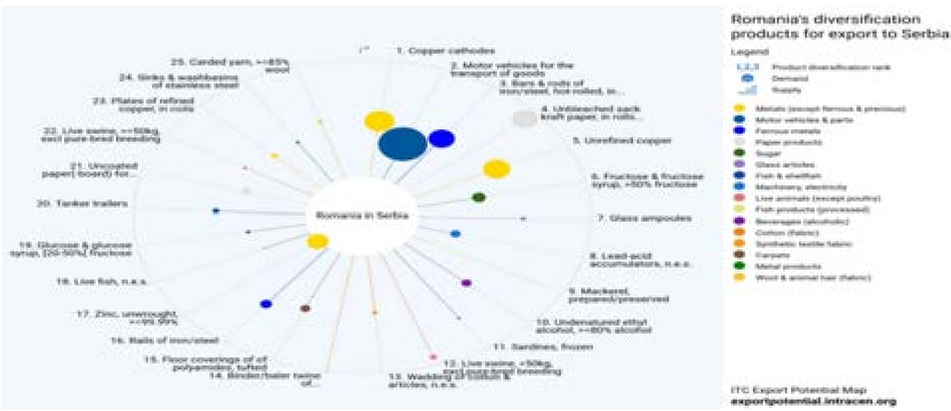


Source: *Edited by the authors based on ITC data*

The figure no. 3 indicates the sectors in Serbia that have export potential and can be competitive in the Romanian market. This means that, based on factors such as demand, price, geographical proximity, and production complementarity, Serbia has the opportunity to expand its exports of these products to Romania.

Such products could include categories in which Serbia is competitive and where Romania either imports a significant amount or produces less, such as: cat and dog food, ignition wiring sets for vehicles, electric motors, and mineral/chemical fertilizers with nitrogen, among others.

Figure 4. *Romania's products with potential to Serbia*



Source: Edited by the authors based on ITC data

Graph 4 highlights a range of products that Romania could export to Serbia, indicating a diversification of the trade offer. Among these are copper cathodes, used in the electricity and electronics industries due to copper's high conductivity; live fish, suggesting a demand for fresh products in the agri-food sector; freight transport vehicles, underscoring the potential of Romania's automotive sector; iron/steel bars and rods, important for construction and heavy industry; and glass vials, necessary in the pharmaceutical and medical fields for quality packaging, among others. Diversifying exports with these products can support Romania's economic growth and strengthen trade relations with Serbia.

Conclusions

In conclusion, this article highlights the importance of international trade in the economic stability of Romania and Serbia, emphasizing that the volume of exports and imports directly influences macroeconomic balance, exchange rates, and inflation. In this context, foreign trade not only supports GDP growth and job creation but also contributes to the development of regional economic relationships, fostering economic integration. The analysis shows that Serbia manages its agri-food trade balance more effectively than Romania, recording a surplus in certain sectors of plant products, such as cereals, and in processed food products. In contrast, Romania presents a consistent deficit, suggesting a need for diversification and an increase in competitiveness in external markets, particularly in the agri-food sector.

The study also provides insights into trade opportunities. Serbia has export potential in the Romanian market for competitive products, such as pet food and electrical equipment for vehicles. At the same time, Romania could diversify its exports to Serbia through products such as copper cathodes, live fish, transport vehicles, iron/steel bars and rods, and glass vials, thereby supporting national economic growth and strengthening bilateral trade relations. These conclusions provide a basis for trade policies that stimulate exports and reduce dependence on imports, promoting sustainable economic development and balance in the trade balance of both countries.

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STUDY ON OPPORTUNITIES FOR RECOVERY OF WASTE AND BY-PRODUCTS FROM THE CEREAL SECTOR

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Abstract

The cereal sector is considered one of the most important sectors in agriculture and food economy. Major cereal crops, like wheat, maize, and rice, provide the food base for much of the world's population and are used for animal feed and industries such as bioethanol and biofuel production. The waste and by-products from this sector (straw, husks, and bran) can be used in circular system for closing the materials loop. The valorization avenues include production of biogas, bioethanol, compost, animal feed, and biodegradable material. The national and international legislative framework supports efficient management and recycling of agricultural wastes with a view to sustainable development and environmental protection. In this context, this article is providing a review of the importance of the cereal sector in the world agricultural context, highlighting the dual function of ensuring food security and the possibility of recovering cereals' waste in a sustainable way by integration into a circular economy process.

Key words: *circular economy, cereals, byproducts.*

Introduction

Given the need to promote an intelligent, resilient and diversified agricultural sector that ensures food security, cascade processing implies an innovative approach to economic activity, transforming concerns for environmental pro-

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tection into opportunities for obtaining profit and benefits. As a result of any agricultural activity, organic material results that can be used by the farmer either in his own farm or by selling it to third parties.

For thousands of years, cereals have been an important component of the human diet, covering 20% of the daily food ration. Their processing involves a complex procedure from the execution of which results products intended for consumption, by-products and waste. Since cereals are an important source of carbohydrates, proteins, lipids, vitamins (B complex and vitamin E) and trace elements, the recovery of by-products and waste resulting from their processing represents a great challenge for the sustainable development of the agri-food sector (M. Papageorgiou & A. Skendi, 2018).

The growth of the global population has determined the increase in the demand for food and implicitly for food waste, paying more attention to environmental protection measures. In the process of grain processing, a series of industrial waste results, which are discharged into natural water sources (rivers and canals) or onto land. According to expert estimates, about 35% of the total grain production is waste in North America, Europe and Asia, while in Asia the amount of waste reaches 18% (N.Belc et al., 2019; Gul Hassan et al., 2021).

In 2019, Grippo et al evaluated alternative uses of grain waste, particularly bran for feed, biodiesel and paper production, using a multi-criteria approach involving technical, environmental, circularity, social and economic criteria, demonstrating that by-products and waste cereals could be successfully used for energy production and job generation. The same conclusion was reached by Watanabe in 2009 and Zahrim, Nasimah and Hilal in 2015.

FAO estimated as early as 2011 that 1.3 billion tons of food waste are produced annually, of which an enormous share, 39%, occurs in production level, which indicates that there is unexplored potential (Mirabella, Castellani & Sala, 2014). According to UN experts on global food security, food systems are not working as they should and that is why the loss/waste percentage is so high while over 800 million people suffer from hunger.

Greater attention is paid both to strategies for optimizing food manufacturing processes to obtain higher yields, and to the near-total exploitation of existing food resources (Dragomir et al., 2023) The use of by-products in the food production industry involves branches of the industry with underestimated capacity, and the increasing amounts of by-products are unjustifiable on the basis of sustainability. Consequently, leading food processing companies have begun to adopt the Life Cycle Assessment (LCA) method to assess the environmental impact of food products as part of their corporate and sustainable image. With LCA, efficiency in food production can be increased by identifying and evaluating high impact factors such as environmental impact compared to product reformulation or alternative raw materials (Miah et al., 2018). In the near future, a full exploitation of raw materials will be inevitable, as a growing world population and declining agricultural productivity due to fertilizer shortages and barren soils will limit available resources (Chandrasekaran, 2013; Charis M. Galanakis, 2022).

Nowadays, the need to valorize secondary products is determined by fundamental problems such as population growth, climate change or the decrease in agricultural productivity due to barren soil (Chatzifragkou et al., 2016). One of the biggest challenges for humanity is to live in a society without hunger, but with high quality and safe food. To achieve this, we must assume that global food losses must be drastically reduced (Cattaneo et al., 2021).

Food loss and waste is also a substantial drain on important resources such as water, land, energy and labour. These losses go hand in hand with environmental damage caused by ineffective management of these wastes. In order to reduce these inadequacies, a viable solution is represented by the concept of circular bioeconomy, whose main objectives are to achieve sustainability and economic viability, reduce costs, increase competitiveness and reduce poverty and hunger (A. Skendi et al., 2020; P . Sharma et al., 2021; Anca Fărcaş et al., 2021).

Material and method

The study aims to evaluate cereal waste production and recovery methods to identify opportunities for sustainable agriculture and circular economy practices. Data were collected from national and international sources regarding cereal production, waste generation, and recovery practices. Estimates of cereal waste volumes were calculated based on global production statistics, using ratios of waste to primary crop yield reported in the literature.

The methodology involved quantitative data analysis, using statistical indicators such as minimum, maximum, average, and annual growth rates, to assess trends in cultivated areas and production. Data for Romania, covering a ten years period, were obtained from the open acces data from National Institute of Statistics (NIS). International data were collected by accessing the databases of Eurostat, FAO

To evaluate potential recovery methods, a review of international and national case studies was conducted. The review focused on key recovery methods such as biogas production, composting, bioethanol production, and the use of cereal waste in animal feed, building materials, bioenergy, and biodegradable plastics. Examples from countries such as Sweden, Germany, France, and India were compared to initiatives in Romania, highlighting successful practices and their applicability.

Results and discussion

Spread worldwide, cereal culture is diversified, each cereal species having its specificities in terms of cultivation, uses, environmental and economic impact. Wheat, maize and rice are the most widely grown and consumed cereals, representing an essential component of world food security. Cereal production and processing generate significant amounts of by-products and waste, the effective management of which is crucial for sustainability.

Estimates of the volumes of cereal waste produced annually vary depending on the type of cereal, agricultural practices and processing methods used in different regions of the world. For every ton of wheat produced, approximately 1-1.5 tons of straw is generated. With a world production of about 750 million tons of wheat per year, it is estimated that between 750 and 1,125 million tons of straw are produced annually.For every ton of barley produced, approximately 1-1.5 tons of straw is generated. With a world production of about 150 million tons of barley per year, it is estimated that between 150 and 225 million tons of straw are produced annually. In oats, for every ton produced, approximately 1-1.5 tons of straw and other residues are generated. With a world production of about 25 million tons of oats per year, it is estimated that between 25 and 37.5 million tons of straw and residues are produced annually.For every ton of rice produced, about 1.5 tons of straw is generated. With a world production of about 500 million tons of rice per year, it is estimated that about 750 million tons of straw are produced annually. Rice husks make up about 20% of the weight of unprocessed rice grains. Thus, approximately 100 million tons of rice husks are produced annually. For every ton of corn produced, approximately 1-2 tons of stalk residues are generated. With a world production of about 1.1 billion tons of corn per year, it is estimated that between 1.1 and 2.2 billion tons of residues are produced annually.

From an economic point of view, cereal waste can be transformed into value-added products such as animal feed, compost, biofuels or construction materials. By using waste as a source of energy or raw material, farmers and processors can reduce disposal costs and acquisition of new resources. The recovery of waste contributes to the creation of a circular economy, where resources are used efficiently and repeatedly, minimizing loss and waste. Investment in waste recovery technologies will stimulate the development of new industries and jobs, contributing to economic growth.

Table 1. *Indicators regarding the area cultivated with wheat, hectares*

The region	*Minimum*	*Maximum*	**Average**	**Abaterea**	*Deviation*	*Coefficient of Variance Annual Rate*
NORD-VEST	122.922	165.060	148.655	11.826	0,0796	3,3293
CENTRU	88.552	93.894	91.126	1.472	0,0162	0,0621
NORD-EST	149.284	230.289	178.517	26.821	0,1502	4,2455
SUD-EST	452.745	511.464	477.003	21.631	0,0453	0,0972
SUD-MUNTE-NIA	582.361	624.696	593.919	12.507	0,0211	0,6259
BUCURESTI - ILFOV	17.978	23.398	19.144	1.634	0,0854	1,0869
SUD-VEST OLTENIA	363.815	421.360	401.667	17.175	0,0428	1,0945
VEST	214.096	292.343	241.101	21.788	0,0904	0,4736
TOTAL	**2.052.917**	**2.317.692**	**2.151.131**	**69.470**	**0,0323**	**1,0334**

Source: *NIS data processing, accessed October 14, 2024*

As can be seen from Table 1, the area cultivated with wheat, in Romania, in the period 2014-2023 varied between 2,052,917-2,317,692 hectares, in a 10-year interval. The increase was 264,775 ha (12.9%). We believe that this attests to a stable situation in terms of areas cultivated with wheat. The smallest area cultivated with wheat is located in the Bucharest-Ilfov Region, which is explainable, as it is located in the bordering area of the capital. The largest area cultivated with wheat is located in the South-Muntenia Region, the explanation coming from the climatic and soil conditions favorable to this crop. However, the annual growth rate of cultivated areas was the best in the North-East Region, and the weakest in the Central Region.

The estimation of grain production is done in the ripening phase, for a field of up to 100 ha. For sampling, 5 sampling points are established on the diagonal. The obtained results are multiplied by 10,000 to find out the production per hectare. The optimal time to harvest wheat is at full maturity, when the grains reach a moisture content of 14-15%. At this stage, the harvesting machines work without losses and the grains can be kept in good conditions, without the need for special drying operations. The calculation formula takes into account the number of ears per square meter, the average number of grains in the ear and the mass (weight) of 1,000 grains.

To demonstrate the above we will take the wheat crop as an example. First we will estimate the production in irrigated and non-irrigated systems, on three levels: minimum, medium and maximum, depending on the variety and soil fertility, then we present the average productions of grain wheat (considered main production) and straw (considered secondary production), carried out in the 2014-2023 time frame, at the level of the country and development regions. Table 2 shows the estimates of wheat production in irrigated and non-irrigated systems.

Table 2. *Estimation of wheat production in irrigated and non-irrigated system*

Wheat production	SYSTEM					
	NON-IRRIGATED			IRRIGATED		
	Minimum Kg/ha	Average Kg/ha	*Maximum* Kg/ha	*Minimum* Kg/ha	Average Kg/ha	*Maximum* Kg/ha
main	2.800	3.500	4.200	4.000	5.000	6.000
secondary	960	1.200	1.440	1.600	2.000	2.400

Table 3. *Indicators regarding wheat production, thousands of tons*

The region	*Minimum*	*Maximum*	Average	Abaterea	*Deviation*	*Coefficient of Variance Annual Rate*
NORD-VEST	472,42	671,79	589,91	65.667,37	111,3177	3,9895
CENTRU	334,47	416,46	369,29	29.136,44	78,8991	2,3541
NORD-EST	509,03	936,18	651,78	142.997,61	219,3952	5,5952
SUD-EST	645,69	2.399,90	1.889,51	512.481,56	271,2253	0,6257
SUD-MUNTENIA	1.760,15	3.024,49	2.591,32	403.634,25	155,7640	2,4214

The region	*Minimum*	*Maximum*	Average	Abaterea	*Deviation*	*Coefficient of Variance Annual Rate*
BUCURES-TI - ILFOV	60,94	118,04	83,14	14.889,08	179,0868	2,3952
SUD-VEST OLTENIA	1.210,00	1.944,70	1.619,71	298.862,86	184,5158	3,8274
VEST	970,07	1.534,49	1.164,20	158.674,25	136,2950	2,8960
TOTAL	**6.392,37**	**10.433,75**	**8.958,85**	**1.365.941,29**	**152,4683**	**2,6811**

Source: *NIS data processing, accessed October 14, 2024*

From Table 3, it can be seen that the average production of wheat in Romania, in the period 2014-2023, varied between 6,392.37 thousand tons and 10,433.75 thousand tons. The increase was 4,041.38 thousand tons (63.22%). We believe that this attests to a favorable situation from the point of view of the productions made. The lowest wheat production was achieved in the Bucharest-Ilfov Region, which is explainable, as this is the region with the smallest cultivated area in the country. The highest production was achieved in the Sud-Muntenia Region, also on the basis of the cultivated area. At the country level, the average annual production growth rate was 2.6811. However, the annual growth rate of wheat production was the best in the North-East Region, and the weakest in the South-East Region.

By county, Bistrita Nasaud had the lowest average production of 8,206 thousand tons of wheat. Bistriţa-Năsăud County is located in the northern part of Romania, between parallels 46°47’ and 47°37’ north latitude, presenting a varied and complex relief, arranged in the form of a natural amphitheater opening in steps to the Transylvanian Plain. The area occupied by hills and meadows is 70% of the county’s area. (https://bistrita.insse.ro/despre-noi/despre-judetul-bistrita/geografie-in-statistici/). Constanța County achieved the highest average production of 1,017.95 thousand tons of wheat. Constanța County is located in the south-eastern part of Romania, between 44°16′ north latitude and 28°19′ east latitude, it has an area of 7,071 km2, i.e. 3% of the total area of the country, being the eighth largest among counties of the country. In Constanța County, low-altitude plateau relief predominates, with values below 200 m, only in its north reaching 250 m in some places (https://constanta.insse.ro/despre-noi/despre-judetul-constanta/).

Although there is wide variation depending on the genotype, on average wheat plant mass (without roots) is represented by 51% grain, 32% by stalks (straw), 11% pale and arable (chaff) and 6% dead leaves and shoots (Lazar et al., 2023). From Table 4 it can be seen that the average production of wheat straw in Romania varied between 5,155 tons and 10,509 tons. The increase was 5,354 tons (103.86%). The lowest production of wheat straw was achieved in the Bucharest-Ilfov Region (39 tons), which is explainable, as this is the region with the smallest cultivated area in the country. The highest production was achieved in the South-Muntenia Region (2,332 tons), also on the basis of the cultivated area. At the country level, the average annual production growth rate was 3.6275. However, the annual growth rate of wheat straw production was the best in the Southeast Region (+6.0535), and the weakest in the West Region (-0.1022).

Table 4. *Indicators regarding the production of wheat straw, tons of straw*

The region	*Minimum*	*Maximum*	Average	Abaterea	*Deviation*	*Coefficient of Variance Annual Rate*
NORD-VEST	545	927	726	135,98	0,1872	4,8167
CENTRU	351	551	450	68,48	0,1522	4,7038
NORD-EST	691	1.301	977	225,23	0,2306	4,8404
SUD-EST	615	2.186	1.577	491,05	0,3114	6,0535
SUD-MUNTE-NIA	1.273	2.332	1.871	364,61	0,1949	2,4870
BUCURES-TI-ILFOV	39	72	53	9,43	0,1775	4,1516
SUD-VEST OLTENIA	808	1.489	1.096	247,63	0,2260	2,3554
VEST	833	1.651	1.042	273,20	0,2623	-0,1022
TOTAL	**5.155**	**10.509**	**7.799**	**1.582,36**	**0,2029**	**3,6275**

Source: *data processing according to Lazar et al., 2023*

To develop an effective strategy, it is essential to analyze the main categories of waste and by-products, their potential uses and the added value they can generate. As I said before, harvesting wheat results in waste and by-products:

- *wheat straw* - approximately 1.3 - 1.4 tons of straw are produced for every ton of wheat harvested. At a wheat production of about 10 million tons, it means that about 13-14 million tons of straw can be generated.

- *bran* - from the milling process of wheat, about 25% of the weight of the wheat turns into bran. At a production of 10 million tons of wheat, about 2.5 million tons of bran can be produced.

- *dust and residues from cleaning the wheat* they can constitute about 2-3% of the weight of the processed wheat. At a production of 10 million tons, this would mean between 200,000 and 300,000 tons of dust and residues.

The recovery of cereal waste is an important aspect of sustainable agriculture and the circular economy. There are several methods by which this waste can be transformed into useful resources:

1. *Biogas production* - cereal waste can be used in anaerobic digestion to produce biogas, a renewable energy source. Biogas can be used to generate electricity and heat, thus helping to reduce dependence on fossil fuels.

2. *Composting* - grain residues can be composted to produce organic fertilizers. Compost improves soil quality by increasing organic matter content and water-holding capacity.

3. *Bioethanol production* - by fermenting cereal waste, bioethanol can be produced, an alternative fuel that can be mixed with gasoline to reduce greenhouse gas emissions.

4. *Animal feed* - cereal waste such as bran and other by-products can be used as animal feed. They can supplement food rations by providing fiber and essential nutrients.

5. *Manufacture of building materials* - fibers from cereal waste can be used to produce environmentally friendly building materials such as insulation boards or composite blocks. These materials are durable and can replace conventional wood or plastic products.

6. *Production of chemical and pharmaceutical products* - biomass from cereal waste can be used to extract valuable chemical compounds such as xylan, which can be used in the chemical and pharmaceutical industry for the production of additives, biodegradable polymers and other specialized products.

7. *Use in horticulture* - cereal waste can be used in horticulture to create growing substrates for plants. These substrates can improve soil aeration and drainage, facilitating healthy plant growth.

8. *Production of industrial enzymes* - certain cereal wastes can be the source of raw material for the production of industrial enzymes, which are used in various biotechnology processes, such as the production of biofuels or the treatment of wastewater.

9. *Production of biodegradable plastic materials* - by processing cereal waste, biopolymers can be obtained that can be used in the manufacture of biodegradable plastic materials. These materials have the advantage of reducing pollution and being compostable at the end of their life cycle.

10. *The utilization of straw and stalks for the production of paper and cardboard is a sustainable solution,* which contributes to the reduction of deforestation, the efficient management of agricultural waste and the reduction of greenhouse gas emissions.

11. *The production of pellets and briquettes from straw and stalks* is a sustainable alternative to fossil fuels. The advantages of this way of capitalization are: reduction of CO_2 emissions, energy efficiency, economic benefits for farmers and rural communities.

The implementation of these methods not only helps to reduce the amount of cereal waste, but also contributes to the protection of the environment, promoting the sustainable use of resources. The recovery of cereal waste has become a widespread practice in many regions of the world, contributing to agricultural sustainability and reducing the ecological impact. Here are some examples in this regard:

- **Sweden** uses straw and other cereal residues to produce bioethanol. Sweden is a leader in the use of biofuels for transport, and projects of this type contribute significantly to reducing CO2 emissions.
- **Germany** developed the technology to produce cellulosic ethanol from wheat straw and other agricultural residues. This technology is applied in the factory from Straubing to Bavaria.
- **France**, Champagney Region, straw is used to produce biogas through anaerobic digestion. The biogas produced is used to generate electricity and heat, reducing dependence on fossil fuels.
- **Canada** uses grain waste to produce bioenergy. Straws are used to generate electricity and heat needed in industrial processes.
- **India,** Punjab Region, collects wheat waste and converts it into pellets and briquettes for fuel. These fuels are used for cooking and heating, reducing the use of wood and fossil fuels.

In Romania, the recovery of cereal waste is under development, and several initiatives and projects demonstrate success in this direction:

- In Buzău County there is a company that produces pellets and briquettes from agricultural residues, including straw and cereal stalks. Their products are used as biofuels for heating in households and institutions, thus helping to reduce dependence on fossil fuels.
- Several farms in Romania have started to use straw and other plant residues for biogas production. The biogas generated is used to produce electricity and heat, thus reducing energy costs and greenhouse gas emissions.
- In Maramureș County there is a successful company regarding the use of agricultural waste for energy production. It uses grain residues and other organic waste to produce biogas, which is then converted into electricity and heat.
- In Cluj County there is a company that produces and markets equipment for the manufacture of pellets and briquettes from agricultural biomass, including cereal waste. It promotes the efficient use of agricultural residues to obtain ecological fuels, which can be used in thermal power plants and heating systems.

Conclusions

Cereal wastes and by-products hold good potential for sustainable recovery and utilization. Through statistical analysis of data regarding wheat production and waste in Romania during the period 2014–2023, as well as based on some examples of international best practices, one may notice that efficient waste management contributes to ensuring agricultural sustainability, economic growth, and environmental protection. Recovery methods such as biogas production, composting, bioethanol production, and waste usage in animal feed, construction materials, and bioenergy offer feasible transition ways toward a circular economy. While Sweden, Germany, and France have demonstrated more advanced approaches to waste recovery, Romania illustrates small steps in developments for utilizing agricultural residues. Further investment in technology and infrastructure will be required to upscale such initiatives and unlock the full economic and environmental benefits of recovering cereal waste. By embracing sustainable practices, the agricultural sector could contribute significantly to resource efficiency and climate resilience.

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CONSUMER PREFERENCES FOR ORGANIC FOODS FROM DIVERSIFIED AGRICULTURAL SYSTEMS

Steliana Rodino[1], Ruxandra Pop[2], Ion Toncea[3]

Abstract

Understanding the underlying motivations and barriers that influence consumer decisions regarding food purchases, particularly plant-based protein products, is essential for businesses and policymakers aiming to meet market expectations and drive growth in this sector.

This study had as its target audience consumers of agri-food products from Romania, Poland, Estonia and Italy and evaluated consumer expectations about diversified and plant-based protein sources within ALL-organic living labs established across Europe. The analysis showed gaps in consumer awareness of the health benefits, diversity, and value of plant-based protein products. The majority of respondents ranked price and taste higher than health or dietary benefits, which means that the critical factors for purchase are mainly related to affordability and sensory appeal. Additionally, the analysis highlighted the discrepancies in consumer perceptions, such as the confusion between minimally processed pulses and highly processed plant-based products, offering valuable insights into market trends and potential strategies for encouraging greater adoption of plant-based protein foods.

Key words: *all-organic, living labs, consumer preferences, plant-based protein foods.*

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Introduction

As the global population continues to grow rapidly, the food industry is nowadays tackling challenges related to nutrition and food security. Coupled with shifting sociodemographic factors, this growth will inevitably exert pressure on global resources for being able to answer the demand for nutritious food products. Plant-based proteins have emerged as an alternative to animal-sourced commodities, driven by a growing interest in diversifying diets (Hartmann et al., 2017).

Organic products are increasingly recognized as sustainable sources of protein, contributing to both environmental preservation and economic benefits, particularly in family farming systems (Subić et al., 2022). In addition, modern agricultural technologies play a crucial role in enhancing production efficiency, particularly in cereal crops, which are fundamental for ensuring food security and sustainability (Dragomir et al., 2023). Functional and medicinal beverages are gaining attention for their role in providing essential nutrients and supporting overall health, aligning with the demand for sustainable and nutritious food products (Rodino & Butu, 2019).

In the current context, the demand for healthier and more sustainable food products has increased significantly, driven by factors such as health concerns, climate change and social responsibility (Aschemnann et al., 2019, Butu et al, 2019). To better understand the dynamics behind the increasing interest in plant-based proteins, it is essential to explore consumer behavior and attitudes toward these alternatives. Consumer perception plays a pivotal role in the widespread adoption of plant-based protein sources, as preferences, cultural influences, and personal values shape purchasing decisions (Necula et al., 2020). While some consumers are motivated by health benefits and environmental concerns, others remain hesitant due to factors such as unfamiliarity, sensory preferences, or misconceptions about nutritional value. Studies show that more and more consumers are interested in alternatives to animal products, and plant-based protein products represent a promising option (Fresan et al, 2019). This trend is supported by research demonstrating the health benefits of plant-based diets, including a reduced risk of cardiovascular disease and obesity (Springmann et al., 2018). However, studies indicate that there are still significant barriers to the adoption of these products, such as taste perception, price and the level of food processing (Malek et al., 2023; Byrne et al., 2020).

To fully understand the perceptions of consumers with regard to expectations and willingness to accept such alternatives this study explores the socio-demographic profile of consumers, the primary factors shaping their purchasing decisions, and the challenges and opportunities associated with promoting plant-based protein products.

Methodology

The research was conducted on a sample of 501 respondents and the target audience were consumers of agri-food products located in ALL-Organic living labs from Romania, Poland, Estonia and Italy.

The research instrument was a questionnaire, structured in 3 parts according to the general research objectives: outlining the socio-demographic profile of the consumer and the agri-food lifestyle, determining the perception and awareness of products based on proteic plants, determining the perception and awareness of respondents regarding local production systems. The typology of questions is that specific to marketing research (open questions, closed questions with a single answer option, with multiple answer options, matrix questions and others), also using specific measurement scales (Semantic Differential Scale, Likert Scale).

For the application of the questionnaire and the analysis of the answers, the Google forms tool was used, generating an initial database in Excel. For the coding of the questions and answers, the centralization, querying and interpretation of the results, the SPSS statistical calculation program was used.

Results

Socio-demographic profile

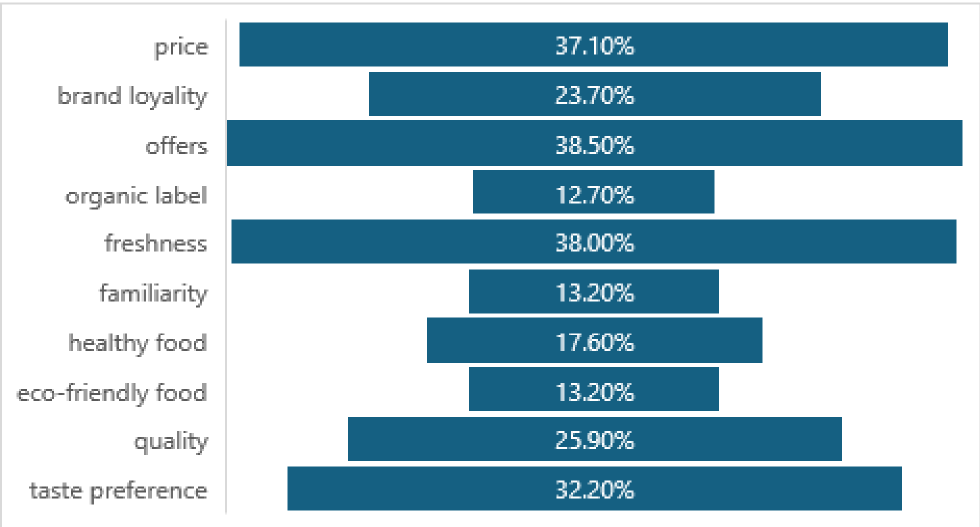
The analysis of socio-demographic data highlights the profile of consumers who participated in the research: more than half were women, aged between 40-55 years and 24-29 years, with an above-average income and education level, from the active population, living mainly in urban areas of the mentioned countries.

Objective 1: Identify the most important factors influencing the respondent's food buying choice.

Hypothesis 1. Mostly, respondents aren't searching a minimum price, in the purchasing process, they are searching the best ratio between the price and the quality of the products. In this case, quality could be defined through several coordinates, such as freshness, healthy food and taste. Also, consumers may prefer products that are labelled 'high in protein'. Purchase criteria, such as taste or price are important than health or diet benefits, in the consumer's plant-based protein products buying decision.

Data interpretation: According to answers, special promotions, freshness, price and taste are the main product characteristics in the food acquisition process searched by the consumers (figure 1). Also, regarding the high protein content characteristic, over 80% of the total respondents ignore this mention regarding their food consumption choice. This hypothesis is partially confirmed. The respondents search for the price/quality optimal ratio, but not for a product labelled with high protein content mentioned.

Figure 1. *The most important factors influencing the respondent's food shopping choice*

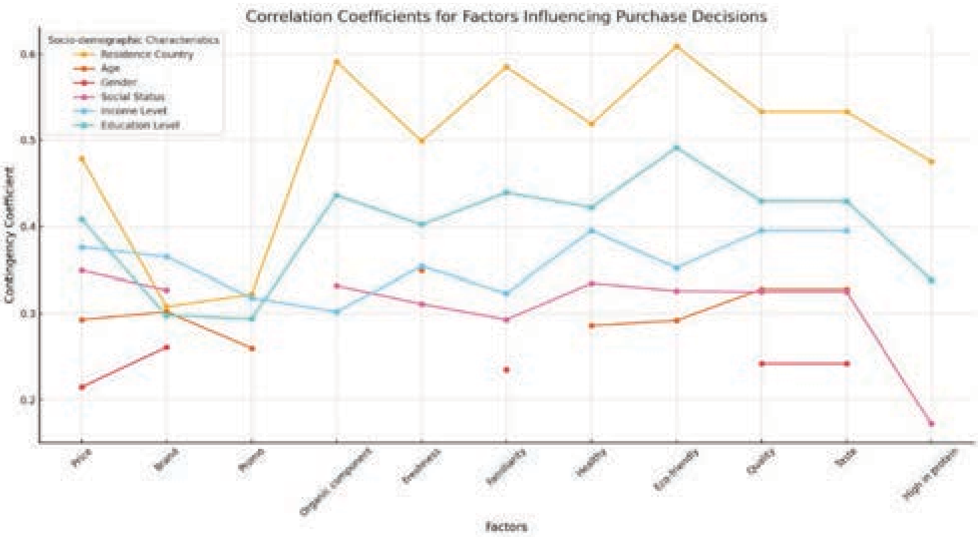


According to the data retrieved from the survey, the price is an important factor when making a purchase decision, mentioned by over 37 % of respondents, but is slightly surpassed by specific promotions and freshness, a share of 38 % indicating these two parameters as their food choice factors (Figure 1). Therefore, there is a tendency of the consumers to search for products that offer a good balance between value and quality, as it was stated in our hypothesis.

However, taste and quality were also important factors, reinforcing the idea that consumers place an emphasis on the food experience and the perception of quality. In contrast, eco-labeling play a much lower role, with a share of 13 percent, suggesting that environmental impact is not a major priority in making purchasing decisions for the interviewed consumers.

These data partially support the stated hypothesis that consumers are looking for an optimal price-quality ratio, but emphasize that freshness and the taste are more important than health or dietary benefits. This leads to the idea that business opportunities for plant-based protein products should focus on features such as freshness, taste, and promotions to attract consumers.

Figure 2. *Correlations between socio-demographic characteristics and the importance of product characteristics in consumer's purchase decision.*



The correlations between socio-demographic characteristics and the importance of factors in purchasing decisions showed that different consumer groups prioritize distinct aspects depending on variables such as country of residence, age, income or education. In the case of price, it is strongly influenced by country of residence and education level indicating that the perception of price as a decisive factor varies between regions and is more important for consumers with a lower educational level. In contrast, variables such as gender and geographical area (not significant) have a limited influence on this factor.

Product freshness was another important aspect, with a strong correlation with country of residence (0.499) and education level (0.402). This indicates that freshness is a priority for consumers in certain regions and for those with a higher educational level, which may reflect a better understanding of the benefits of food quality. Similarly, the eco-friendly component shows a significant correlation with the level of education (0.491) and the country of residence (0.609), highlighting that these characteristics are more appreciated by consumers with a high awareness of environmental issues.

Factors such as quality (0.533), taste (0.533) and labeling as high in protein (0.475) were influenced by the country of residence, but also by the income of consumers, suggesting that these attributes are more appreciated by consumers with higher financial resources. In contrast, characteristics such as promotions or brand have a weaker correlation, indicating that they play a secondary role compared to factors that define the quality or nutritional value of the products.

In short, purchasing decisions are strongly influenced by characteristics such as price, freshness and quality, but these vary according to demographic factors such as education and income. Therefore, business opportunities should be tailored to highlight factors relevant to each consumer segment, such as promoting freshness and eco-friendly features for educated consumers or emphasizing nutritional value for those with higher incomes.

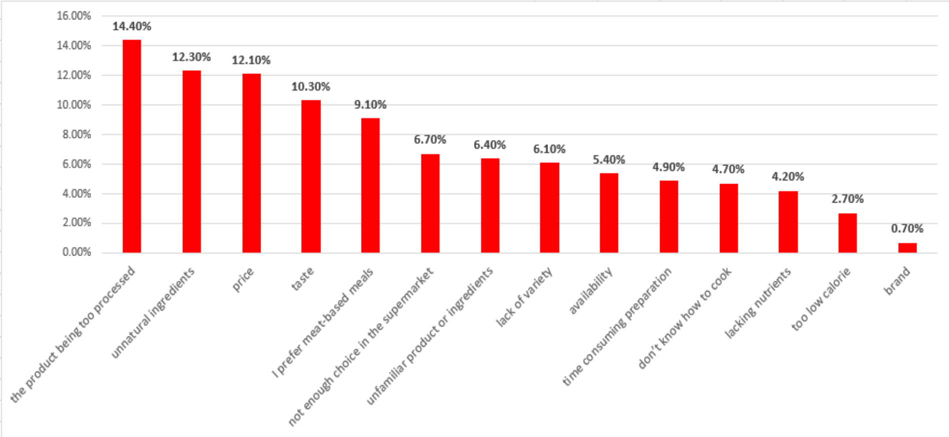
Objective2: Identify the main factors that are discouraging/ encouraging for respondent's in the plant-based protein food products purchasing process

Hypothesis2: The main factors that discourages the respondent's from purchasing plant-based protein food products are related to taste, price, unnatural ingredients, time consuming preparation and the lack of variety. Also, it may that the respondents gender have a great impact on the meat-based meals preference, eating meat being considerate masculine

Hypothesis3: The main respondent's motivations for eating plant-based protein food are: environmental impact, animal welfare and improving health.

Data interpretation: The main factors which represent barriers in increasing the pulses consumption are represented by the high level of processed characteristic, unnatural ingredients, price and taste. "I prefer meat-based" is also a discouraging factor mentioned by a 9.10% respondents, regardless the consumer's gender.

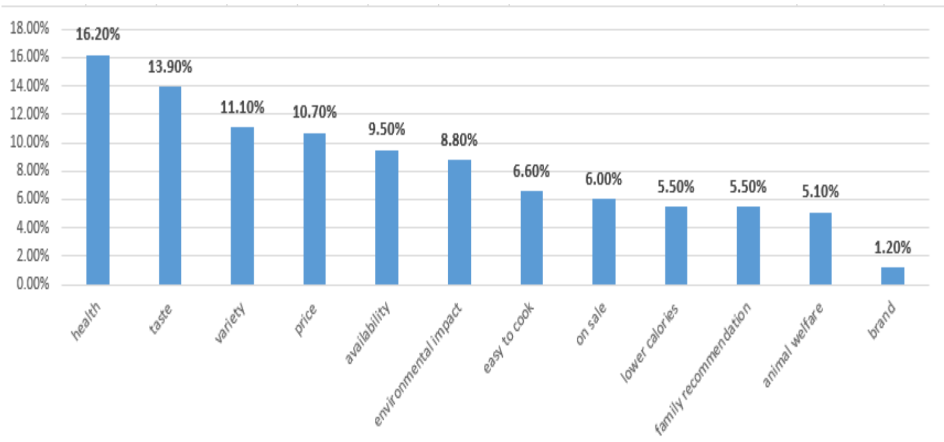
Figure 3. *Main factors that discourages the respondent's from purchasing plant-based protein food products.*



This hierarchy shows a low level of awareness regarding pulses among consumers, who confuse the main plant based protein food products with the semi-processed ones, which are more intensively promoted and more often found on supermarket shelves. (Figure 3). Hypothesis 2 is partially confirmed.

Data interpretation: The main factors which represent encouraging factors from the consumer's perspective in increasing the pulses consumption are represented by the impact on health status, taste, variety and price (Figure 4). Thus, H3 is partially confirmed.

Figure 4. *Main factors that encourages the respondent's from purchasing plant-based protein food products.*



The correlations between socio-demographic characteristics and the main factors that encourage the consumption of plant-based foods showed that factors such as health (0.363), price (0.427) and family recommendations (0.515) show the strongest correlations. Therefore, economic accessibility, health benefits and family influence are the most relevant factors in increasing purchasing intention. Factors such as taste (0.229) and variety (0.243) have showed moderate correlations, suggesting the importance of the food experience in consumption decisions. In contrast, factors such as environmental impact (0.189) or quick cooking (0.151) have weak correlations, indicating a limited interest in these aspects in the context of future consumption.

Conclusions

The research focuses on two key objectives: identifying the most important factors that influence food purchasing choices and determining the primary motivations and barriers for plant-based protein product consumption. Following the analysis of the results obtained, the socio-demographic profile of consumers highlighted a predominance of women aged between 24-29 and 40-55, with above-average income and educational level, living mainly in urban areas. This category of consumers showed a clear orientation towards an optimal price-quality ratio in the process of purchasing food products, with an emphasis on freshness, taste and promotions, to the detriment of characteristics such as high protein content or eco-friendly labeling. At the same time, the analysis of correlations between socio-demographic characteristics and decision-makers highlighted the importance of education and income in the appreciation of attributes such as freshness, quality and eco-friendly impact of products.

Regarding the purchase of plant-based protein foods, the results showed that the main barriers were represented by the negative perception of taste, the level of processing, unnatural ingredients and price, along with the preference for meat-based products. However, the main motivations for increased consumption included improved health, taste, product diversity and affordability. Correlations revealed that economic aspects and family recommendations have a significant impact on purchase intention, while factors such as environmental impact and fast cooking time have a limited influence.

In conclusion, purchase decisions are mainly guided by freshness, taste and promotions, but vary according to socio-demographic variables. To stimulate the consumption of plant-based protein products, marketing strategies should emphasize health benefits, product diversity and affordability, adapting to the preferences of each consumer segment.

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VARIATIONS IN THE INFLATION MOVEMENT CAUSED BY THE VOLATILITY OF FOOD PRICES IN THE REPUBLIC OF SERBIA

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Abstract

In recent years, inflation caused by rising food prices has become a global challenge. Various crises have influenced the historical instability of food and energy prices. The rise in inflation was caused by rising demand for goods, reduced inventories, and monetary and fiscal measures that put pressure on prices. There are significant variations in the inflationary movement of food prices, and in the long term, volatility in the prices of food and agricultural products can be observed. As a cumulative impact of crises of various causes on the global economy, the peak of food inflation in Europe was in March 2023 (17.5% in the euro zone). In middle-income and developing countries, inflation poses an even greater challenge as consumers spend a greater proportion of their income on food. Disruptions in the global food market also affected domestic inflation in Serbia through import inflation. Therefore, the goal of the paper is to determine the impact of food price growth on inflation in the Republic of Serbia.

Key words: *Agricultural products, Consumer Price Index, base inflation, monetary policy, crises.*

Introduction

Europe recorded the peak of inflation caused by the growth of consumer prices (headline inflation) a few months after the peak of inflation in the US was recorded in October 2022, when the harmonized Consumer price index (CPI) of the euro zone was 11.5% of annual inflation. Food price inflation in Europe grew more slowly than in the USA, but grew more sharply due to severe supply shocks from the war in Ukraine. Thus, Europe reached a peak in food inflation in March 2023 of 17.5% in the euro zone.

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In middle-income and developing countries, inflation is an even greater challenge than in developed countries, as consumers spend a larger portion of their income on food. However, viewed in the long term, periods of high food and energy prices did not always cause global inflation, but only had short-term or regional effects. In recent years, food price inflation has become a global challenge.

In order to determine the nature of the food price shock, it is necessary to find the causes of price movements in supply and demand on the market, as well as other causes. This is important in order to formulate an effective monetary policy and reduce the volatility of food prices, which is important especially in developing countries, such as the Republic of Serbia, where the impact of food prices on the CPI is relatively high. The reduction of unnecessary food price volatility is significant both from the point of view of agricultural producers and consumers, as well as from the point of view of the central bank and the state as a whole.

In addition to the introduction and conclusion, the paper consists of three key thematic chapters. In the first chapter, through a review of the relevant literature, the importance of food price movements for inflation will be analyzed, offering a comparative overview of the experience of other countries, primarily the EU, based on available research. The second and third chapters are related and deal with global trends in food prices and inflation, as well as components of food price inflation in the Republic of Serbia, respectively, in order to highlight key limitations and propose recommendations for reducing food price volatility.

Literature Review

There is a significant influence of global factors on inflation trends. The importance of examining the effects of global cost pressures has grown in particular since 2020, when a series of supply-side shocks caused inflation to rise in most countries. This refers to the disruptions in global supply chains caused by the pandemic, the effects of the energy crisis and the conflict in Ukraine, which affected the prices of food and energy, but also the prices of products and services within the base inflation. The subject of numerous studies were global and domestic factors, demand factors versus supply factors, short-term or long-term effects of influence on prices and inflation.

Carriere-Swallow et. al. (2022) proved that a shock in transport costs in the period of the pandemic increased inflation, and the impact on inflation in the case of shocks in the movement of world food and oil prices has similar magnitude, but more permanent. Finck & Tillmann (2022) believe that disruptions in global supply chains have influenced a significant increase in consumer prices and a decline in economic activity in the euro zone. Di Giovanni et al. (2022) concluded that the effect of global factors and disruptions in global supply chains was stronger than domestic demand shocks on euro area inflation in 2020-2021. Muk & Postek (2023) estimated that disruptions in global supply chains have an inflationary character, that they affect the prices of products to a greater extent than services and that the effect is more significant in the long term than in the short term. Miletić et al. (2023) observed that in the case of developed countries, the impact of global shutdowns and the world price of oil on consumer prices of industrial products is stronger than overall inflation, while in the case of developing countries, the impact of cost pressures based on the price of oil is significantly greater than that of global shutdowns on producer prices in the industry due to dominance of branches with a lower level of technological development and less efficiency of the technological processes in the industry.

The largest number of studies are based on commodity price indices that also include the price of food. Gelos & Ustyugova (2017) indicate that economies with higher headline inflation or a higher share of food in the CPI are more vulnerable to food price shocks, and that the adoption of an inflation targeting regime helps to anchor inflationary expectations, thereby reducing the second-round effects of food price shocks.

Parker (2017) investigates the role of global factors driving consumer price inflation with a particular focus on price movements of the food, housing and energy sub-indices in a sample of 223 countries. Global factors account for a large share of the variance of national inflation rates in developed countries (countries with higher GDP per capita, financial development and central bank transparency), but not in middle- and low-income countries. Global factors have a large impact on the variation in food and energy prices. In high-income countries, inflation was stable until the global financial crisis. This volatility is mainly attributable to changes in food and energy prices. Food and energy prices represent the most volatile sub-index and show the highest average in the last three decades also. Consumer price inflation excluding food, housing and energy is relatively low and stable. Although Ciccarelli & Mojon (2010) confirmed the findings that global factors can explain about 70% of the variation in inflation in developed economies, Parker (2017) believes that this conclusion does not hold for a more diverse group of countries. This suggests the conclusion that advanced economies are more successful in eliminating domestic sources of inflation variation, resulting in a greater proportional role of global factors.

The results of the Anderl & Caporale (2024) study show that mean global food prices and volatility shocks have significant effects on food price inflation in all countries, as well as persistent second-round effects on core inflation in most countries. The presence of persistent second-round effects on core inflation implies that there is a strong transmission channel either through inflation expectations or corporate margins. Also, the impact of the Food Consumer Price Index on global volatile food price shocks is more variable in countries with a higher share of food consumption in total consumption and a higher share of food in the CPI. They believe that food price inflation can affect non-food price inflation as results of shocks originating from global food prices. This means that policymakers need to distinguish between the two types of global food price shocks (means and volatility) and their effects on core inflation in order to formulate effective policy.

Radukić & Marković (2015) believe that prescribing maximum margins in trade, as an instrument of indirect price control, can have a positive effect on the stability of the food market only in the short term. As a special problem, they single out the low degree of competition in the trade sector, which significantly affects the prices of final products.

It should be noted that food prices are correlated with oil price movements. According to Milanović et al. (2011) oil prices affect food prices directly (through the price of raw materials, fuel and fertilizers) and indirectly (higher oil prices increase the demand for biofuel) which puts additional pressure on food prices. Also, they believe that the increase in the prices of primary agricultural products in the world is also transferred to the domestic market, but also that food prices in developed EU countries recorded significantly lower growth than in the Republic of Serbia. The explanation is based on the relatively higher share of food in the Consumer Price Index in the Republic of Serbia.

The impact of changes in food prices on inflation is directly related to the level of wealth or economic development of the country, because the share of income spent on food decreases with the increase in the level of income, which is reflected in the structure of the CPI. In developing countries, the share of food in the CPI is about 30% on average, while in developed countries, which are more resistant to food price movements, it is about 13% on average (Cecchetti & Moessner, 2008).

Blanchard & Bernanke (2024) argue that food price shocks had a small but consistently positive impact on inflation through 2022, which increased in 2023. They performed a decomposition of the factors affecting inflation and concluded that inflationary shocks caused by price shocks were variable, and their effects were direct and indirect. For example, in the USA in the second quarter of 2023, the drop in energy prices influenced the drop in inflation, while higher food prices had the opposite effect; in Japan, the drop in energy prices was completely offset by the increase in food prices; in Italy, rising energy prices contributed more to inflation than rising food prices.

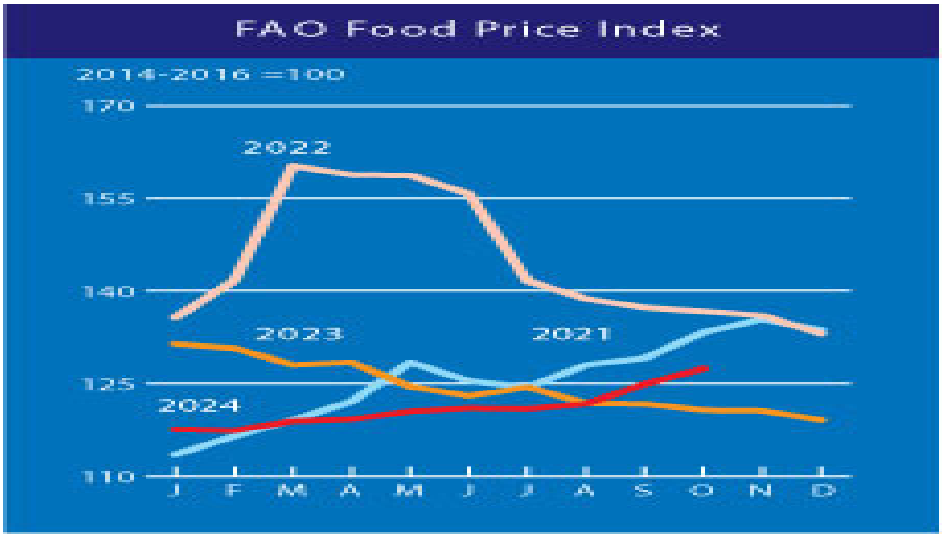
Mihajlović (2020) indicates that inflation in Serbia reacts more intensively to negative than to positive shocks of supply and demand, which means that it decreases more significantly during the recession phase than it increases during the economic expansion phase. „It is necessary to state that it is possible that mild and short-term inflation has a stimulating effect on the course of reproduction and economic development as a whole, especially in conditions where there are unemployed or insufficiently employed capacities and an unemployed workforce, but today it is difficult to maintain inflation within the limits of tolerant and mild inflation and prevent its cumulative flow, that is, turning inflationary pressure into open inflation (the emergence of an inflationary spiral)“ (Obradović, 2013, p. 330).

Global trends in food prices and inflation

"The peak of headline and base inflation in most European countries was recorded at the end of 2022 or at the beginning of 2023, where the maximum value of the base inflation was lower than the headline and mostly ranged between 11% and 13% interannually (i.a.) in the region of Central and South-Eastern Europe. If we look at the current levels of base inflation, it is currently two to three times lower than the peak" (NBS, 2024). The slowdown in inflation was caused by the reduction of food and energy prices, as well as thanks to the restrictive monetary policy. Since the beginning of 2024, core inflation has been above headline inflation in most countries, including the euro zone and the USA, due to a faster interannual slowdown in food price growth, which has also contributed to a faster decline in headline inflation.

According to the FAO, FAO Food Price Index (FFPI) in October 2024 was 2% higher than the revised September level and it is the highest since April 2023 (Figure 1). Price quotations for all products in the index increased, and vegetable oils recorded the largest increase. The FFPI in October was 5.5% higher than its value a year ago but is 20.5% below its peak reached in March 2022 (FAO, 2024).

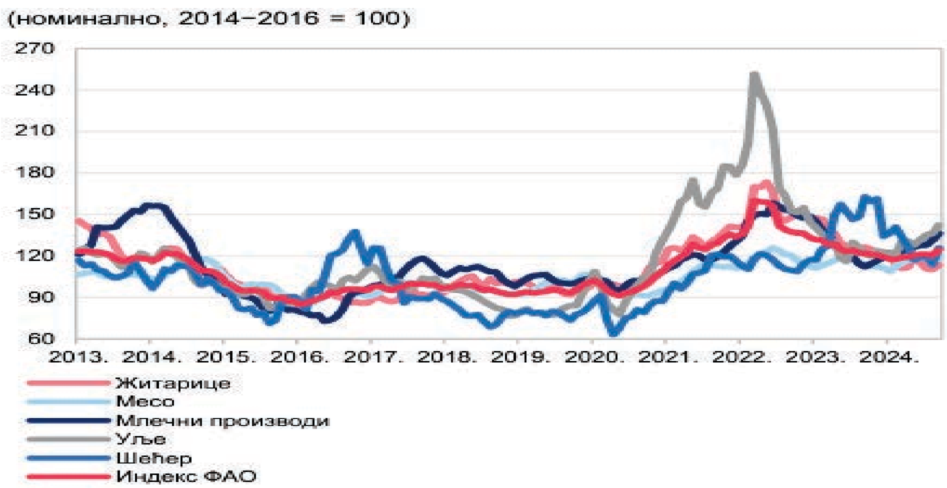
Figure 1. *Movement of the FAO Food Price Index in the period 2021-2024.*



Source: *FAO*

In September, world food prices increased by 3% compared to August, which is the largest increase since March 2022. The NBS sees the risk of additional food price increases in changing weather conditions, protectionist measures and trade restrictions, as well as slower global growth.

Figure 2. *World food price index*

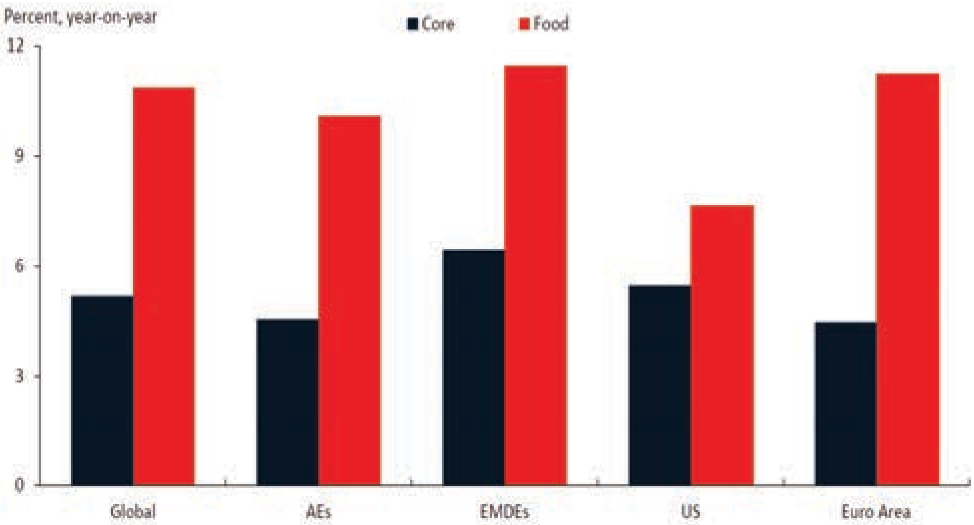


Source: *NBS, Inflation Report - November 2024, p. 56.*

Based on the FAO index (Figure 2), world food prices increased moderately during the third quarter of 2024, and in September compared to June 2024 they were higher by 2.7%, and i.a. observed, they are higher by 2.1%. The data show that there was an increase in the prices of almost all food categories, where the prices of vegetable oils (8%), dairy products (6.6%), sugar (5.3%) and meat (0.9 %). On the contrary, the prices of cereals in September 2024 were lower by 1.5% compared to June, which is unfavorable considering that the Republic of Serbia is a net exporter of cereals. Influenced by the new agricultural season and weaker global demand, world prices for primary agricultural products declined in July and August 2024, but rose in September and October due to unfavorable weather conditions that led to reduced yields and poorer grain quality in Europe compared to to the previous year. Based on market futures, it is assumed that the world prices of primary agricultural products at the end of 2024 will be lower by 2.3% compared to the previous year, and at the end of 2025 by 0.7% more than at the end of this year.

It is significant to compare core inflation and food price inflation, which can be seen in Figure 3. Globally, food price inflation is during 2022-2023. was twice as high as base inflation. The average monthly change in inflation in percentage during 2022-2023 compared to the previous year is taken as a measure.

Figure 3. *Comparative analysis of base inflation and inflation of food prices during 2022-2023.*



Legend: AEs = Advanced Economies; EMDEs = Emerging Market and Developing Economies
Source: *Baffes, 2024*

In the figure you can see that food price inflation was higher than base inflation. At the same time, food price inflation was higher in developing countries compared to developed countries, as well as in the euro zone compared to the USA. However, developed countries had lower base inflation compared to developing countries, as well as countries in the euro zone compared to the USA.

Components of food price inflation and its impact on headline inflation in the Republic of Serbia

In the Republic of Serbia, the base inflation was always lower than the headline, and the peak of the base and headline inflation was at a lower level than in most countries of Central and South-Eastern Europe, which was mostly contributed by restrictive monetary policy measures, the relative stability of the exchange rate, the anchoring of medium-term and significant decline in short-term inflationary expectations.

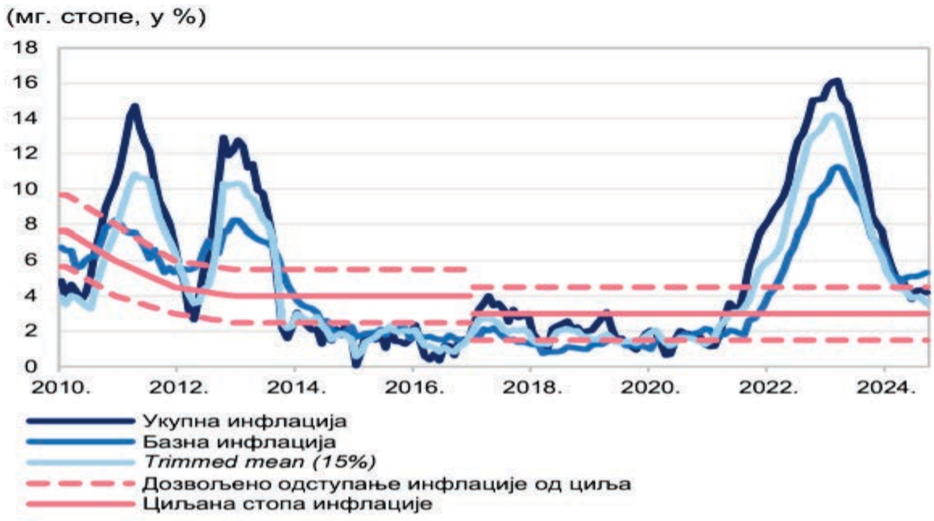
There is a difference between inflation measured in retail price growth or consumer goods price growth (headline inflation), on the one hand, and core inflation, on the other hand. Core inflation is obtained by excluding the prices of food, energy, alcohol and cigarettes from the Consumer Price Index. The reason for excluding these categories from the headline inflation is the volatility of their movements, because the state affects the prices of cigarettes and alcohol through excise taxes, the prices of energy products are determined by the global market, while the prices of food depend on the agricultural season, weather conditions, but also on global trends. The headline inflation is more comprehensive and indicates the movement of all or total prices, so it reacts to price changes, primarily of energy and food, while base inflation most often excludes the prices of those goods. Changes in food and energy prices are volatile categories and affect the costs of products and services, so the movement of headline inflation is often influenced by the growth of these categories. Thus, by excluding the mentioned products from the calculation of inflation, the short-term effects on the growth of inflation are ignored, so the fundamental inflationary pressures in the country can be singled out.

After several months, inflation returned to the inflation target in the Republic of Serbia and in October of this year it was 4.5%. After reaching the highest level of inflation in Serbia in March 2023, all its key components contributed to the reduction of inflation. The most significant factor in the growth of inflation was the increase in food prices, whose interannual growth since February 2024 has been consistently lower than headline inflation. Also, a strong decline in the same period was recorded by base inflation, which in March 2023 was at the level of 11%, so in the last months it was more than halved and stabilized at around 5% interannual level since February. Core inflation (which excludes the prices of food, energy, alcohol and cigarettes) hovers around 5% interannually, driven by the growth of service prices, while the slowdown in the prices of industrial products had the opposite effect on inflation. After that, base inflation, i.e. the Consumer Price Index (CPI) since May has been at a higher level than headline inflation, as in other countries of the region and in the euro zone.

The interannual inflation should gradually slow down in the coming period, i.e. inflation should be within the target range. The measures of the restrictive monetarist policy, the anchoring of medium and short-term inflationary expectations, but also lower import inflation and the drop in world oil prices will contribute the most to such a movement of inflation. Wage growth in line with productivity growth will reduce core inflation and equalize it with headline inflation. The increased risk of negative effects of drought on the supply and prices of fruits and vegetables, as well as slightly faster growth of domestic demand can be compensated by the lower world price of oil and lower import inflation due to the slower economic recovery of the euro zone than expected.

Core inflation (measured by the change in the CPI excluding food, energy, alcohol and cigarettes), which was slightly higher in the third quarter compared to the second and amounted to 5.3% i.a. in September 2024, was driven by the rise in the prices of services, and at the same time the slowdown in industrial product price growth continued. The derived measure of base inflation, trimmed mean, which is obtained by excluding 15% of products and services from the consumer basket whose prices record the biggest changes, was below the total inflation in the third quarter, i.e. lower than in June, so in September it was 3.6%. Dynamics of headline, base and trimmed mean inflation in the period 2010-2024 is shown in Figure 4.

Figure 4. *Dynamics of headline, base and trimmed mean inflation*



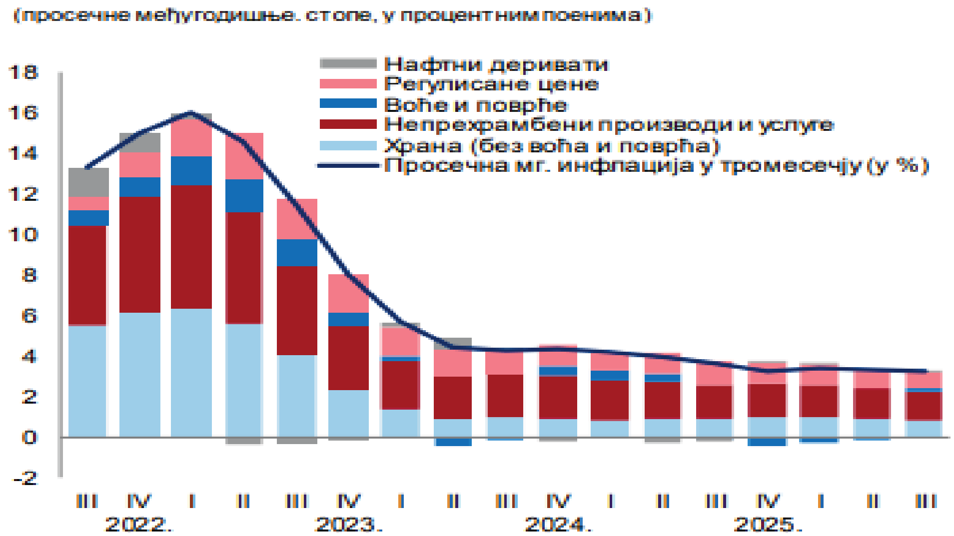
Source: *NBS, Inflation Report - November 2024*

Inflationary expectations of the NBS are that food prices (excluding fruits and vegetables) will have a reduced impact on i.a. inflation with 1 p. p. to 0.8 p. p. Due to the assessment of a positive gap in real marginal costs (deviation of the ratio of input prices and prices of final food products from the trend) until the middle of 2026 due to the expected increase in world prices of primary agricultural products, expectations of moderate inflationary pressure on food prices are realistic. A reduction in the pressures of the growth of raw material costs on food prices, lower import inflation and a slowdown in the growth of real wages are expected (NBS, Inflation Report - November 2024).

The direct effect of the rise in world prices of primary products on domestic inflation would come from higher prices of oil derivatives on the domestic market, and the indirect effect from the increased costs of food and industrial production, as well as the growth of inflation in the euro zone through higher import prices, which, according to estimates, would increase the average inflation in 2025 for 0.3 p. p.

In the Republic of Serbia, in September there was an increase in the contribution of food prices to interannual (i.a.) inflation, primarily unprocessed food (by 1 p. p.) due to the negative effects of the drought on the supply of fresh fruits and vegetables. In particular, during the third quarter of 2024, the prices of fresh vegetables slowed down significantly i.a. decline, while fresh fruit prices accelerated i.a. growth. Also, processed food prices increased the contribution of i.a. inflation in September (by 0.2 p. p.), primarily due to the increase in the price of coffee and confectionery products due to the rise in the prices of raw materials in their production on the world market. In contrast, energy prices recorded for the first time i.a. decline (-0.3%) in September 2024 from 2021, due to the decline in the prices of oil derivatives stemming from last year's high base and the decline in world oil prices. Minor contribution of i.a. inflation (by 0.1 p. p.) came from the prices of industrial products (excluding food and energy), while the prices of services increased the contribution of i.a. inflation in the third quarter (by 0.2 p. p.). Contributions to interannual inflation by CPI components can be seen in Figure 5.

Figure 5. *Contributions by CPI components to interannual inflation in the Republic of Serbia*



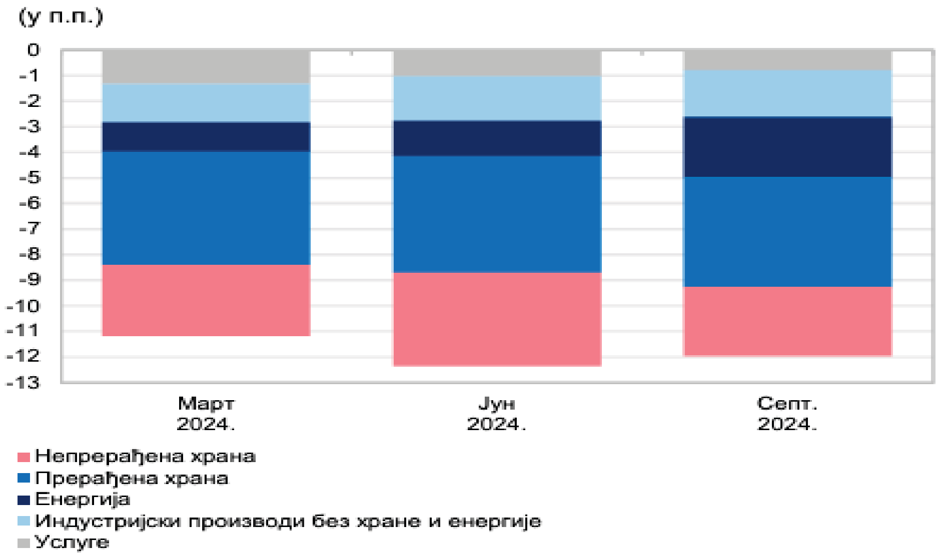
Source: *NBS, Inflation Report - November 2024*

In the third quarter of 2024 consumer prices increased by 1%, which was the average increase in previous quarters. Prices of personal consumption products and services in October 2024, compared to September 2024, increased by 0.6% on average. In October 2024, compared to the previous month, the price increase in the Food and non-alcoholic beverages group was 0.6%. In the structure of the Consumer Price Index, the group Food and non-alcoholic beverages is represented by 31.38%, with the largest share of food at 27.89% (Statistical Office of the Republic of Serbia, 2024).

According to the Report of Statistical Office of the Republic of Serbia (2024), food prices rose by 4% from October 2023 to October 2024. At the same time, no food category recorded a price drop in October 2024 compared to October 2023, and „the sugar, jam, honey and chocolate" had the biggest price increase by 15%, followed by „coffee, tea and cocoa" by 9.1%, then fruit for 8.7%, etc.

The biggest contribution to inflation in the third quarter of 2024 came from the prices of food and non-alcoholic beverages, which increased by 2.1%. Due to the drought, an unusual seasonal increase in vegetable prices was recorded, with fresh fruit prices also rising significantly by 13.3%, which led to an increase in unprocessed food prices of 2.6%. In the same quarter, the price growth of 1.8% in the processed food category was influenced by higher prices of confectionery products due to higher world prices of sugar and cocoa, as well as higher prices of coffee and bread.

Figure 6. *Change in the contribution of the basic components of the CPI to i.a. inflation compared to March 2023*



Source: *NBS, Inflation Report - November 2024*

Contribution of basic components of CPI to i.a. inflation is presented in Figure 6 in relation to March 2023, when i.a. inflation reached its peak.

Agricultural production has a direct impact on the realization of GDP, and bearing in mind that the Republic of Serbia is a net exporter of food, this is also reflected in the state of the current account. The decline in total agricultural production of around 5% due to unfavorable weather conditions in 2024 was larger than expected, i.e. 8-10% lower than the ten-year average, which is about the same decline as in 2022 and 2017. Therefore, the negative contribution to GDP was 0.4-0.5 p. p. This was reflected in lower exports of the food industry and the current account deficit.

The effect of drought on inflation is primarily related to the movement of prices of fruits and vegetables, while the prices of domestic primary agricultural products, which make up the cost of production of other food, mainly follow the movement of prices on the world market since they represent stock exchange goods.

Conclusion

Inflation in the Republic of Serbia is very sensitive to the volatility of food prices due to the large participation of this category in the Consumer Price Index compared to other more developed countries. In the conditions of the crisis and the global increase in food prices, food prices are a significant factor contributing to the deviation from the inflation target. In 2024, inflation in the third quarter returned to the limits of the inflation target, so it amounted to 4.5% in October, with core inflation more than halved compared to March last year and hovering around 5%, while food rose in price by 4% and had the biggest contribution to inflation in the third quarter.

The high share of food in the structure of the CPI (27.89%), which is accompanied by the instability of food prices, seriously complicates the implementation of the central bank's inflation targeting and inflationary forecasts. Some of the recommendations for reducing volatility, i.e. stabilizing food prices in the Republic of Serbia can be: an adequate policy of commodity reserves aligned with market trends, subsidies for agricultural production in order to reduce volatility in food production, loans to agricultural producers and production insurance, reduction of customs and non-tariff barriers for food import and export, measures to increase competition on the market, improvement of the food production and trade system.

Although there are many factors that influence the increase in food prices, increased competition in the market would lead to lower prices. Effective implementation of the Law on Competition Protection on the domestic market, which would limit the market power of domestic and foreign producers and traders, would contribute to this.

Global factors and crises, as well as unfavorable weather conditions, affect the growth of food prices, which has a negative impact, especially on developing countries, which includes the Republic of Serbia. Bearing in mind that our country is also a net exporter of certain primary agricultural products, the volatility of food prices, via import inflation, has a negative impact on domestic inflation and the current account deficit. That is why an effective monetary policy is necessary, which will take timely and concrete measures to prevent the acceleration of inflation caused by the rise in food prices on the domestic market in order to protect the living standards of the population.

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ENVIRONMENTAL PERFORMANCE OF AGRICULTURE IN SERBIA AND POLAND[1]

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Abstract

The aim of this paper is to present the achieved level of national economies' environmental performance, especially of the agricultural sector, for two countries: Serbia (non-EU country) and Poland (EU country). The analysis was based on the Environmental Performance Index (abbreviated EPI) reports and covered the period 2020-2024. According to the 2024 EPI, Serbia is ranked at the 64th place in the world, in terms of national environmental sustainability, while Poland is in a better position, at the 19th place. When it comes to the agriculture, according to the 2024 EPI, Serbia is at the 26th place, with the best result in sustainable nitrogen management, and the worst result in pesticide pollution risk. Comparing to Serbia, the ecological performance of Poland's agriculture is more unfavourable, considering that it is ranked at 35th place, with the best result in sustainable nitrogen management, and the worst result in regarding phosphorus surplus.

Key words: *environmental performance index; agriculture; Serbia; Poland.*

Introduction

Agricultural production, which is not based on the principles of sustainability, is a factor that degrades the environment, impairs the health of the population and causes global climate change (Alvarado et al., 2021; Lamb et al., 2021; Lykogianni et al, 2021; Rad, Ray & Barghi, 2022; Usman et al., 2022). During the last decades, in the entire world, the concept of ecological

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and sustainable agriculture is becoming more and more prominent in debates dedicated to agricultural policy (Latruffe et al., 2016). When it comes to the European continent, EU and non-EU countries do not have the same achievements regarding transforming the agriculture towards more sustainable and "greener" agricultural practices.

EU countries are successfully "paving the way" towards sustainable agriculture and reducing agriculture's environmental footprint, through adopting and implementing numerous directives, policies and strategies, based on the "*The European Green Deal*" initiative (European Commission, 2019; European Commission, 2020; European Union, 2021; Karamfilova, 2022). For example, in Poland's Strategic Plan for 2023-27, the focus of agricultural policy on environmental and climate objectives, has been expanded beyond rural development measures, so that now, it also includes the first pillar of direct payments, the so-called voluntary eco-schemes (European Commission, 2024). These schemes (with an allocation of 25% of the direct payments envelope) provide support to farmers for activities that go beyond legal requirements, and which are directed towards sustainable methods of production, especially in the segment of soil protection and preservation (European Commission, 2024).

In non-EU countries of the Western Balkans (according to the World Bank classification, all countries belong to the group of upper-middle-income economies) the environment and the protection of natural resources are still not in the focus of agricultural and rural development policies, and the level of sustainable, green and circular economy is lower, compared to EU countries (Volk, et al., 2017; Volk et al., 2019; Erjavec et al., 2021). In Serbia, support of agriculture and rural development is not sufficiently harmonized with the EU's common agricultural policy (CAP), neither in terms of the amount nor the structure of the support (Volk, et al., 2019; Erjavec et al., 2021). Agro-ecological measures have not yet been implemented, although the line ministry is aware of the need for increased policy focus on environmental and climate actions, as well as the problems in this segment (Government of the Republic of Serbia, 2022).

The aim of this paper is to present the impact of the agricultural sector on the environmental performance of two national economies: Poland (EU member) and Serbia (EU candidate status). At the same time, the authors provide practical guidelines and recommendations for policymakers, so that countries can more quickly and efficiently trace the path towards sustainable and green economy, in which agriculture has a central place.

Material and method

For the purpose of this paper, authors used *Environmental Performance Index* (abbr. EPI) reports, regularly published by the Yale Center for Environmental Law and Policy. The first EPI report was presented to the public in 2006, and over time the number and the name of the indicators within the EPI varied. Based on the 2024 EPI rank and score (3 policy objectives, 11 categories and 58 indicators), for totally 180 countries, it can be seen where they are regarding various aspects of the environment (Block et al., 2024), and where it is necessary to engage more intensively, in order to reach higher environmental quality standards.

One of the 11 EPI framework category is the Agriculture, within the third policy objective (*Ecosystem Vitality*). The EPI contribution of category Agriculture is measured using four indicators (Block et al., 2024, p. 112):

- *Relative Crop Yield* makes 40% of the category Agriculture. This indicator represents the average yield of 17 main crops, in relation to their maximum, historically speaking, possible yield, and in accordance with regional climatic differences. The logic behind this indicator is that yield-maximizing countries can reduce demands for expanding agricultural land. Indicator score is between 100 (full yield gap closure - the best result) and 0 (the worst performance).

- *Sustainable Nitrogen Management Index* (SNMI) makes 40% of the category Agriculture. This indicator represents the balance between the efficient use of nitrogen fertilizers and the achievement of satisfactory yields. Indicator score is between 100 (optimized application of nitrogen fertilizers - the best result) and 0 (the worst performance). This indocator is important because the excess nitrogen in the soil leads to eutrophication of waters.

- *Pesticide Pollution Risk* makes 15% of the category Agriculture. This indicator measures the level of accumulation of pesticides in the soil, in relation to assumed safe levels. Indicator score is between 100 (no risk - the best result) and 0 (the worst performance).

- *Phosphorus Surplus* makes 5% of the category Agriculture. Phosphorus is necessary for the growth and development of agricultural crops and can accumulate in the soil over time. Phosphorus surplus indicates the potential pollution of the soil with phosphorus, due to the irrational use of fertilizers. In essence, it represents the difference between the amount of phosphorus introduced into the soil by fertilization and the phosphorus content in the harvested crops. Therefore, this indicator indicates an excess of phosphorus fertilizers in the soil, which can lead to eutrophication of water bodies. Indicator score is between 100 (no surplus - the best result) and 0 (the worst performance).

The data were presented using descriptive statistics, and appropriate conclusions were drawn based on comparative analysis and inductive-deductive methods.

Environmental Performance Index and Agriculture: results from Poland & Serbia

According to 2024 EPI, out of a total of 180 countries, Serbia is ranked 64th in terms of environmental sustainability, while Poland is in a much better position, at 19th place (Table 1). Serbia's EPI score/rank in 2024 is lower than in 2020, in compare to Poland, which has a significantly better rank in 2024, than five years ago (Table 1).

Table 1. *EPI, score & rank, 2020-2024*

	Serbia						Poland					
	2020		2022		2024		2020		2022		2024	
	score	rank	score	rank	score	rank	score	rank	score	rank	score	rank
EPI Index	55.2	45	43.9	79	49,3	64	60.9	37	50.6	46	64.4	19
Agriculture	69.9	8	45.3	51	71.4	26	57.4	32	42.7	61	68.3	35
Sustainable Nitrogen Management	69.9	8	69.9	8	78.1	7	57.4	32	57.4	32	60.8	28
Pesticide Pollution Risk	-	-	20.7	115	46.3	138	-	-	28.0	84	72.0	58
Relative Crop Yield	-	-	-	-	77.1	49	-	-	-	-	76.3	51
Phosphorus Surplus	-	-	-	-	47.7	116	-	-	-	-	43.1	128

Source: *Yale Center for Environmental Law and Policy, online database.*

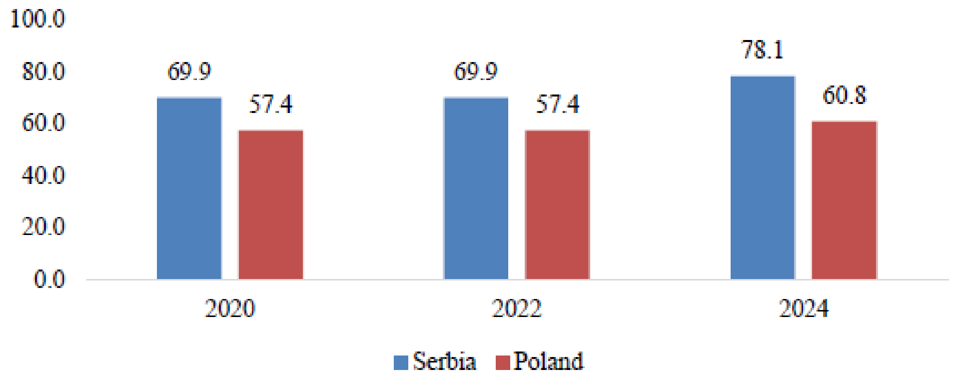
Lower EPI rank for Serbia, can potentialy be explained by: a) worsening situation regarding environmental quality and/or b) a greater coverage of environmental indicators that are observed in 2024, in which Serbia has poor performance (namely, the number of indicators in the 2024 EPI Report is 58, which is 26 indicators more, compared to 2020).

When it comes to the 2024 EPI category Agriculture, out of a total of 180 countries, Serbia is at 26th place, while Poland is at 35th place (Table 1). A significantly lower ranking for Serbia, compared to 2020 (8th place), can be explained by the introduction of two new indicators to this category (Pesticide Pollution Risk and Phosphorus Surplus), where Serbia has poor management. The position of Poland in this category for the period 2020-2024 has not been changed significantly (down two places, from 32nd in 2020 to 35th in 2024).

Below are the results of the indicators used to measure the environmental performance of the agricultural sector.

Sustainable nitrogen management (SNMI). If we observe the indicator's score in the period 2020 - 2024 (score from 69.9 in 2020 to 78.1 in 2024), it can be concluded that the Republic of Serbia has slightly increased the sustainable management of nitrogen fertilizers. Improvement in this matter has been achieved also in Poland, which went from 57.4 in 2020 to 60.8 in 2024 (Graph 1).

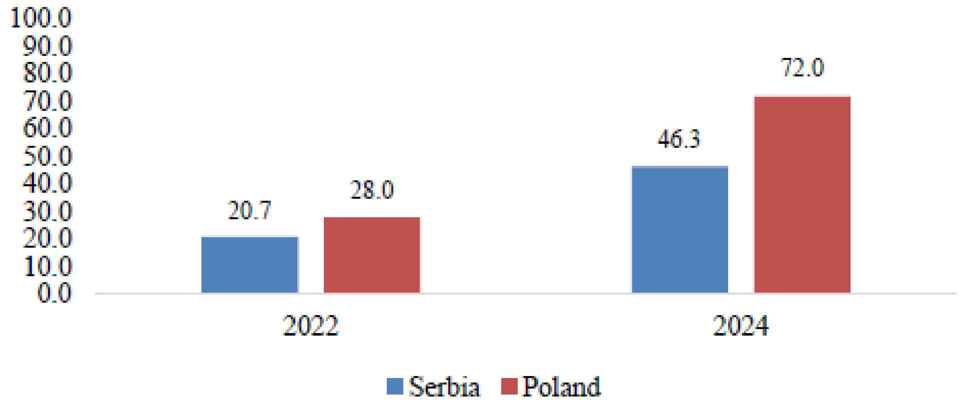
Graph 1. *Sustainable nitrogen management, score for years 2020, 2022, 2024*



Source: *Yale Center for Environmental Law and Policy, online database.*

Pesticide Pollution Risk. When it comes to the sustainable management of pesticides, Serbia has a score of 46.3 which puts her at 138th place, while Poland is in a much better 58th position (72.0 score).

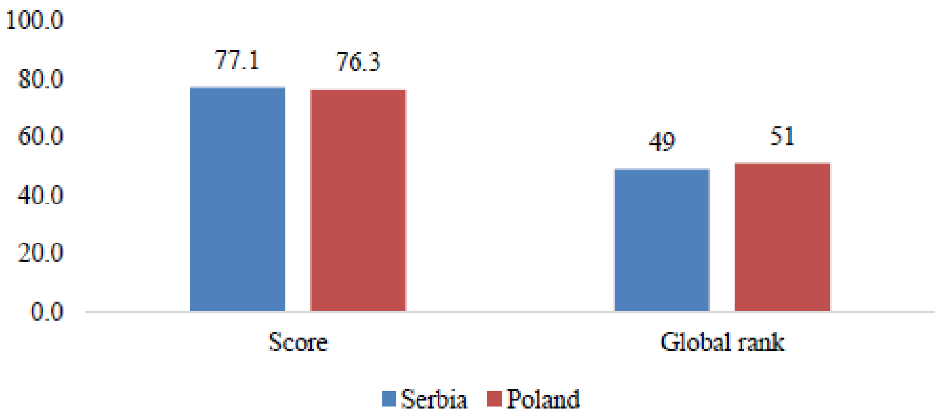
Graph 2. *Pesticide pollution risk, score for years 2022 and 2024*



Source: *Yale Center for Environmental Law and Policy, online database.*

Relative Crop Yield. Regarding this indicator, Serbia and Poland have similar results. The Republic of Serbia has a score of 77.1, which ranks it 49th in the world in terms of the relative yield of the main crops, while Poland is in a slightly lower 51st place (Graph 3).

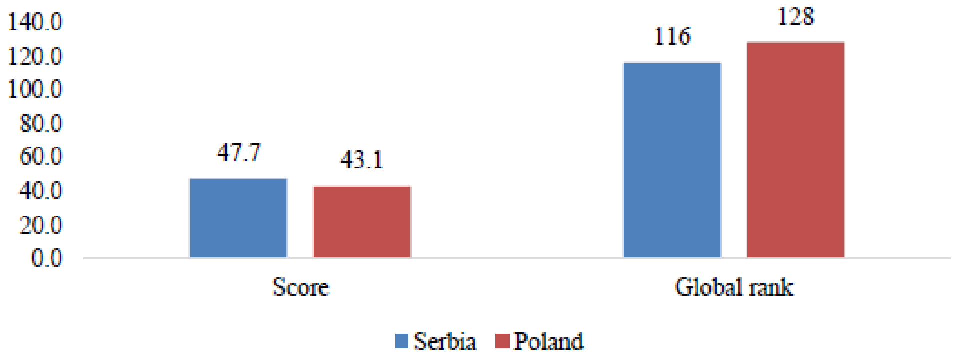
Graph 3. *Relative crop yield, score and rank for year 2024*



Source: *Yale Center for Environmental Law and Policy, online database.*

Phosphorus surplus. Serbia has a score of 47.7, which ranks it 116th in the world, in terms of phosphorus surplus in the soil, while Poland with a score of 43.1 is in a worse position, with the 128th position out of a total of 180 countries (Graph 4).

Graph 4. *Phosphorus surplus, score and global rank for year 2024*



Source: *Yale Center for Environmental Law and Policy, online database*

Conclusion and recommendations

In Poland, as a EU country, environmental and climate objectives of agricultural policy have been extended beyond rural development measures and they additionally include the first pillar of direct payments, within CAP Strategic plan for 2023-27. On the other hand, Serbia is still waiting for the accreditation of IPARD measure 4 "*Agro ecological climate measures and organic production*" (within the IPARD III program for 2021-2027), as well as the programming and implementation of the national measure "*Support to agro ecological measures, good agricultural practice and other environmental protection and preservation policies*" (within the national measures of rural development). For the implementation of agro ecological measures in Serbia, it is necessary to work on fulfilling numerous assumptions in the coming period, such as: passing and amending the appropriate laws (while ensuring their implementation), implementing Land Parcel Identification System (LPIS) and Integrated Administration and Control System (IACS), cross compliance, and strengthening the personnel and capacity of control/inspection services (Government of the Republic of Serbia, 2022).

Besides the previous one, according to the ecological performance of agriculture in 2024 EPI, Serbia is at the 26th place out of 180 countries, while Poland ranks at 35th place. Both countries have the best result in sustainable nitrogen management. The worst result Serbia has in pesticide pollution, while the biggest problem for Poland's agriculture is phosphorus surplus.

In general, all countries that want to transform their agriculture towards more sustainable solutions, and strengthen its ecological and climate component, must investment in innovation, R&D technologies, environmentally friendly pesticides, with simultaneous implementation of Integrated Pest Management principles and implementation and certification of different certification schemes for sustainable agriculture (FAO, 2018; Alvarado et al., 2021; Lykogianni et al., 2021; EU, 2022; Rad, Ray & Barghi, 2022). Additionaly, for less developed countries, numerous adjustments are needed, not only in agricultural and rural development policy, but also in environmental protection policy and macroeconomic policy (Uddin, 2020; Erjavec et al., 2021).

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ECONOMIC PROFITABILITY OF ŠUMADINKA SOUR CHERRY PRODUCTION ON A FAMILY FARM[1]

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Abstract

The subject of this work is the analysis of the characteristics and production results of the Šumadinka sour cherry, which is intended for fresh marketing. The main goal of the work is to determine the economic profitability of the production of this cherry variety on the family farm (FF) located in the Rasina district. The description method, the calculation method and the interview method were used in the preparation of the paper. The research was conducted on the basis of data collected on the farm itself, and the database of the Statistical Office of the Republic of Serbia (RZS) and the Food and Agriculture Organization (FAO), as well as relevant scientific and professional literature, was used. The analysis showed that the production of sour cherries, the Šumdinka variety, on a family farm can be economically profitable.

Key words: *sour cherry, šumadinka, economic profitability.*

Introduction

Climatic conditions in Serbia are suitable for the cultivation of sour cherries, as evidenced by its wide distribution throughout the country. Small investments in the raising of plantations and modest requirements for production technology have influenced the fact that sour cherries rank high in the total area represented in Serbia.

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In terms of position and soil, it is a very modest fruit tree, so it can be successfully grown in all positions and different types of soil, the exception being too wet and heavy soils (Sredojević, 2011). From the point of view of export to the international market, sour cherries are an important and very promising Serbian fruit (Sredojević et al., 2011). Cherry fruit is of great technological value and represents an extremely suitable raw material for industrial processing. In addition to being used for the production of juices, jams, syrups, sweets, liqueurs, for drying and freezing, the fruits of certain varieties of cherries are gladly consumed fresh. In Serbia, production is dominated by Oblačinska sour cherry, with a share of 60% of the total number of sour cherry trees (Milatović et al., 2011). The large presence of this variety in production is a consequence of high and regular fertility and high quality of the fruit, which is highly valued in the processing industry (Radivojević et al., 2006). In second place are the so-called domestic sour cherries or gypsy sour cherries, which make up about 20% of the total number of trees. All other varieties are represented by about 20%, of which the most cultivated are: Reksele, Hajmanova konzervna, Keleris 14 and Šumadinka (Milatović et al., 2011). The fruits of most of the mentioned varieties are only suitable for sale in a frozen state, and the variety that stands out due to its good transportability is Šumadinka. The fruits of this variety are suitable for sale and export fresh. The good placement of this cherry both on the domestic and foreign markets and the stable price have influenced the spread of cherry plantations under this variety. The subject of this work is the examination of the characteristics and production results of the Šumadinka cherry variety, which is intended for fresh marketing. The main goal of the work is to determine the economic viability of the production of this sour cherry on a family farm (FF) located in the Rasina district.

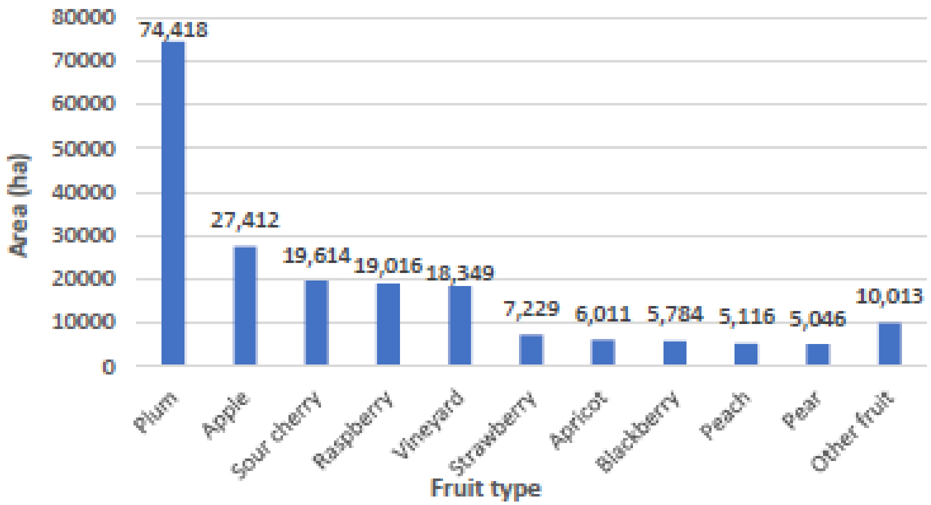
Methods and data sources

When preparing the work, the following scientific methods were used in appropriate combinations: method of description, method of calculation, method of interview. The research was carried out on the basis of data collected from the internal documentation of the FF, as well as through an interview with the holder of an agricultural holding in the Rasina district. In addition to the data collected on the farm itself, numerous domestic scientific and professional literature relevant to the subject of the research was used. To analyze the basic parameters of sour cherry production in Serbia and the world, the database of the Republic of Serbia Statistical Office (RZS) and the database of the Food and Agriculture Organization (FAO) were used.

Status and trends in cherry production in Serbia and the world

According to representation in total areas, in the group of stone fruits, the sour cherry occupies the second place in Serbia (19,614 ha), right behind the plum (74,418 ha), which is traditionally in the first place (graph 1).

Graph 1. *Areas under certain fruit species in Serbia in 2023 (ha)*



Source: *Authors based on data www.stat.gov.rs*

According to the agricultural census, which was conducted in 2012, large areas under sour cherry trees are located in southern and eastern Serbia, Mačva, parts of Šumadija, Srem, northern Bačka and central Banat. The municipalities with the largest sour cherry production are: Prokuplje (2,085 ha), Merošina (1,411 ha), Leskovac (1,353 ha), Knjaževac (926 ha) and Šabac (588 ha). According to the data of the Food and Agriculture Organization (FAO) for the year 2022, Serbia with a total production of 164,446 tons came in fifth place, behind Russia (297,200 t), Poland (183,800 t), Ukraine (180,240 t) and Turkey (176,770 t). Presentation of basic parameters in sour cherry production in the world, Europe and Serbia is given on the basis of calculated basic valuesindicators of descriptive statistics (table 1).

Table 1. *Presentation of the basic parameters of sour cherry production in the period 2013-2022. year*

Indicators	Area harvested (ha)	Yield (t/ha)	Production (t)
The world			
Average 2013-2022.	214,920.50	6.62	1,423,838.11
minimum	204,824.00	5.73	1,186,334.20
maximum	223,910.00	7.15	1,593,024.70
Rate of Change (%)	0.97	0.58	1.56
Coefficient of variation (%)	3.35	6.06	8.30
Europe			
Average 2013-2022.	144,765.80	6.25	906,323.54
minimum	135,858.00	4.93	669,312.45
maximum	151,073.00	6.95	1,034,868.04
Rate of Change (%)	0.65	0.85	1.51
Coefficient of variation (%)	3.40	9.21	11.74
Republic of Serbia			
Average 2013-2022.	17,535.90	7.08	123,853.92
minimum	13,990.00	5.07	91,659.39
maximum	19,875.00	10.06	165,738.00
Rate of Change (%)	3.98	-2.15	1.74
Coefficient of variation (%)	12,22	21.25	23.43

Source: *Author's calculation based on data www.fao.org*

From the data presented in Table 1, it can be seen that Europe is the leading continent in the production of sour cherries, because in the observed period (2013-2022), it produced an average of 906,323.54 tons per year, which is 63.65% of the total world production of this kind of fruit. Production was realised on an average area of 144,765 hectares, ie 67.36% of the total area under cherry plantations in the world. In the same period, the areas under sour cherry trees in the Republic of Serbia increased on average at a rate of 3.98%, which is more than in Europe (0.65%) and the world (0.97%). However, the growth of the area did not follow a significant increase in the total volume of production (1.74%), which is a consequence of the fact that in the observed period the yield decreased on average at a rate of 2.15%. However, the average yield in Serbia (7.08 t/ha) was higher than the European (6.25 t/ha) and world average (6.62 t/ha).

Characteristics of the Šumadinka variety

The Šumadinka variety was created in 1969. at the Institute of Fruit Growing in Čačak (Serbia) by crossing the Kereška and Hajmanova konzervna varieties, and it was recognized as a variety in 1984. The selectors are prof. dr Asen Stančević and prof. dr Petar Mišić (www.institut-cacak.org). The tree of this variety is weak to medium lush. It forms a round and branched crown with branches that are bent under the weight of the crop. It is suitable for dense planting (4 x 3 m), and good production results can be achieved even with planting density (4 x 2.5 m). This variety is relatively resistant to winter frosts and drought. It is self-fertile and gives birth already in the second year, while the first economically significant crop can be realized in the third year. From the fourth year, it gives birth regularly and abundantly.

The fruit is very large (7 g), round in shape, dark red in color. The petiole is medium-long and medium easily separated from the fruit, which makes it unsuitable for mechanized harvesting. The fruits are suitable for various types of processing in industry and household. It has a pronounced tendency to bare branches that bear fruit, so it requires regular pruning (Milatović et al., 2011). The fruits have good transportability, which makes them suitable for sale in fresh condition (figure 1).

Figure 1. *Harvesting of Šumadinka sour cherries intended for fresh sale*

Source: *Authors*

Investments in raising cherry orchards

Investments in the raising of perennial plants include the costs of soil preparation, planting costs, the costs of setting up supports and possibly anti-hail nets and nets for shading, as well as irrigation, drainage, frost protection (antifrost) systems. However, as the plants do not go into production immediately, but it takes a certain amount of time, the investment costs of raising the plants also include the costs of caring for the plants until they enter the first economically significant crop (Dimitrijević et al., 2021). An economically significant crop is the first crop whose value is greater than the costs of its production (Milić et al., 2013). Table 2 shows investment investments in the raising of cherry trees, which include the zero year in which cherry trees were planted and and three years of seed care until the first economically significant harvest. It is a form of a kettle-shaped fruit tree crown (vase), on a basibiont of wild cherry. The planned exploitation period of the plantation is 20 years.

Table 2. *Investment in planting of sour cherry trees of the Šumadinka variety (area 1 ha, planting density 4 x 3 m, 833 seedlings)*

No.	Purpose	Year				In total (din)
		0	I	II	III	
1.	**Machine work** - Land preparation for planting (plowing, milling) - Loading, transport and spreading of manure - Tillage (5 times)	96,000 36,000	12,500	12,500	12,500	169,500
2.	**Direct labor** - Planting - Hoeing (3 times) - Pruning	35,000	31,500 7,500	31,500 15,000	31,500 20,000	172,000
3.	**Material** - Manure - Seedlings - Mineral fertilizers - Chemical protection	60,000 100,000 7,200	7,200 2,500	12,600 5,000	18,000 10,000	222,500
A.	**Total investments (1+2+3)**	334,200	61,200	76,600	92,000	**564,000**

Source: *Author's calculation*

Sour cherry has low requirements (no need for fruit tree support, shade, it can be grown in dry farming conditions), so the costs of planting are low. The total investments in the planting of Šumadinka sour cherry trees amount to 537,300 dinars. In the costs of raising plantations, the largest items are seedlings (100,000 din).

Economic profitability of cherry production

In order to determine the economic profitability of production, it is necessary to make an analytical calculation of production for a representative year in sour cherry production. The analytical calculation of production was made on the basis of the average achieved price and yield in cherry production at FF for a time period of 3 years (table 4). A more detailed presentation of the costs of basic and auxiliary materials in production is shown in table 3.

Table 3. *Plan of costs of basic and auxiliary materials in the production of cherries on an area of 1 ha*

Type of material	Unit measures	Quantity	Value (din)	
			Per unit	In total
I. Basic material				39,100
1. NPK fertilizer	kg	300	72	21,600
2. KAN fertilizer	kg	350	50	17,500
II. Supporting material				32,260
1. Chemical protection				
- Insecticides				3,685
- Fungicides				26,175
- Herbicides				2,400
Total costs:				**71,360**

Source: *Author's calculation based on internal documentation of FF*

The average sales price for the period from 2022 to 2024 was 110 dinars/kg, while the average yield was 9.2 t/ha.

Table 4. *Average realized yield and sales (purchase) price in the exploitation of the Šumadinka cherry variety on an area of 1 ha for the period 2022-2024. year*

Year	Yield (kg)	Price (din/kg)
in 2022	10,450	120
in 2023	8,000	100
in 2024	9,200	110
Average	**9,216**	**110**

Source: *Calculation of the autor based on the internal documentation of the farm*

Based on the analytical calculation (table 5), it was concluded that the financial result in the production of 1 ha of Šumadinka sour cherries is positive and amounts to 580,700 dinars. The production cost of 1 kilogram of sour cherries, determined by calculation, amounts to 47 dinars.

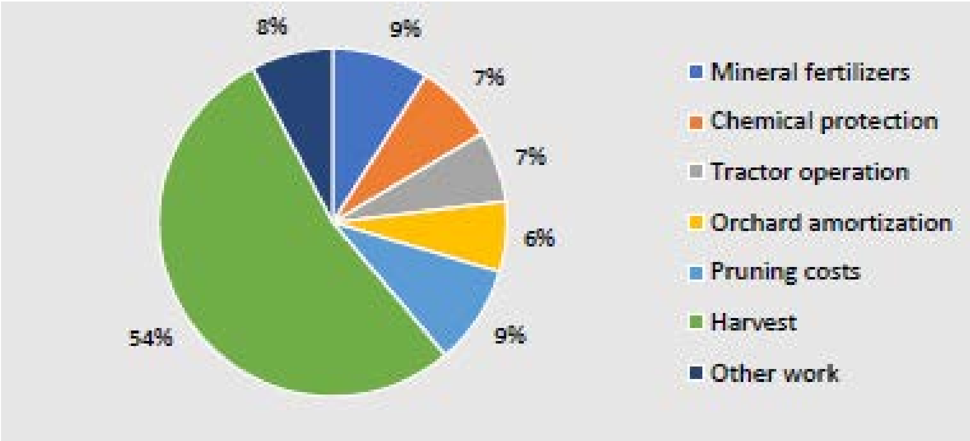
Table 5. *Analytical calculation of the production of the* **Š***umadinka sour cherry variety in a plantation of 1 ha, planting density (4 x 3 m)*

Products	**Area (ha)**	**Yield (kg) Per unit**	**Value (din)**	
			In total	
First class sour cherry	1	9,216	110	1,013,760
A. PRODUCTION VALUE				**1,013,760**
Type of expenses				
a) Basic material Nitrogen fertilizers		NPK fertilizers		21,600
		17,500		
b) Supporting material		Chemical protection		32,260
1. Direct material costs (a+b)				71,360
c) Costs of running machines		Tractor		28,500
d) Service costs		Pruning costs		40,000
2. Direct production services (c+d)				68,500
3. Orchard amortisation				28,200
4. Direct labor costs Other works		Harvest		232,000
		33,000		
B. PRODUCTION COSTS (1 + 2 + 3 + 4)				**433.060**
C. FINANCIAL RESULT (A – B)				**580,700**
D. PRICE OF 1 KG OF SOUR CHERRIES				**46.99**

Source: *Author's calculation based on FF's internal documentation*

Based on the analysis (graph 2), it can be concluded that the biggest expense in regular sour cherry production is the cost of harvesting (54%). In the case of sour cherry varieties intended for processing, this problem was solved by the introduction of mechanized harvesting. However, this is the harvesting of sour cherries for fresh consumption, which requires careful picking of ripe fruits with the stem and leaf on the stem (figure 1).

Graph 2. *Cost structure of Šumadinka variety sour cherry production*



Source: *Authors based on analytical calculation (table 5)*

This sour cherry variety does not have uniform ripening of all fruits, so harvesting can be done in 2-3 passes. This way of harvesting allows better engagement of the own members of the household. The effect of this method of harvesting ranges from 150 - 170 kg picked sour cherries per worker, for 10 hours of work.

Conclusion

Small investments in the raising of cherry orchards, regular and stable yields, a relatively stable purchase price of the Šumadinka variety compared to the purchase price of the Oblačinska sour cherry, caused the growth of areas under sour cherry plantations of the Šumadinka variety. The analysis showed that the production of sour cherries, the Šumdinka variety, on a family farm can be economically profitable. The realized profit in production on an area of 1 ha amounts to 580,700 dinars. One of the shortcomings in the production of sour cherries, and therefore of this variety, is the high consumption of labor during harvesting, which in this case cannot be replaced by mechanized harvesting, given that sour cherries are intended for sale fresh. In the area of Rasina district, the ripening period of this variety is the last decade of June, a time period in which there is no harvesting of other fruit species, which allows agricultural producers to supplement their production range with this variety.

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METHODOLOGICAL FRAMEWORK FOR ASSESSING THE IMPACT OF CLIMATE RISK ON AGRICULTURAL PRODUCTION THROUGH THE VULNERABILITY INDEX IN SERBIA

Zoran Tomić[1]

Abstract

Climate change is one of the most critical challenges facing humanity on a global scale with a major impact on the ecosystem and people's way of life. Agriculture is a sector on which climate change has a significant impact, as it is one of the key sources of livelihood in most countries in the world, including Serbia. As a result of climate change, extreme natural events occur, such as floods, droughts, hail, strong winds, which lead to significant economic costs and damages in the agricultural production process. Such events can threaten the survival of farmers and bring them to the brink of poverty, but also endanger the food supply. This paper describes the index of vulnerability of agricultural production in Serbia due to the risk of climate change, which in its analysis takes parameters that describe the exposure, sensitivity and adaptability of agricultural production with the aim of better understanding the impact of climate change on agricultural production, as a tool for better development of future agricultural protection strategies of production from the mentioned risks which can be adaptation strategies and reduction strategies.

Key words: *vulnerability, sensitivity, exposure, adaptability, agriculture.*

Introduction

Agriculture is one of the important pillars of economic development in Serbia. In Serbia, agriculture has a share of up to 10% in the country's GDP, and in exports it makes up to 20% of the share (FAO, 2021). Also, agriculture is one of the sectors that is most susceptible to the effects of climate change, because agriculture is characterized by biological specificities, or rather high production risks (Radović, 2016). This especially applies to farming, i.e. plant production, which is exposed to the widest range of negative impacts,

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i.e. risks - from local weather disasters and the dangers brought by climate change on Earth, to speculation with the prices of oil, mineral fertilizers and agricultural products on the market. Animal husbandry, although more profitable than farming, is an extremely risky activity. Risks in animal husbandry are mainly determined by price shears (more expensive food for livestock than meat or milk), market anomalies and speculations, i.e. the human factor. Weather conditions, in contrast to vegetable growing, fruit growing and viticulture, mostly affect livestock production indirectly, through the prices of animal feed, but not directly as in crop production. Climate change has a significant impact on food production and it is estimated that there will be a 22 to 52% reduction in corn production in the period 2071 - 2100 in non-irrigated areas (FAO, 2021). Also due to the effects of climate change, the occurrence of extreme weather risks (heat waves, droughts and floods) is expected to intensify, which will also have significant material and financial damages, losses and impact on human lives (IPCC, 2012; Lobell, et al, 2011; Nelson et al, 2010). Such effects will have a significant impact on the incidence of poverty among farmers, and since poverty and vulnerability are closely linked, it will make smallholder farms located in high-risk areas vulnerable due to a lack of resources to mitigate the adverse impact of natural hazards through risk insurance or technical measures. That's why the problem of vulnerability occupies an important place in research, but also among policy makers of world countries. How vulnerable a country and its population ultimately are to climate change depends on how vulnerability is conceptualized, quantified, and communicated — so defining what a country is vulnerable to and what time frame is observed is crucial.

Due to the aforementioned, the challenge is to create an appropriate index of vulnerability that will be able to quantify the conditions in which farmers in a country are in the best way and to indicate the impact of climate change on agricultural production, which is the starting point for creating the necessary adaptation measures to climate change, but primarily to reduce the impact of climate change on agricultural production (Fussel, Klein, 2006). In this paper, we will present the existing definitions of vulnerability in the literature and we will present several models dealing with the quantification of the vulnerability index as a measure of the impact of climate change on agriculture and analyze their applicability to Serbia based on the availability of data from national databases.

Definition of vulnerability in agriculture

Vulnerability is associated with predisposition, susceptibility, fragility, weaknesses, deficiencies or lack of capacity that favor adverse effects on exposed elements. Vulnerability is a complex topic and is subjective in nature (Brugère and De Young, 2015). A wide range of definitions can be found in the literature. One definition of vulnerability is that vulnerability refers to the propensity of certain exposed elements such as people, their livelihoods and assets to suffer adverse effects from hazardous events (Cardona 1990; UNISDR 2009). When it comes to the management of catastrophic risks, vulnerability is defined as the most noticeable manifestation of the social construction of risk (Wisner et al., 2004). This involves answering questions such as: how human activities affect the level of exposure and vulnerability in relation to various events; how human intervention in the environment leads to the creation of new hazards or an increase in the level of potential damage; how human perception, understanding and assimilation of risk factors affects social reactions, prioritization and the decision-making process.

Historically, there have been several views of vulnerability: the political economy perspective; perspective of political ecology; resilience approach and risk-hazard approach (WFP, 2009). Depending on the perspective, certain aspects are emphasized, so from the aspect of political economy sociological, cultural and economic factors are emphasized; from the second aspect, the biological and ecological component is emphasized; the resilience approach looks at the impact of sociological and environmental factors on a certain geographical area and the last aspect looks at biophysical hazards. Vulnerability arises from complex interactions between socio-economic, institutional and ecological systems, which complicates any assessment or quantification. Vulnerability is defined as a function of how households (or communities, or countries or regions) are affected by negative consequences (injury, damage and/or loss) as a result of a shock, and how they cope with this exposure (FAO, 2021).

One of the most well-known definitions is formulated in the International Strategy for Disaster Reduction: “Conditions determined by physical, social, economic and environmental factors or processes, which increase the vulnerability of a community“ (UN/ISDR, 2004).

The United Nations Development Program (UNDP) defines vulnerability as "a human condition or process resulting from physical, social, economic and environmental factors that determine the likelihood and extent of damage from the impact of a given hazard" (UNDP, 2004).

According to the IPCC Assessment Report, vulnerability is defined as an integrated measure of the expected magnitude of adverse effects on the system caused by a given level of certain external factors (IPCC Assessment Report). Vogel and O'Brien emphasize the fact that vulnerability is: multidimensional and differential (it varies depending on physical space and between and within social groups depending on scale (in terms of time, space and units of analysis such as the individual, household, region, system) dynamic (the characteristics and driving forces of vulnerability change over time) (Vogel and O'Brien, 2004).

Almost all concepts of vulnerability see it as the „inside of risk" closely related to the discussion of vulnerability as an essential characteristic of a system or element at risk.

Climate Vulnerability Index of Agriculture

Climate vulnerability assessment has four steps that are carried out and analyzed, namely: data collection, data processing, indicator selection and index calculation.

The first step refers to the collection of all relevant quantitative indicators that can lead to an impact on the vulnerability of agricultural production. In the works that were analyzed, data from the databases of: World Bank, World Resources Institute, EM-DAT, CIESIN, UN organization (FAOSAT, UNFPA, IMF) were used (Krishnamurthy, Lewis, Choularton, 2014). When it comes to Serbia, in addition to the above-mentioned databases that have part of the data for Serbia, domestic databases such as the Republic Institute of Statistics, the National Bank of Serbia, the Republic Hydrometeorological Institute and data obtained from the competent ministries (Ministry of Agriculture, Water Management and Forestry, Ministry of Trade) can be used.

The second step refers to the selection of relevant data that may have an impact on agricultural production. Depending on which problem is considered, it is important to choose a parameter that will be used to measure that problem. Kristhnamurthy et al in their work where they dealt with the problem of nutrition used FAO data on hunger. When we talk about agricultural production and measuring the vulnerability index of agriculture, the value of GVA of agriculture in the GDP of the observed country can be used.

The third step refers to the selection of appropriate indicators to be observed and analyzed. It is necessary to carry out statistical processing of the data, in the sense of checking the correlation with the observed parameter in relation to which the index of vulnerability is measured. If there is a significant statistical correlation, then the observed parameter is used to establish indicators that are divided into exposure indicators, sensitivity indicators and adaptive capacity indicators. It is also necessary to perform autocorrelation testing, so in that case the indicator with a higher degree of correlation is taken. Since the calculation of the index involves numerous indicators, the indicators are measured with different values, and their normalization must be carried out (Jones and Andrey, 2007).

Normalization needs to be carried out because the values of individual parameters are not compatible with each other, as they are expressed in different measurement units, so their value is reduced to a value between 0 and 1, where 0 represents the least impact on vulnerability, and 1 the greatest impact. Normalization is done according to the following formula.

$$X_i = \frac{X_i(t) - MinX_i}{MaxX_i - MinX_i} \tag{1}$$

where, Xi is normalized indicator value, Xi (t) is the actual value of the indicator, Min Xi: the minimum real value of the indicator, Max Xi: the maximum real value of the indicator (Loi et al., 2022).

Another suggest normalization can be done in the following way (Krishnamurthy, Lewis, Choularton, 2014):

$$X_i = \frac{X_i(t)}{MaxX_i} \tag{2}$$

In order to obtain the value of the observed component, it is calculated:

$$Komponenta = \frac{Indikator_1 + Indikator_2 + \cdots + Indikator_n}{n} \tag{3}$$

Among the indicators used are: E - exposure, S - Sensitivity and AC - adaptive capacity. According to the authors, the formula for obtaining vulnerability in agriculture is

$$AV = \frac{(E+S+1-AC)}{3} \tag{4}$$

AC gets a negative prefix because adaptive capacities inversely affect the value of the vulnerability index, ie. they diminish it (Krishnamurthy, Lewis, Choularton, 2014). The results of the calculation are used to express relative vulnerability at the country level. Values associated with the model were divided into five different categories using the quintile method, with each range cumulatively representing 20% of the maximum vulnerability: less than 0.2 - very low; 0.2-04, - low; 0.4-0.6 - medium, 0.6-0.8 - high and above 0.8 very high. When it comes to the database from the Republic of Serbia, the parameters that are available with data periodicity are given in the following table.

Table 1. *Parameters from databases in the Republic of Serbia*

No.	Parametar	Periodicity	Period	Area	Parameter for index	Source
1	Precipitation	monthly	1949 - 2022	The places	exposure	Hydrometeorological Institute
2	Temperature	monthly	1949 - 2022	The places	exposure	Hydrometeorological Institute
3	Hail	monthly	1949 - 2022	The places	exposure	Hydrometeorological Institute
4	Inflation	annual	2005 - 2023	National	sensitivity	NBS
5	Irrigation	annual	2009 - 2020	National Regional	sensitivity	Bureau of Statistics
6	Unemploy-ment	annual	2010 - 2023	National The places	Adaptive capacity	NBS
7	GDP per capita	annual	1995 - 2023	National	Adaptive capacity	Bureau of Statistics
8	Agricultural holdings	annual	2023, 2018, 2012	National The places	Adaptive capacity	Bureau of Statistics
9	Yields	annual	1995 - 2023	National	sensitivity	Bureau of Statistics
10	GDP	annual	2005 - 2023 1995 - 2023	National	Adaptive capacity	NBS Bureau of Statistics
11	GAV Agri-culture	annual	1995 - 2023	National	sensitivity	Bureau of Statistics
12	Poverty	annual	2008 - 2022	National	Adaptive capacity	Bureau of Statistics

Source: *Data processed by the author*

Based on the presentation in table 1, we see that there are available data in the Republic of Serbia for the mentioned parameters of sensitivity, exposure and adaptive capacities. In most cases, these are data for the period from 2010 to 2023, on an annual basis. From the aspect of the territory that is covered, they are based on a national basis, except for the aspect of hydrometeorological data, which are also recorded on the national average, but can also be found by measuring stations in Serbia, while for irrigation, they are formed according to statistical regions. In order to determine the most precise value of the vulnerability index, it is necessary to have fragmented data in the territorial sense, so that as an element of improvement it would mean that the observed parameters such as yield, poverty, irrigation can be observed from the element of districts or municipalities in Serbia.

Conclusion

Climate change today has one of the biggest impacts on the lives of all people, and above all on agriculture. As a result of changes in the weather conditions, the average temperature, there are also changes in the conditions for doing agriculture, an increase in the occurrence of extreme risks that, with their appearance, bring enormous economic damage and can threaten food production. Therefore, the research of the vulnerability of each state and region to climate change is an important segment in the strategy and policy that states and local governments should lead.

In this paper, we presented a theoretical model that is used in research and the formation of an index of vulnerability of agriculture to climate change. At the global level, databases are used by organizations such as FAO, IMF, World Bank, etc., while in the Republic of Serbia, information from national frameworks can be used (Republican Institute of Statistics, National Bank of Serbia, Hydrometeorological Institute and relevant ministries). Based on the review of national databases, we determined that there are parameters that can help in creating a national index of vulnerability of agriculture to climate change. Of course, we can expand the observed base with data from the insurance sector, incurred damages and collected damages. The databases mainly contain data at the national level, but in order to obtain the highest quality index, it is necessary to reduce certain indicators to lower territorial units such as units of local self-governments or districts, which would raise the level of quality of the index that could be obtained.

For further research, it is necessary to expand the base of parameters that would be observed and, by applying the models that are theoretically described in this paper, determine which of the parameters meets the criteria to be applied and finally measure the vulnerability index of the Republic of Serbia. A comparative analysis should also be done with index values that would be obtained by applying data from international databases.

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SECTION II

BIOTECHNOLOGY

TWO MODES IN NUTRITION OF COMMERCIAL ISA BROWN HENS AS FACTOR OF EGG PRODUCTION AND QUALITY

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Abstract

In order to find out effect of hens feeding once and twice daily, on egg production and quality, the experiment was performed on a sample of 120 birds, for 62 days. Two groups of hens were formed, experimental and control, both equalized regard age and egg production. Hens in experimental group were fed once daily, and twice in control group. Differences between groups were not statistically significant for the average feed consumption, egg production, egg size (weight, height, width), inner egg weight and yolk weight (p>0.05). Egg whites weight, as well as the shell weight, was statistically significantly very higher in hens fed twice in a day, compared to those fed once (p<0.01). The weight of egg whites was 38,07 g and 36,27 g in experimental and control group, respectively, while the shell weight was 8,71 g and 8,13 g in same order.

Key words: *feed consumption, egg production, egg quality*.

Introduction

Production of consumer eggs in intensive system of poultry breeding is based on exploitation of high-producing hybrid layers distinguished by a high production potential (Đekić et al., 2012). The breeding of Isabrown (SSL) hybrids is represented in a high percentage in our region due to their

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exceedingly high egg production, strong constitution and good acclimatisation ability (Pandurević et al., 2010). Their potential for the production of consumer eggs depends about 30% on genetic factors, i.e. inherited traits and about 70% on paragenetic factors, i.e. conditions of breeding and technology of egg production (Rajičić et al., 2007; Đekić et al., 2013).

Evidently, one of the most significant factors which intensity of consumer egg production depends on is the nutrition of layers. Feed consumption depends on a number of factors among which the most significant ones are body mass, ambient temperature, energy level and balanced mixture. Both balanced energy and protein in concentrated mixtures along with an optimal content of vitamins and mineral matters and the method of feed distribution have a great effect on egg quality (Leeson and Summers, 2005). An appropriate nutrition regime in intensive system of birds` breeding plays an important role from the aspect of control of body mass and uniformity of flock (Lu et al., 2021), improvement of egg quality (Tolkamp et al., 2005), efficiency of nutrition and profitability of flocks (Olavumi, 2014).

An egg quality is a concept which relates to various standards that define both external and internal traits of eggs. A degree of utilization of eggs by the consumers also depends on these traits (Portillo-Salgado et al., 2020). Fajemilehin (2008) reports that an external quality of egg includes mass, size and shape of egg, as well as an eggshell strength and texture while an internal quality of egg involves the traits related to yolk and white of eggs. According to Pandurević et al. (2015) external traits of the quality of egg include egg mass, egg shape, eggshell colour, eggshell strength, eggshell thickness and eggshell mass. The mass of eggs is the most important trait of external egg quality and depends directly on the way of supplying the feed to the layers (Anene et al., 2023). Internal traits of egg quality are yolk colour, height of yolk, diameter of yolk, mass of yolk, index of yolk, height of white, Haugh units, USDA quality, and blood and meat spots. Some authors report that due to high correlation between some external traits of egg quality (mass of egg, length and width of egg, shape and weight of eggshell) they can serve as indicators of quality of some internal traits of eggs such as mass of yolk and white (Fajemilehin, 2008) what seems to facilitate the assessment of the quality of the internal traits of eggs without having to break them.

Numerous studies conducted worldwide (Herron and Fernandez, 2004; Jones, 2009) refer to the fact that an egg represents a highly valuable foodstuff that contains a high level of nutrients entirely matching the needs of human organism. Đoković et al. (2018) reported that simple culinary preparation and wide availability of eggs on the market along with their low prices compared to the other sources of protein of animal origin like meat and milk make this foodstuff indispensable both for healthy human nutrition and proper development of human organism.

Material and method

The present research was conducted on a hen-layer farm in the vicinity of Kruševac town, Serbia. In the course of the trial Isabrown (SSL) hens were housed in 50x50 cm cages, mounted at three levels. Each cage housed 5 hen layers. The watering was supplied automatically, by means of water nipple drinker while the distribution of food was done manually. Trial period lasted 62 days and included two groups of hens, namely a trial group and a control. Each group included 60 individual birds.

A control group of hens was fed once daily and received in total 7.2 kg concentrate mixture every day in afternoon hours. A trial group was fed twice daily (at 6.00 am and 18.00 pm) with 3.6 kg of concentrate in every diet. A composition of the mixture is shown in Table 1.

Table 1. *Composition of concentrate mixture*

Components of concentrate mixture	Quantity of feed (%)
Corn	61
Soybean meal	10.6
Sunflower meal	8
Exstruded full fat soybean	9
Calcium carbonate	9
Monocalcium phosphate	0.74
Salt	0.4
Vitamin and mineral premix*	1.25

*Composition of vitamin and mineral premix, 1 kg: Vitamin A (1000 UI) – 10000; Vitamin D (1000 UI) – 1500; Vitamin E – 10 mg; Vitamin K – 1 mg; Vitamin B_1 – 2 mg; Vitamin B_2 – 3 mg; Vitamin B_4 – 300 mg; Vitamin B_6 – 1.5 mg; Folic acid – 1.5 mg; Niacin – 50 mg; Met – 100 mg; P – 7 gr, J – 1.4 mg, Fe – 50 mg, Zn – 50 mg, Co – 0.7 mg.

Table 2. *Nutritive value of ration*

Dry Matter, g/day	105.88
Crude Protein, %	15.05
Lysine, %	0.71
Methionine + cystine	0.55
Crude Fat, %	4.03
Fiber, %	2.50
Ash, %	12.61
Calcium, %	3.70
Phosphate, %	0.47
Sodium, %	0.17
ME, MJ/kg	10.40

During a trial period, data on feed consumption and number of eggs produced were recorded every day. Data on feed consumption were defined by measuring the quantity of feed consumed during a trial period on the basis of feed leftovers upon each feeding. On the other hand, the mass, height and width of eggs were recorded at the end of the month. The mass of eggs was measured on a digital scale while the height and width of eggs were measured by Vernier caliper. An internal quality of egg was analysed by means of different parameters such as mass of eggshell, mass of white and mass of yolk. The masses of white and yolk, separated by sepator, and the mass of eggshell were both measured on a digital scale.

Data statistical analysis

During the procedure of data statistical processing the indicators of descriptive statistics (arithmetic mean, standard deviation, coefficient of variation) were being determined. Statistical data processing was done by means of a PSPP (https://www.gnu.org/software/pspp/ computer software, accessed on 15.6.2024.). The estimation of statistical significance of differences of mean values was done by a Student t – test. Statistical significance was determined at $p<0.05$ and $p<0.01$ levels of significance.

Results and discussion

The average food consumption and average egg production during trial period are shown in Table 3.

Table 3. *Average feed consumption and average egg production*

Indicators	N	One distribution of feed			Two distributions of feed			p
		$\bar{X}$	SD	CV	$\bar{X}$	SD	CV	
Feed consumption	60	6.39	0.32	5.00	6.43	0.25	3.89	0.398^{ns}
Egg production	60	55.97	2.64	7.72	56.47	2.45	4.32	0.277^{ns}

SD – standard deviation; *CV* – coefficient of variation (%); *ns* – non- significant.

On the basis of the results shown in Table 3 it can be said that feed consumption in layers fed twice a day was higher by 0.04 kg in comparison with the layers fed once a day but these differences were not statistically significant. Saibaba et al. (2021) reported, on average, a smaller volume of feed consumption by 11.7 % in Leghorn breed layers fed twice a day in relation to a control group. The research conducted by Anene et al. (2023) showed that different regimes of nutrition of layers can improve feed consumption and egg quality. However, an increased volume of feed consumption is not necessarily connected with higher egg production (Lacin et al., 2008). Some studies show that greater volume of feed consumption and varying of daily feed consumption in layers can negatively affect both a uniformity of flocks and external and internal parameters of egg quality (Parkinson et al., 2015).

The average egg production in trial group of layers was about 1 % higher compared to the control group (Table 3). These differences were not statistically significant. In certain studies the production of eggs in the same hybrid was similar regardless the differences in feed consumption (Ahsan-ul-haq et al., 1997; Anene et al., 2021). Some other studies show that restrictive nutrition during the first 40 weeks of age can decrease egg production by 3.6 %. However, in older age, such nutrition can increase the egg production by 0.7 % (Saibaba et al., 2021). A major factor of production costs in intensive production of consumer eggs seems to be the nutrition of layers while profit in this production is being determined both by a volume of feed consumed, number, size and quality of eggs, and health state and concerns regarding birds welfare (Anene et al., 2023). Table 4 shows average values of external and internal indicators of quality of eggs in examined groups of layers.

Table 4. Egg quality indicators

Indicators	Control group		Trial group		p
	$\bar{X}$	SD	$\bar{X}$	SD	
Egg mass, g	62.32	4.06	62.70	6.24	0.690^{ns}
Egg height, mm	56.60	1.84	57.13	2.11	0.143^{ns}
Egg width, mm	44.53	1.24	44.85	1.81	0.266^{ns}
White mass, g	36.27	3.69	38.07	4.95	0.026**
Yolk mass, g	16.73	1.33	16.33	1.57	0.134^{ns}
Eggshell mass, g	8.13	1.11	8.71	0.88	0.002**

SD – standard deviation; *ns* – non- significant. **($p<0.01$)

By analysing the data (Table 4) it can be seen that in the majority of egg quality indicators there was no statistically significant differences between analysed groups of layers except in the case of mass of egg white and mass of an eggshell ($p<0.01$). The average egg mass in studied groups of layers was approximatelly the same (62.32 : 62.70 g), the differences being no statistically significant. Similar results were obtained also by Anene et al. (2023) who reported almost the same average masses of eggs in control and trial groups of layers (64.5; 64.6 g). The studies carried out by some authors indicate the fact that restrictive nutrition in layers older than 50 weeks can have a positive effect both on production and internal quality of eggs (Saibaba et al., 2021). However, the same authors determined that average mass of eggs of trial group of layers was lower by 4.2 grams compared to control group.

The average values for the height and width of eggs were 0.53 mm higher in layers fed twice a day i.e. 0.32 mm in relation to layers fed once a day (Table 4) but these differences were not statistically significant. In the research conducted by Anene et al. (2023) almost identical values for the height of eggs were determined in analysed groups of layers (56.8; 57.1 mm) an increase in the width of eggs in trial group of layers being determined (50.1 mm) in relation to the control group (44.7 mm).

The average mass of egg white in layers fed twice a day was 60.71% of total internal mass of egg, i.e. 58.20% in layers fed once a day (Table 4). It indicates the fact that the mass of white in layers trial group was on average 1.8 grams higher compared to control group. These differences were statistically very significant ($p<0.01$). Similar results were also attained by other authors who determined that all the parameteres of indicator of quality of egg white were higher in layers fed twice a day in comparison with the layers fed once a day

(Anene et al., 2023). These authors suggest that average mass of egg white in trial group of layers was 62.1 % of an internal mass of egg, i.e. 40.1 gram what is by 0.6 grams higher in relation to control group. However, differences were not statistically significant. Many authors suggest that control of volume of feed consumption in layers can stimulate production of eggs that have better quality of egg white (Anene et al., 2021; Moreira et al., 2012; Ahsan-ul-haq et al, 1997).

The results of the research show that average mass of yolk of control group of layers was 16.73, and of trial group 16.33 grams (Table 4). These differences were not statistically significant. A smaller mass of yolk indicates greater egg compactness while greater mass of yolk can be connected with an increased accumulation of fats in the layers body or deposition of fatty substances in the yolk (Anene et al., 2023). The above mentioned group of authors determined that layers fed twice a day have smaller mass of yolk compared to layers fed once a day (14.5; 15.0 g). Similar results were obtained also by Akter et al. (2018) who determined that layers fed once a day in the age over 50 weeks had greater mass of yolk in relation to the layers on a restricted diet. The research showed that greater mass of egg is not often a consequence of higher volume of feed consumption but the result of an increased depositing of lipids in yolk what leads both to the increased mass of yolk and mass of egg (Li et al., 2011).

The average mass of eggshell in layers fed twice a day had a greater mass by 0.6 grams in relation to control group (Table 4), obtained differences being statistically significant ($p<0.01$). It indicates the fact that the treatment of feeding twice a day had a positive effect on eggshell mass. The results obtained are not in harmony with the results obtained by Anene et. al, 2023. These authors determined approximatelly the same mass of eggshell in analysed groups of layers (6.8; 6.7), while mentioned difference was not statistically significant.

Conclusion

The results of the research conducted indicate that alteration in the model of nutrition from feeding once daily to feeding twice daily did neither more significantly impact the volume of feed consumed nor the number of produced eggs. However, two distributions of feed resulted in significantly greater mass of egg white what indicates better utilisation of nutritive matters in a diet. It is a significant indicator of the fresshness and quality of eggs. A greater mass of eggshell in trial group of layers represents an important parameter of egg quality since greater thickness of eggshell increases the egg breaking resistance and increases their commercial value. The results of the research can serve as the basis for optimising egg productivity and profitability. The analysis of data of this research provides a possibility to determining the trends connected with feed consumption through better conversion and more efficient increase of some indicators of egg quality.

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PERMACULTURE AND REGENERATIVE AGRICULTURE

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Abstract

This paper examines the concepts of permaculture and regenerative agriculture, highlighting their importance for sustainable agriculture and environmental conservation. Definitions and fundamental principles of permaculture and regenerative agriculture are discussed, as well as methods of implementing these practices in various ecological and social contexts. The paper addresses the benefits of permaculture and regenerative agriculture, such as improving soil health, increasing biodiversity and reducing negative environmental impacts. A case study demonstrating the success of permaculture and regenerative agriculture systems in a community is also presented. The conclusions emphasize the need to adopt integrative and collaborative approaches to promote a sustainable future through these two alternatives for traditional agriculture.

Key words: *permaculture, regenerative agriculture, sustainable, soil.*

Introduction

At a time when industrial agriculture is increasingly criticized for its negative impact on the environment and intensive consumption of resources, permaculture and regenerative agriculture have gained wider recognition as viable and sustainable alternatives. These concepts, originally emerging as sustainable farming methods, have expanded into a complex design system that aims to create harmonious human ecosystems, inspired by natural interactions and designed to function regeneratively over the long term. At the heart of permaculture and regenerative agriculture is the idea of creating systems that meet current needs without compromising the resources needed by future generations.

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As issues related to climate change, biodiversity degradation and soil depletion become more pressing, regenerative agriculture and permaculture offer an approach that integrates agriculture, water management, renewable energy and building sustainable communities. Although these principles are attracting increasing interest, the coherent implementation of regenerative agriculture and permaculture often faces challenges such as, resistance to change in conventional communities or lack of knowledge.

In a world where regenerative agriculture and sustainability are becoming necessities and not just options, permaculture offers a way to redefine human's relationship with nature. This paper aims to explore the principles of permaculture and regenerative agriculture, highlight their importance for the development of a sustainable agriculture and present a medium-scale regenerative farm, holistically designed and founded on the principles of regenerative agriculture and permaculture.

Defining and substantiating the concept of permaculture and regenerative agriculture

Permaculture is a system of agricultural and social design principles focused on mimicking and harnessing the patterns and characteristics found in natural ecosystems (Bill Mollison and David Holmgren, 1978, pp. 2-10). Also, Permaculture promotes restoring environmental balance by applying ecological principles in practical ways. Moreover, permaculture combines principles of ecology and geography with careful observation and intentional design (Ferguson et al., 2014, pp. 251-274). It integrates every aspect of human environments and cultures—urban and rural alike—alongside their effects at both local and global scales. At its core, permaculture embraces earth care ethics, recognizing that sustainable land use is inseparable from lifestyle choices and broader philosophical values.

According to the one of the founders of permaculture, David Holmgren, (2002, pp.16-121), there are 12 principles.

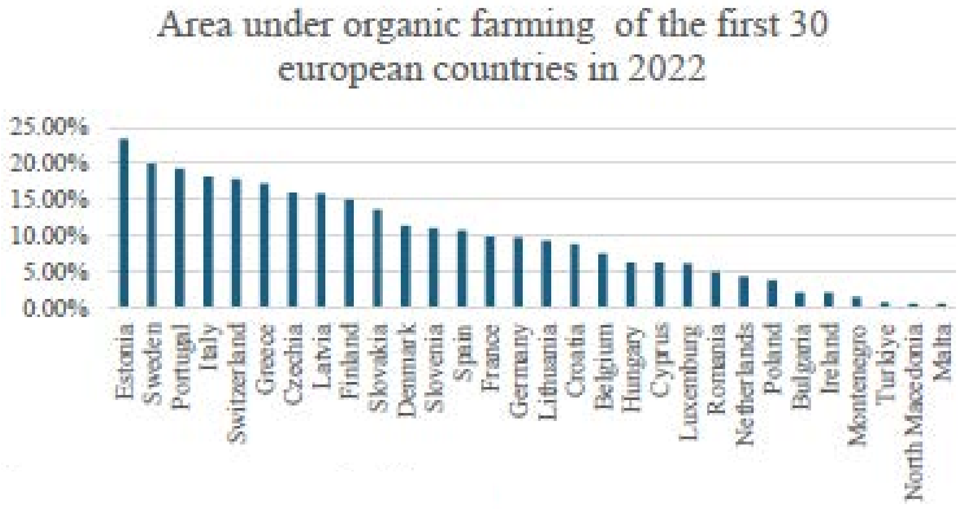
Picture 1. The 12 principles of permaculture

Source: *own representation*

Regenerative agriculture is a sustainable approach to agricultural practices that focuses on improving and restoring agricultural ecosystems. This model integrates techniques designed to promote soil health, biodiversity and natural cycles, helping to regenerate natural resources damaged by conventional agricultural practices (Newton et al. 2020).

So, permaculture is a holistic design philosophy and regenerative agriculture is a style of farming. Both have similar aims and are two green alternatives for conventional agriculture.

Chart 1. *Analysis of organic farms from the total agricultural area*



Source: *own representation after Eurostat*

The country with the most organic farming area is Estonia with 23,42% of the total of agricultural area. The next four countries are Sweden (19,94%), Portugal (19,31%), Italy (18,14%), Switzerland (17,87%). These percentages are proof that sustainable agriculture is an alternative to conventional agriculture, but it is at the beginning of implementation.

In the graphic from above, is stressed that there is a huge lack of sustainable agriculture knowledge or the resistance to change in conventional communities. This might be the reason why a lot of countries have less than 10% of organic farming from the total agricultural area.

In Eurostat Database is no information about regenerative agriculture, perhaps because it is a new style of farming.

There is a difference between organic and regenerative farming. Both conserve and improve soil health, eliminate the synthetic chemicals, promote biodiversity, long-term sustainability, integrated pest management. But, the main aim of the regenerative agriculture is to regenerate actively the ecosystem, not just on avoiding its damage (Leu, 2020).

The advantages of permaculture compared to traditional agriculture

- Conservation of natural resources

Permaculture encourages the rational use of resources such as water and soil through methods, such as composting and rainwater harvesting. These techniques help maintain soil health and reduce dependence on external resources (Whitefield, 2005, pp. 1-37). Although the conventional agriculture uses chemical fertilizers and pesticides to increase production, the permaculture relies on natural methods.

- Ecological Diversity

Permaculture systems are designed to integrate a variety of plants and animals, which increases biodiversity and ecosystem resilience. This not only protects against pests and diseases, but also supports pollination and improves soil quality. Traditional agriculture, especially industrial agriculture, is often based on monoculture, which reduces ecological diversity and makes systems more vulnerable.

- Healthy Food Products

Products grown using permaculture methods are often healthier, due to the absence of chemicals and the diversification of crops (Nishant, 2023). This can lead to better nutrition for consumers. In addition, permaculture encourages local consumption, which reduces the carbon footprint associated with transporting food.

- Low Ecological Impact

Permaculture has a lower ecological impact because it encourages environmentally friendly production methods. For example, using beneficial insects for pest control and incorporating perennials instead of annual crops helps maintain ecological balance. In contrast, conventional agriculture can lead to soil and water pollution through the excessive use of chemicals.

- Improving Local Communities

Permaculture supports the development of local communities by encouraging community farming and resource exchanges. This promotes social cohesion and the active participation of citizens in the management of local resources. Traditional agriculture, especially industrialized agriculture, can lead to the centralization of resources and reduced economic opportunities for small farmers.

- Capacity to Adapt to Climate Change

Permaculture systems are designed to be more resilient to climate change by integrating multiple layers of vegetation and using perennial plants that require less water. Traditional, monoculture-based agriculture is often more vulnerable to climate extremes such as droughts or floods.

Permaculture offers a viable and efficient alternative to traditional agriculture, having a positive impact on the environment, human health and communities. By integrating diversity and using resources in a sustainable way, permaculture contributes to the creation of resilient and sustainable agricultural systems.

The advantages of regenerative agriculture compared to traditional agriculture

- Improving soil health

Regenerative agriculture focuses on restoring soil quality through practices that promote structure, fertility and organic matter content. Through methods such as mulching, crop rotation, and composting, the soil becomes healthier and better able to retain water and nutrients. Conventional agriculture, on the other hand, degrades the soil through monoculture, use of synthetic fertilizers and intensive plowing, which lead to erosion and loss of water retention capacity.

- Carbon capture and storage

Regenerative practices such as controlled grazing and the use of perennial plants help the soil capture and store carbon dioxide from the atmosphere. This contributes to reducing greenhouse gas emissions and combating climate change.

Conventional agriculture constantly releases carbon into the atmosphere through deforestation, intensive plowing and fertilizer application, thus contributing to global warming.

- Increasing biodiversity

Regenerative agriculture promotes a diverse ecosystem by integrating plants, animals and insects, creating a healthy environment that is resistant to pests and diseases (O'Donoghue et al., 2022). This reduces the need for pesticides and chemical fertilizers.

Conventional agriculture tends to limit biodiversity, favouring monocultures that are more vulnerable to pests and require more chemical interventions.

- Efficient use of water resources

Regenerative practices improve the soil's ability to retain water, thereby reducing the need for excessive irrigation. Soil rich in organic matter can retain more water, protecting crops during periods of drought.

In conventional agriculture, impoverished soil requires intensive irrigation, and water loss through evaporation and nutrient runoff is significantly higher, resulting in inefficient water use.

- Resistance to extreme climatic conditions

Healthy soils rich in organic matter, specific to regenerative agriculture, help crops to be more resistant to climate change, such as drought or flooding.

Conventional farming, based on intensive techniques, makes crops more vulnerable to such extreme conditions, as the soil is often degraded and lacks the natural structure that can cushion these effects.

- Long-term economic sustainability

Regenerative agriculture reduces reliance on expensive inputs such as fertilizers and pesticides through natural practices that reduce long-term expenses. In addition, healthy soil ensures constant and long-term productivity.

Conventional farming requires continuous investment in chemical inputs and intensive technologies, which increases costs and reduces farmers' long-term financial sustainability.

Case study - the first regenerative farm called "Soil and Soul" from Romania

"Soil and Soul" is a medium-scale regenerative farm, holistically designed and founded on the principles of regenerative agriculture and permaculture. It has 6 hectares consisting of:

- 10,000 square meters of vegetables grown in the field in a biointensive system;
- 10,000 square meters of large culture;

- 5,000 square meters of pasture in a holistic management system;
- 2,500 square meters of protected space (caterpillar solariums and tunnels);
- 300 square meters' greenhouse for the production of ecological seedlings;
- 7,000 square meters of mixed orchard interspersed between vegetable soils with a role of production, forest cover and habitat creation to increase biodiversity;
- 4,000 square meters of protective forest curtain on the property's contour;
- 350 square meters of multifunctional agricultural hall;
- Gray water collection and treatment system;
- Residential Education Center and event space;
- 1,000 square meters camping area;
- 1,000 square meters of pond for collecting water for irrigation, creating a microclimate and habitat, increasing biodiversity and ensuring the farm's water supply in the long term in case of drought;
- 200 square meters of pond for the capture, filtration and biological treatment of rainwater from the roofs of the structures, as well as gray water from the living space and that for conditioning and washing vegetables.

"Soil and Soul" produces vegetables in organic regenerative system which means that:

- do not use synthetic chemicals – they spray with extracts and oils from beneficial plants, algae, bacteria and fungi;
- treat soil as a living organism and apply techniques to increase natural soil fertility and activate soil microbiology as the primary source of fertility – don't plow or turn the furrow;
- feed the soil first and then the plants by continuously adding compost and green manure;

- use biodiversity as a disease and pest control tool;
- use innovative tools and equipment that increase the efficiency of work and the quality of life of the farmer.

Community Supported Agriculture is a form of partnership and solidarity between consumer and producer. The consumer buys part of the harvest in advance and the farmer can thus cover production costs and make initial investments without resorting to bank loans, to concentrate on crop care. The consumer's commitment to pre-purchase part of the crop over a long period of time provides the producer with a context of safety in production and investment, mitigating risks on both sides.

The sharing of risks and benefits between producer and consumer is an intrinsic characteristic of the Community Supported Agriculture model. Depending on the weather, climatic conditions, the pressure of diseases, pests or other reasons (from the long list of risks in agriculture) "Soil and Soul" cannot guarantee that the vegetables will be delivered exactly according to the crop plan. It is possible that in some weeks the variety of vegetables in the basket will decrease, in which case they will compensate with quantities (less varieties, more quantities) or with other extra products compared to the subscription offer.

Occasionally, customers will have vegetables in the basket with an imperfect appearance, slightly stained or attacked by pests but with the same taste and freshness. "Soil and Soul" will do this to reduce food waste and ensure variety at the basket. They will notify the customers each time by email about this.

There are certain times of the year when customers` baskets will be smaller (variety and quantity), depending on natural cycles, the transition between seasons and the pressure of risk factors. In this case the organic farm will compensate by adding additional products to the other baskets or by delivering an additional basket at the end of the season.

On the other hand, in cases where production and distribution go according to plan and there are times of abundance, customers` baskets will be more generous.

Conclusion

The "Soil and Soul" farm illustrates how regenerative agriculture and permaculture can transform the way we understand food production and our relationship with the environment. By adopting sustainable and ecosystem-friendly agricultural practices, this farm manages not only to produce healthy food, but also to contribute to soil regeneration and the preservation of local biodiversity. "Soil and Soul" demonstrates that a farming model based on ecological principles can be both economically and ecologically viable, serving as an inspirational example for other farms and communities. In a world where the impact of climate change and resource depletion are increasingly evident, regenerative agriculture and permaculture offer lasting solutions, and examples like the "Soil and Soul" farm show that a sustainable future in agriculture is possible and achievable.

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GENETICALLY MODIFIED CROPS IN THE CONTEXT OF FOOD AND CLIMATE CRISES: A BIOTECHNOLOGICAL SOLUTION FOR SUSTAINABILITY

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Abstract

New possibilities in agriculture have been accessible by biotechnological engagement with crop development. Biotech-agriculture is essential to achieving the goals set by the Millennium Development Goals of the Sustainable Development Agenda. By reducing the losses and boosting results while using fewer pesticides, biotech crops have already made a small contribution to guaranteeing food and nutrition security. Some of the main issues facing agriculture based economies brought on by climate change projections, crops will face more abiotic stress-related difficulties as a result of rising greenhouse gas emissions, environmental aridization, abrupt and frequent temperature swings, and altered rainfall patterns in both space and time. In order to overcome obstacles and meet the food needs of the world's growing population, which is predicted to reach 9 billion people by 2030, we must create and employ biotech crops that can reduce the negative effects of climate change, make them resilient to harsh environmental conditions, address to concerns and non-issues brought up by non-governmental organizations, and inform the general public about the advantages of biotech crops.

Key words: *agriculture, climate, stress, temperature, resilience.*

Introduction

Genetically Modified Crops are an important biotechnological perspective to promote food security and agricultural sustainability in the current global environment and climate change significantly strain agricultural resources. These crops are designed to increase agricultural productivity without ne-

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cessitating the expansion of agricultural land and to be more resilient to unfavourable factors like pets and drought. The Food and Agriculture Organization (FAO) states that the sustainable intensification of agriculture through biotechnology, which permits more economical use of resources and less environmental impact, is one of the key answers to the world food issue.

Vulnerable areas are especially affected by recurring food crises and climate instability. Genetically Modified Crops provide a calculated way to guarantee a steady supply of food while protecting ecosystems from unchecked agricultural growth. For instance, a study shows how genetically engineered crops, such as corn and cotton, have drastically decreased the usage of pesticides in nations like U.S., preserving soil health and lowering water pollution.

In order, to meet the food and clime challenges of the 21st century, genetically modified crops are thus becoming an essential part of a flexible and resilient agricultural system.

What is Genetic Modified Crops and how is it done?

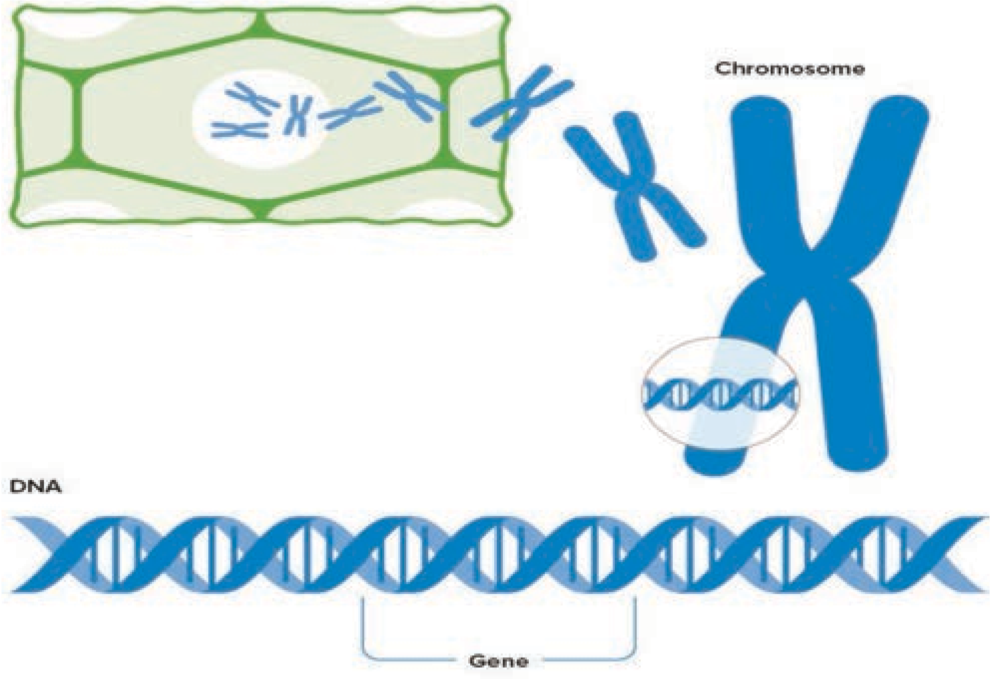
The process of making genetically modified crops involves inserting DNA into an organism's genome. To produce a genetically modified plant, the new DNA is transferred to the plant cell. Typically, cells are grown in tissue cultures where they will be developed as plants. The crops produced by these plants have the ability to gain the new DNA.

The characteristics of all living organisms are determined by their genetic structure and interaction with the environment.

An organism's genetic structure is represented by its genome, which is comprised of DNA in every plant and animal. The genome contains genes, region of the DNA that carry the protein preparation guide. For instance, genes that carry the guide for manufacturing te proteins needed to produce the pigments that colour petals influence de colour of flowers.

Adding a specific piece of DNA to a plant's genome to give it new or modified characteristics is known as genetic modification. This may involve the plant's gowth pattern or providing disease resistance. The new DNA is incorporated into the genome of the genetically modified plant, wich is found in the crops that these plant generate.

Figure 1. *The relation between DNA, genes and Chromosomes*



Is consuming genetically modified crops safe?

The fact that a crop is genetically modified does not prove that it is unsafe to consume. Every crop that has a new trait added by genetic modification is closely examined since there may be dangers connected to the particular new gene. There has been no proof of any negative consequences associated with consuming any approved genetically modified crop since the first large-scale commercialization of genetically modified crops produced eighteen years ago.

A variety of tests must be finished before any food made with genetically modified method is allowed to be sold. The authorities in charge of evaluating the safety of every new genetically modified product take into account the findings of these experiments. Certain food created with this technology have been linked in a few studies to harm the people health or animals. The specific gene inserted into the crop or related agricultural practices, including pesticide treatments, were the subject of the accusations rather than the genetic modification process itself.

The intervention of biotechnology:

Contributed to the open development of agricultural technologies to enrich it. Biotechnology crops have contributed a lot and very well to ensuring nutritional and food security, modestly achieving their security by reducing growth losses. A productivity, with a reduced consumption of pesticides that are not good or healthy to anyone. These cultures can contribute vigorously to address the economic challenges based on agriculture created by negative or positive changes in the world's climate. Globally, the projections that change the climate most likely show that the concentration of greenhouse gases will increase greatly temperature fluctuations to appear suddenly and frequently in the spatial and temporal distribution of precipitation to be extremely disturbed in the future, all of these will produce quite high stress for crops.

To combat these challenges and to meet the food needs of the population of the whole world everywhere which is growing, the biotechnological culture must be developed densely to mitigate the climate change which is negative in favor of crops, or to develop biotech crops that are resistant to random climatic changes to combat adverse environmental conditions.

The benefits of biotechnology crops are:

1. A great resistance to diseases, the plants have been genetically modified, they can withstand much longer the attacks of insects that can wreak havoc on normal crops, reducing the use of chemical pesticides,

2. A high improvement in nutrition. More vitamins and minerals that are essential for us a high forte growth.

3. A great reduction of the devastation of the environment, through a reduction of chemical fertilizers, the biotechnical culture can contribute in a friendly way to the environment.

On the other hand, these biotechnologies can also have negative effects on everything that involves the environment and people. There are some that talk about:

1. Genetically Modified Crops can have effects on local ecosystems by reducing biodiversity. For example, crops that are modified to resist pests can affect non-target organisms, such as beneficial insects or pollinators, which play an essential role in the ecosystem. In addi-

tion, widespread cultivation of genetically modified crops can lead to "genetic pollution" where genes spread to wild or unmodified plants through cross-pollination. This genetic contamination could lead to the loss of genetic diversity of plant species, affecting the resilience and adaptability of ecosystems.

2. Genetically modified crops are often designed to be resistant to certain herbicides, allowing farmers to control the overgown grass. However, excessive use of these herbicides can lead to the emergence "super-damagers" resistant to herbicides and pesticides used on genetically modified crops. This resistance can, over time, increase the amount of herbicides and pesticides needed, undoing the initial benefits of genetically modified crops and contributing to soil and water pollution, and the increase in costs for farmers.

3. The adoption of genetically modified crops often involves buying patented seeds from certain biotech companies, sometimes annually, because the seeds can be "terminal seeds" that do not produce viable offspring. This dependence can create economic pressures on small-scale or low-income farmers, who may have difficulty allowing themselves these costs year after year. In addition, some farmers have reported loss of traditional farming practices and control over seeds, which may affect cultural farming practices.

Where are this genetically modified crops consumed?

Soybeans and corn, the two principal genetically modified crops, are mostly used to feed animals. People in many nations, consume meat, milk and eggs from animals grown on modified crops. Additionally, as lot of processed foods consumed worldwide, such as cooking oils and other additives, contain modified seeds.

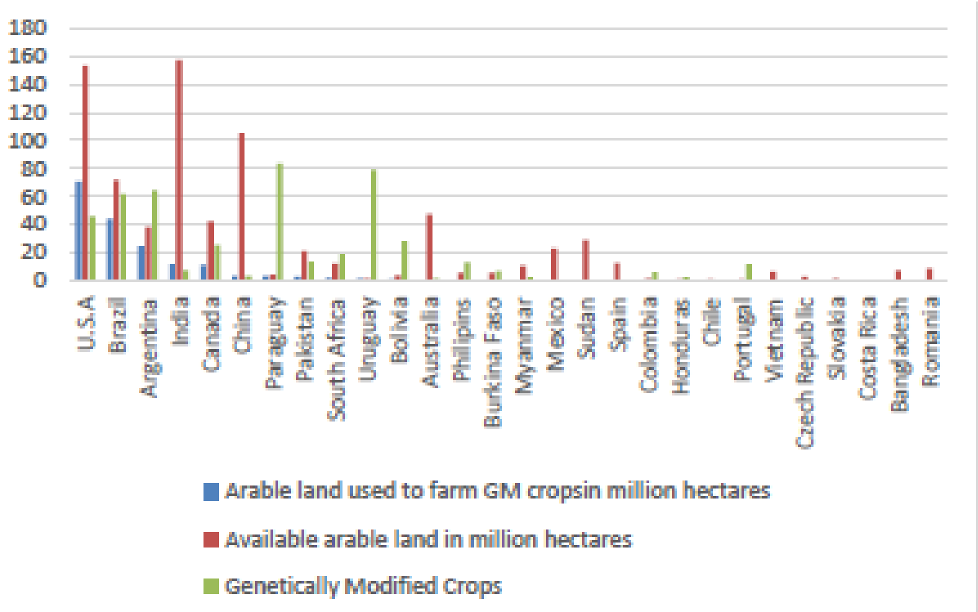
Globally, there are different levels of genetically modified crop consumption. For example, approximately 70% of the soy used in Europe is imported and more than 90% of it is made from genetically engineered soybeans.

Which genetically modified crops are being grown and where?

These modified crops were cultivated on 179.7 million hectares, or more than 10% of the world's arable land, in 28 countries by 2015. The top producers are Argentina, Brazil and the United States.

In the same year, soybeans represented 92.1 MHa (million hectares) of all modified seeds cultivated, followed by maize (53.6 MHa), cotton (24 MHa), oilseed rape (8.5 MHa). This contributes to 75% of global cotton production and 83% of global soybean production. Nearly a quarter of the world's oilseed rape that year and 29% of the world's crop of maize were made of modified technology.

Figure 2. *Countries that use the Genetically Modified Crops technology and their surfaces*



Intervention of biotechnology in Medical Care

Challenges for the intervention of biotechnology in the field of health for the best possible economic evaluation. The intervention of biotechnology in medical assistance represents one challenge, if not more challenges that must be addressed regarding the economic evaluation in order to be of a good kind.

Some of the key challenges would be:

- Medical costs that are high in addition to its financing. The development of biotechnological solutions such as new medicines and medical devices that require high investments.

- The high costs associated with research studies but also their development, and clinical studies which are a huge significant barrier. regulated obstacles: ensuring compliance with various international and national regulations can be expensive and require a lot of time and effort.

-Biotechnological interventions, which in particular require involvement in genetic modifications or stem cell research, among others they often have a confrontation with an ethical and social control and not finally the acceptance of the public everywhere, have an impact on the adoption of biotechnological innovations as well as financing

Industrial biotechnology

While the adoption of GM technology requires careful consideration of ethical, environmental, and socio-economic aspects, its advantages in promoting sustainable agriculture are evident. Moving forward, a coordinated approach—grounded in sound science, transparent regulation, and international collaboration—will be essential to harness the full potential of GM crops. By integrating biotechnological innovation into our food systems, we can advance toward a future where agriculture can sustainably meet the nutritional needs of a growing global population while preserving the planet's ecosystems for generations to come.

Another vital sphere is that of bioplastics – that type of plastics which is produced from the raw materials of biological origin such as starch or cellulose – corn starch, plants or certain species of algae. These are eco-friendly alternatives to aggressively made petroleum plastics, as they can decompose naturally.

Enzymes are essential proteins that accelerate numerous useful and beneficial chemical reactions in the body and are used widely across different industries. Some for example enzymes are applied in the food sector for improvement of fermentation processes in food preparation, in the textile sector during nyfiber processing and in the detergent sector for better washing effectiveness.

One such area where the implementation of industrial biotechnology is concentrated is bioremediation: the application of microorganisms to remove environmental contaminants such as soils and waters contaminated with toxic chemicals. This would aid in recovering an ecosystem that has been impacted by such types of pollution.

Conclusions

In order, to address pressing problems with food security and climate change, these genetically modified crops present an achievable path to a more resilient and sustainable agricultural system. Genetically engineered crops help create a food production system that is efficient and environmentally responsible by increasing crop productivity, decreasing reliance on chemical inputs and building resilience to environmental challenges like pesticides and drought.

The benefits of these crops In adv"ncin' sustainable agriculture necessitates careful consideration of environmental and socioeconomic factors. To fully realise the promise of genetically modified crops in the future, a concerted strategy based on solid science, open regulation and international cooperation will be necessary. We can move closer to a dat when the agriculture can sustainably supply the nutritional requirements of a growing world population while protecting the Earth's ecosystems for future generations by incorporating biotechnological innovations into our food systems.

Acknowledgments

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EXAMINING THE MULTISCALE INTERRELATIONSHIP BETWEEN ETHANOL AND AGRICULTURAL COMMODITIES[1]

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Abstract

This paper investigates the multiscale interdependence between ethanol and three agricultural commodities—corn, wheat, and soybeans—used as feedstock for ethanol production. Two wavelet approaches are applied in the analysis: wavelet coherence and wavelet cross-correlation. The first method reveals the strength of the connection, while the second indicates the leading (or lagging) interconnection between assets. According to the wavelet coherence results, the link between ethanol and agricultural commodities is relatively weak in the short term but progressively strengthens as the time horizon increases. In the short-term horizon, the strongest link is observed between ethanol and corn. Wavelet cross-correlation indicates that the short-term connection is only relevant for ethanol and corn due to their relatively strong short-term relationship. Conversely, all long-term interdependencies are relevant since strong correlations are found at higher wavelet scales. According to the results, larger agricultural markets tend to lead the smaller ethanol market in most cases.

Key words: *ethanol, multiscale interlink, wavelet methodologies.*

Introduction

Global warming and CO_2 emissions are pressing global challenges, with biofuels seen as a viable path toward a sustainable energy future. However, because biofuel production relies on organic materials and agricultural commodities that also serve as essential food sources for both humans and animals, it is intricately linked to

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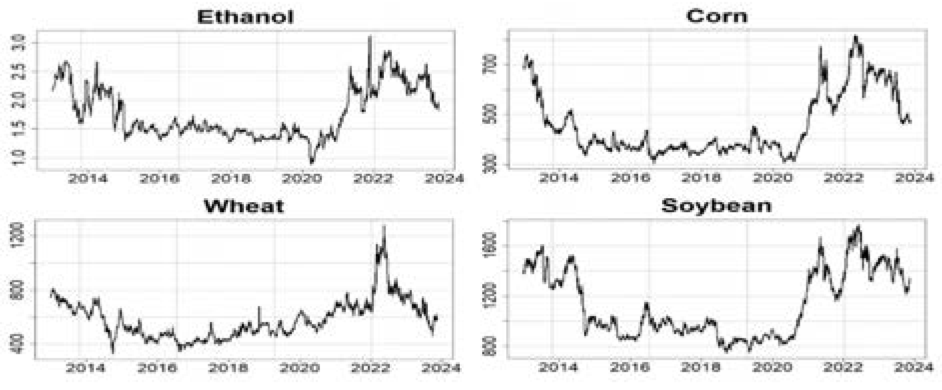
the agricultural sector (Sarmiento et al., 2012). Ethanol, in particular, stands out as a major renewable energy source derived from biomass, making its relationship with agricultural commodities inevitable.

Understanding the connection between ethanol and agricultural prices is essential for several reasons. First, this close relationship affects the volatility of agricultural prices; fluctuations in biofuel demand can lead to price changes in the agricultural sector (Wu et al., 2023). Second, farmers' incomes are influenced by crop prices, and any shifts in the demand for crops used in ethanol production can directly impact their profitability (Leonardo et al., 2015). Additionally, agricultural investors must account for biofuel demand trends, as these influence crop prices and, consequently, inform decisions on resource allocation and risk management. Increased demand for crops in ethanol production also drives changes in farming practices, as noted by Lundberg et al. (2023). Consequently, understanding ethanol impact on agricultural commodities enables farmers to make informed choices about crop planning and production levels, manage risks through hedging and crop insurance, and explore diversification opportunities that may enhance income stability.

Based on the above, this study aims to determine the strength of the interdependence between ethanol and three agricultural commodities—corn, wheat, and soybeans—used as feedstocks in ethanol production. Figure 1 displays the empirical price dynamics of ethanol and these three agricultural assets over a period of more than 10 years. The similarity in their price movements suggests that a relatively strong correlation may exist between ethanol and these grains.

Figure 1. *Empirical dynamics of four commodities*



Note: The price of ethanol is in USD per gallon, while corn, wheat and soybean are in USD cents per bushel.

Source: *Author's calculation.*

The analysis utilizes a multiscale framework, enabling the assessment of correlation strength across multiple time horizons. This approach is essential as different stakeholders – speculators, farmers, traders, portfolio managers, and policymakers – have varying time preferences. For example, market participants who seek profits from price volatility prioritize short-term interdependencies, while farmers and commodity traders, who aim to mitigate price risk, find long-term relationships more valuable for their hedging strategies.

This study applies two advanced wavelet-based methodologies: wavelet coherence (WTC) and wavelet cross-correlation. WTC captures the strength of interdependence across both time and frequency domains, visualized on a color-coded surface map, though it lacks precise numerical values for coherence (Singh et al., 2022). On the other hand, wavelet cross-correlation provides insights into leading and lagging relationships among assets across different time frames. Identifying lead-lag connections can aid in forecasting, as a leading asset may signal changes in a lagging one. By combining these methods, a well-rounded perspective of the interdependence between ethanol and its agricultural feedstocks emerges.

Regarding existing literature, Bilgili et al. (2022) analyzed the interdependencies between corn and ethanol in the U.S. using wavelet analysis. They found that the connection between ethanol production and corn prices exists over both short and long terms; specifically, since 2010, increases in corn prices have been followed by increases in ethanol production in U.S. markets. Tanaka et al. (2023) examined whether ethanol production strengthens the link between energy and food prices using a DCC-GARCH-MIDAS model and wavelet coherence approach. Their findings revealed positive linkages between ethanol-crude oil, crude oil-corn, and ethanol-corn, indicating that dynamic correlations between ethanol and corn can influence ethanol production across short and long horizons. Subramaniam et al. (2020) assessed the impact of biofuels on food security across 51 developing countries using a dynamic generalized method of moments, concluding that the link between environmental quality and biofuels significantly enhances food security. Finally, Guo and Tanaka (2022) explored interrelations among ethanol, gasoline, and corn markets, specifically examining wholesale and producer prices. By applying the spillover index and partial wavelet coherence methods, they observed that ethanol and gasoline prices are positively correlated with corn prices in the short term.

Material and methods

Wavelet coherence

The initial method employed to analyze the connection between ethanol and agricultural commodities is wavelet coherence. This approach offers localization in both time and frequency, enabling us to observe how the relationship between two-time series changes across various time scales. Unlike Fourier-based methods, wavelet coherence can detect nonlinear connections between time-series, capturing nuances that might otherwise be overlooked (Hung, 2022). Given that our dataset spans a substantial time period with frequent outliers and extreme values, the wavelet approach is especially suitable due to its robustness against noise. The squared wavelet coherence is calculated as shown in equation (1):

$$R^2(u,s) = \frac{\left|S\left(s^{-1}W_{xy}(u,s)\right)\right|^2}{S(s^{-1}|W_x(u,s)|^2)S\left(s^{-1}\left|W_y(u,s)\right|^2\right)}, \quad (1)$$

whererepresents a smoothing operator and *s* indicates wavelet scale. The squared wavelet coherence coefficient ranges $0 \le R^2(u,s) \le 1$, where values near zero point to weak correlation, while values near one indicate to strong correlation.

Wavelet cross-correlation

Wavelet cross-correlation further enriches the analysis by identifying which asset leads and which lags across different time horizons. This insight is particularly valuable for short-term investors, as it helps them understand the origin and direction of market shocks (Živkov et al., 2023). While this method also examines two time series, it incorporates the lagged correlation function (ρ_τ) with lag τ, enabling the construction of a symmetric lagged correlation profile ($\rho_\tau = \rho - \tau$). Symmetry is disrupted when significant deviations arise between $\rho_\tau$and $\rho - \tau$, introducing asymmetry in the information flow. In cases of asymmetry, the leading asset demonstrates predictive power over the lagging asset. Based on Gencay et al. (2002), the MODWT cross-correlation equation for scale j and lag τ is represented as follows:

$$\rho_{x,y,j,t,\tau} = \frac{COV(\widehat{D}_{x,j,t}, \widehat{D}_{y,j,t+\tau})}{\left(Var(\widehat{D}_{x,j,t})Var(\widehat{D}_{y,j,t+\tau})\right)^{1/2}}, \quad (2)$$

whereVar and COV are variance and covariance, respectively, and cross-correlation takes value $-1 \le \rho_{x,y,j,t,\tau} \le 1$.

Dataset and descriptive statistics

This paper utilizes daily near-maturity futures prices for ethanol and three key agricultural commodities – corn, wheat, and soybeans. Futures markets were selected for their higher liquidity, which makes these prices more representative than spot prices. The dataset spans a substantial period, from January 2013 to December 2023. Each commodity's prices were converted to log-returns using the formula: , where represents the price at a specific time. All time series data were sourced from stooq.com, with each agricultural commodity synchronized with ethanol to create three equal-length pairs. Table 1 provides descriptive statistics for these assets.

The statistics indicate that all assets have an average value close to zero, suggesting that, on average, prices remained stable over the observed period. As depicted in Figure 1, there were notable price peaks in 2013, 2014, 2021, and 2022, while prices stayed comparatively low from 2015 to 2020, resulting in a near-zero average. The standard deviation reflects relatively high risk, with ethanol displaying the highest volatility. Negative skewness in ethanol, corn, and soybeans reveals a greater frequency of negative returns. High kurtosis, particularly for ethanol, indicates the occurrence of extreme returns. According to the Jarque-Bera test, none of the assets follow a normal distribution. The DF-GLS test confirms the absence of a unit root in each time series, meeting a key requirement for wavelet analysis.

Table 1. *Descriptive statistics of the selected assets*

	Mean	St. dev.	Skew.	Kurt.	JB	DF-GLS
Ethanol	-0.003	0.883	-3.338	43.189	188166.2	-46.824
Corn	-0.006	0.726	-1.482	19.424	32181.810	-27.577
Wheat	-0.005	0.839	0.489	8.848	4102.268	-25.926
Soybean	-0.001	0.583	-0.689	8.951	4345.385	-53.378

Notes: JB stands for value of Jarque-Bera coefficients of normality, while DF-GLS is unit root test where 1% and 5% critical values are -2.566 and -1.941, respectively.

Source: *Authors' own calculation based on data from stooq.com (2023).*

The paper researches the nexus in a multiscale environment *via* six wavelet scales. These scales represent different time-horizons:scale 1(2-4 days), scale 2(4-8 days), scale 3(8-16 days), scale 4 (16-32 days), scale 5(32-64 days) and scale 6(64-128 days). The first four scales represent the short-term horizon, whereas the fifth and sixth scales are regarded as midterm and long-term, respectively.

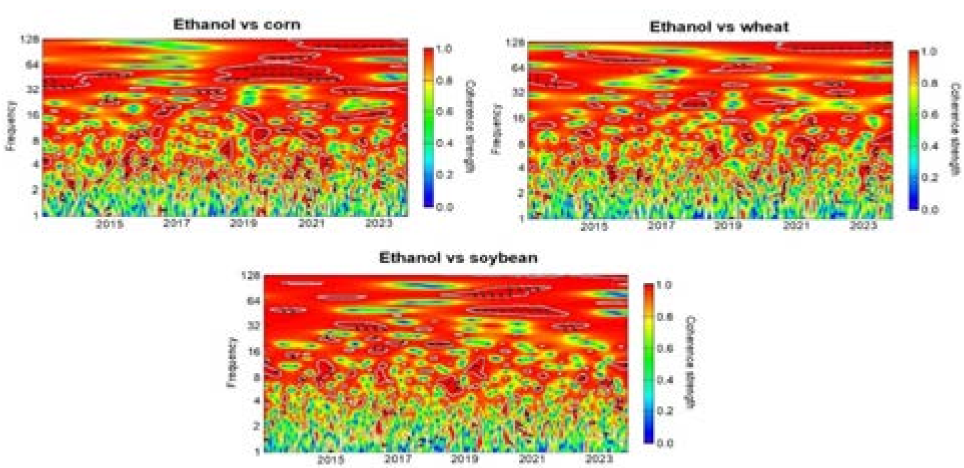
Results and discussion

Wavelet coherence

This section presents the wavelet coherence results for each of the three pairs, illustrated in Figure 2. Wavelet coherence offers an intuitive visual of the relationship between two-time series across both time and frequency domains, capturing complex interaction patterns that other analyses might miss. The horizontal axis represents time, while the left vertical axis shows frequency scales, expressed in days from 1 to 256, to represent different time horizons. The color-coded surface depicts the strength of the coherence between the two-time series, with cooler colors indicating weaker connections and warmer colors signaling stronger coherence. Dark-red areas denote very high coherence between variables.

As seen in the plots, cooler colors dominate at lower wavelet scales, suggesting weak short-term linkages between ethanol and the three agricultural commodities. This likely reflects the impact of various unique factors that drive each market, leading to relatively independent price movements in the short run. In contrast, warmer colors appear more prominently at higher wavelet scales, indicating that price dynamics between these markets become more synchronized over longer time horizons. This synchronization occurs because fundamental factors tend to influence global markets more uniformly over extended periods, resulting in more aligned price trends. However, wide bands of high coherence are generally absent, except in the ethanol-corn pair during the pandemic period.

Figure 2. *Wavelet coherence plots*



Source: *Authors' own calculation based on data from stooq.com (2023).*

Wavelet cross-correlation results

To enhance the analysis, this section presents the pairwise wavelet cross-correlation results between ethanol and the three agricultural commodities. This method uncovers the lead and lag relationships between the markets, identifying the source of market shocks and the recipient of those shocks. Such insights can be valuable for market participants seeking to mitigate the impact of shocks from related markets. Table 2 summarizes the wavelet cross-correlation results for the three pairs, while Figure 3 provides visual representations of these findings. In the analysis, ethanol is treated as the first variable, while the respective agricultural commodity is the second. This distinction is crucial because negative (positive) lagged correlations correspond to ethanol (the agricultural commodities) in Figure 2.

The wavelet cross-correlation analysis indicates lead-lag relationships based on the orientation of the cross-correlation curve. If the curve tilts to the left, it signifies that the first time series leads the second, and vice versa. At lower wavelet scales, the tilt of the cross-correlation curve may not be distinctly visible, which is why the cross-correlation values are also included in Table 2. In interpreting the results, only the fifth cross-correlation values, highlighted in bold, will be discussed.

Table 2. *Wavelet cross-correlation results*

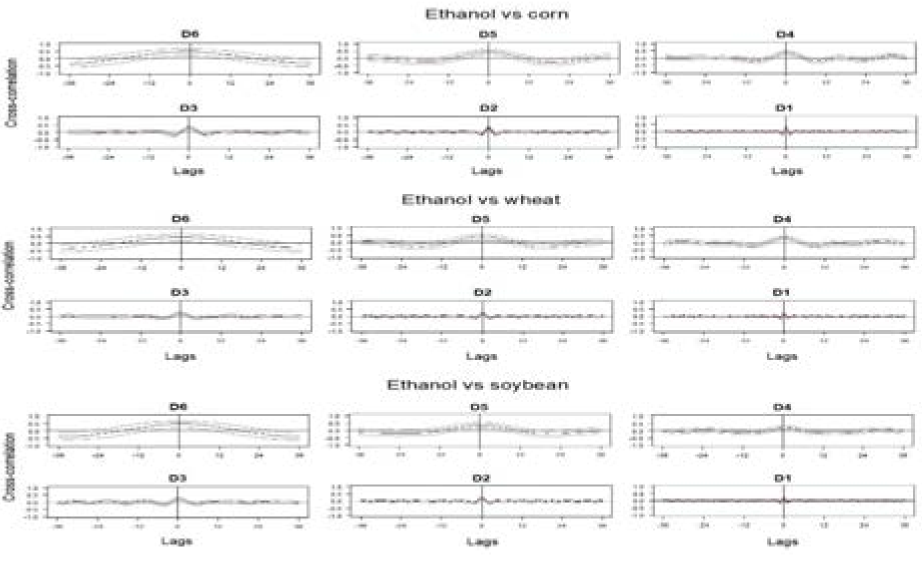
		Negative lagged correlations				Positive lagged correlations			
		-20	-15	-10	-5	5	10	15	20
Ethanol vs corn	D1	0.023	0.023	-0.017	**0.018**	**0.019**	0.025	-0.003	-0.011
	D2	0.031	-0.002	-0.044	**-0.013**	**0.036**	0.001	-0.029	-0.031
	D3	0.016	-0.007	0.037	**-0.205**	**-0.167**	-0.005	0.046	-0.012
	D4	-0.007	-0.035	-0.184	**-0.011**	**0.049**	-0.199	-0.002	-0.063
	D5	-0.235	-0.195	0.043	**0.304**	**0.302**	0.014	-0.252	-0.298
	D6	0.052	0.219	0.365	**0.458**	**0.432**	0.312	0.159	-0.004
Ethanol vs wheat	D1	-0.001	-0.006	-0.020	**-0.025**	**0.004**	0.022	0.006	-0.028
	D2	0.019	-0.004	0.000	**-0.004**	**0.032**	-0.031	-0.013	-0.008
	D3	-0.012	0.015	0.005	**-0.122**	**-0.110**	-0.033	0.073	-0.054
	D4	-0.037	-0.062	-0.180	**0.041**	**0.021**	-0.180	-0.040	-0.052
	D5	-0.229	-0.219	0.000	**0.272**	**0.278**	0.013	-0.203	-0.230
	D6	-0.015	0.144	0.291	**0.394**	**0.395**	0.290	0.148	-0.007
Ethanol vs soybean	D1	0.027	0.009	0.013	**-0.021**	**0.015**	0.002	0.034	0.017
	D2	0.034	-0.023	-0.017	**-0.016**	**0.023**	-0.025	-0.054	-0.005
	D3	0.055	-0.079	0.089	**-0.168**	**-0.126**	0.030	0.008	-0.035
	D4	0.020	-0.068	-0.102	**-0.007**	**0.072**	-0.084	-0.051	-0.079
	D5	-0.168	-0.116	0.068	**0.253**	**0.282**	0.071	-0.141	-0.223
	D6	-0.090	0.098	0.285	**0.425**	**0.456**	0.330	0.152	-0.040

Source: *Authors' own calculation based on data from stooq.com (2023).*

Examining the ethanol-corn pair reveals an absence of a consistent leading or lagging pattern, as the leading asset shifts across different wavelet scales. At certain scales, the cross-correlation values are nearly identical, indicating a lack of a clear pulling effect. Specifically, at the D1 and D5 scales, the cross-correlation values are so similar that it becomes difficult to identify any lead-lag interdependence. However, at the D2 and D4 scales, corn demonstrates a leading position, while ethanol leads at the D3 and D6 scales. These results suggest that, in the short term, shocks from the corn market influence the ethanol market, whereas, in the long term, ethanol shocks become more dominant.The short-term advantage of corn can be attributed to its significantly larger futures market in terms of liquidity, as indicated in Table 4. This greater liquidity allows external shocks to be processed more swiftly in the corn market. Consequently, it is plausible that external shocks are first identified in the corn market before they are transmitted to the ethanol market. Conversely, the relationship shifts over the long term, likely because corn is the primary feedstock used in ethanol production.

When analyzing wavelet cross-correlation, it is crucial to assess the level of correlation at specific scales. Higher interdependence between the variables enhances the reliability of the cross-correlation findings. In this case, the wavelet correlations between ethanol and corn remain relatively strong even at the lowest scales, lending further credibility to the short-term wavelet cross-correlation results.

Figure 3. *Wavelet cross-correlation plots*



Source: *Authors' own calculation based on data from stooq.com (2023).*

Table 3. *Average trading volumes of the selected assets*

	Ethanol	Corn	Wheat	Soybean
Trading volumes	315	409,476	120,663	211,636

Note: Average trading volumes are observed in 2019 in order to avoid possible biasedness that can be caused by the pandemic and the war in Ukraine.

Source: *stooq.com website*

In examining the ethanol-wheat and ethanol-soybean pairs, the wavelet correlations are lower than those found in the ethanol-corn relationship, prompting a focus on the long-term connections rather than short-term cross-correlations in these cases. Notably, at the D5 and D6 scales, wheat exhibits a slight leading edge over ethanol, indicating that the wheat market tends to lead in the long term. As highlighted in Table 3, the liquidity in the wheat market is significantly higher than that of the ethanol market, suggesting that external shocks can be absorbed and processed more rapidly in the wheat market. This factor accounts for the observed influence of wheat on ethanol.

For the ethanol-soybean pair, only the long-term cross-correlations warrant discussion due to the relatively weak short-term wavelet connection. According to Figure 3 and Table 2, the cross-correlation curve tilts noticeably toward soybean, indicating that soybean leads ethanol in both midterm and long-term time frames. This finding aligns with expectations, as the soybean market is the second largest in terms of liquidity (refer to Table 3), making it likely that external shocks are recognized more swiftly in the soybean market compared to the ethanol market. This dynamic underscores the leading role of soybean in this relationship.

Conclusion

This study examines the multiscale interdependence between ethanol and three major grains that serve as raw materials in its production. The analysis employs two wavelet techniques: wavelet coherence and wavelet cross-correlation. While the first method assesses the strength of interdependence, the latter identifies the lead-lag dynamics between the assets. The findings from wavelet coherence, indicate that the strongest short-term connection exists between ethanol and corn, with correlations significantly exceeding 30%. In contrast, the correlations between ethanol and the other two grains are weaker. These results align with expectations, given that corn is the primary feedstock for ethanol production.

Regarding lead-lag relationships, the short-term connection is particularly significant for the ethanol-corn pair, which maintains a relatively strong correlation even in the short term. Conversely, all long-term interdependencies warrant attention, as robust correlations emerge at the highest wavelet scales. The results suggest that larger agricultural markets, characterized by higher trading volumes, typically influence the smaller ethanol market. These findings have several implications. Firstly, the strong short-term correlation between ethanol and corn indicates that price fluctuations in one asset can substantially impact the other. This necessitates caution among short-term participants, including speculators and investors. In the long run, the connections among agricultural commodities and ethanol are robust, often exceeding 50%, suggesting that long-term stakeholders, such as farmers and ethanol producers, should implement hedging strategies to safeguard against rising prices in agricultural and ethanol markets.

Moreover, portfolio investors should consider avoiding the combination of ethanol and corn across all time horizons due to their high correlation, which yields poor diversification outcomes. A more favorable strategy in the short term is to pair ethanol with wheat or soybean, as these grains exhibit lower correlations with ethanol. However, for long-term portfolios, it is advisable to refrain from combining ethanol with any agricultural commodities due to their strong interconnectedness, which often surpasses 50%.

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SUNFLOWER RESTORERS OF FERTILITY OBTAINED BY APPLYING INTERSPECIFIC HYBRIDIZATION AND EMBRYO CULTURE

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Abstract

Interspecific hybridization was successfully applied between cultivated sunflower lines (Helianthus annuus L.) and accessions of annual species Helianthus neglectus, and perennial species H. decapetalus. The embryo cultivation method was used to overcome post-zygotic hybrid incompatibility and realize sufficient number of seeds. Some morphological, phenological and biochemical characters of hybrid forms were investigated. The degree of crossability was determined. As a result of self-pollination, sib-pollination and backcrossing F_2 and BC_1 generations were obtained. Lines NEG 1- 8, originated from wild annual H. neglectus were characterized with high seed oil content and resistance to broomrape. Line DEC 2 was distinguished with resistance to foliar pathogens and to the parasite broomrape. The hybrid plants, carriers of Rf genes for CMS Pet 1 could be used in sunflower breeding programs for developing new restorer lines. The obtained various lines are suitable initial material to extend the diversity of sunflower germplasm.

Key words: *Helianthus neglectus, Helianthus decapetalus, embryo rescue.*

Introduction

Interspecific hybridization was widespread in sunflower breeding programs as a method for introduction of new genes for various agronomic traits, resistance to diseases and pests, resistance to abiotic stresses such as drought resistance or cold tolerance and varied chemical composition of sunflower oil. First attempts of its implementation has been carried out at the beginning of XX century (Pustovoit G, 1973). As a result of crossing of cultivated sunflower with different *Helianthus* species were obtained a lot of new sun-

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flower forms, resistant to some diseases and parasite broomrape (Christov, 2008; Valkova *et al*., 2015; Nenova *et al*., 2016). First CMS source originated from the cross between cultivated sunflower and wild annual *Helianthus petiolaris* Nutt. Was found by Leclercq (1969) and very soon some other CMS sources were found by Whelan (1980), Vranceanu *et al*. (1986), Serieys and Vincourt (1987); Christov (1999) and etc. Interspecific hybridization in the genus Helianthus offers opportunities to exploit the diversity of rich genetic material and has posed crossbreeding challenges to scientists in recent decades. The sterility of the hybrids, the abortion of the hybrid embryo, the obtaining of seeds with an underdeveloped endosperm, as well as the long dormant period of the hybrid seeds are barriers to the successful implementation of interspecific hybridization. To overcome it, the application of the embryo culture method, developed for the first time by Chandler & Beard (1983) had a great importance. Espinasse *et al.* (1985) indicate that the development of sunflower embryos is determined by their age, size and shape during cultivation. According to Azpiroz *et al*. (1988) embryo culture techniques can be accelerated to obtain 4-5 generations per year. Successful results were obtained by Sukno *et al.* (1999), Dagustu (2010), Nenova *et al.* (2016). The method of embryo rescue was applied for overcoming the difficulties in applying classical breeding methods, connected to the incompatibility of cultivated sunflower, and to obtain the sufficient number of hybrid plants for further testing. Dobrudzha agricultural institute maintained a collection of wild annual and perennial sunflower species is and study in. Accessions from genus *Helianthus*, maintained in the collection, have already been used as donors of genes controlling cytoplasmic male sterility, restorer genes, resistance to abiotic and biotic stress factors, genes for varied fatty acids content.

The aim of this study was to obtain sunflower lines, restorer of fertility, applying both classical and *embryo rescue* methods from interspecific crosses between two wild Helianthus species and cultivated sunflower lines.

Material and methods

Interspecific hybridization was successfully applied in Dobrudzha agricultural institute between sterile sunflower lines 656A, 696A, 912A and accessions of annual species *Helianthus neglectus* GT-E-017, and perennial species *H. decapetalus* GT-M-043. The selection of the specified samples is based on that they are rarely included in hybridization and information about their hybrids is found rarely in literary sources. Interspecies crosses were carried out on scheme "*cultivated sunflower x wild accession*" under field conditions applying classical methods of isolation, pollen collecting and pollination. The sterile analogues of fertile sunflower lines with normal cytoplasm were included in the investigation as maternal components.

In order to overcome the difficulties in applying the methods of classical breeding, associated with the poorly expressed crossability of cultivated sunflower and in order to obtain the maximum number of hybrid plants, the method *embryo rescue* was applied (Azpiroz *et al.* 1988, Nenova, 2002). The immature embryos were isolated on the methods of Nenova *et al.* (2016). The obtained fertile F_1 plants were self-pollinated. Backcrossing, self-pollination and individual selection were applied for developing of uniformed and stabile lines. Biochemical characteristics were obtained applying NMR. The reaction of interspecific genotypes to foliar pathogens was determined on the method of Encheva V. and Kiryakov I. (2002). The resistance of studied genotypes to downy mildew was determined on the method of Vear, F. and Tourvieille D. (1987). The evaluation of studied genotypes for resistance to broomrape was determined on the method of Panchenko A. (1975). The phytopathological studies was carried out in laboratory conditions.

Statistical processing allows analyzing the obtained results by applying different mathematical methods, tailored to the research objectives. Cluster analysis was used to group the traits of the studied lines depending on their mean values, variability and correlations (STATISTICA) based on squared Euclidean distance and weighted centroid pairs. Correlation analysis was performed to measure the strength of the relationship between variables and compute their association.

Results and discussion

The cultivated sunflower lines 656A, 696A and 912A were pollinated with many inflorescences of wild annual species *Helianthus neglectus,* accession GT-E-017. Crossing was going in field conditions. The obtained embryos were isolated and cultivated on tissue culture media. The obtained F_1 plants were annual, fully branched with or without central head. Branching was a typical trait for wild species, as the cultivated line was unbranched. Anthocyanin coloration was a second marker, typical for wild species, observed on stems and rarely on leaves and petioles of hybrid plants. These morphological markers were suitable for early confirmation of hybrid nature of obtained plants. Their height varied from 135 cm to 160 cm. Some differences were observed in plant height, color of disk florets, leaves shape and branches length among plants from the same cross and between crosses. The plants seed set, number of isolated embryos and obtained plants grown in the soil, were presented on table 1.

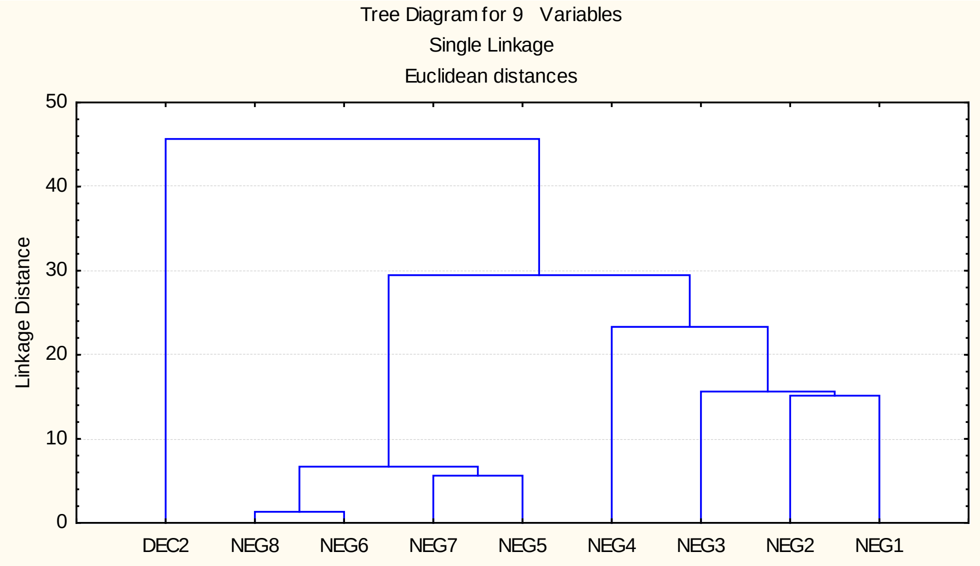
Table 1. *Number of isolated embryos and obtained plants from F_1 hybrid combinations*

Hybrids	pollinated inflorescences with seeds, %	Number of isolated embryos	Number of obtained plants
656 A x E-017	42,5	52	36
696 A x E-017	51,2	58	41
912 A x E-017	33,4	46	30
H. annuus x E-017	**42,37**	**52**	**35,7**
656 A x M-043	2,2	9	4
696 A x M-043	1,7	11	6
912 A x M-043	1,6	7	2
H. annuus x M-043	**1,83**	**9**	**4**

The bract leaves, like the wild type, are lance-shaped, almost hairless and with a sharp, curved tip. A hundred and seven hybrid plants were obtained, sixty-five of which were male fertile. This proved that the wild accession E-017 carried genes for fertility restoration of CMS Pet-1. Plants that release pollen were isolated and self-pollinated. The 147 seeds obtained from them were gray-black with dark gray stripes, elongated with curved tip. The results, presented on table 1 showed, that higher seed set was established for crosses, originated from wild annual *H. neglectus* (acc. E-017), compared to crosses, obtained with participation of perennial species *H. decapetalus* GT-M-043. This result pointed that incompatibility of wild perennials and cultivated sunflower was higher. Twelve plants were obtained after successful application of interspecific hybridization and *embryo rescue* method – four annuals and eight plants with perennial growth cycle. Among the annual plants, two were fertile, which showed that accession M-043 possesses genes for fertility restoration of CMS Pet-1.

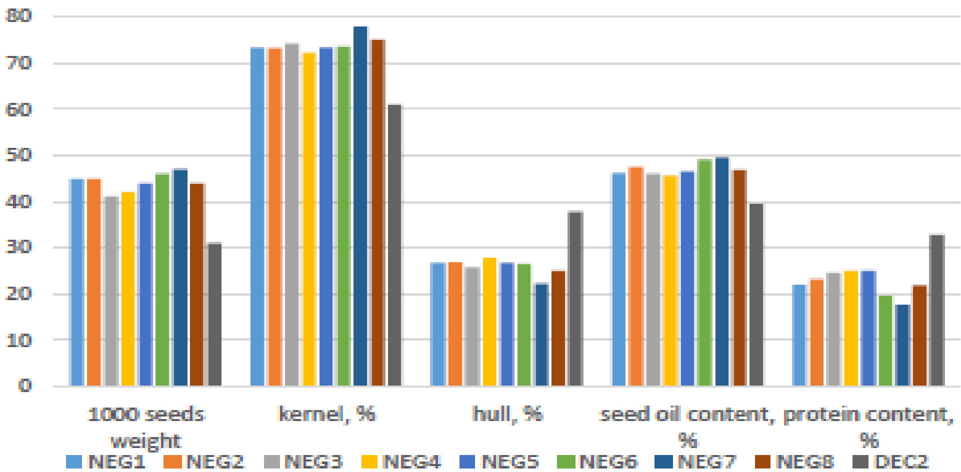
All F_1 plants were sown in nursery conditions and F_2 generations were grown in the field. Each plant was isolated separately. F_2 plants differed from each other in the stem height, the length of the branches and petioles, size of ray florets, color of disk florets. Varying degrees of pronounced anthocyanin pigmentation were observed. After pollination of sterile inflorescences of lines 656A and 696A with pollen from F_1 plants, 55 seeds were obtained, with a seed set of 19.5-23.2%. Morphologically, the plants obtained after self-pollination and sib-pollination of the hybrid F_1 plants are more diverse compared to the BC_1 generation. Similar results were published by Valkova *et al.*,(2016) concerning obtained lines, originated from wild *H. praecox*. As a result of long-term selection and self-pollination, 9 uniform lines, fertility restorers, originated from *H. neglectus* and *H. decapetalus* differing from each other in morphological and phenological terms, were obtained. This was established through the cluster analysis (fig.1). The lines were grouped according to the characteristics of plant height, length and width of ray florets, length and width of leaves, petiole length, number of branches, duration of flowering, vegetation period. In fig. 1 presents a dendrogram of the studied lines, grouped into 3 clusters, applying the Tree Diagram and determining the Euclidean distances. The lines NEG6, NEG8, and NEG7 and NEG5 fall into the first cluster, with the distances between the first two being the shortest and the degree of similarity high. The lines NEG1, NEG2 and NEG3 and NEG4 fall into second cluster, with the distances between the first two also shorter. Line NEG4 partially overlap NEG1, NEG2, NEG3, which proves their common origin, but the existing distances show the changes that have occurred, as a result of prolonged selection and self-pollination. The line DEC2 fall into the third cluster because of the existed long distance compared to other two clusters. The presented dendrogram proved the distinction between lines

Figure 1. *Cluster analysis of obtained R lines on their morphological and phenological traits.*



based on their origin. Lines NEG1, NEG2 and NEG3 originated from the cross 656A x E-017. Line NEG4 originated from cross 696A x E-017. Lines NEG5, NEG6, NEG7 and NEG8 originated from cross 912A x E-017. Line DEC2 originated from cross 696A x M-043. Its different origin was proved by the cluster analysis.

Fig. 2 Average values of some biochemical characters of studied lines, connected to oil content.



Variation of some biochemical characters were determined for the studied restorers of fertility (fig.2). Lines, originated from *H. neglectus* differed on the studied characters insignificantly. This is due to the constant selection of high-oil forms in the process of self-pollination. Line DEC 2, originated from *H. decapetalus,* differed from the other lines on its higher protein content and lower oil content (41,5%) as well 1000 seeds weight.

Continuous self-pollination and individual selection was accompanied by testing for the presence of resistance to the main pathogens on sunflower (table 2).

Table 2. *Phytopathological evaluation of restorer lines for resistance to the main pathogens.*

Line	Resistance % / Type of reaction
NEG2 NEG6 NEG7 DEC2	Resistance 75-99% to *Pl. helianthi* Novot. and *Orobanche cumana*
NEG1 NEG2 NEG6 NEG7 DEC2	Resistant type of reaction to *Phomopsis helianthi* and *Phoma macdonaldii*

Some of the main purposes of interspecific hybridization in sunflower was connected to transfer of genes for resistance to diseases and parasite broom-rape. The evaluation of obtained restorer lines showed that except transferring of Rf genes for restoration of CMS Pet-1, the successful transfer of genes for resistance was realized. Accession E-017 was included in our previous investigations as donor of such genes (Valkova et al., 2016).

Conclusion

New uniformed restorer lines were obtained applying interspecific hybridization and embryo rescue method for overcoming the incompatibility between cultivated sunflower and wild annual species *H. neglectus*, and wild perennial *H. decapetalus*. Nine restorers of fertility for CMS Pet-1 were studied and presence of resistance to the pathogens caused grey and black spots were established. Lines NEG2, NEG6 and NEG7 were distinguished by highest seed oil content 47-49,5%. Their vegetation period varied from 118 to 124 days.

Application of embryo rescue method was successful and the obtained seeds were sufficient for completion the process of evaluation and study of the new initial material for the purposes of sunflower breeding. The availability of vital pollen proved the presence of Rf genes for restoration of cytoplasmic male sterility Pet-1. The obtained lines, the result of the conducted interspecies hybridization and application of *embryo rescue* method, are a diverse initial material for expanding the possibilities of heterosis breeding for enriching the genetic plasma of cultivated sunflower.

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APPLICATION OF BIOSTIMULATORS IN THE PRODUCTION OF DIFFERENT PEPPER GENOTYPES

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Abstract

Mineral-based biostimulators are increasingly used in sustainable production. During 2024, an experiment was conducted in the greenhouse of the Institute of Vegetable Crops Smederevska Palanka. The pepper genotypes that were included were the Morava and LPK 12 varieties, with the aim of examining the influence of biostimulators based on Ca, Mg and B on the morphological characteristics of the fruits. Every 10 days, a biostimulator was applied in the amount of 20 g/10 l of water in three applications (T1 - 1x application, T2 - 2x, T3 - 3x). In treatment T1, the highest average fruit weight was measured in both genotypes (Morava 69.80 g, LPK 12 193 g) compared to the control. The highest number of fruits was measured in T3 (Morava 12.3, LPK 12 5.0), which is 8.84% more in Morava and 35.13% in LPK 12 compared to the control.

Key words: *pepper genotype, Ca, Mg, B, biostimulator.*

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Introduction

Pepper (*Capsicum annuum* L.) belongs to the Solanaceae family, which contains large amounts of compounds beneficial to human health, including vitamins, flavonoids, carotenoids, capsaicinoids, volatile oils, fatty acids, proteins, fibers and minerals (Nejati Sini et al. 2024). As one of the most important vegetable crops, due to its high nutritional and biological value and economic importance, it occupies large production areas (Marković, 2001). Achieving high yields of sweet pepper from the open field in less favorable conditions largely depends on the choice of variety and the level of applied agrotechnics (Buczkovska, 2007), including mineral feeding of plants and the level of feeding (Marin et al., 2009; Michałojć and Dzida, 2012). An insufficient amount of nutrients for plants can negatively affect the growth and development of the cultivated culture. For crops that require large amounts of nutrients such as peppers, continuous fertilization is often applied to ensure nutrient availability to the plants. This type of production can lead to environmental pollution and increase the cost of agricultural production. In order to reduce the negative impact on the environment and promote sustainable agriculture, the use of biological fertilizers is encouraged. Biological fertilizers not only reduce the use of chemical fertilizers, but also help restore microbial diversity in the soil (Sofyan et al. 2019). The application of these fertilizers is an important link in the system of sustainable agriculture and an alternative to the traditional approach in plant production (Berova et al. 2010), considering that production technology based on the use of natural components tends to be economically profitable and environmentally acceptable (Bajagić et al., 2024a). Biological fertilizers are useful sources of plant nutrients that improve crop growth and quality, produce plant hormones, and contribute to sustainable crop production by maintaining soil fertility (Nejati Sini et al., 2024). In addition, their influence is reflected in increasing the efficiency of the use of nutrients by plants, alleviating the stress caused by agroclimatic changes, verifying crop protection, and improving the quality of crops as a whole (Bajagić et al., 2024b). The aim of this research was to examine the effect of the applied biostimulator based on the minerals Ca, Mg and B in different treatments on the morphological characteristics of the fruit in two pepper varieties.

Material and method

The experiment was set up during 2024 in the greenhouse of the Institute of Vegetable Crops Smederevska Palanka according to a random block system in four repetitions. Morava varieties, old varieties, semi-bell type and LPK 12 varieties, kapya type, were used as plant material for research. The research examined the impact of a biostimulator based on Ca, Mg and B, with the commercial name Mineral fortePlus, which has a role in plant nutrition and soil improvement, and which can also be used in organic production. The biostimulator is powdery, white-gray, odorless, contains CaO (50%±3%), MgO (12%±3%), B (1%±0.2%). It was applied foliarly and by watering (250 ml/plant) in the amount of 20 g per 10 l of water. The treatments included three applications from before the beginning of the flowering phase of plants every 10 days (T1 - 1x application, T2 - 2x application, T3 - 3x application) and a control variant (without application of biostimulator). The application of biostimulators aimed to intensify the growth and development of plants and fruits, to increase the resistance of plants to stress caused by lack of water and the resistance of fruits during ripening, and therefore to increase the yield. Special advantages are manifested in the protective effect of mycorrhizal Ca from Mineral forte Plus on the fruit, reducing the need to use protective agents. Plants need a greater presence of Mg and B, because these minerals have a positive effect on the flowering phase. The application of soil improvers enables better utilization of nitrogen, which is located in the immediate vicinity of the root system, and reduces the need for additional amounts. During the growing season of the plants, standard agrotechnical measures were applied (feeding, plant protection and irrigation). The harvest was carried out at the biological maturity of the fruits and the parameters of fruit weight, length and width of the fruit, thickness of the pericarp, number of fruits per plant and number of chambers were measured. 10 fruits per treatment were analyzed. Precise measurement of fruit parameters was performed with a digital caliper.

The results obtained in this research were statistically processed by analysis of variance (ANOVA) and tested by the LSD test (Least Significant Difference Test) in the program IBM SPSS Statistics, version 26.0. and are presented tabularly and graphically.

Results and discussion

One of the most important roles in achieving the total yield is played by the morphological characteristics of the pepper fruit. After statistical processing of the data, Table 1. shows the results showing the effect of the applied biostimulator based on the minerals Ca, Mg and B on the examined parameters of the fruit of two pepper varieties (length, width and thickness of the pericarp). The best result in the Morava variety was achieved in the T1 treatment, where the biostimulator was applied once at the beginning of the flowering phase, where the impact on fruit width (5.3 cm) was statistically significant, while there was no statistically significant difference between the different fertilizer treatments for the other two traits. and control variants (10 cm and 4.9 mm). The maximum length of the LPK 12 fruit was measured in the T3 treatment and was 13.9 cm with a pericarp thickness of 6.2 mm.

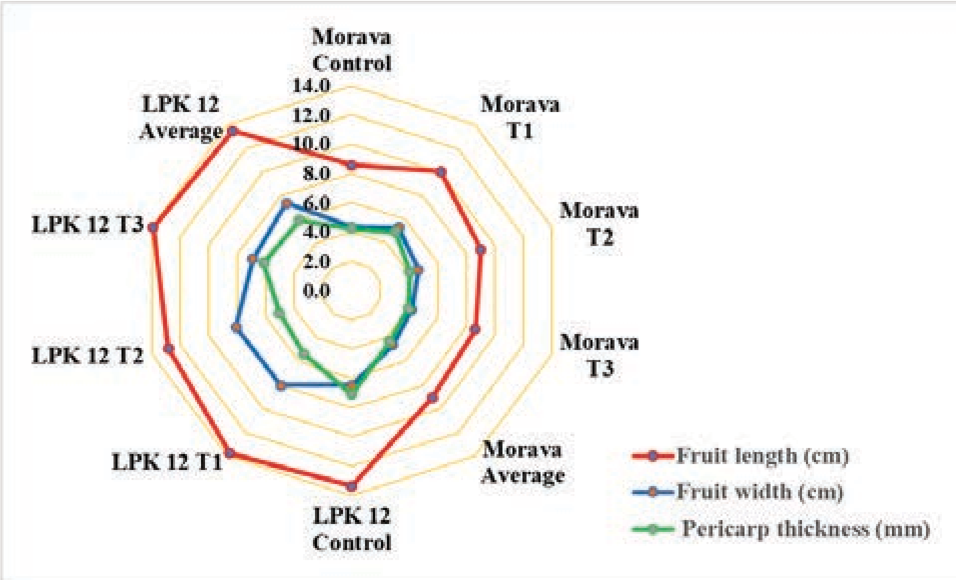
Table 1. *The influence of biostimulators on the morphological characteristics of different pepper varieties*

Sort (A)	**Treat. (B)**	Fruit length (cm)			Fruit width (cm)			Pericarp thickness (mm)		
Morava	Control	8.6			4.3			4.2		
	T1	**10.0**			**5.3**			**4.9**		
	T2	9.0			4.6			4.1		
	T3	8.6			4.2			4.0		
	Average	**9.1**			**4.6**			**4.3**		
LPK 12	Control	13.4			6.5			**7.1**		
	T1	13.8			8.0			5.4		
	T2	12.8			**8.1**			5.1		
	T3	**13.9**			6.9			**6.2**		
	Average	**13.5**			**7.4**			**5.9**		
Factors		**A**	**B**	**AB**	A	B	**AB**	A	**B**	**AB**
Sig.		**	**ns**	**ns**	**	*	**ns**	**	**ns**	**ns**
F test		58.76	0.62	0.45	107.22	5.04	0.95	24.49	1.87	2.76
LSD 0.05		1.29	1.74	2.46	0.57	0.81	1.14	0.71	1.00	1.42
LSD 0.01		1.71	2.41	3.41	0.79	1.12	1.58	0.98	1.39	1.96

P<0.01 very significant (**); P<0.05 significant (*); P>0.05 no significant (ns)

According to the results of research in the greenhouse production of the semi-bell variety, the fruits were measured to be about 11 cm long and about 8.2 cm wide (Danojević et al., 2021). The highest value of the pericarp thickness (Figure 1.) was measured in the control variant (7.1 mm) in the variety LPK 12, which is a very important feature in peppers intended for industrial processing. In their previous results, Danojević et al. (2018) state that plants whose fruits had a thicker pericarp also had a larger fruit mass, which partially coincides with the obtained results. Proper fertilization (feeding) of plants with minerals plays an important role in their growth and development, as well as the quality of fruits and the formation of the total yield (Buczkowska et al., 2016). The necessary amounts of mineral fertilizers in combination with organic fertilizers and biofertilizers led to a significant increase in the growth, yield and quality of peppers, according to Raturi et al. (2019).

Figure 1. *The effect of biostimulator treatment on fruit characteristics of Morava and LPK 12 pepper varieties*



Based on the data presented in Table 2., we can see that the genotype as a factor exerted a statistically significant influence on the weight of the fruit and the number of fruits per plant, traits that represent the main components of the yield, while there were no statistically significant differences in the obtained values for the number of chambers. The highest weight of the fruit was measured in the variety LPK 12 in the T1 treatment and was 193.0 g, while the predominant number of chambers in the fruit in both varieties is 2-3. The highest number of fruits per plant was achieved in the variety Morava and in all treatments and was significantly higher compared to LPK 12. The most fruits (Figure 2.) were in T3 (12.3), then in T1 (12.0), while the lowest number fruits were 9.7 in T2. Calcium is one of the basic plant nutrients, which is crucial in many cellular processes. Calcium in the plant is very poorly mobile, so the symptoms of the lack of this component are observed on the youngest leaves, tops of stems and roots, and most importantly, on the fruits (Buczkowska et al. 2016). Low concentration of Ca in plant tissues is the main cause of various physiological disorders. Magnesium (Mg) is an essential element for crops, animals and humans, the lack of which affects photosynthesis and the distribution of carbohydrates in crops (Nejia et al., 2016). Boron can affect the overall uptake of different nutrients and their nutrient utilization efficiency resulting in high plant productivity (Sarafi et al. 2018).

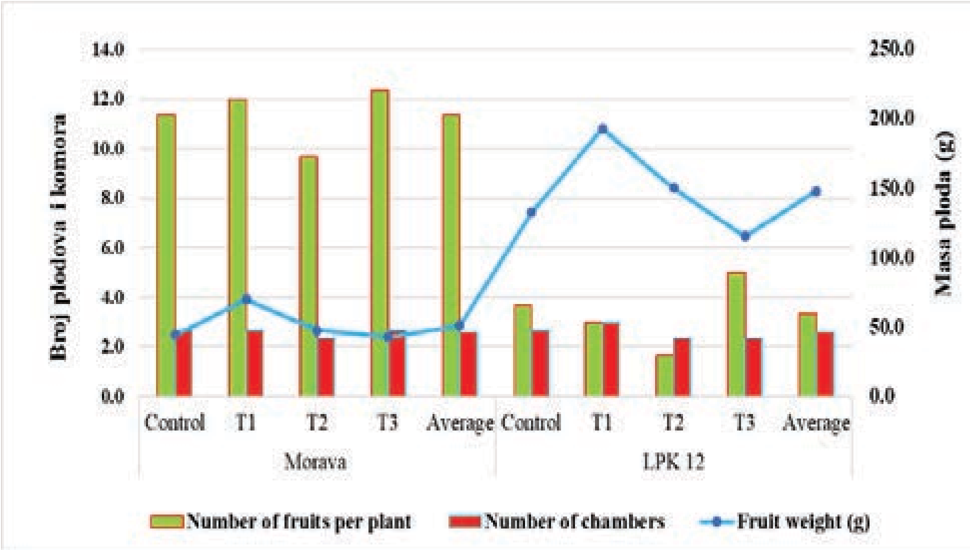
Table 2. *Characteristics of different types of fruit in fertilization treatments*

Sort (A)	**Treat. (B)**	Fruit weight (g)			Number of fruits per plant			Number of chambers		
Morava	Control	44.2			11.3			2.7		
	T1	**69.8**			12.0			2.7		
	T2	47.8			9.7			2.3		
	T3	43.0			**12.3**			**2.7**		
	Average	**51.2**			**11.3**			**2.6**		
LPK 12	Control	132.9			3.7			**2.7**		
	T1	**193.0**			3.0			3.0		
	T2	150.1			1.7			2.3		
	T3	115.3			**5.0**			2.3		
	Average	**147.8**			**3.3**			**2.6**		
Factors		**A**	**B**	**AB**	**A**	**B**	**AB**	**A**	**B**	**AB**
Sig.		**	*	**ns**	**	**ns**	**ns**	**ns**	**ns**	**ns**
F test		83.52	4.62	1.04	55.42	1.33	0.11	0.00	0.89	0.36
LSD 0.05		22.68	32.07	45.36	2.30	3.26	4.61	0.49	0.69	0.97
LSD 0.01		31.48	44.52	62.96	3.19	4.52	6.39	0.68	0.96	1.35

P<0.01 very significant (**); P<0.05 significant (*); P>0.05 no significant (ns)

One of the most frequent disturbances in the nutrition of peppers in the conditions of a protected area, as well as in the open field, which occurs during the period of the most intensive fruit growth, is the rot on the top of the fruits, which negatively affects the market value of the fruits as well as the yield itself (Cobanero et al., 2004). The most effective way to limit the occurrence of symptoms of Ca deficiency in the plant is foliar treatment of those parts of plants where its transmission is limited (leaves, fruits) (Casado-Vela et al., 2007; Kovalska and Sadi, 2012). Magnesium deficiency is a frequent limiting factor for crop production due to the low level of exchangeable Mg in the soil, which negatively affects the sustainability of agricultural development (Wang et al. 2020). The same authors in their research found that Mg fertilization improves crop performance by increasing yield or resulting in favorable physiological outcomes, providing great potential for integrated Mg management for higher yield and crop quality.

Figure 2. *The influence of different biostimulator treatments on the important fruit characteristics of pepper varieties Morava and LPK 12*



Conclusion

The results of this work show that the application of bistimulators based on the minerals Ca, Mg and B can have an impact on the improvement of the main components of the yield and fruit characteristics of different types of peppers, which also determine its quality. It is necessary to further develop scientific research regarding sustainable agriculture, where the use of mineral nitrogen and phosphorus fertilizers will be rationalized and reduced, with an emphasis on the introduction of biological fertilizers and fertilizers that refine the soil into plant production, all with the aim of producing healthy and safe food for human consumption.

Acknowlegdement

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CORRELATION ANALYSIS OF STRUCTURAL ELEMENTS IN DIFFERENT OILSEED SUNFLOWER HYBRIDS TREATED WITH HUMAT ROST

Georgi Georgiev[1]

Abstract

Sunflower is one of the main agricultural crops grown in Bulgaria. Due to rapidly changing climatic conditions (drought, attack by diseases and enemies, etc.), it is necessary to study the structural components treated with different doses of organic fertilizers related to an increase in seed yield. In sunflower, seed yield and oil content are complex characteristics that are influenced by different factors that may act individually or collectively. The study of a complex of traits is a crucial approach to increase seed yield. (Chandirakala et al., 2015). The effectiveness of selection depends mainly on the direction and magnitude of the relationship between yields and its components. Some of the indicators related to the yield significantly affect the yield and the direct effect has a different influence. Therefore, it is necessary to study which of the signs have a greater influence than others. Singh et al. (2018) found that yield was significantly affected by 100-seed mass, seed mass per plant, seed diameter, growing season % oil. Correlation describes the mutual relationship between variables and helps to improve different features simultaneously. An attempt was therefore made to estimate a correlation between yield and yield components. 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.

Key words: *vegetation, sunflower, yeld, plant height, head diameter, corellation*

Introduction

The sunflower (Helianthus annuus L.) is eaten as the most important oil crop in the world, as well as in Bulgaria. High and stable performance characteristics of greatest value for commercial production. The success of sunflow-

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er seed depends on the genetic and physiological quality of the seeds, high plant growth rate and resistance to agro-ecological stress (Miklič et al. 2011). Contrary to what is known, the performance and productivity of sunflowers is strongly influenced by the factors affecting the environment, which makes it mainly in the development and improvement of the culture. Achieve the highest economic indicator with almost all crops. Achievement is a complex entity and is inherited from the achievement of a degree of recognition, which is polygenic in nature and strongly influenced by the factor in the surrounding environment. Known by the genetic system, controlling the achievement and neutralization of components, researched on the helpline parent site and all positive genetic potential with valuable recognition. For an effective selection, program, the mutual interaction between the achievements and the negative components is inevitable and mutually related to the characteristics (recognition) of the plant, some of which are determined by the correlation coefficient and all the benefits for which the degree (Silat) is established, the mutual interaction between the distinguishing features of the plant and the character of the component by which it is arranged in finishing. But information about the relative importance of the antecedent and the indirect effect is an overarching element that must be achieved without being provided by such a study. The factor five is useful in breaking down correlations of the advantages and disadvantages of effects so that you can assess the relative benefits of all the components of the nature of what you are trying to achieve. On the other hand, analyze five measures of direct and indirect results on different independent indicators. Therefore, the present study was undertaken to determine the interplay between the discriminating indicators of sunburn and the technical advantages and disadvantages in achieving the effect by using coefficient analysis, genotype and leaf tertirate on plants. Some completion components significantly affect slurry completion with different procedures at different stages of the stretch, from prospecting to stacking to reclamation. Therefore, it is necessary to know as much as possible about the interplay between the achievement and cancellation components. The adequate supply of fertilizer increases sunflower yield appreciably (Bhattacharyya et al., 2015). Fertilizer plays

an inevitable and imperative role in determining oil content and oil quality of sunflower. Therefore, improved agrotechniques like use of improved cultivars (hybrids), adequate water and nutrient supply are the keys to achieve higher productivity of the crop even under fertile land situation. Seed yield of sunflower, a complex dependent character, is contributed by a number of component characters. (Hassan et al., 2013). 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. 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.

Material and methods

In the experiment, 4 hybrids were studied - hybrid Enigma CLP, Deveda, Krasi CLP, Prometey SU (table 1.). All studied hybrids were treated with two doses of the organic preparation HumatRost-5ml, 9ml. and untreated plot. 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), mass of 1000 seeds (g), number of full seeds, number of empty seeds, number of seeds per plant, yield kg/ dka, % oil, oil in absolute dry matter %, moisture %, oleic acid. The study examined the interrelationships between individual traits to determine how they affect seed yield.

Table 1. *Testing hybrid combinations of oilseed sunflower with different doses of HumatRost preparation.*

ENTRY no	Replication	Treatment with organic fertilizer Humate Rost	Genotype	Technology	Yield	Yield/2 replication
1	I	control without treatment	Hybrid Enigma	CLP-technology	218,5	195,2
2	II	5ml/30m2	Hybrid Enigma	CLP-technology	248,9	215,4
3	III	9ml/30m2	Hybrid Enigma	CLP-technology	308	252,7
4	I	control without treatment	Hybrid De-veda	classic technology	247,6	245,1
5	II	5ml/30m2	Hybrid De-veda	classic technology	314,1	287,3
6	III	9ml/30m2	Hybrid De-veda	classic technology	299,5	302,4
7	I	control without treatment	Hybrid Krasi	CLP-technology	227,9	270
8	II	5ml/30m2	Hybrid Krasi	CLP-technology	262,8	297,3
9	III	9ml/30m2	Hybrid Krasi	CLP-technology	270,5	302,7
10	I	control without treatment	Hybrid Pro-metey	SU-technology	260,7	254,7
11	II	5ml/30m2	Hybrid Pro-metey	SU-technology	273,6	274
12	III	9ml/30m2	Hybrid Pro-metey	SU-technology	357,2	351,6

Sree Vathsa Sagar US (2023) et al. found, in their research, that it is necessary to create good sunflower hybrids for different climatic conditions, including in the selection program good parental lines. The selection of the lines would be effective if it is done according to the traits that are related to the yield. The statistical processing of the obtained results was carried out using the program Past 4.17.

Results and Discussion

Seed yield is directly related to all other quantitative indicators, with the values of the correlation coefficients varying widely (Table 2). This table shows the correlation dependence between individual quantitative indicators. The mass of 1000 seeds (r=0.983) is predetermined and influenced mainly by the index of the seed diameter. In the studied hybrids, seed yield is most strongly influenced by the parameters seed diameter (r=0.762), number of seeds from one seed (r=0.725) and number of seeds from one plant. The average yield of the two repetitions is determined by the same indicators and mass of 1000 seeds (r=0.801), number of plants per plot (r=0.889). The size of the pit has a positive effect on the number of seeds per plant (r=0.908). The mass of 1000 seeds is influenced by the diameter of the pit (r=0.973). Number of full seeds is determined by seed diameter (r=0.561), number of seeds per plant (r=0.860). Plant height has a direct effect on the increase in the size of the seed diameter in the treated sunflower hybrids (r=0.346). The highest correlation dependences were obtained between the indicator pit diameter and mass of 1000 seeds (r=0.973), number of complete seeds (r=0.561), number of seeds per 1 plant (0.908), seed yield (r=0.762) and average yield of 2 replicates (r=0.442). Similar results were found by (Miller & Fick, 1997; Kaya et al., 2003, 2005, 2009).

The following quantitative indicators have a positive effect on the average yield of 2 repetitions in the hybrid combinations tested: diameter of the comb (r=0.442), mass of 1000 seeds (r=0.801), number of full seeds (r=0.489), number of empty seeds (r =0.831), number of seeds per 1 plant (r=0.584), number of seeds per plant (r=0.889). The plant height index (r=0.188) did not lead to an increase in the yield of the two repetitions in the studied hybrids.

Table 2. *Correlation coefficients between the yield and its components in 4 hybrids of oilseed sunflower.*

	Plant height	Head diameter	weight per 1000 seeds	number of full seeds	number of empty seeds	number seeds from 1 plant	Number of planth	Yield	Yield for 2 replication
Plant height		**0,346**	0,002	0,009	0,314	0,006	**0,629**	0,066	0,188
Head diameter	0,201		**0,973**	**0,561**	0,263	**0,908**	0,043	**0,762**	**0,442**
weight per 1000 seeds	**0,608**	-0,007		0,055	0,027	0,008	0,305	0,162	**0,801**
number of full seeds	-0,519	0,125	-0,397		0,268	0,346	**0,581**	**0,725**	**0,489**
number of empty seeds	-0,214	-0,238	-0,45	-0,235		0,262	0,089	0,469	**0,831**
number seeds from 1 plant	-0,54	0,025	-0,525	**0,861**	0,238		0,763	**0,773**	**0,584**
Number of planth	-0,103	-0,417	-0,218	-0,119	0,365	0,065		0,018	**0,889**
Yield	**0,381**	0,065	0,295	-0,076	-0,155	-0,062	-0,478		0,005
Yield for 2 replication	**0,407**	-0,245	-0,082	-0,222	0,069	-0,176	-0,045	**0,746**	

Figure 1. *Values of the deviations of the correlation dependences for individual indicators in four genotypes of oilseed sunflower*

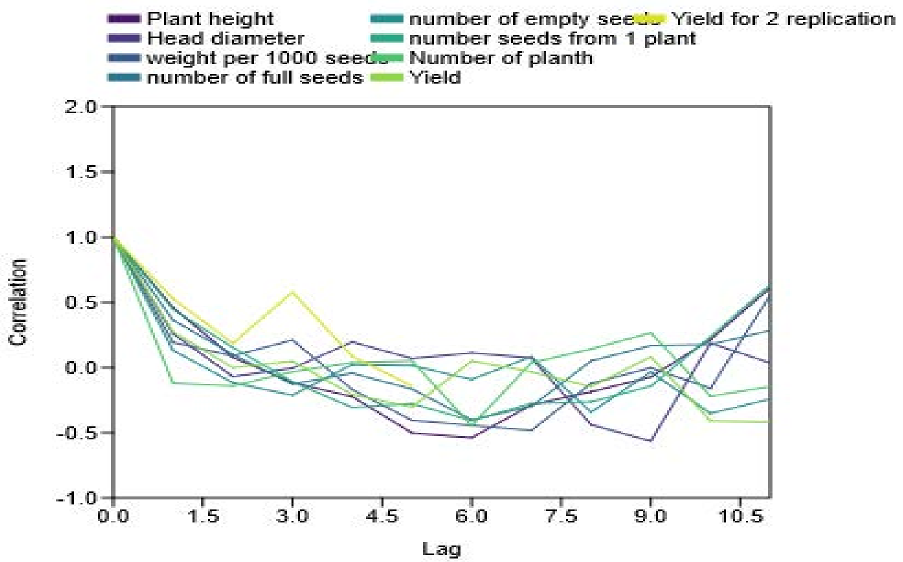


Figure 1 shows the deviations of the correlation dependences for individual indicators. The trait with the greatest variation in the studied indicators is plant height, followed by seed diameter and mass of 1000 seeds. With constant values and a smaller change in the correlation values, it was found for the indicators: seed yield, number of seeds per plant, number of plants per plot, number of seeds full seeds.

Hybrid Enigma CLP

Hybrid Deveda

Hybrid Krasi CLP

Hybrid Promethey SU

Table 3. *Principal component analysis (PCA) of 9 sunflower quantiles (PCA) across 4 sunflower genotypes*

Traits	Eigenvectors								
	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7	PC 8	PC 9
Plant height	-0.0251	-0.0173	0.0632	-0.0099	0.1389	-0.0813	0.8895	-0.4032	-0.1234
Head diameter	0.0007	-0.0050	0.0013	-0.0203	-0.0155	-0.0412	0.0532	-0.1790	0.9811
weight per 1000 seeds	-0.0192	-0.0355	0.0318	-0.0997	0.1138	-0.0822	0.3931	0.8912	0.1373
number of full seeds	0.700	-0.4202	-0.1146	0.1953	-0.4128	0.3002	0.1352	0.04386	0.0082
number of empty seeds	0.002	0.8009	-0.0264	0.1429	-0.4974	0.2494	0.1518	0.06645	0.0135
number seeds from 1 plant	0.711	0.4077	0.1471	-0.1730	0.42017	-0.2983	-0.0925	-0.0319	-0.0089
Number of planth	-0.002	0.09158	-0.1786	0.1890	0.5943	0.7537	0.0060	0.0146	0.0480
Yield	-0.018	-0.07526	0.9231	-0.1750	-0.0675	0.3249	-0.0305	-0.0051	0.0079
average of 2 repetitions/ yield kg/da	-0.020	0.0042	0.2746	0.9135	0.1234	-0.2642	-0.0234	0.05903	0.0214
Eigenvalue	45259.4	8928.48	2825.39	714.829	429.76	207.923	49.7005	24.6673	2.1850
% variance	77.443	15.277	4.8313	1.2231	0.7353	0.3557	0.08504	0.0422	0.0037

Principal component analysis (PCA) reduces the number of dimensions in large datasets to principal components that retain most of the original information. It does this by transforming potentially correlated variables into a smaller set of variables, called principal components.

In the present study (table 3), 9 components were traced with principal component analisys. Loadings of 0.30 or higher can be considered significant in the analysis performed Kline, P., 2014. The first principal component (PC1), which accounts for 77.4% of the total variability between genotypes mainly derives from the indicators number of complete seeds and number of seeds per plant. In this component, high values of the vector values were found - number of complete seeds and number of seeds per plant. In the second main component (PC2), which represents 15.2% of the total variability in the studied genotypes, the following components have discriminating characteristics - number of full seeds and number of seeds per plant.

Conversely, plant height, seed diameter, 1000 seed mass, number of full seeds and total yield have negative loadings in (PC2). The third principal component (PC3) with a variability of 4.83% contributed less negative magnitudes than the total variability among genotypes due to discriminating indicators namely mass per 1000 seeds and seed yield. The fourth principal component (PC4) which represents the total variability between genotypes is due to the total seed yield of the two replicates. In the fifth component (PC5), high values were found for number of seeds per plant and number of plants per hectare. For the sixth, seventh, eighth and ninth components, negative variables were found for plant height, seed diameter, 1000 seed mass and number of seeds per plant. The sixth investigated component (PC6), number of seeds per plant, had a positive effect on the yield increase in individual genotypes. Many scientists and researchers apply principal component analysis in hybrid development research programs. Kholghi, M. Et. Al 2011. also applied principal component analysis to estimate genetic diversity in sunflower. The importance of principal component analysis also suggested by other sunflower researchers in breeding improvement Masvodza DR. (2015), Ghaffari M (2004), Ghaffoor A & Arshad M (2008).

Figure 2. *Correlation dependences between seed yield and some quality indicators in 4 oilseed sunflower hybrids*

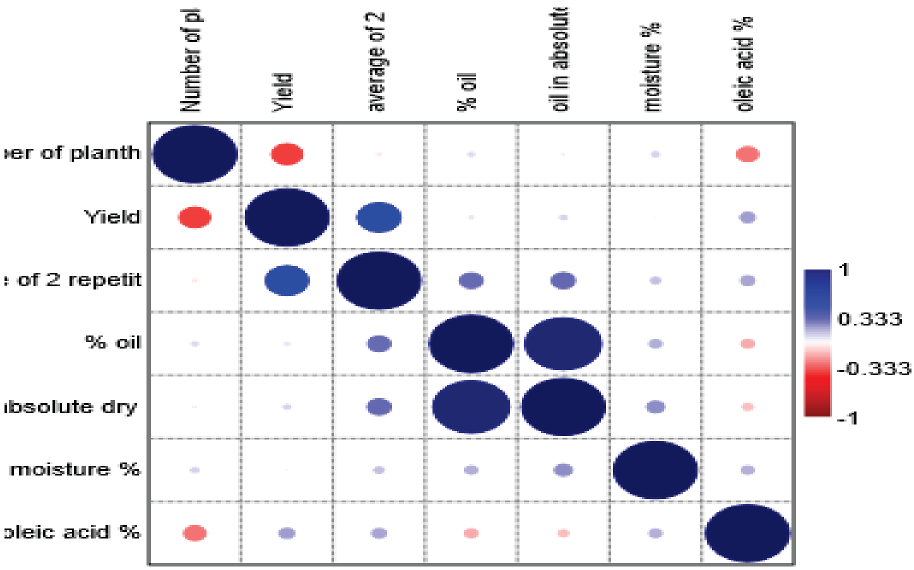
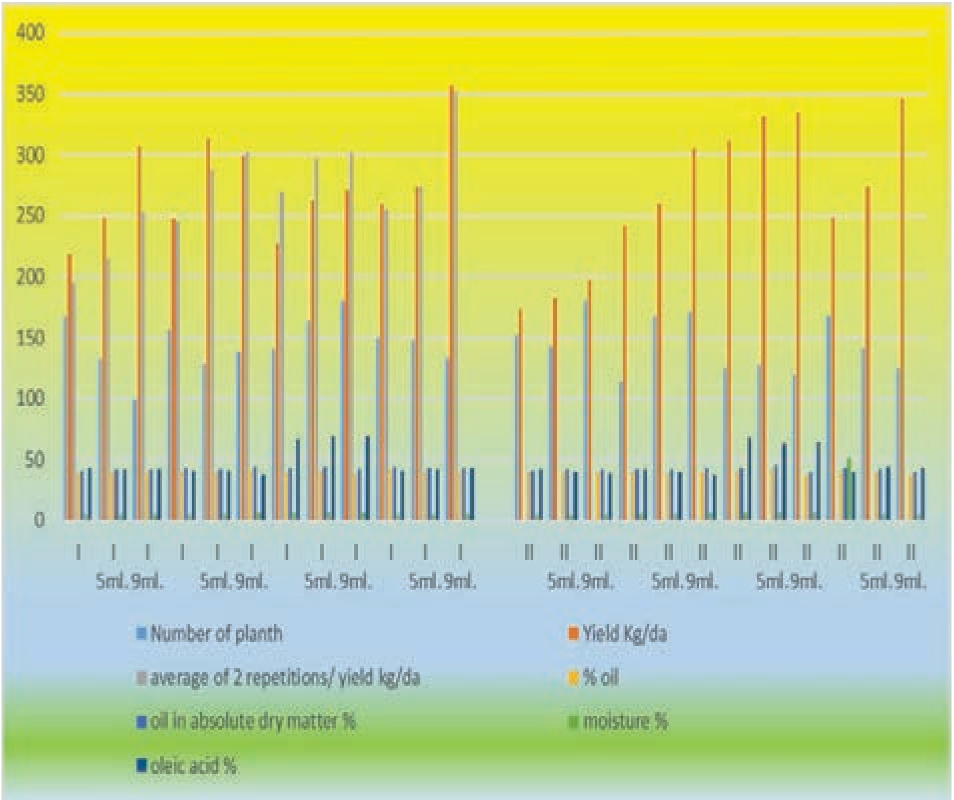


Figure 2, 3 shows the correlation dependences between the following indicators in the tested hybrids: number of plants per plot, seed yield kg/ha, average yield of 2 replications, % oil, oil in absolute dry matter, % moisture, and % oleic content acid. Seed yield in the investigated sunflower hybrids is predetermined and correlated with the number of plants in a plot. The content of oleic acid is directly dependent on the number of plants per plot, yield, % oil in the seeds and % moisture. Seed yield in the experiment performed is determined by the number of plants in a plot, from the average yield of 2 replicates. From the data obtained on the Figure 3, it was found that the yield of the four studied hybrids of oilseed sunflower changes significantly depending on the dose of treatment with the organic preparation HumatRost.

Figure 3. *Study of quantitative signs in treatment with different doses of HumatRost in 4 hybrid combinations*



Legends: 1. Hybrid Enigma CLP 2.Hybrid Deveda 3. Hybrid Krasi CLP 4. Hybrid Prometey SU

Conclusions

In the studied hybrids, it was established that the index mass per 1000 seeds (r=0.983) is predetermined and influenced mainly by the index of seed diameter. Seed yield is most strongly influenced by the parameters seed diameter (r=0.762), number of seeds per seed (r=0.725) and number of seeds per plant.

The first principal component height (PC1), which accounted for 77.4% of the total variability between genotypes, mainly originated from the parameters number of full seeds and number of seeds per plant. In this component, high values of the vector values were found - number of complete seeds and number of seeds per plant. In the second main component, seed diameter (PC2), which represents 15.2% of the total variability in the studied genotypes, the following components have discriminating characteristics - number of full seeds and number of seeds per plant. Seed yield in the four studied oilseed sunflower hybrids changes significantly depending on the dose of treatment with the organic preparation HumatRost.

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COMPARISON OF NDVI INDEX IN VINE WITH THE APPLICATION OF DIFFERENT CHEMICAL TREATMENTS[1]

Irina Marina Stević[2], Biljana Bošković[3], Danijela Živojinović[4], Nevena Stevanović[5], Nikola Stanković[6], Maša Buđen [7]

Abstract

This paper investigates the impact of various chemical treatments (organic and conventional) on the values of the NDVI index (Normalized Difference Vegetation Index) in grapevines. NDVI is used as a reliable indicator of plant health and vitality. By analyzing vegetative changes, it allows for the identification of differences between protection methods. The research included an analysis of a vineyard treated with organic and conventional preparations at two intervals after spraying. The results showed that the index values in areas treated with the organic preparation 30 days after spraying had high values. This finding suggests that the application of organic treatments plays multiple roles, contributing to sustainable agriculture while also impacting fruit quality. Therefore, the application of the NDVI index can be highly beneficial in assessing the effectiveness of different chemical treatments used in vineyards, thereby positively influencing vineyard management strategies.

Key words: *vegetation indices, NDVI index, vines, organic, conventional.*

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Introduction

The vine (Vitis vinifera) is a plant from the Vitaceae family. Today's grapevine production, both in the Republic of Serbia and in the world, represents a highly developed branch of agriculture. Thanks to adequate conditions, a moderate climate and fertile soil, the production of numerous varieties of vines is possible. The vine is primarily grown for the production of grapes, so it is possible to obtain wines from the highest quality to lower quality table wines. According to the latest data in 2023, the area under vineyards was 18,349 ha(MPŠV, 2023).

Recently, great importance has been given to organic agricultural production in viticulture and their development is encouraged in areas where there was no intensive agriculture, in fact in unpolluted nature conditions (Gvozdenović et al., 2007; Korać et al, 2011; Korać et al, 2016 Willer, 2008).

The digitization of agriculture has contributed to the rapid development of new technologies for monitoring agricultural production, and thus the introduction of the concept of precision viticulture began. Precision agriculture (PA) can often help maximize yield while reducing resource use to minimize losses. Thus, PA can reduce variability and input costs (Cisternas et al., 2020).

Precision viticulture enables adequate management of production within the vineyard with the help of new technologies, which enable data collection. By further analyzing the collected data with a high level of accuracy, better quality decisions can be made in the management of viticulture production. (Rendulić Jelušić et al., 2020).

In order to further improve crop condition monitoring and increase yields, research based on remote sensing is increasingly being used today, which can be extremely important when making decisions in crop management. (Muruganantham, et al., 2022; Stevanović et al., 2024). The processing of data collected by remote sensing, using sensors, enables the calculation of vegetation indexes. These indexes provide the possibility of calculating simple algorithms for quantitative and qualitative analysis of vegetation cover, vitality and growth dynamics (Xue & Su, 2017).

The most commonly used vegetation indexes in viticulture are:

- NDVI (*Normalised Difference Vegetative Index*) - the most commonly used vegetation index for determining vegetation characteristics and monitoring growth and lushness (Xue i Su, 2017; Matese & Di Cennaro, (2021). It represents the ratio between the near infrared (NIR) and the visible red part of the spectrum (R) that plants reflect.

- GNDVI (*Green Normalised Difference Vegetative Index*) - uses the green channel (G) instead of red because green has been shown to be more sensitive to chlorophyll than the red part of the spectrum and the near-infrared (NIR) part of the electromagnetic spectrum (Mwinuka et al., 2021; Ferro et al., 2023)
- SAVI *(Soil Adjusted Vegetation Index*) - this index also uses a soil adjustment factor (L) (Huete, 1988; Ren et al., 2018). This index is very important when monitoring the condition of vegetation with less vigor or in the initial stages when it is necessary to remove the influence of soil reflection.
- NDRE (*Normalized Difference Red Edge Index*) - indicates the chlorophyll content in the plant. Unlike the NDVI index, which observes the values of "greenness" only on the upper parts of the plant, this index penetrates to lower levels, so there can be a significant difference in values, especially in taller and denser crops. (Ferro et al., 2023).

Material and method

The experiment was monitored in the vineyard of the Agricultural School with the home of students "Sonja Marinković" in Požarevac, in the 2024 production year. The data obtained were taken from four repeated experiment, the vines of the "gama" variety were recorded in three terms

1. Control recording before chemical protection
2. First recording after chemical protection - 15 days after spraying
3. Second recording after chemical protection - 30 days after spraying.

Chemical protection was carried out using a conventional crop protection chemics (*Orvego* 2ml/100 l vode) and organic crop protection chemics (*Fitomil l60* 50ml/10l vode). Chemical protection was implemented against blight.

From each repetition, the values of the following index were calculated:

$NDVI = (\frac{NIR-RED}{NIR+RED})$ (Wang et al., 2022)

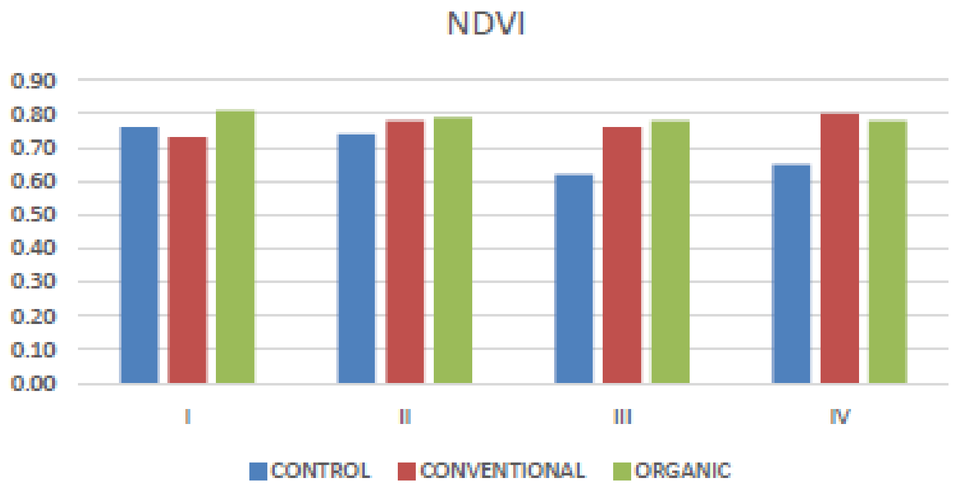
Three treatments of grapevines were observed, which were treated: with a conventional crop protection chemics, an organic crop protection chemics, as well as a treatment that was not treated with chemical crop protection chemics (control). The value of the vegetation indexes was obtained using a hand-held, proximal multispectral sensor, called a plantometer.

“Plant-O-Meter”, this sensor allows the calculation of more than 30 vegetation indices. It uses six optical channels (https://www.plant-o-meter.com/): blue (wavelength 455 nm), green (wavelength 528 nm), red (wavelength 657 nm), red edge (wavelength 740 nm), near-infrared 1 – “NIR1” (wavelength 810 nm), and near-infrared 2 – “NIR2” (wavelength 940 nm)

Results and discussion

The control recording was carried out before the application of chemical protection on the same day, June 15, 2024. The values of the NDVI index are shown in the following graph (Graph 1.).

Graph 1. *NDVI index values before chemical protection*

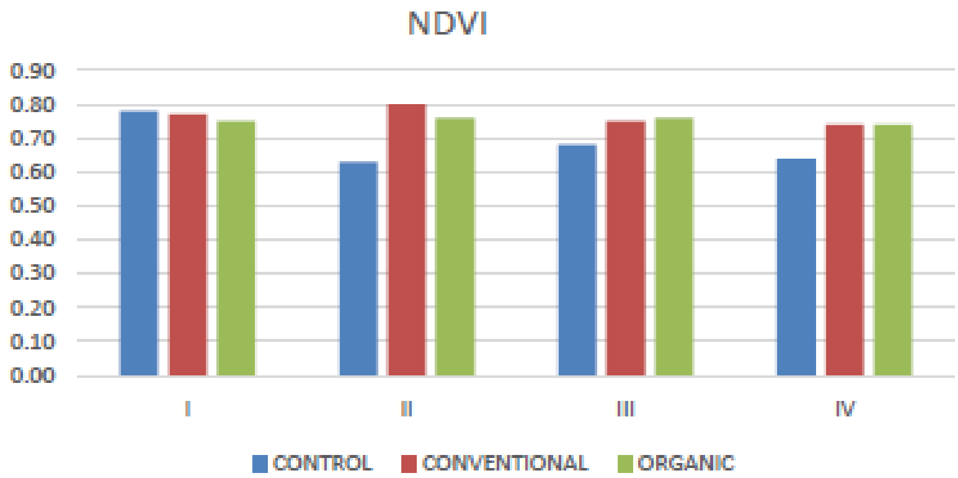


Source: *According to authors calculations*

The values of the NDVI index in the I and II repetition showed minimal differences, while in the IV and III (0.62) repetition it is clearly seen that the value of the index even before the protection itself in the control part has lower values.

The next recording, which was carried out 15 days after the application of different crop protection chemics for chemical protection, showed greater differences compared to the first recording. The values of the NDVI index are shown in the following graph (Graph 2.)

Graph 2. *NDVI index values - first recording after chemical protection*

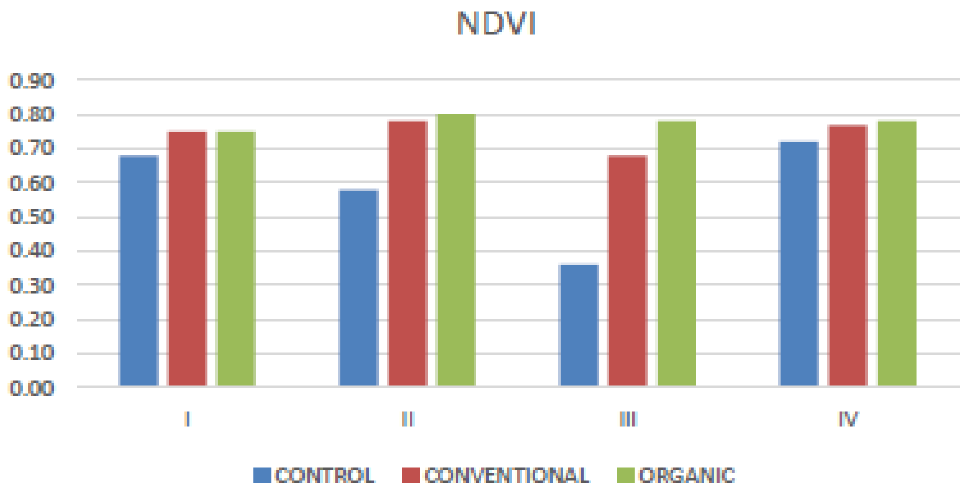


Source*: According to authors calculations*

The values of the NDVI index of the control part only in the first repetition had higher values (0.78) than the treated coppices (0.77 and 0.75). In the II repeat, the value of the NDVI index was the best for the conventionally treated coppices (0.8), while in III and IV the indices of the treated coppices were very similar and even.

The third recording was performed 30 days after the application of chemical protection and based on the calculated values the following conclusions were established. The values of the NDVI index (Graph. 3) after the application of organic preparations in three repetitions have the highest value (II repetition 0.8).

Graph 3. *NDVI index values - second recording after chemical protection*



Source: *According to authors calculations*

The importance of the application of chemical protection is clearly seen because the NDVI index values of untreated shoots are significantly lower, the biggest difference is noticeable in the III repetition where the value of the index of untreated shoots is 0.36 and organically treated 0.78).

At the same time, the importance of the application of organic preparations, because the highest values are observed in the parts treated with organic preparations.

Conclusion and recommendations

Observing the results obtained regarding the effects of conventional and organic preparations, it is important to mention that conventional preparations often have a faster and more intense effect on pest control, but they can cause stress in plants and thus reduce the process of photosynthesis, which directly affects the reduction of the NDVI index value. These spills can have lasting consequences and a negative impact on the ecosystem. On the other hand, organic preparations consisting of natural substances have less impact on the environment. The use of such preparations often leads to minor damage to the plants themselves, thus the recovery is shorter, and the photosynthetic activity is stronger. All this is reflected by higher values of the NDVI index.

The NDVI index proved to be a good indicator of the condition of the plant after the application of both types of protection, because it provides an objective picture and thus favors the application of organic preparations in order to achieve sustainable, environmentally acceptable and healthy agricultural practices.

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STATE OF VEGETABLE ORGANIC PRODUCTION IN THE REPUBLIC OF SERBIA[1]

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Abstract

The areas under organic crop production in Serbia in 2021 amounted to 23,527 ha and were 12.2% higher compared to 2020. The largest areas in 2021 were under organic fruit production - 36%, under cereals - 28%, fodder plants - 19%, while the smallest land was planted and sown with vegetables, medicinal and herbs. Looking at regions, organic production was most represented in Vojvodina, where these areas accounted for 38.36%, followed by the region of Southern and Eastern Serbia with a share of 31.58%. Vegetable organic production in Republic Serbia has been gaining traction in recent years, driven by increasing consumer demanding for organic products and growing awareness of sustainable farming practices. Serbia has estrablished regulations for organic farming that aligh with EU standards, allowing producers to access both local and international markets. Serbia's diverse climate and fertile soil provide a good foundation for organic vegetable production. Farmers are increasingly adopting practices such as crop rotation and integrated pest management. Local markets, supermarkets, and export opportunities are expanding for organic products, supported by initiatives aimed at promoting Serbian organic goods. Farmers face challenges such as transitioning from conventional to organic practices, pest management, and market competition. The organic vegetable sector in Serbia shows promise for growth, contributing to both the local economy and environmental sustainability.

Key word: *vegetable, organic production, Republic of Serbia.*

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Introduction

Organic production is sustainable agricultural system that used biological fertilizers, ecologically based pest controls and nitrogen-fixing cover crops (Adamchak, 2024). This way of agricultural production is response to excessive use of chemical pesticides and synthetic fertilizer in a system known as conventional agriculture (Sumberg et al., 2022).

The advantage of the organic production lies in reducing soil erosion, decreasing nitrate leaching into groundwater and the recycling animal wastes. The counter arguments that make balance to the benefits of the organic production are higher food costs and lower yields (25% lower overall than conventionally grown crops, depending on the type of crop) (Seufert et al., 2012).

The concept of organic agriculture was developed in early 1900s thanks to scientifics who believed that the using of animal manures, cover crops, crop rotation and biologically based pest control resulted in a better farming system (Kirchmann et al., 2008). Throug 20th century organic practices are developing, establishing rouls and improves existing discoveries. In the lates decadess of the 20th century the organic production is experiencing rapid spread. The main reasons lies in greatr environmental awareness, concerns over the health impact of pesticides residues in soil and underground water and consumption of gentically modified crops (GMO) (Brookes, 2022). One of the most important things about organic production is that the price of organic products is generally higher than prices of conventional grown food. Depending on the product, the season, and the vagaries of supply and demand, the price of organic food can be anywhere from less than 10 percent below to more than 100 percent above that of conventionally grown produce (Adamchak, 2024).

Organic vegetable farming is subject to precise standards and certification that ensure organic food authenticity and quality. In the EU (EU Organic Certification in Europe) and USA regulatory bodies (USDA Organic Certificating), develop and enforce these standards to meet the increasing demand for organic products while consumer trust. The regulatory bodies maintain the list of banned substances, including synthetic pesticides, herbicides, and chemical fertilizers, that are incompatible with organic production. Farmers who practices sustainable agriculture must adhere to these lists and use natural pests, disease management alternatives, and other organic methods to have their healthy food certified as organic (European Commission, 2024).

In organic vegetable production one of the most important part is choosing a location and preparation of the land (Bažok et al., 2022): soil testing (pH, nutrient levels, and any deficient); soil preparation (adding the organic compost or well-aged manure to improve soil fertility and structure) and crop rotation (rotation of crops each season to prevent soil depletion and pest buildup).

Organic vegetable production in Serbia is a significant tool for the development of agricultural production in general. It is characterized by constant growth, constant advancement in knowledge, and numerous benefits for both the economy and the environment.

In 2022, 96.4 million hectares were under organic agricultural management worldwide (Fibl & IFOAM, 2024). This constituted 2.0 percent of the total farmland. Organic farmland increased by 26.6 percent or by 20.3 million hectares in 2022.

The region with the most organic agricultural land was Oceania, with 53.2 million hectares, followed by Europe with 18.5 million, Latin America (9.5 million), Asia (8.8 million), Northern America (3.6 million) and Africa (2.7 million).

The European Union brings set of Regulatory acts, begun with Regulation 2018/8489, focusing on the production and labelling of organic products[5]. This adopted legislation today is known as Basic Act that evolve until 2023. In 2023, two of the secondary regulatory acts underwent regular amendments. Specifically, the implementing regulation (EU) 2021/116512[6], containing the lists of authorized products and substances for use in organic production and the implementing regulation (EU) 2021/23251[7], which establishes the lists of third countries and third country control bodies recognized on the basis of equivalence under the relevant Article of the previous organic regulation, were both subject to two amendments each within the course of the year.

5 Regulation (EU) 2018/848 of the European Parliament and of the Council of 30 May 2018 on organic production and labelling of organic products and repealing Council Regulation (EC) No 834/2007; http://data.europa.eu/eli/reg/2018/848/oj

6 Commission Implementing Regulation (EU) 2021/1165 of 15 July 2021 authorizing certain products and substances for use in organic production and establishing their lists https://eurlex.europa.eu/eli/reg_impl/2021/1165/oj

7 Commission Implementing Regulation (EU) 2021/2325 of 16 December 2021 establishing, pursuant to Regulation (EU) 2018/848 of the European Parliament and of the Council, the list of third countries and the list of control authorities and control bodies that have been recognized under Article 33(2) and (3) of Council Regulation (EC) No 834/2007 for the purpose of importing organic products into the Union https://eurlex.europa.eu/eli/reg_impl/2021/2325/oj

In Europe, there is 18,5 million hectares were managed organically in 2022 (with EU countries – 16,9 million hectares). Leading country in terms of farmland under organic management is France with 2,9 million hectares; followed by Spain (2.7 million hectares), Italy (2.3 million hectares), and Germany (1.9 million hectares). These four countries collectively account for more than half of the European organic farmland.

The legislation of the Republic of Serbia related to organic production relies on EU regulations. Since 1990s when is established Terra's association is Subotica and founding Serbia Organic in 2009, a national association for organic production has the aim to unite organic stakeholders and support organic development. In cooperation with the Ministry of Agriculture, Forestry and Water Management and Serbian Chamber of Commerce and Industry, the promotion of the organic production in Republic Serbia has been raised to a higher level. Thus, Serbia is positioned as a stable producer of organic products, with plenty of room to expand and improve production.

Material and method

In this paper main focus is presenting the current state of vegetable organic production in Republic of Serbia, due to favorable climatic conditions and the population's growing needs for healthy food. In the paper will be used and systematically processed data of relevant public reports and published literature.

Results and discussion

The Republic of Serbia is located in the southeastern part of Europe, on the Balkan Peninsula, covering an area of 88,361 km^2. It extends between 41°53' and 46°11' north latitude and 18°49' and 23°00' east longitude. The climate of Serbia can be described as moderate-continental with more or less exposed local characteristics. Spatial distribution of climate parameters is conditioned by geographical position, relief and local influence (Jovanović Todorović et al., 2024). The average air temperature is 10.9°C at an altitude of 300 m; at altitudes between 300-500 m. above sea level is 10.0°C, and above 1000 m. above sea level it is 6.0°C. The annual sums of precipitation on average increase from above sea level and in lower areas, they range from 540 mm to 820 mm. In areas with altitudes above 1,000 m, the average annual rainfall ranges from 700 to 1,000 mm, while on certain mountain peaks the average value of precipitation is over 1,500 mm of water sediment (hidmet.gov.rs).

According to the first results of the 2023 Census of Agriculture, 4,073,703 are available ha of agricultural land, which is 21.3% less than available of agricultural land included in the Agricultural Structure Survey farms, 2018. Of that, 3,257,100 ha are used for agriculture land (UAA), 504,104 ha of forest area and 190,242 ha of other land. The largest area of agricultural land is located in the Region Vojvodina, 1,474,709 ha, and the increase in area compared to 2018 it was recorded only in the Belgrade region (increase of 2.3%).

The demand for organic products is the only one that has grown in the world, and in Serbia, after the great global economic crisis in 2008. The growth trend continued. Today in the world, the organic market is growing faster at the global level than the area under organic agricultural land, so its price is also increasing. The domestic market of organic agricultural products is still underdeveloped, despite significant advances in recent years. At the moment, the hilly and mountainous area of Serbia has the greatest perspective for the fastest expansion of organic production, and that means agribusiness from ecological agriculture. It provides the most favorable conditions for organic agriculture because more than 60 percent of Serbia's agricultural land is located in that area (Škorić, 2018).

Based on the certification process, Serbia has two types of organic producers. In the first type are individually certified producers who are the owners of the certificate, and in the second type are members of the group production who do not have physical certificate, but are part of the company that is controlling farmers and is a holder of the certificate (Kešelj Milovanović, 2022). According to the data from 2020 Serbia had 5315 cooperants involved in the system of group production, and 42 companies / organizers of the group production. In 2021 group production included 5805 cooperants which is an increase in the number of cooperants by 9.2 %.

According to the last Census of agriculture in 2023, areas under organic production in the Republic Serbia have increased by tree times than areas included in data of Census of the Agriculture in 2012. In structure of sown arable land areas, vegetable covers 1,8% of area, what is much less than areas under fodder crops (9,0%), Industrial crops (18,9%) and cereals (66,8%). During 2023 Serbia mostly exported vegetables and fruits, as well as cereals, wheat and corn.

In 2023 the organic vegetable production is spread on total area of 223,6480 ha, of which the organic status has 143,1139 ha, and 80,5341 ha are in period of conversion. Organic production is dominant in Vojvodina, following with production capacities in South and East Serbia, Šumadija and West Serbia, and on last place are production capacities in Belgrade region (MAFWM, 2024).

Most dominant production is organic production of the chickpea, potato, melon, bean, pumpkin, onion, etc. About 7,000 households in Serbia are engaged in the production of organic food today and the exports worth about 60 million dollars a year.

The export of the organic products, including the vegetable is most intensive to the Germany (18,3 mill. EUR), The Netherlands (6,9 mill. EUR), France (4,2 mill. EUR), Poland (3,5 mil EUR), etc., with the total export to the EU countries with approximately of 44,0 mil EUR.

Conclusion

In the Republic Serbia, organic production represents the unused potential. Interest in organic production is primarily driven by the economic characteristics. Organic production in Serbia has an upward trend and represents an opportunity for small scale family holdings to provide economic sustainability through value added production. The support measures are not part of the long-term strategy, organic producers cannot plan investments in capacities and infrastructure. Farmers lacking managerial skills and marketing knowledge can and should be improved if future. Vegetable production is small, but can be expanded with adequate measures, with education of farmers, by making the knit network and opening to the market.

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EFFECT OF BREED AND BREEDING DISTRICTS ON THE REDUCTION OF MILK PRODUCTION IN COWS DURING HEAT STRESS

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Abstract

Global warming and rising air temperatures are expected to directly affect summer milk production in dairy cows across Europe, particularly in regions with high dairy cattle concentrations. The impact on milk production may vary widely, as cows respond differently to environmental changes. They adapt more easily to favorable conditions but struggle with sudden stressors. This paper reviews the climatic influences on milk production and cow behavior under heat stress, categorizing impacts into indirect long-term effects and direct short-term effects. Economic losses in milk production can be assessed using the milk prediction decline (MPD) feature, demonstrated for four cow breeds in three districts of Serbia.

Key words: *air temperature; global warming; milk production; cows; breed.*

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Introduction

The effects of the global warming of the planet can be felt in a wider spectrum of social, economic, market and ecological-sanitary sectors of the economy of each country. The effects of climate change on livestock production are constantly debated, as climate change increases running costs on the farm; reduced yields and thus incomes, rising production costs, rising food and energy prices, investing in new infrastructure investments for cooling, sprinklers and fans (Koc and Uzmay, 2019). It is recognized that the global heat load has a significant negative economic effect on the dairy industry (St-Pierre et al., 2003), achieved by the reduction of milk yield (West, 2003), damage to the mammary tissue function of the mammary gland (Tao et al., 2018), reduction fertility in cows (Schüller et al., 2016), as well as on fetal development during late gestation (Dahl et al., 2016), and others (Collier et al., 2017). The ability of the mammary gland to use and convert nutrients and produce milk can be greatly impaired by changes in energy metabolism caused by heat stress (Ouellet et al. 2019a).

Negative feelings (pain or frustration) such as suffering (Polsky and Von Keyserlingk, 2017), which are difficult to quantify and describe in the state of the organism during heat stress, further increase losses (Schütz et al., 2008; Daros et al., 2014). All the effects in milk production can include: the effects of reducing the yield and quality of milk, reducing the intake and digestibility of food and reducing the body weight of cows, disorders in the reproduction of cows, then hormonal changes in adapting to climate change, and the proliferation of various diseases and pathological conditions (Sejian et al., 2018).

The increase in global temperatures affects all sectors of agriculture (Schär et al., 2004), which also includes the overall economy of developing countries (von Keyserlingk and Hotzel, 2015), which includes the Republic of Serbia. Problems caused by climate change and heat stress can cause significant economic problems on dairy farms (Sejian et al., 2015; Sinha et al., 2017). Under heat stress, besides producing significantly lower milk yield, cows also produce lower concentrations of milk fat and milk protein, and heat stress inhibits production processes through direct and indirect mechanisms (Fan et al. 2019; Ouellet et al., 2019b). Therefore, when the temperature of the animal's body is registered inside the hypothalamus above the thermoneutral comfort zone of the organism, the first mechanisms of heat release from the body surface, such as vasodilation and sweating, are activated. In addition, due to the redistribution of blood flow to the periphery of the body (in an attempt to give off heat to a higher degree) and the subsequent decrease in blood flow to the gastrointestinal tract, the processes of normal food intake and digestion are disturbed. Cows in thermally neutral conditions usually consume food 12 to 15 times a day, and in negative unpleasant conditions they reduce the frequency of food intake to 3 to 5 times a day during heat stress (Collier et al., 2019).

Apart from all this, the impact of climate change on feed yield is also a significant reason for increasing costs (Calil et al., 2012; Lakew, 2017). Furthermore, there are other reasons that may increase farmers' costs, such as new investments to implement climate-smart agricultural practices and technology transfer to mitigate the effects of climate change (Branca et al., 2015; Alrusheidat et al., 2016). The decrease in milk yield under the negative influence of microclimate parameters (MPD - milk production decline) was taken as an indicator of resistance to heat stress.

Temperature - Humidity Index (*THI*)

To assess the level of heat stress, mathematical indicators such as the widely accepted temperature and humidity index - THI indicator (Temperature-Humidity Index) are used to investigate the effects of climatic factors on dairy cows (Thom, 1959; Dikmen and Hansen, 2009; Bernabucci et al., 2014; Sinha et al., 2017). Although the THI index was not developed solely on cow data, many studies have shown that it is related to and can predict the milk yield of cows (Bohmanova et al., 2007). THI is easily calculated using only two elements - temperature and relative humidity of the environment. THI can be calculated using data measured on the farm or data from meteorological stations. The differences between the THI measured on the farm and the adjusted THI calculated with weather station data are still significant (Ouellet at al., 2019a).

It is widely accepted in the literature that THI=72 is the starting point of stress in dairy cattle, after which milk yield, milk fat and milk protein content begin to decrease (Du Preez et al., 1990; Armstrong, 1994; Ravagnolo and Misztal, 2000; Bouraoui et al., 2003). Some other studies found this threshold to be even lower than 72 (68-70) for high-producing dairy cattle (Collier et al., 2012; Gantner et al., 2015).

Yield losses calculated by researchers as a result of THI increases; 0.18-0.36 kg/day for Poland (THI>72, Ravagnolo and Misztal, 2000), then 0.41 kg/day for Tunisia (THI>69, Bouraoui et al., 2002), then 0.2 kg/day for the United States (THI>72, Herbut and Angrecka, 2012), as well as 0.24-0.72 kg/day for Croatia (THI from 68 to 76, Gantner et al., 2015). Milk yield and quality are highly correlated, although milk components are more sensitive to heat stress than milk yield, the potential annual economic loss of $34.5 million attributable to heat stress in Ontario and Quebec is based on a THI threshold of already 58 for fat and protein yields in dairy cattle and an average of 156 days per year with an average of 10 THI units above that threshold (Campos et al., 2022).

Material and methods

The measurement of ambient temperature and relative air humidity in cow sheds was performed with the help of a DATALOGER device for automatic registration of two microclimate parameters (Datalogger AMTAST, AMT-116, Qingdao Shandong China). The measurements were made during 5 warm months (May-September) from 2013 to 2019. Measurements were made continuously every hour. The initial microclimatic data set consisted of over 500,000 measured daily values of temperature and relative humidity.

Based on the measured values of temperature and air humidity for every hour during the day, THI index values were calculated using the formula:

$THI = (1{,}8 \times t + 32) - (0{,}55 - 0{,}0055 \times rh) \times (t - 26{,}8)$; (Dunn et al., 2014),

where is:

t = air temperature in °C;

rh = relative air humidity in percent.

Based on the values of the TH index measured during 24 hours, the average daily values of the TH index were calculated and the values of the thus calculated TH index were used in the analysis of the influence of heat stress on the trait milk production decline (MPD).

To estimate the daily losses in milk production, and using a model that predicts the average daily decrease in milk production per head under the influence of heat stressogenic action, the observed trait per day (MPD) was derived, which is obtained through the formula (Berry et al., 1964):

$$MPD\ kg/day = -1{,}075 - 1{,}736 \times MPL + 0{,}02474 \times MPL \times THI$$

where is:

MPD = milk production decline;

MPL = milk production level;

THI = average daily value of the TH index (temperature – humidity index).

By including this MPD trait in the model with the sequence of factors' influence, the phenotypic expression and variability of the MPD trait was shown.

Results and discussion

Table 1 shows the influence of fixed system factors on the daily rate of milk yield reduction (district, breed, year of calving, season, month of measurement, stage of lactation, THI, breed interaction*THI). A highly significant influence of all factors ($p<0.001$) was found, while the factor of the number of lactations of cows ($p>0.05$) did not have a significant influence on the trait of reduction in milk production (MPD) under the influence of heat stress during the summer.

Table 1. *Influence of systematic factors on the MPD trait of milk yield during the two observed periods*

Trait	**Systemic factors during the warm period of the year**									**R^2**
	O_i	R_j	G_k	S_l	L_m	M_n	F_o	T_p	R_j*T_p	
d.f.$_1$	2	3	6	3	5	4	4	3	9	
MPD kg/day	***	***	***	***	ns	***	***	***	***	0,7478

*** $p<0.001$ very highly significant; ** $p<0.01$ highly significant; * $p<0.05$ significant; ns $p>0.05$ is not significant

By comparing the values of the means of the least squares of the MPD observed by districts, in table 2, the smallest decrease in daily milk yield per head is achieved by the heads of the Šumadija administrative district -2.27 kg/head/day, and the largest decrease in the daily yield is achieved by the heads of the Mačvan district -2. 34 kg/head/day.

By showing the means of the least squares of milk reduction by breed, the smallest reduction is recorded in the Simmental breed -2.24 kg/head/day, and the largest in the Red Holstein breed -2.33 kg/head/day. In table 2, from the previous results of these researches, by comparing breeds based on the characteristics of the total daily milk yield, it was found that the Simmental breed is also the most resistant to heat stress, and the Holstein breed is the least resistant.

Table 2. *Least Square Means (LSM) of MPD traits by districts and breeds during summer*

Trait		MPD kg/head/ day	The average price of milk in Serbia (roughly)	Estimated loss per kilogram of milk per day
Districts	Mačvan	-2,34 kg/day		-1.17 euro/kg/day
	Danube	-2,28 kg/day		-1.14 euro/kg/day
	Šumadija	-2,27 kg/day		-1.13 euro/kg/day
Breeds	Simmental	-2,24 kg/day	0,50 euro/kg	-1.12 euro/kg/day
	Holstein	-2,31 kg/day		-1.16 euro/kg/day
	Red Holstein	-2,33 kg/day		-1.17 euro/kg/day
	Brown Swiss	-2,30 kg/day		-1.15 euro/kg/day

The author Zimbelman (2009) states that the average milk yield during the day decreased by 2.2 kg/day/head in Holstein cows exposed to THI values higher than 65. In the comparison of breeds shown in Table 2, also two Holstein genotypes have a greater decrease in milk during on warm days compared to the other two breeds (Simental and Brown Swiss), which can be justified by the higher genetic predisposition of Holstein genotypes for higher daily milk production. In addition to the effect on cows during lactation, cows exposed to heat stress during the 60-day dry-off period before calving also show changes that lead to a subsequent decrease in milk production of about 5–7.5 kg per day in the next lactation (Skibiel et al., 2022). Koc and Uzmay (2019) state that heat stress contributes up to 70% to the increase in milk production costs during the summer in Turkey. From the results of their three different scenarios, they concluded that the costs of small and medium farms will increase by 17-50%, while the costs of larger farms will increase by 10-41% due to climate change. Observed through the economic losses in table 2, the biggest loss is realized in red Holstein cattle and in cattle raised in the territory of the Mačva administrative district of the Republic of Serbia, of -2.34 kg/day, which corresponds to the parity of -1.17 euros/kg expressed for each kilogram of cow's milk. In the United States, a total loss of $2.36 billion per year due to heat stress in the livestock sector has been estimated (St-Pierre et al., 2003). Mauger et al., (2015) also reported that economic losses from heat stress were $670 million per year (1950-2000), $1.7 billion per year by the 2050s, and $2.2 billion per year by the 2080s. them to the US. Key et al. (2014) estimated a decrease in the total value of milk production in the USA by 198.6 million dollars by 2030. According to the result of the study of Calil et al. (2012), US dairy farm costs will increase in 2050 between 2.7% and 15.1% due to changes in all climate impacts. Cortignani et al. (2015) stated that climate change would reduce the net income of Italian dairy farms by 2.1% by 2030. In Australia, milk production is expected to decline by 5-15% nationwide by 2050, and the economic loss will be around 100 million dollars per year (Hanslow et al., 2014).

In addition, Ferreira et al. (2016) suggested that the absence of measures to mitigate heat stress for cows during periods of drought could result in economic losses exceeding $800 million per year for the United States dairy industry. However, if the average temperature increases by 1.7°C, farm food costs will increase by 10-18%, in Turkey (Koc and Uzmay, 2019). In Africa, the continent most affected by climate change, it has been reported that would climate change cause an income loss of $177,351.24 by mid-century (Lakew, 2017). This economic loss due to the direct effect of heat stress on milk production, as well as due to decreased immunity increases susceptibility to infections and affects udder health in cows (Wanjala et al., 2022).

Along with the ongoing climate changes, the negative effects of heat stress will be more pronounced in the coming time (Roland et al. 2016). Fabris et al. (2020) also state that the drying period and the involution of the mammary gland for milk production in the upcoming lactation, during heat stress, are impaired as processes of renewal, growth and development of mammary gland cells, where heat stress interferes with the proliferation components during the early dry period. The average daily temperature in the UK is predicted to rise by 4°C by the end of the century, causing an economic loss of £2,000 to £6,000 a year in income in average years and £6,000 to £14,000 a year in extreme years for average-sized dairy farms (Fodor et al., 2018). Producers would benefit from knowing the possible volume of milk production in conditions of thermal fluctuations, and as dairy cattle are more susceptible to the effects of changes in climate factors than other ruminants, they are affected faster and more (Bernabucci et al., 2010).

Conclusion

The environment of dairy cattle breeds, and therefore the ability of the cattle organism to adapt to a changing climate, is greatly influenced by the actions of farmers and breeders, as dairy cattle are mostly kept in intensive production systems. By controlling the selection of the appropriate breed for a certain climate and conditions inside the facility, as well as nutrition and well-being, it is possible to somewhat control the microclimate of the cattle in the barn. It should also be noted that during winter, global warming can also have beneficial effects, such as reducing food costs, energy and ventilation levels, which can somewhat counteract the negative impacts during summer. In this paper, the largest economic losses in daily milk production of -1.17 euros/kg/head/day are achieved by the heads of the two Holstein breeds, as well as the heads raised in the Mačvan district compared to the heads raised in the Danube and Šumadija administrative districts of the Republic of Serbia.

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INFLUENCE OF DIFFERENT COMBINATION OF NUTRIENT ON THE LEAVES NUMBER AND AREA AND SUGAR BEET ROOTS MASS

Radmila Bojović[1], Vera Popović[2], Marijana Jovanović Todorović [3]

Abstract

Sugar beet is a plant that has been a part of our daily diet for centuries because it has been cultivated as a garden plant for 3000 years. It is mostly grown in the temperate climates of Europe and Asia. Sugar beet is a plant from which sugar - sucrose - is obtained from its roots. All parts of sugar beet are useful: root, head and leaves. Considering that the main reason for cultivation is the root, the leaves remain unused in further processing and are used mainly for animal feed. What should be emphasized is that these leaves have the potential to be used further in the food and chemical industries because they contain a large amount of protein and polyphenols. Therefore, more attention should be paid to the study of factors that would contribute to the growth of not only the roots but also the leaves of sugar beet. This paper dealt with the influence of different amounts of NPK on the number and surface area of leaves and the weight of roots in two sugar beet varieties - Original and Ventura. The experiment was carried out on the fields of "Tamiš" Institute, Pančevo, it lasted two years and the impact of 9 combinations of NPK was tested and the tenth was the control. The variety Original had the highest average number of leaves at $N_{100}P_{50}K_{50}$ and $N_{130}P_{50}K_{50}$ in the first year and at $N_{130}P_{100}K_{100}$ in the second year (25.9) and Ventura at $N_{100}P_{100}K_{100}$ in the first year (34.2) and at $N_{50}P_{50}K_{50}$ and $N_{130}P_{100}K_{100}$ (33.6). The highest average leaf area was for the Original variety in both years at $N_{130}P_{50}K_{50}$ (7493.17 cm2; 7501.12 cm2) and for the Ventura variety at $N_{100}P_{100}K_{100}$ (9805.59cm2; 9846.96 cm2). The highest average root weight in the Original variety was $N_{130}P_{130}K_{130}$ (1kg) in the first year, and $N_{100}P_{50}K_{50}$ (0.99kg) in the second year.

Key words: *Sugar beet, number and area of leaves, weight of roots.*

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Introduction

Sugar beet is a plant that has been a part of our daily diet for centuries because it has been cultivated as a garden plant for 3000 years. It began to be cultivated for commercial production in the 18th century and in Serbia at the end of the 19th century. It is mostly grown in the temperate climates of Europe and Asia. It represents a plant whose processing produces sucrose in an amount that makes up 35% of the world's production of this sugar. Today, 120 million tons of sugar beet is produced in Europe, from which about 16 million tons of sugar are extracted, which makes up 50% of European sugar production (Caliceti et al. 2022).

Sugar beet is a plant from which sugar - sucrose - is obtained from its roots. All parts of the sugar beet are useful: root, head and leaves. Considering that the main reason for cultivation is the root, the leaves remain unused in further processing and are used mainly for animal feed. What should be emphasized is that these leaves have the potential to be used further in the food and chemical industries because they contain a large amount of protein and poly-phenols. Therefore, more attention should be paid to the study of factors that would contribute to the growth of not only the roots but also the leaves of sugar beet.

Sugar beet production is very important for many industries. All parts of the sugar beet are useful: root, head and leaves. By Milosevic (1989), the yield of leaves with root heads is about 25 t/ha if a yield of roots is 40 t/ha.

The main root is the technologically most important part of the sugar beet root. This part of the beet root represents about 79% of the length of the whole root and is on average about 27 cm long. It contains 75% water and 25% dry matter, of which 17.5% is sucrose and 7.5% is unrefined matter (Pastović, 2017). In addition to sucrose, sugar beet produces noodles and molasses, which are widely used as feed for domestic animals or raw material for further processing. Molasses is used in the production of yeast, alcohol and beverages.

In the first year, sugar beet germination leads to the development of a rosette of glabrous, dark green, glossy leaves (Elliot and Weston, 1993). Ebrahimi et al., (2022) state that sugar beet leaves can be considered as a powerful source of bioactive compounds are because they are rich in essential amino-acids, fatty acids, poly-phenols and proteins.

According to Stanaćev (1979), flour from dried beet heads and leaves has the following average chemical composition: organic matter about 73%, mineral matter about 18% and water 9%. Organic matter consists of 49% nitrogen-free extractives, 13% crude proteins, 8% crude cellulose and 3% crude fat.

Sugar beet leaves are an underutilized source of protein in the diet. About 400-600 kg/ha of protein is present in its leaves, similar to the protein of soy (450-600 kg/ha) and cereals (570 kg/ha) (van Krimpen et al., 2013).

Soil and agro-ecological conditions, agro-technical measures, as well as seed quality (Petrović et al. 1997) and planting density (Filipović et al. 2008) affect the yield and quality of sugar beet roots.

Sugar beet is an important food, industrial and strategic foodstuff (Bojović et al. 2024). Considering the great importance of sugar beet, it is necessary to find ways to increase the yields since the increase in the area on which it is grown is difficult to increase to a greater extent. Achieving an increase in yield is done by various measures. One of the most important is the use of mineral nutrients. Glamočlija et al. (1990) conclude that the influence of NPK mineral nutrients is significant on the yield of sugar beet roots.

Agro-ecological conditions

Precipitation

Average amounts of precipitation in the growing season were in May, June and July of the first year and in May, June and August of the second year higher than the multi-year average. The total average amount of precipitation in the vegetation period of the first year (330.9 mm) was lower than the average (376.4 mm) by 45.5 mm, and in the second year (429.8 mm) it was higher by 53.4 mm. The total amount of precipitation in the first year was lower (543.2 mm), and in the second year higher (736.5 mm) than the multi-year average (669.6 mm).

Temperature

The average annual temperatures in the examined years were close to the long-term average (12.8°C), 12.6°C in the first year and 12.8°C in the second. In the first year, during the growing season, temperatures in April, June, August and September were higher than the long-term average, and in the second year, they were only in July.

Material and Method

The study of the influence of increasing amounts of mineral fertilizer on the weight of roots and the number and surface area of sugar beet leaves was carried out in the course of two years in the area of southern Banat on the experimental fields of PSS Institute Tamiš. Two varieties of sugar beet were used in the experiment – Original (Sesvanderhave) and Ventura (Maribo). The experiment was carried out on carbonate chernozem type soil according to a random block system in four repetitions.

Basic processing was carried out at autumn, and pre-sowing preparation and sowing at the end of March. The main crop for both years was wheat. Care and protection measures were standard. The supplemental nutrition system included 10 variants of using mineral nutrients, half of the amount by basic processing and the rest by pre-sowing. The following variants are applied:

1. $N_0P_0K_0$	6. $N_{100}P_{50}K_{50}$
2. $N_{100}P_0K_0$	7. $N_{100}P_{100}K_{100}$
3. $N_0P_{100}K_0$	8. $N_{130}P_{50}K_{50}$
4. $N_0P_0K_{100}$	9. $N_{130}P_{100}K_{100}$
5. $N_{50}P_{50}K_{50}$	10. $N_{130}P_{130}K_{130}$

Leaf data were recorded during August. Extraction of the roots was done during autumn.

Research results

The variety Original had the highest average number of leaves at $N_{100}P_{50}K_{50}$ and $N_{130}P_{50}K_{50}$ in the first year and at $N_{130}P_{100}K_{100}$ in the second year (25.9). Ventura had the highest average of leaf number at $N_{100}P_{100}K_{100}$ in the first year (34.2) and at $N_{50}P_{50}K_{50}$ and $N_{130}P_{100}K_{100}$ (33.6) in the second year. There was a smaller variation in the number of leaves in the second observed year. The variety Original had the lowest average number of leaves in the first year in the control (23.5) and in the second at $N_{100}P_0K_0$ (24.0), while the variety Ventura had the lowest number of leaves in both the first and second year at $N_0P_{100}K_0$ (30.3/32.4).

Tabela 1. *Number of leaves (average by year)*

	Average number of leaves			
	Original		Ventura	
	I	II	I	II
$N_0P_0K_0$	23,5	24,5	31,0	33,0
$N_{100}P_0K_0$	24,2	24,0	32,0	33,4
$N_0P_{100}K_0$	24,2	24,7	30,3	32,4
$N_0P_0K_{100}$	25,2	24,4	31,5	32,7
$N_{50}P_{50}K_{50}$	24,2	25,5	32,3	33,6
$N_{100}P_{50}K_{50}$	25,9	25,2	32,4	32,5
$N_{100}P_{100}K_{100}$	25,2	24,8	34,2	33,4
$N_{130}P_{50}K_{50}$	25,9	25,3	32,2	33,2
$N_{130}P_{100}K_{100}$	24,5	25,9	33,7	33,6
$N_{130}P_{130}K_{130}$	24,8	25,8	32,7	32,8

The highest average leaf area was for the Original variety in both years at $N_{130}P_{50}K_{50}$ (7493.17 cm^2; 7501.12 cm^2) and for the Ventura variety at $N_{100}P_{100}K_{100}$ (9805.59cm2; 9846.96 cm^2). The average leaf area was higher in the second year for both cultivars, except for Ventura which at $N_{130}P_{130}K_{130}$ had smaler average leaf area at second than at first year. The Original variety had the smallest average leaf area both years in the control (6275.52/6449.63 cm^2), and the Ventura variety had it both years at $N_0P_{100}K_0$ (8133.35/8983.32 cm^2).

Tabela 2. *Average leaf area (cm^2)*

	Average leaf area (cm^2)			
	Original		Ventura	
	I	II	I	II
$N_0P_0K_0$	6275,52	6449,63	8562,51	9298,70
$N_{100}P_0K_0$	6679,06	6771,60	8554,90	9126,22
$N_0P_{100}K_0$	6382,41	6702,35	8133,35	8983,32
$N_0P_0K_{100}$	6363,44	6472,71	8418,04	8994,54
$N_{50}P_{50}K_{50}$	6419,66	6835,60	9189,32	9537,85
$N_{100}P_{50}K_{50}$	6876,92	7046,56	9013,94	9302,60
$N_{100}P_{100}K_{100}$	6903,34	7280,06	9805,59	9846,96
$N_{130}P_{50}K_{50}$	7493,17	7501,12	9348,22	9638,44
$N_{130}P_{100}K_{100}$	6946,58	7343,52	9751,63	9819,53
$N_{130}P_{130}K_{130}$	6634,73	6886,41	9510,16	9461,53

The highest average root weight in the Original variety was $N_{130}P_{130}K_{130}$ (1kg) in the first year, and $N_{100}P_{50}K_{50}$ (0.99kg) in the second year. In the Ventura variety, the highest root weight was at $N_{130}P_{100}K_{100}$ (0.65kg) in the first year and at $N_{100}P_{50}K_{50}$ (0.69kg) in the second year. The lowest average root weight for the variety Original was at $N_0P_0K_{100}$ in the first year (0.67kg) and at $N_0P_{100}K_0$ (0.60kg) in the second year. In the Ventura variety, the lowest average root weight was at control ($N_0P_0K_0$) in the first year (0.40kg) and at $N_{100}P_0K_0$ in the first (0.40kg) and second year (0.38kg).

Tabela 3. *Average root weight (kg)*

	Average root weight (kg)			
	Original		Ventura	
	I	II	I	II
$N_0P_0K_0$	0,72	0,86	0,40	0,41
$N_{100}P_0K_0$	0,80	0,80	0,40	0,38
$N_0P_{100}K_0$	0,77	0,60	0,49	0,59
$N_0P_0K_{100}$	0,67	0,88	0,45	0,51
$N_{50}P_{50}K_{50}$	0,79	0,82	0,53	0,58
$N_{100}P_{50}K_{50}$	0,79	0,99	0,51	0,69
$N_{100}P_{100}K_{100}$	0,87	0,92	0,54	0,57
$N_{130}P_{50}K_{50}$	0,92	0,80	0,64	0,52
$N_{130}P_{100}K_{100}$	0,94	0,92	0,65	0,61
$N_{130}P_{130}K_{130}$	1,00	0,81	0,64	0,60

Conclusion

- Sugar beet is a plant from whose roots sugar - sucrose - is obtained. All parts of the sugar beet are useful: root, root head and leaves.
- The main root is the technologically most important part of the sugar beet root.). It contains 75% water and 25% dry matter, of which 17.5% is sucrose and 7.5% is unrefined matter.
- Sugar beet leaves are rich in essential amino acids and fatty acids, proteins and poly-phenols. Because of these many beneficial properties, there has been an increased interest in the development of extraction methods for obtaining proteins and poly-phenolic compounds.

- ❖ Given the great importance of sugar beet, it is necessary to find ways to increase yields. Achieving an increase in yield is done by various measures. One of the most important is the use of mineral nutrients.

- ❖ In the observational view at the observed location, the influence of different amounts of used nutrients was evident, more on the average weight of the roots and the area of the leaves than on the leaf number.

- ❖ In the second observed year with more precipitation, the number of leaves was higher at a higher concentration of N nutrients N_{100} and N_{130}.

- ❖ For leaf area, the best ratio was $N_{100}P_{100}K_{100}$ for Original and $N_{130}P_{50}K_{50}$ for Ventura in both years.

- ❖ The highest average root weight in the first year for the Original variety was with the combination of $N_{130}P_{130}K_{130}$ and for the Ventura variety at $N_{130}P_{100}K_{100}$ and in the second year with the combination of $N_{100}P_{50}K_{50}$ for both varieties.

- ❖ Combination of nutrients that is best for root is not best combination for leaves, but has the positive influence.

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APPLICATION OF CLASSICAL METHODS AND EMBRYO CULTURE IN THE HYBRIDIZATION OF CULTIVATED SUNFLOWER AND HEXAPLOID PERENNIAL SPECIES *HELIANTHUS RESINOSUS*

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Abstract

Aninterspecific hybridization was carried out between cultivated sunflower Helianthus annuus L. and the perennial wild species Helianthus resinosus, accession GT-M-046, with the aim to create hybrid plants with enriched heredity and increased resistance to various stress factors. To overcome the difficulties in crossing, the embryo rescue method was applied. The cultivated sunflower was used as the maternal parent, represented by the male sterile (CMS) line 830-1/18A. Self-pollination was applied in F_1*, resulting in an* F_2*hybridgeneration. The resulting hybrid material was subjected to phenological and morphological studiesand biochemical studies. Hybrid plants were found to possess intermediate morphological characters tending to the wild parent and to have a perennialgrowth cycle. The oil and oleic acid content of both the parental forms and the hybrid generation was determined. The plants were transferred to the wild species collection of DAI, Gen. Toshevo and are grown under field conditions.*

Key words: *distant hybridization, Helianthus resinosus, embryo rescue.*

Introduction

Sunflower is a highly productive crop, but very often yield is compromised due to a number of biotic and abiotic factors. Wild species of sunflower pos-

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sess genes for resistance to abiotic and biotic stress (Thompson et al., 1981, Christov M., 1990). The application of interspecific hybridization in the sunflower breeding to create resistant varieties and hybrids is a successful solution to the problem of overcoming the negatives of the environment.

The wild perennial species *Helianthus resinosus* is also known as the resinous sunflower, due to the presence of resin glands on the leaves and inflorescences, is native to North Carolina, where it is found growing along roadsides and meadows, in pine or mixed forests. It can be propagated both by seeds and vegetatively, due to the presence of underground rhizomes. Good tolerance to dry soils and resistance to diseases and pests characterize the species. According to Skoric (1987), the species is resistant to *Phomopsis helianthi*, *Alternaria helianthi*, *Puccinia helianthi* and *Plasmopara helianthi*. Block (2005) and Snow et al. (2006) found resistance to *Alternaria helianthi* and *Plasmopara helianthi* in sunflower populations of *H. resinosus* origin. Its seeds are characterized by a low percentage of oil but a high protein content. There is evidence that the species possesses genes to restore the fertility of CMS Pet-1. For these reasons, the species is included in a breeding program to create lines and hybrids, resistant to biotic and abiotic stress. Due to various isolation barriers in remote hybridization, the development of embryos under ordinary conditions is difficult, which is overcome by the application of *in vitro the embryo rescue* method. Chandler and Beard (1983) successfully applied a modified B_5nutrient medium (Gamborg et al., 1968) to obtain hybrid combinations.

The aim of the present study is to perform a hybridization between cultivated sunflower and the perennial species *Helianthus resinosus*and analysis of the resulting hybrid material.

Methods and materials

The experiment was conducted in 2022 and 2023 in the Dobrudzha Agricultural Institute, General Toshevo. The cultivated CMS line 830-1/18 A was used as the maternal parent, and the wild hexaploid species *Helianthus resinosus*, accession GT-M-046, was used as the paternal parent. The hybridization was carried out under field conditions in the collection of wild sunflower species of DAI-Gen Toshevo. Five crosses were made and 12 viable embryos were obtained, which were cultured *in vitro*modified B_5 nutrient medium (Gamborg et al., 1968), containing macrosalts, microsalts MS (Murashige, T.

& F. Skoog, 1962), vitamins B_5 (Chandler & Beard, 1983), inositol, sucrose and agar (Azpiroz et al., 1987). medium is brought to pH=5.7 and autoclaved at 121 ^{0}C and 1.1 atm for 20 min. Four embryos were placed in each Petri dish. F2 hybrid generation was obtained by self-pollination of F_1 plants.

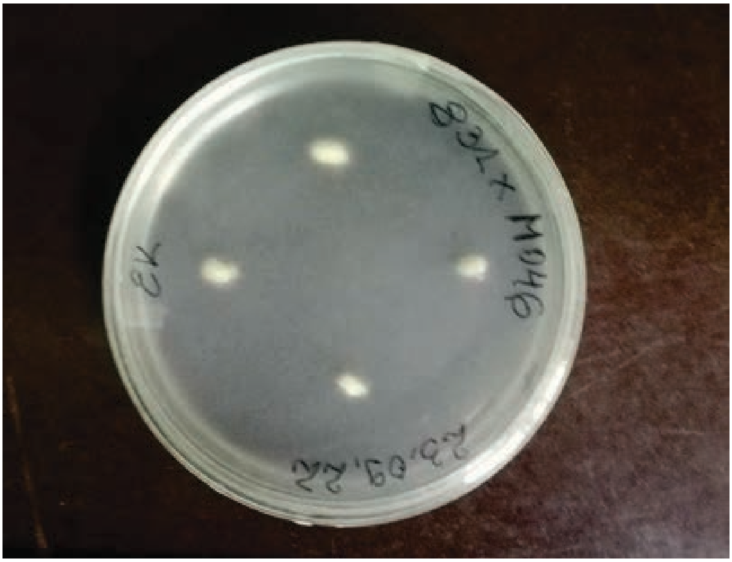
3. 1. Preparation of embryos and sterilization

The inflorescences of the pollinated plants were cut, the bracts were removed and the formed young embryos were separated from the pith with tweezers. Then they were placed in a gauze bag for sterilization in a 70% solution of sodium hypochlorite NaClO (1.6% active chlorine) for 20 min. In a laminar box, they were washed 6 times with distilled sterilized water.

3.2. Cultivation and nutrient medium

Modified enriched B_5 nutrient medium was used to cultivate the embryos.The process was carried out in a laminar box under sterile conditions. With sterile tweezers and a scalpel, the boats were removed, and the embryos were placed in Petri dishes, in which the autoclaved nutrient medium had previously been poured (Fig. 1). The Petri dishes were sealed with paraffin tape, after which they were transferred to a phytostat room at a temperature of 24 $^0 \pm 2$ ^{0}C and 2500-3000 lux. lighting. The photoperiod was 16/8 hours per day. Plant development was recorded.

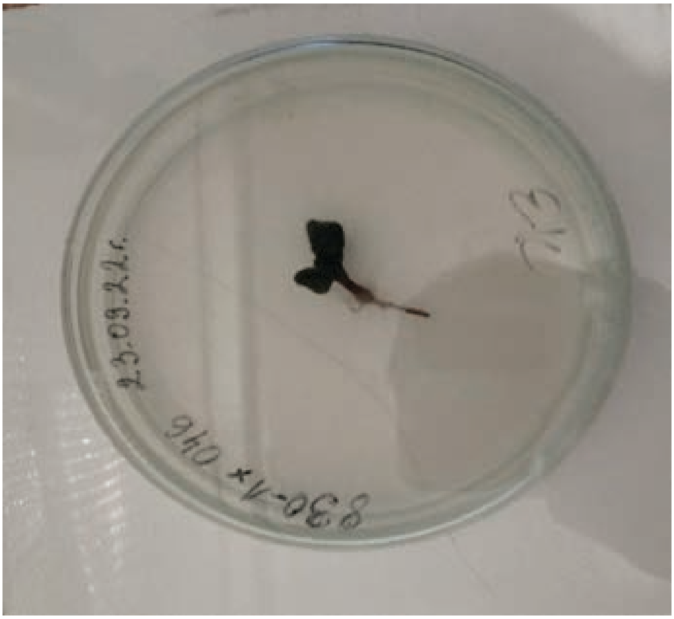
Figure 1. *Embryos from cross 830-1/18 x GT-M-046*



3.3. Transfer plants to soil

According to the condition and development of the plants, the time for transferring them to a soil substrate with a composition of soil and sand in a ratio of 1:1 was estimated. This was done on the 19th day after cultivation when the root length reached 3-4 cm.

Figure 2. Plant from cross 830- 1/18Ax GT-M-046



Results and discussion

The experiment was carried out in two stages - first stage - pollination of line 830-1/18 A withaccession GT-M-046 (*H. resinosus*) and second stage - self-pollination of $F_1$the hybrid generation. Five crosses according to the scheme “*cultivated sunflower x wild species”*were obtained. Twelve embryos were obtained, from which three plants developed, the rest necrotized at a different stage of development. On the third day, the appearance of a root was observed, and on the fifth - of a leaf (Fig. 2). After reaching 3-4 cmroot length plants were transferred to soil and grown under greenhouse conditions. All have a perennial growth cycle (Fig. 3). In April, they were planted in the collection of wild sunflower species, maintained in DAI.

Figure 3. *Cross F 1 830-1/18 A x GT-M-046*

Accession GT-M-046was characterized by anthocyanin coloration on stem and leaves. In the cross 830-1/18A x GT-M-046 anthocyanin staining of the mosaic type was found on the stem. On the leaves and inflorescencesa lack of anthocyanin was observed. As the leaves age, anthocyanin spots appear. Since in the cultivated sunflowerthe anthocyanin coloration was absent, it can be concluded that, its presence in the hybrid combination is early morphological marker for successful interspecific hybridization and transfer of genesfrom the wild species.

The vegetation period of the hybrid combination is intermediate compared to that of the parents. The same applies to the other phenological characteristics - duration of flowering and days from germination to flowering (Table 1). The coefficient of variation (VC) of the phenological characteristics in the hybrid combination is higher compared to the parental forms.

Table 1. *Phenological characteristics of parental forms and hybrid generations*

Characteristics	P1		F1		P2	
	830-1/18 A		830-1/18 A x GT-M-046		GT-M-046	
	$\bar{x}$	VC	$\bar{x}$	VC	$\bar{x}$	VC
Vegetation period (days)	118	1.06	150	2.89	180	1.87
Flowering duration (days)	7	2.11	35	4.75	62	6.87
Initial flowering (days from emergence)	56	1,78	92	2.85	105	1.87

From the morphological characterization of the cultivated and wild parent and the realized cross, it can be seen that according to some indicators such as plant height, length and width of leaves, number of leaves, length and width of tongue flowers in F_1 a decrease in values is observed. The remaining indicators are of average values, but closer to those of the wild parent. It can be assumed that this is due to the interaction between the genes of the cultivated and the wild species. The high values of the coefficient of variation (VC) of the investigated morphological indicators at F_1 are strikinggeneration, which can be explained by its hybrid nature. The coefficient of variation of the investigated morphological indicators in the cultivated sunflower has low values, due to the alignment of the maternal line (Table 2) F_1 generation is male fertile, therefore it has Rf genes, fertility restorers.

Figure 4. *g H. resinosus* (sample GT-M-046)

Figure 5. Cross F_1 830-1/18 A x GT-M-046

Table 2. *Morphological characteristics of the parental forms and the cross*

Characteristics	P1		F1		P2	
	830-1/18 A		830-1/18 A x GT-M-046		GT-M-046	
	$\bar{x}_{x^{-}}$	**VC**	$\bar{x}$	**VC**	$\bar{x}$	**VC**
Plant height (cm)	155	1.59	100	11.29	155-160	2.34
Leaf length (cm)	23.2	4.11	8.6	10,17	9.5	2.05
Leaf width (cm)	25.5	1.21	4.3	11.76	5.2	1.57
Leaf petiole (cm)	7.5	6.05	1.1	24.94	0.5	13.55
Number of leaves	36	5.56	10-12	40.82	26	6.01
Number of branches	0		1-2	22,22	4-7	5.22
Length of longest branch (cm)	0		14.5	5.53	38	5.55
Number of bracts	58	2.82	30-36	5.56	20-25	6.48
Number of ray flowers	43	3.80	12	14,21	11	9.62
Length of disk flowers (cm)	6,7	1.86	3.5	28,28	4.2	5.61
Width of ray flowers (cm)	2,3	7,10	0.5	25,20	0.7	10,11
Number of disk flowers	1625	0.38	100-240	21.10	120-200	14.67
Diameter of the head (cm)	22	6.78	2.23	18.56	1.98	14.02
Seed length (cm)	1.1	9.58	0.6	37.84	0.4	48,59
Seed width (cm)	0.6	7.86	0.4	26.35	0.2	40.82
Seed thickness (cm)	0.4	11.79	0.2	27,14	0.2	40.70
Seed color	black		grey		gray-brown	

The weight of 1000 seeds was calculated by measuring two samples of 50 seeds each. Table 3 shows that the weight of 1000 seeds and the oil content of seeds in F_1 are average values. The oleic acid content of the cross was higher compared to that of the parents. This is evidence of the additive action of genes (Chernova, 2021). The same applies to the protein content of the hybrid combination and it can be assumed that the reason is additive in nature. The coefficient of variation of the investigated biochemical indicators in the cultivated sunflower is low, in the paternal parent-wild species it is slightly higher, but with the highest values in the hybrid combination. This is due to the significant variation in the values of the investigated biochemical parameters in the F_1 cross (Table 3).

Table 3. *Some biochemical characteristics of the parental forms and the cross*

Characteristic	P1		F1		P2	
	830-1/18 A		830-1/18 A x GT-M-046		GT-M-046	
	$\bar{x}$	VC	$\bar{x}$	VC	$\bar{x}$	VC
1000 seeds weight (g)	64.4	0.56	21.4	10.50	7.5	6.22
Oil (%)	47	1.73	25.15	10.31	15,23	3.5
Oleic acid (%)	44.93	1.14	64.87	34.03	58,57	2.42
Protein (%)	22	3.16	61.35	0.59	49.3	1.36

When self-pollinating $F_{1,}F_{2}$ was obtained generation. In it, a decrease in the values of the reported phenological indicators was reported compared to the F_1 generation. The vegetation period of F_2 is shorter compared to that of F_1(130 days). The time from emergence to flowering in F_2 is 87 days and in $F_1$is 92 days. Flowering duration in F_2 is also shorter (30 days), compared to F_1(35 days).

Conclusion

From the research done, it can be concluded that successful interspecies hybridization in sunflower can be carried out by classical method of selection and embryo cultivation. The interspecific cross possesses intermediate markings that are closer to those of the wild parent. The coefficient of variation of the studied indicators shows higher values in the cross, compared to the coefficient of variation of the studied indicators in the parental forms.

A study of the F_1 and F_2 generations for resistance to diseases and the parasite broomrape and subsequent inclusion in selection programs to create new starting material is pending.

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COMPENSATION FOR DAMAGE DUE TO OMISSIONS IN KEEPING AND MANIPULATING APPLE SEEDLINGS

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Abstract

Raising large fruit plantations, very often involves the delivery of seedlings and their planting in a period of 2-3 days. It depends on the available workforce and mechanization, as well as on the accommodation capacity for keeping seedlings until the moment of planting. The passage of time and inadequate conditions for keeping seedlings can damage some seedlings, which is why they will progress differently after planting, and later bring an uneven crop and different yields. The owner of the orchard often blames the seller of the seedlings for the poor reception of the seedlings. Such cases often end in litigation, when the court hires licensed appraisers (experts) or commissions of experts, who will assess the causes of the damage. In this paper, one such case is analyzed, which ended with a court case and an expert assessment of the damage and the net value of the lost crop. It is indisputable that the owner of the fruit plantation suffers damage, which is shown by the evaluations of the experts, which were analyzed in this paper, and the court, based on the expertise and the evidence presented, makes the final verdict on who is to blame for the damage.

Key words: *apple planting, lost net worth, care of seedlings, care after planting, court experts.*

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Introduction

In recent years, fruits and fruit products have been in first place in the structure of foreign trade exchange of agricultural and food products in Serbia. In the period from 2000 to 2020, oscillations are recorded in the volume of fruit production, most often due to the action of unfavorable agro-climatic factors, but a significant increase in total production is evident. In 2020, the volume of fruit production is 45% higher compared to 2005 and even 63% higher compared to 2002. (Keserović et al., 2022)

The apple is grown in a temperate climate zone, with extremely high importance in world fruit growing, as it is the second largest fruit after bananas, followed by oranges, grapes and mangoes. That is why the apple is one of the most important fruits in the world and in Europe, so it can be said that the production of apples shows the development of the entire fruit production in any country. (Subić et al., 2017)

In developed countries, apple production is at a high technological level, so the volume of production does not change or even increases regardless of the reduction of areas. The apple is currently the leading fruit species in Serbia, the areas under apple are constantly increasing, and the reason is good agroecological conditions, adaptability and resistance of the apple to low temperatures and spring frosts. Proper soil maintenance, fertilizing, use of bioregulators and high-quality planting material, which includes seedlings with premature branches, so-called "Knip" seedlings that give the first crop already in the year of planting, and can give a full crop in the fourth year, also contribute to this. (Magazin et al., 2022)

Modern apple production enables the achievement of high and stable yields, and this implies standard planting technology and the application of necessary agrotechnical measures, irrigation and protection from hail and frost, which reduces the risk of production to the lowest possible extent (Potkonjak et al., 2011). By applying modern agricultural techniques in production, it is possible to achieve high yields, satisfying fruit quality and high financial results. In plantations that are intensively irrigated, the fruits are larger, more uniform, tastier, more intense in color and ripen earlier, but irrigation requires moderation, because too much water leads to a loss in the quality of the fruits. (Djurović et al., 2023)

In this paper, the authors analyze the circumstances of the damage and the net value of the lost crop in an apple orchard. The apple orchard in question was planted in the spring of 2017 and is now in the period of full bearing. It is currently covered with an anti-hail net and has a drip irrigation system installed, and standard apple varieties are represented: Golden Delicious, Greni smith and Gala.

In the paper, the authors will show that the passage of time and inadequate conditions for keeping the seedlings until the moment of planting can completely or partially damage some seedlings, which is why they will progress differently after planting, and later bring an uneven crop and different yields, which reduces the overall financial results. The resulting damage is very often the subject of a court dispute, when based on evidence and an expert's assessment, the question of whether the damage was caused by the poor quality of the seedlings or inadequate manipulation of the same should be answered.

Material and methods

According to Article 154 and Article 155 of the Law on Obligations, "damage is the reduction of one's property (ordinary damage) and the prevention of its increase (lost benefit), as well as the infliction of physical or psychological pain or fear on another (immaterial damage). Whoever causes damage to another is obliged to compensate for it, unless he proves that the damage occurred without his fault".

It is a civil proceeding, and the subject of the dispute is the apple seedlings that the defendant (Nursery) delivered to the plaintiff (owner of the orchard). The subject of the dispute is the quantity of 23,620 apple seedlings Knip 7+, varieties Greni Smith and Golden Delicious. The phytosanitary inspection issued a plant passport for the total amount of planting material. Seedlings were delivered in two rounds, 5 days apart. The first delivered quantity consisted of 15,000 seedlings of the Greni Smith variety and 2,720 seedlings of the Golden Delicious variety, and after 5 days a quantity of 5,900 seedlings of the Golden Delicious variety was delivered.

The first delivered quantity of apple seedlings was placed in a cold store, and the second delivered quantity of seedlings was delivered directly to the field. The prosecutor noticed that one part of the seedlings that were planted started to grow well, while the other part did not. He informed the defendant about this, who has visited so far. After that, phytosanitary inspectors, court experts and commissions of experts[5] (appraisers) went to the field to give their opinion on the circumstances of determining the compensation for damages and the net value of the lost crop in the apple orchard in question.

The assessors went to the field and interviewed the owner of the plantation, the seller of the planting material, as well as the owner of the cold store where the first delivered quantity of apple seedlings was stored. By going to the field, an inspection and analysis of the condition of the plantations was carried out on the spot, the number of trees, their development, structure of assortment, lushness, fertility and state of health were determined. An analysis of the production and economic possibilities of the agricultural production realized so far has been carried out. A calculative method is used to determine the net value of the lost crop and the resulting damage.

A licensed appraiser, depending on the available data, should choose the most appropriate valuation technique, and the valuation is done with the application of relevant market data. The assessment of the value (damage) of lost profit includes a market approach, a yield approach and a cost approach, with a comparative analysis of income and costs, and with the application of the principles of independence and independence, the principles of integrity, the principles of responsibility and the prohibition of causing damage, as well as the principles of transparency. (Regulation on national standards, code of ethics and rules of professional conduct of a licensed appraiser)

Results and discussion

Location, quality and appearance of plots (micro and macro)

The apple orchard was raised on an area of 2.29 ha KO Irig. It is about state agricultural land, which the owner has leased for a period of 40 years. In the vicinity of this plot there are other plots where mainly agricultural production is represented. The area where the apple orchard is located is on a slight rise and is flat (Figure 1).

5 The authors of this paper form the committee for expert opinion in the subject litigation.

Figure 1. *Location of plot 7428/28 in KO Irig*

***Source**: https://a3.geosrbija.rs/katastar https://katastar.rgz.gov.rs/eKatastarPublic (date of access 07/05/2024)*

The plot in question can be accessed by an asphalt road, the land has a flat relief and is located at about 200m above sea level, with loamy mechanical composition, crumbly structure, good permeability, good physical properties and a favorable water-air regime. It is suitable for processing and organizing fruit and viticulture production.

<u>Perennial plantings on the plot in question</u>

Upon going out into the field, it was established that there is a perennial vegetable plantation (apple plantation) on the plot in question. At the moment of going out into the field, the apple trees were in the phase of setting fruit. So far, it was raised in the spring of 2017 and is now in the period of full fertility. It is currently covered with an anti-hail net and has an installed drip irrigation system (Figure 2). Standard varieties are represented in the plantation: Golden Delicious, Greni Smith and Gala. On the part of the plot where the disputed varieties were planted, it cannot now be determined which seedlings were produced by the defendant, and which were subsequently planted in June 2017.

Picture 2. *Layout of the apple plantations*

Picture 3. *Layout of the cold store*

***Source**: Autors*

During the visit to the field, the commission visited the cold storage room where the seedlings were stored. At the time of our arrival, the refrigerator was quite empty and there were apples in it (Figure 3). In such a refrigerator, only the temperature can be regulated, which was set at 3-5°C, while the air humidity cannot be regulated. These types of refrigerators are not suitable for storing seedlings, because they quickly dehydrate. The relative humidity of the air in such refrigerators is below 50%. Cold and dry air dries out seedlings very quickly. It is possible to store seedlings in specialized cold rooms where the temperature should be around 2°C and the relative humidity should be over 90%.

Analysis of damage and net value of lost crops

As the reason for the drying of the seedlings, the prosecutor cites an inadequate way of storing the seedlings in the trap during the winter of 2016/17. year, that is, their freezing in the trap, which is why they were not received. The authors of this paper (committee of assessors) believe that the trap is an acceptable way of keeping seedlings during autumn and winter. It is important that the trap is properly made, 40-50 cm deep, in which the seedlings are placed and covered with a layer of sand or soil up to a height of 20-30 cm above the root neck. When seedlings are stored in a trap for a long time, the growth of root veins and swelling of buds can occur, especially when the temperatures are higher in March. Therefore, it is recommended to plant earlier in such years, as well as to soak the seedlings in water for 24 hours before planting. (Medigović, 2007).

From the data of the Republic Hydrometeorological Institute for the meteorological station Kruševac, which is the closest to the place of the defendant, it can be seen that the winter of 2016/17. was cold. The coldest month was January 2017, with an average monthly temperature of 5.2°C and an average minimum temperature of -10.5°C. The lowest temperature of -21.2°C was measured on January 8. (Republic Hydrometeorological Institute)

During this period, the apple was in deep (biological) winter dormancy. Apple is a species that tolerates low winter temperatures quite well, and in this period it can withstand temperatures below -25°C (Mišić, 1994). The most sensitive parts of the tree are the tops of branches and extensions. A certificate was issued for the seedlings by the authorities responsible for controlling the production of fruit tree planting material. The Republic's phytosanitary inspector made a plant passport during the preparation of which an inspection of the seedlings and the state of the trap was carried out, when no defects were observed on the seedlings, which is why it can be concluded that there was no freezing of the seedlings in the defendant's trap.

As already mentioned, out of the total delivered quantity of 23,620 apple seedlings, the quantity of 15,000 seedlings of the Greni Smith variety and 2,720 seedlings of the Golden Delicious variety was delivered first. These seedlings were not planted immediately after reception, but were placed in a refrigerator, where they spent 7 to 15 days. This is too long a period of keeping seedlings, and since it is an inadequate refrigerator, which is not specialized for keeping seedlings, it most likely led to their dehydration. This is especially evident in seedlings that were stored in a trap before the cold storage and were exposed to high temperatures, which can cause their activation.

The second delivered quantity of 5,900 seedlings of Golden Delicious, arrived five days after the first quantity, was delivered directly to the field and the seedlings were immediately planted. After the planting of these seedlings, the planting of the seedlings that were placed in the cold room began. The seedlings were transported from the cold store every day by a tractor trailer to the field, where they were spread out in rows (half), and the other half of the seedlings were unloaded on the ground and covered with a tarp. The seedlings would remain on the ground for about 2.5 hours. During the deployment, the seedlings were placed in previously dug trenches, which were opened mechanically. Then the workers buried the roots of the seedlings and trampled the soil around them. Planting lasted 7 to 15 days.

The phytosanitary inspector stated in his report that a total of 63% of the seedlings of the Greni Smith variety and 25% of the seedlings of the Golden Delicious variety had dried up. All the seedlings of the Greni Smith variety were the first to be delivered and were placed in a cold storage room, as well as part of the seedlings of the Golden Delicious variety. However, most of the seedlings of the Golden Delicious variety arrived in the second delivery, directly to the plot and were immediately planted. Most of the seedlings of this variety were received. This indicates that the storage of seedlings in inadequate conditions (refrigerators) contributed to the greatest extent to the poor reception of the Greni Smith variety.

In the case of late spring planting, which we are talking about here, it is recommended that the seedlings be submerged in water for 24 hours before planting in order to refresh the veins and improve their reception. Upon arrival from the cold store, these seedlings were not immersed in water, but were spread around the plot and planted. At the time of planting, the drip irrigation system was not in operation, so the seedlings were watered from cisterns. Each seedling was watered with 5-6 l of water, and it is recommended that apple seedlings be watered with 10 l of water per seedling after planting (Mišić, 1996). Watering from cisterns is uncertain, especially when it comes to a larger area and later planting, where watering should be done in a short period of time, with a sufficient amount of water for a large number of seedlings. This is especially evident in apple seedlings with premature branches, which, as a rule, need a larger amount of water after planting for good reception and growth. That is why it is much safer to water the seedlings with the “drop by drop” system.

The seedlings were not shortened after planting, and the shortening of the seedlings is a mandatory measure that should be done after planting. This measure significantly reduces the above-ground system, which establishes a correlation between the underground and above-ground systems, reduces transpiration and ensures the reception and growth of seedlings in the year of planting. This is especially evident in late spring planting and in seedlings with a larger number of premature branches.

On the basis of everything presented, the commission concluded that there were omissions by the prosecutor in the manipulation of seedlings and care measures after planting. The plaintiff kept the largest number of seedlings longer than the optimal time in inadequate conditions (refrigerators without regulating the relative humidity of the air), which is the main reason for the poor reception of the seedlings. In addition, the seedlings were not immersed in water before planting, the drip irrigation system was not in operation, and the cisterns could not provide adequate watering in accordance with the time of planting and the type of seedlings. The shortening of the seedlings as a mandatory measure after planting was not carried out either, which are the main reasons that led to the drying out and poor reception of the seedlings.

Transplanting seedlings in a plantation is a more expensive operation than when planting on an empty surface. Transplanting seedlings involves removing dry seedlings, digging pits and planting new seedlings in their place in different places in the plantation. Based on empirical data from the field, from 2017, one worker can plant 90 seedlings in eight hours of work. If the hourly rate is 250 RSD, the price of planting per seedling would be 22 RSD. To this price should be added the costs of transporting the seedlings to the plantation. When the costs of transporting seedlings are added to the cost of replanting, then the cost of planting per seedling is 27 RSD.

Considering that it was planted late, in the first year after planting, no serious crop could be expected. From experience, it could be from 0.5 kg per seedling (for one-year-old seedlings) to 1 kg per seedling (for two-year-old seedlings). Out of a total of 23,620 seedlings delivered (15,000 seedlings of the Greni Smith variety and 8,620 seedlings of the Golden Delicious variety), there were 14,400 one-year and 9,220 two-year seedlings, which is 61% one-year and 39% two-year seedlings.

Table 1. *Apple yield in the first year*

Age of seelings	Number of dried seedlings	Yield per seedling (kg)	Total yield (kg)
One-year	7,079	0.5	3,539.5
Two-year	4,526	1.0	4,526.0
Total	11,605		8,065.5

Source: *Author's calculation*

Since 63% of the seedlings of the Greni Smith variety (9,450 seedlings) and 25% of the seedlings of the Golden Delicious variety (2,155 seedlings) have dried, this makes a total of 11,605 dry seedlings. As we do not have exact data on how many one-year and two-year seedlings were dried, the authors used the percentage of seedlings delivered to the customer (61% one-year and 39% two-year), resulting in 7,079 one-year and 4,526 two-year seedlings dried, which is shown in Table 1.

Table 2. *Value of the lost crop in the 2017 production year*

Age of seelings	Price (RSD/kg)	Production and sales costs (RSD)	Net price (RSD/kg)	Total yield (kg)	Net value of lost crop (RSD)
One-year	55.0	19.25	35.75	3,539.5	126,537.1
Two-year	55.0	19.25	35.75	4,526.0	161,804.5
Total					288,341.6

Source: *Author's calculation, according to the average prices of apples for the Belgrade Quanta market in 2017 (STIPS)*

If a one-year seedling can have a yield of 0.5 kg, and a two-year seedling 1 kg per tree, then the yield loss is 3,539.5 kg (one-year seedling) and 4,526.0 kg (two-year seedling), i.e. a total of 8,065.5 kg. The price of apple fruits per kilogram at the Quanta market in Belgrade at the time of the harvest of these varieties was on average 55.0 RSD (STIPS). When production and sales costs are included, the net price of apple fruits was 35.75 RSD per kilogram (Table 2). In the end, when this price is multiplied by the total yield, then the value of the lost crop for 2017 would amount to 288,341.6 RSD.

Conclusion

In the analyzed apple orchard, it was determined that the time of planting, the method of keeping the seedlings and the actions carried out during and after planting, led to the drying of the seedlings. The trap is an acceptable way of storing seedlings, so the seedlings did not freeze in the defendant's trap. After being received by the plaintiff, the seedlings were kept in inadequate conditions, they were watered from cisterns, and the seedlings were not pruned, as a mandatory measure that should be done immediately after planting. With this kind of late spring planting, the seedlings had to be soaked in water for 24 hours, in order to refresh their roots and speed up their reception. These are circumstances that point to the plaintiff's omissions, which is why the authors believe that the drying of seedlings cannot be blamed on the defendant. The seedlings were purchased in the same condition, and a certificate was issued for them by the competent authorities, which is a guarantee of their quality.

The authors calculated by calculation that the cost of replanting per seedling amounted to 27 RSD, and that the net value of the lost crop in the 2017 production year was 288,341.6 RSD. The court will make a final decision as to who is to blame for the desiccation of the seedlings, that is, whether the cause of the losses is the poor quality of the seedlings or their inadequate manipulation.

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REACTION OF THE HERBICIDES ON THE STRUCTURAL ELEMENTS OF THE YIELD IN VARIETIES TRITICALE

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Abstract

The investigations were carried out during 2018 –2021 at Dobrudzha Agricultural Institute – General Toshevo. The aim of this investigation was to determine the reaction of the application of the herbicides on the structural elements of the yield in varieties triticale (xTriticosecale Witthm.). The following herbicides were used: Ergon WG (50 g/ha), Starane Gold (1800 ml/ha), Biatlon 4D+Desh (50g/ha+500ml/ha) and *Korelo Duo+Das Oil (260.5 g/ha+500ml/ha) from the group of sulfunylureas with various mechanism of* action. *The preparations were applied at stage 29 and 37 of three varieties triticale, Akord, Kolorit and Dodbrudzhanets. These were the followed structural elements of the yield: hight plant (cm),* length of spike (cm), *number of spikelets per spike, number of grains per spike, weight of grain per spike (g).* Correlation analysis was apllied. Strong positive and negative correlations *were established between the investigation parameters.*

Key words: *triticale, varieties, herbicides, application stages, structural elements of yield.*

Introduction

Weeds are considered the leading cause of crop yield losses worldwide, affecting food, fiber and biofuel production. In addition, weeds can impact the quality of the final product and increase production costs, with severe economic impact on agricultural activities (Soltani et al., 2017;Chauhan, 2020). Therefore, adopting weed management practices is essential for maximizing crop yield and quality.

The chemical control is one of the most widely adopted methods to manage weeds in agriculture, primarily because it is easy to use, fast action, and

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efficiency (Dan et al.,2011). However, the absence of new molecules with new modes of action in the last decades, along with the reliance on herbicides promoted the evolution of weed resistance to herbicides (Chauhan, 2020; Gaines et al., 2020). With few effective herbicides available, the need to use alternative active ingredients, and increased weed control costs, diverse management strategies are needed to prevent resistance evolution.

Triticale *(xTriticosecale Witthm.)* has lower input requirements compared to wheat, giving it both economic and environmental advantages. Furthermore, disease resistance is considered as one of the most important and durable advantages of triticale. In many crop species sensitivity to (selective) herbicides has been reported. Cultivar susceptibility to herbicides is hardly affected by weather conditions during the vegetative growth stage, type of herbicide and sowing rate (Drews et al., 2009).

In wheat (*Triticum aestivum* L.) varietal differences in susceptibility to chlortoluron and metoxuron were experienced in the past. In rye problems with susceptibility to phenoxy-propion acid derivatives were experienced. Because both wheat and rye are the parent species of triticale an increased herbicide sensitivity and varietal differences in susceptibility to herbicides may be expected in triticale.

In triticale certain doses and times of application of mecoprop caused chlorosis and growth inhibition. Chlortoluron applied pre-emergence seemed to be safer for triticale than when it was applied post-emergence. Isoproturon and methabenzthiazuron generally cause more crop injury than chlortoluron (Haesaert et al., 1990). Higher doses of isoproturon in triticale result in crop damage, which results in not negligible yield losses.

The main method for the control of weeds in cereal crops upon surface continues to be – the use of herbicides. The number of grains per spike and weight of 1000 grains was important biometric indicators. Significantly as many number of grains per spike (55.7) was established after treatment with Puma super (1235 l/ha), followed by Bristol EV69 (1250 ml/ha), Topic 15VP (247g/ha), Safener 15VP (247g/ha). Minimum number of grains per spike (45.7) were in weeded control. The highest weight of 1000 grains established under variant Safener 15VP (247g/ha) - 35.3g, and lowest in variant with weeded control - 32.0 g (Mehmood et al., 2014). Maximum mass of 1000 grains (39.8 g) was detected after treatment with Eim 40DF (34.7 g) used post emergemce, a minimum one at weeded variant (22.3 g) (Fahad al et., 2013).

After treatment cereals crops with herbicides applied post emergence with Buktril super 60EK (1.5l/ha) has established a considerable number of grains per spike 104 grains. The lowest number of grains per spike was in weeded control – 42 number of grains (Hussain et al., 2013).

The aim of this investigation was to determine the reaction of the application of the herbicides on the structural elements of the yield in varieties triticale (xTriticosecale Witthm.).

Materials and Methods

The investigations were carried out during 2018 – 2021 at DAI – General Toshevo. The fired trial was designed according to the block method in three replications, the size of the trial area being 10.5 m^2. Two check variants were involved: $К_1$ – weed-free variant manually cleaned till stage heading of wheat, and $К_2$ – check variant infested with weeds till the end of the crops' vegetation period.

The following herbicides were used: Ergon WG (metsulfuron-metil+tifensulfuron-metil) - 50 g/ha, Starane Gold (florasulam+fluroksipir) - 1800 ml/ha, Biatlon 4D+Desh (tritosulfuron+florasulam) - 50 g/ha+500 ml/ha, Korelo Duo+Das Oil (piroksulam+florasulam+klokvintotset-meksil) – 260.5 g/ha+500 ml/ha. The preparations were applied at stage "end of tillering", "stage 29" and stage "emergence of flag leave", "stage 37" according to Zadoks et al., (1974) of three triticale cultivars Acord, Kolorit and Dobrudzhanets.

Variety Akord, „stage 29"

Variety Akord, „stage 37"

Variety Kolorit, „stage 29"

Variety Kolorit, „stage 37"

Variety Dobrudzhanets, „stage 29"

Variety Dobrudzhanets, „stage 37"

Variety Akord – weed-free control

Variety Akord -weeded control

Variety Kolorit – weed-free control Variety Kolorit – weeded control

Variety Dobrodzhanets–weed-free control Variety Dobrodzhanets– weeded control

Before planting of wheat, artificial background of weed infestation was created using the most widespread weeds in the region of DAI – General Toshevo: the annual broad-leaf weeds ivy-leaved speedwell- *Veronica hederifolia (L.)*, wild mustard - *Sinapis arvensis (L.)*, cleavers - *Galium tricorne Stok*, the German chamomile - Matricaria chamomila *(L.)*, field chamomile - *Anthemis arvensis (L.)*, Royal knight's spur- *Consolida orientalis J. Gay*; and the perennial broad-leaf weeds creeping thistle - *Cirsium arvense (L.) Scop* and field bindweed- *Convolvulus arvensis (L.)*. Weed density was measured quantitatively per unit area by species using ¼ frame in four replications prior to introduction of herbicides.

The herbicide efficiency was estimated 25-30 days after the use of the preparations according to species, by amount and weight, using ¼ frame in four replications, measuring the weight of the weeds in fresh and dry condition. The effect was evaluated according to the 9-degree scale of EWRS for reading of the herbicide activity and selectivity, 1 corresponding to 100 % efficiency of the preparation, without symptoms of phytotoxicity on the cultural plants; and 9 corresponding to 29.9 % - 0 % effect of the preparation and complete perishing of the plants (Table 1).

Table 1. *Herbicide activity and selectivity according to 9-degree scale of EWRS*

Rank	Herbicide efect %	Damage symptoms	General evaluation
1	100	No symptoms – healthy plants	Excellent
2	99.9-98	Very weak symptoms – slight stunt effect	Very good
3	97.9-95	Weak but discernable symptoms	Good
4	94.9-90	Better expressed symptoms (eg. chlorosis) which do not affect yield	Satisfactory
5	89.9-82	Thinning of the crop, strong chlorosis or stunt. Lower yield expected	Indefinitely
6	81.9-70	Heavy damage or perishing of plants	Unsatisfactory
7	69.9-55	Heavy damage or perishing of plants	Poor
8	54.9-30	Heavy damage or perishing of plants	Very poor
9	29.9-0	Heavy damage or perishing of plants	Extremely poor

Characteristics of varieties triticale

Cultivar Akord is characterized with 125 – 140 cm stem height, high resistance to lodging and spike which is awned, with high number of grains and complete resistance to lodging. The cultivar is medium early, with high cold and winter resistance and high drought tolerance. Cultivar Kolorit has stem height 103-126 cm and possesses excellent resistance to lodging and high number of productive tillers. The cultivar is awnless and completely resistant to shedding. It is medium early, with high cold and winter resistance and high drought tolerance. Cultivar Dobrudzhanets is 115-145 cm high, with high resistance to lodging and good number of productive tillers. The spike is awned and highly resistant to shedding. The cultivar is also early maturing and tolerant to drought.

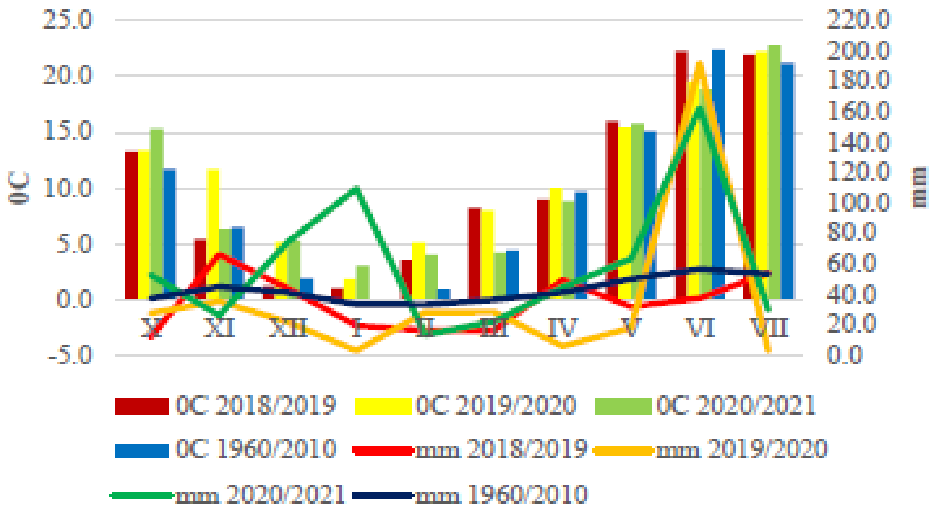
Investigated parameters

These were the followed parameters: hight plant (cm), length spike (cm), number of spikelets per spike, number of grains per spike, weight of grain per spike (g).

Meteorological characterization during the period of investigation

In 2018/2019 harvest year, the presented meteorological parameters - temperature and precipitation, no significant differences were observed compared to the reported long-year period (1960-2010) (Fig. 1). The meteorological situation was within optimal limits. Under optimal conditions, the plants have entered the development stages for the respective year. In 2019-2020 crop year, regarding the precipitation parameter, extreme values were recorded in June of 192.2 mm. Regarding the temperature parameter, no significant differences were observed with those for the long-year period (1960-2010). In 2020/2021, regarding the temperature parameter, no significant differences were observed with those for the long-ear period (1960-2010). Significant amounts of precipitation were reported in the months of January 2021-109.7 mm and in June 2021-162.7 mm. The reported rainfall during this period is a prerequisite for very good development and growth of the tested varieties.

Figure 1. *The air temperature and rainfull in the growing season of winter wheat, accordimg to Meteorological Station at DZI - General Toshevo, 2018-2021*



Statistical Analysis - Correlation analysis was apllied.

Results and discussion

Weed density per unit area is an important parameter in evaluating the impact of herbicide treatments on weed growth (Hussain et al., 2013). The greater the presence of the weeds, the greater is their completion for nutrients from the soil with the crop plants.

The experiment was set up on fields naturally infested by weed species. The weed population over the years of field experiment did not differ extensively. The presence of the weed species are presented. Across the growing seasons following weed species were most abundant: the annual broad-leaf weeds ivy-leaved speedwell - *Veronica hederifolia (L.)*, wild mustard - *Sinapis arvensis (L.)*, cleavers - *Galium tricorne Stok*, the German chamomile - Matricaria chamomila *(L.)*, field chamomile - *Anthemis arvensis (L.)*, Royal knight's spur - *Consolida orientalis J. Gay*; and the perennial broad-leaf weeds creeping thistle - *Cirsium arvense (L.) Scop* and field bindweed - *Convolvulus arvensis (L.)*.

These weed species are typical for the chernozems soils and the crop rotation that is preserved at the experimental trail. Winter annuals weeds are well presented in the population. They emerge after sowing in autumn and over-winter as (small) seedlings and complete their life cycle during spring. Winter annuals compete with the crop and slow the rate of crop development potentially reducing yield.

All the applied herbicides have a good performance against the weedspresent in the field. Regularly, the weed species are reduced for 100 % compared to the corresponding controls. All treatments have yield higher than the untreated yield. No growth inhibition or chlorosis was recorded.

The post-emergence treatments in spring are mostly a combination of contact and systemic herbicides, which should result in anactivity against a broad range of weed species. When products are applied, good weather and crop conditions are required, otherwise chlorosis or growth inhibition can be expected. The active ingredients used in spring time applications often show less selectivity to the crop. Therefore, the climatic and soil conditions are more important than the crop stage. A greater leaf effect of the treatments may be expected. An efficient chemical weed control in triticaleis an achievable objective. There are a range of active ingredient realize a sufficient reduction of the weed population.

It was proved strong positive correlations for cultivar Akord between follow parameters: hight plant and lengh of spike (0,817***) and lengh of spike and number of spikelets per spike (0,759***). It was established a lot of low and negative relationships at other structural parameters (Table 2).

Table 2. *Correlation of biometrical parameters for variety Akord after treatment with herbicides*

Parameters	hight plant, cm	lengh of spike, cm	number of spikelets per spike	number of grains per spike	weight of grain per spike,g
hight plant, cm	1				
lengh of spike,cm	0,817***	1			
number of spikelets per spike	0,717***	0,759***	1		
number of grains per spike	-0,302	-0,010	0,141	1	
weight of grain per spike,g	0,606	0,678	0,725***	0,402*	1

*** - p ≤ 0,01; ** - p ≤ 0,05; * - p ≤ 0,1; n.s. – non significant

It was proved strong positive correlations for cultivar Kolorit between follow parameters: hight plant and lengh of spike (0,841***) and hight plant and number of spikelets per spike (0,765***). It was established a lot of low and negative relationships at other structural parameters (Table 3).

Table 3. *Correlation of biometrical parameters for variety Kolorit after treatment with herbicides*

Parameters	hight plant, cm	lengh of spike,cm	number of spikelets per spike	number of grains per spike	weight of grain per spike,g
hight plant, cm	1				
lengh of spike,cm	0,841***	1			
number of spikelets per spike	0,765***	0,746***	1		
number of grains per spike	-0,283	-0,019	0,137	1	
weight of grain per spike,g	0,613	0,653	0,744	0,417*	1

*** - p ≤ 0,01; ** - p ≤ 0,05; * - p ≤ 0,1; n.s. – non significant

It was proved strong positive correlations for cultivar Dobrudzhanets between follow parameters: hight plant and lengh of spike (0,853***) and length of spike and number of spikelets per spike (0,778***). It was established a lot of low and negative relationships at other structural parameters (Table 3).

Table 4. *Correlation of biometrical parameters for variety Dobrudzhanets after treatment with herbicides*

Parameters	**hight plant, cm**	**lengh of spike,cm**	**number of spikelets per spike**	**number of grains per spike**	**weight of grain per spike,g**
hight plant, cm	1				
lengh of spike,cm	0,853***	1			
number of spikelets per spike	0,728	0,778***	1		
number of grains per spike	-0,323	-0,013	0,153	1	
weight of grain per spike,g	0,624	0,663	0,738***	0,438*	1

*** - p ≤ 0,01; ** - p ≤ 0,05; * - p ≤ 0,1; n.s. – non significan

Conclusions

A greater efficacy of applications in spring can be expected. However, for farmers a herbicide application is not always possible because of the weather or soil conditions. Therefore, intime application of herbicide treatments in springis advisable. No varietal differences in susceptibility to herbicides were recorded in the experiments at the experimental trail during the growing seasons. In the studied period 2018-2021, it was established and proved positive and negative correlations for the studied cultivars: Akord, Kolorit and Dobrudzhanets. Mainly, very good relationships were proved at hight plant and lengh of spike, lengh of spike and number of spikelets per spike. It was not observed visible phitotoxity at all studied cultivars.

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SECTION III

REVITALIZATION OF RURAL AREAS

EFFICIENCY OF AGRICULTURAL EDUCATION IN PERSPECTIVE PROFESSIONAL EMPLOYMENT

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Abstract

The paper reflects the state of the agricultural pre-university and university education system in Romania, highlighting the medium and long-term trends of the main indicators for education in accordance with the educational policies implemented. The methodological steps that were the basis of the elaboration of the work were the bibliometric, bibliographic and statistical-mathematical analysis. The basic indicators used in the paper are included in the National System of Indicators for Education (SNIE). SNIE is compatible with international indicator systems (Eurostat, OECD, UNESCO, World Bank) and includes part of the target indicators specific to common European objectives in the field of education. Official data provided by the Ministry of Education and the National Institute of Statistics for the period 2010-2023 were used to determine the values of the indicators. The efficiency of the education system was analyzed from the perspective of the professional insertion of graduates on the labor market. The purpose of this paper is to highlight the real problems facing education in general, agricultural education in particular, and to suggest possible solutions for them.

Key words: *education, agricultural education, educational efficiency, professional insertion.*

Introduction

Education can be seen as a social phenomenon. It has a historical character and appeared with the first forms of social organization of people, evolving according to the transformations of human society. Through education, the formation of the population is aimed at in accordance with the objective requ-

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irements of society, but also of the individual. The transition from individual to collective education was made simultaneously with the emergence of the need for the school to keep up with technical progress. The need to broaden the spectrum of knowledge, in a relatively short time, to train a growing number of people, constituted the premises and at the same time the effect of a growing production.

Agricultural education was aimed at developing knowledge on subjects useful to farmers. As a result, different types of skills were required, including entrepreneurship, customer orientation, sustainability and innovation. (M. Mulder, H. Kupper, 2007). The pressures on the sector are caused by the enlargement of the EU, by changes in the public support of agriculture, by public protests against genetic modifications, etc. Therefore, Verkaik (1997) indicated the challenges and concepts for a future agricultural knowledge policy. In his opinion, this policy should aim at the development of agricultural knowledge, technologies and innovation. To survive in the 21st century, it is not enough for the government to support the initiatives of the society, it must act as an innovative entrepreneur and build new alliances in order to innovate the sector. Agricultural education, in his opinion, has an extremely important role in preparing young people for this transformation. There are countries where emphasis is placed on dual and full-time learning programs or on practical training for the practical components starting with the gymnasium and upper secondary levels . The drastic decrease in the budgets for agricultural education led to the reduction of the number of agricultural schools, to mergers of agricultural education institutions. (M. Mulder, H. Kupper, 2007). In Asian countries, high unemployment among vocational school graduates, inconsistent policies, inadequate teacher skills and weak support from the state are crucial issues that have been heavily criticized because these people graduate with only academic skills without practical skills. (Suharno et al., 2020).

The problem of education in general, of education with an agricultural profile is topical in the conditions in which societies and science have evolved so much. That is why, in this paper, we focus on the efficiency of pre-university and university agricultural education in Romania from the perspective of professional insertion.

Material and working methods

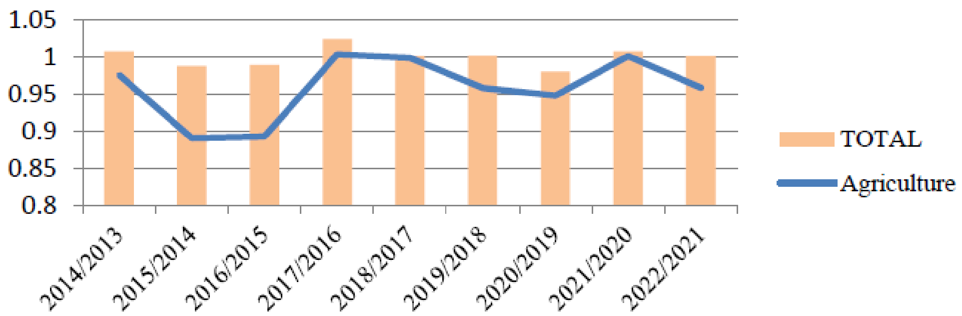
The first research method used in this work is the „bibliometric analysis" which was based on the search, filtering and extraction of scientific articles relevant to the subject addressed, by title, abstract and keywords, with the reference period 2010-2023. The second research method used in this work is „bibliographic analysis". This aims to extract existing official data in the research scope of the work. The data was collected by accessing the databases of Eurostat, the Ministry of Education and the National Institute of Statistics. The third method used was „statistical-mathematical analysis", this studying phenomena and processes from a quantitative point of view, in order to describe them and discover the laws that govern their manifestation, by calculating statistical indicators.

Results and discussions

Developed countries have seen important labor market transformations in recent years, especially from an occupational point of view. The researches carried out as well as the official statistics prove the existence of a tendency to polarize jobs, both towards occupations that require higher qualifications, with high salaries, and low-level qualifications, with very low salaries. The causes of these changes are complex, starting from technological progress, from the outsourcing of some activities, from the slow increase in the number of graduates with higher education, to the consequences of social, economic and health crises. In Romania, from a structural point of view, 84-89% of the population employed in agriculture are self-employed, the difference of 11-16% being salaried. Eurostat data highlights the fact that Romania leads the EU in terms of the population employed in agriculture (over 20%) and has the oldest farmers in the Union. In 2020, around a third (33.2%) of the Union's 9.1 million farm managers were aged 65 and over. Older farmers preferred to work on small and semi-subsistence farms managing 16.9% of the total agricultural area of the European Union. Managers under the age of 40 (11.9%) managed together 17.6% of the used agricultural area. The passage of time has led to the retirement of seniors and the emergence of the need to attract young people to the agricultural field. The PAC prioritizes generational renewal in this sector. Incomes and wages in agriculture have increased in recent years, both as a result of the younger generation taking over agricultural holdings from the elderly, but also due to the increasing demand for skilled workers with secondary or higher education. In order to succeed in improving its agricultural competitiveness, Romania's agriculture needs educated farmers capable of bringing it into the 21st century.

Today's agriculture is linked to the use of drones, biotechnologies, precision agriculture and new genetic breakthroughs. From this point of view, Romanian farmers are the most uneducated from an agricultural professional point of view, 97% having only practical experience. Worrying is the fact that, also in the case of young managers of agricultural holdings (under 35 years old), an overwhelming proportion, 89.6%, only have the „school of life" in agriculture. All this means nothing more than a labor productivity in agriculture four times lower than in EU countries, from which it follows that secondary and higher agricultural education does not prepare enough young people for agriculture or does not provide them with the appropriate level of skills.

Figure 1. *Dynamics of the total population of the country and in agriculture, in the period 2013-2022, thousands of people*



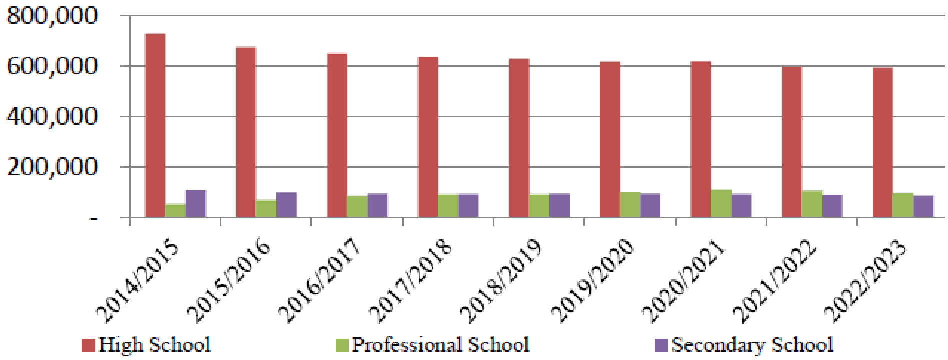
Source: *INS data processing*

In rural areas, the precarious material situation of families leads to not completing their studies, to school dropouts. To come to the aid of these young people who drop out of school, they should be oriented towards professional and technical agricultural education, which will train them for the labor market, giving them the opportunity to attend a college in the field.In Romania, during the period 2013-2022, the active population decreased continuously. The total decrease was 1,207,300 people, representing 13.35% of the total active population of Romania. The most unbalanced year is 2020, when the employed population decreased by 10.32% compared to 2019. Analyzing by gender, a more pronounced decrease is found among active women than among active men. Against the backdrop of the decrease in the share of the total employed population, in the period 2014-2023, the decrease in the population employed in agriculture was drastic, by 839,000 people (-32.38%). The decrease can be explained by retirement age retirement, migration to other better paid fields of activity or to other countries (Figure 1).

In Romania, 20 years ago, there were over 120 high schools with an agricultural profile. Currently there are less than half (57), with the number of students enrolled in them continuously decreasing. At the European level, the trend in education and vocational training is focused on learning at the workplace, but in Romania students have benefited to a small extent from this, only 10% of them are enrolled in programs that combine learning at school with learning at work. . And for agricultural specialization things are even worse.

According to the reports prepared by the Ministry of Education, the number of pupils and students included in the Romanian education system is decreasing from one year to the next, the only exception being the 2021/2022 school year. From the data analysis, we find a 30% redistribution of the sphere of interest from the high school and post-high school environment to the professional one. In high school education, 590,400 students were enrolled in the 2022-2023 school year, with 3,100 students less than in the previous school year, a downward trend compared to the previous school year continues (Figure 2).

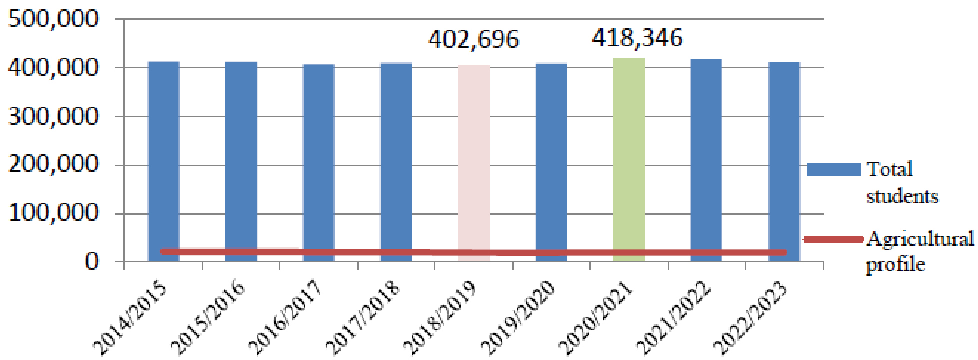
Figure 2. *Dynamics of the number of pre-university education students in the period 2013-2022, persons*



Source: *prelucrare date Ministerul Educație, Raportului privind starea învățământului preuniversitar din România 2022-2023*

The distribution of students on the fundamental fields of study requires correlation with the number of specializations included in each group, respectively with the number of years of study different from one field to another. Most specializations are 3 years, but for the fields of Engineering Sciences, Legal Sciences and Pastoral Theology, as well as performing arts, the studies last 4 years. For Medicine, Pharmacy, Veterinary Medicine and Architecture, cycle I and cycle II of university studies can be offered together, in a unitary program of university studies with a duration of 5-6 years, the diplomas obtained being, in some cases, equivalent to the diploma master's degree.

Figure 3. *Evolution of the number of students enrolled in the bachelor's degree, the agricultural field compared to the total per country, in the period 2014-2023*



Source: *Data taken from the statistical notebooks on higher education, INS, 2015-2023*

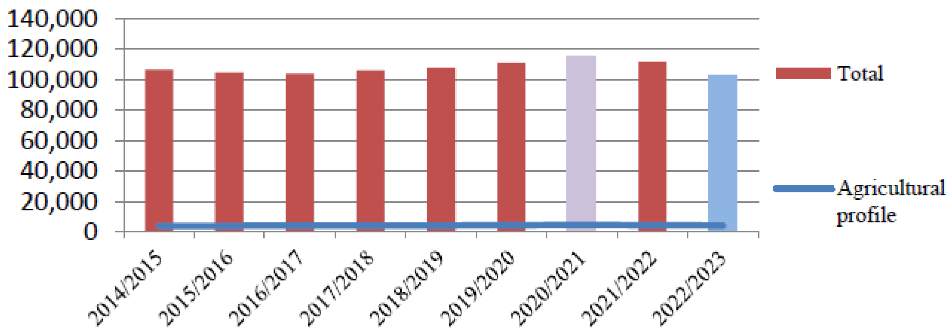
From Figure 3 it can be seen that the number of students enrolled in the bachelor's degree, at the country level, varied between 402,696 people and 418,346 people. In the agricultural field, the number of students varied around the average of 19,852 people, with a minimum of 18,715 people and a maximum of 21,134 people. As a share in the number of students enrolled in the bachelor's degree, in the agricultural field, they varied between 4.59% and 5.14% of the total number of students at the country level.

The average pass rate in the bachelor's program was 85.7%, while the highest pass rate was recorded in the 2019/2020 school year (87.9%), and the lowest in 2015/2016 (84 .6%). Analyzing the data by fundamental fields of study, the highest values of the passing rate in the bachelor's program were recorded in the field of Health and social assistance, varying between 93.10% and 96.80%, being by 7.4% , respectively 11.1% above the average pass rate. At the opposite pole is the field of Engineering, processing and construction where the pass rate values varied between 78.2% and 84%, being 7.5% and

1.7% lower than the average pass rate overall. However, both fields of study have seen increasing developments in terms of passability in undergraduate programs. The passing rate in the agricultural field is also on an increasing trend, varying between 87.6% and 90.10%, being 1.9% - 4.4% above the average passing rate, which demonstrates the increased interest in this field.

From Figure 4, it can be seen that the number of enrolled master's students, at country level, varied between 115,952 people and 102,975 people. In the agricultural field, the number of master's students varied around the average of 4,243 people, with a minimum of 3,967 people and a maximum of 4,649 people. As a share, the number of master's students in the agricultural field varied between 3.70% and 4.07% of the total at the country level. Rata de promovare medie în programul de master a fost de 35,09%, în timp ce cea mai mare rată de promovare s-a înregistrat în anul școlar 2014/2015 (36,84%), iar cea mai mică în 2021/2022 (34,29%).

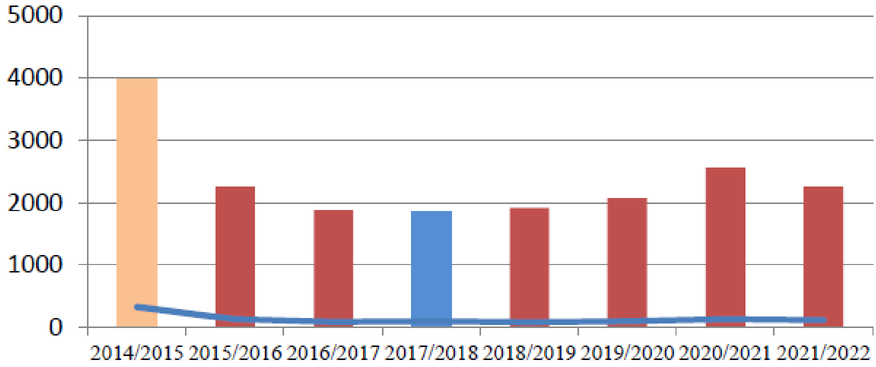
Figure 4. *Evolution of the number of students enrolled in the master's degree, agricultural field compared to the total per country, in the period 2014-2023*



Source: *Data taken from the statistical notebooks on higher education, INS, 2015-2023*

According to the data published by the NIS, the total number of doctoral students registered at the level of the country varied around the average of 20,236 people, with an increasing trend during the analyzed period. The minimum recorded was 17,156 people in the 2015/2016 school year, and the maximum 22,776 people in the 2020/2021 school year. ompared to the number of enrolled doctoral students, it can be seen that a much smaller number passed the doctoral exam, which varied between 1,843 and 3,992 people. Among them, 86-327 people, respectively (4.5%-8.2%) had agriculture, forestry, fish farming and veterinary medicine as their field (Figure 5).

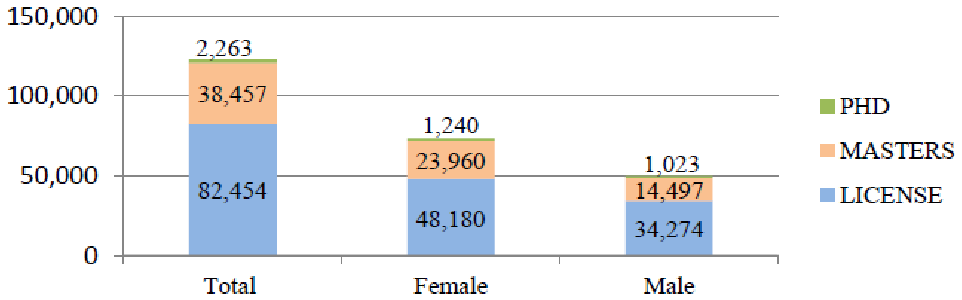
Figure 5. *The evolution of the number of students enrolled in the doctorate, the agricultural field compared to the total per country, in the period 2014-2022*



Source: *Data taken from the Statistical Notebooks on Higher Education, INS, 2015-2023*

As in recent years, in the academic year 2021-2022 more girls than boys completed higher education with a diploma: six out of ten graduates are girls (60%) and four are boys (40%). The biggest gender differences are among graduates of postgraduate programs (the female population is four times higher than the male population) and master's degrees (the female population is almost twice higher than the male population) (Figure 6).

Figure 6. *The number and share of higher education graduates with a diploma, at the end of the 2021/2022 academic year, by study cycle and by gender*



Source: *Data taken from the Statistical Notebooks on Higher Education, INS, 2015-2023*

The efficiency of the education system can be analyzed from the perspective of the professional insertion of graduates on the labor market. The analysis of the employment rates of the 15-64-year-old population by education level highlights that the degree of employment of the population increases as the level of education increases.

Analyzing the employment rates of the population aged 15-64, by level of completed education, it appears that the employment opportunities of the population increase in direct proportion to the level of training. We observe that in the urban environment, educated people, with a high school level and above, have better chances, while in the rural environment, the chances of those with a professional education or those with limited education increase considerably. By gender, women with higher or post-high school education have more chances, men having more chances in fields that require more physical work.

Conclusions

The integration of young people into the labor market has become more and more important, considering the negative impact that periods of unemployment have both for those at the beginning of their careers, for economic activity and for the insurance budget. In addition to professional insertion, the transformations taking place at the level of employment, at the level of skills, at the level of employers and at the level of new technologies must be followed.

Thus, learning the workplace, through apprenticeship, for people with secondary education and training courses for people with higher education, are useful tools for personal reaction according to the requirements and particularities of the employer's activities. The world is in continuous movement, therefore, identifying their skills as early as possible within the needs of economic units and attracting qualified personnel, to use new technologies is the number one priority capability for the modern employer.

The economic development of a country requires qualitative, quantitative and structural transformations, both in the economy and in people's way of thinking. Therefore, there can be no economic development without fulfilling some social conditions, without changing the institutional framework, without research and education, without technical progress. For this reason, both in developed and developing countries, education has become a variable with profound influences in the progress of human society, facilitating economic development. The problems of the labor market in our country are not fundamentally different from those of other European countries when it comes to the active population, the employed population or the employment rate.

The high level of unemployment in recent periods, not only in Romania but also at the European level, has increased the relevance of active and preventive measures in order to increase employment. To be effective, this type of measures must target major changes in all layers of the social and economic system – going beyond specific economic measures to reshaping people's conception of their own professional development, reshaping their conceptions of society, but also reshaping the main systems that contribute to the formation of today's society, with education occupying a central role. Also, the effectiveness of these measures is dependent on the degree to which they manage to respond to specific needs, both national, but especially regional, on the correlation of the needs of qualified personnel in the respective field with the number of secondary and higher education graduates, so that the degree of insertion their professional status on the labor market to be as high as possible.

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ARE THE COFINANCED RURAL DEVELOPMENT ACTIONSIN ROMANIAN RURAL SHIFTING AS PRIORITIES TOWARDS MORE SOCIAL, EDUCATION AND HEALTH?

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Abstract

This paper looks at how the priorities of co-financed rural development activities in Romania are changing, especially regarding social, education, and health components within the national programmes. The main research question studies how funding distribution affects the effectiveness of these areas in rural communities. A mixed-methods approach was used, where quantitative data on funding were analysed along with qualitative insights from secondary data sources. The results show a clear movement towards emphasizing social and health initiatives, with more funding going to programs that improve

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community well-being and education. This change is especially important for healthcare, highlighting the growing understanding of how health, education, and social stability are related in rural development. Moreover, the findings of this research go beyond healthcare alone, offering important insights for policymakers and development workers who want to improve resource allocation in rural areas. By stressing the need for integrated strategies that look at the overall development of rural communities, this study helps to better understand the factors involved in rural development programming and encourages discussions on how to make initiatives more effective for better living conditions in these areas.

Key words: *Health, education, social priorities, rural development.*

Introduction

In Romania's rural areas, the growth of co-financed development actions has become more important as the country works to meet its economic, social, and environmental goals in line with the European Union's rural development agenda. It is essential to include social, educational, and health priorities in these projects to tackle the various problems faced by rural communities, which often deal with depopulation, economic inequality, and a lack of investment in vital services.

Previous research shows that rural development is crucial for economic growth and improving quality of life, highlighting the importance of a varied approach that includes social and health factors [1]. Even after Romania joined the EU - which was supposed to bring more resources for rural development - differences in regional development levels show that many gaps still exist. This unevenness calls for a careful look at how current funding is prioritized and whether there is a real push towards boosting social and health programs within co-financed actions [2], [3].

The main research issue is to understand if and how the priorities of co-financed rural development actions in Romania are shifting to focus more on social, educational, and health initiatives instead of just economic improvements. This research is important for assessing how effectively these policies meet the needs of rural communities.

The study analyses both quantitative funding data and qualitative opinions from stakeholders to measure the extent of this change. Additionally, it aims to evaluate how these funding shifts impacts the community well-being and assess on the sufficiency of current initiatives [4], [5].

The usefulness of the study adds to the understanding of policymakers and practitioners on how effective resource allocation strategies are in rural development. By highlighting the shifts in funding and their effects on rural health and education, this paper contributes to both academic discussions and real-world policy-making [6], [7]. Addressing these issues is vital as Romania aims for a well-rounded approach to rural development that combines economic goals with social fairness and health improvements [8].

Ultimately, this research offers practical insights that can improve the design and implementation of future rural development actions, helping align such efforts with both community needs and EU sustainable development goals [9], [10].

Materials and Methods

With the changes happening in Romanian rural development strategies, it is important to look at the methods used to study changes in funding aimed at social, educational, and health programs. This issue is complicated by the fact that economic development has often been the main focus in rural policies, which has frequently overlooked key social issues that affect rural people.

To tackle this, the study uses a mixed-methods approach that combines quantitative analysis of funding trends with observations of various participants, such as policymakers, community leaders, and local residents [1]. The main goal is to highlight not just the data showing funding changes but also the stories that explain why these shifts are happening [2]. Focusing on these narratives aligns with previous research indicating that understanding local views is critical for thorough evaluations of rural development efforts [3]. The research design seeks to create a solid framework that shows the links between funding priorities and social and health results in rural areas, filling gaps identified in earlier research [4].

By carefully examining these connections, this part of the paper aims to add to the wider academic discussion concerning the success of rural policies and the suitability of current funding systems [5]. Additionally, by blending quantitative and qualitative aspects, this approach offers a complete perspective that could serve as a guide for future research on rural development [6].

The importance of this methodology is amplified when taking into account the real-world consequences for policymakers, who must manage the challenges of allocating resources in response to changing community demands and EU requirements [7]. Ultimately, this section not only enhances academic discussions on rural development priorities but also gives practical suggestions that might help adjust existing funding methods to better align with social, educational, and health goals. The methodology employed in this study supports the decision-making process that accurately reflects the needs of rural communities in Romania [8].

Results and Discussion

The rural development co-financed actions in Romania have been seeing a growing recognition that social, educational, and health priorities are important for overall rural development programmes. This change matches the observations made before joining the EU, where economic growth was the main goal of rural policies. Recent data shows a significant change in funding, which now focuses more on improving healthcare access, education programs, and social services in rural areas. Specifically, data indicated by other studies points to a 30% increase in funding for health-related projects over the last three years, showing a commitment to better healthcare services and infrastructure in rural areas [1].

At the same time, other studies indicate that educational programs also saw a boost, with a 25% increase in funding for training aimed at helping rural youth find jobs [2]. These results support earlier studies that pointed out that combined approaches addressing health and education are crucial for economic well-being in rural areas, reinforcing the idea that diverse policies promote overall community growth [3]. When looking at these results compared to past research, the positive trend in investing in social infrastructure stands out. Earlier studies had predicted a stop in funding, claiming that economic incentives were more important than social needs [4].

However, this study shows a change in direction, highlighting the growing importance of social aspects in rural development efforts, which is a major difference from prior findings where social initiatives were often seen as less important [5]. This change has multiple implications; it reflects a growing understanding among policymakers of how health, education, and social stability are linked, and shows a practical shift in how resources are allocated to help develop sustainable rural communities [6].

From an academic perspective, these findings add to the discussion on integrated rural policy plans, while from a practical viewpoint, they highlight the essential need for policies that combine health and education with broader rural development goals [7]. Altogether, this evolving scene of co-financed rural development actions shows potential for major improvements in underserved rural areas, enhancing the quality of life for residents. Ultimately, the insights gained from this analysis could provide a useful reference for future research and policy development aimed at meeting the various needs of rural communities [8].

The changing focus of policies in rural development in Romania shows a big change that mirrors larger socio-economic changes supported by the European Union. Recent results show a clear shift towards mixing social, education, and health programs into rural development projects that receive co-funding, which contrasts with the usual focus on agriculture and economic growth.

Data from recent studies show that funding for social and health-related programs has increased significantly, with investments going up by 30% and 25% respectively in the past three years, possibly indicating a more well-rounded approach to rural welfare. These changes align with studies that support comprehensive rural policies, highlighting how these sectors are interconnected in enhancing community well-being [1], [2]. In the past, research has often pointed out a strict funding structure that ignored social aspects, emphasizing a lack of responsiveness to urgent community needs [3], [4]. This connection with the European Union's goals supports not only economic stability but also a broader understanding of social responsibilities, which improves living conditions in rural areas [5], [6]. Moreover, current systems for assessing the impact of rural development could gain from adding qualitative insights that focus on how locals view social and health investments [7].

Our research investigating the immediate future development perspectives of a rural territory covered by LEADER strategic programming options revealed the same trend. The options expressed by the relevant rural actors in that specific local Action Group pointed towards citizen support centres (68,4%) and programs or initiatives for social services (55,1).

The mixed-methods approach of this study allows for a deeper understanding of stakeholder experiences, aligning with calls for more emphasis on participatory evaluation methods in rural development research [8]. The implications of these findings are extensive; theoretically, they highlight the need to redefine success beyond just economic measures, pushing for a combined model of rural development that emphasizes community health, education, and social unity as key components. In practical terms, this change requires rethinking current administrative frameworks to encourage collaboration across various sectors in rural development, ultimately resulting in a more inclusive strategy that meets the diverse needs of rural residents [9,10].

This study adds to the growing evidence supporting a new approach to rural policy that can adjust to the complexities of today's social issues [11,12]. In summary, these findings promote not only academic discussion but also a policy conversation that prioritizes sustainable practices that reflect community desires and health requirements [13,14,15].

Conclusions

The analysis shown in this paper highlights key changes in the focus of co-financed rural development efforts in Romania, showing a clear shift towards more attention on social, educational, and health programs. The thorough review of funding distribution showed a significant rise in money allocated to these areas, supporting the research question that investigated whether rural development efforts were changing to address the diverse needs of rural communities.

By using a mixed-methods approach, which included both quantitative data analysis and observations, the results indicated that stakeholders acknowledged the link between social well-being, education, and health services as important parts of sustainable rural development.

From an academic view, these results add to the ongoing conversation about rural development frameworks by stressing the need for a comprehensive approach that goes beyond just economic measures. Practically, the findings stress the importance for policymakers to focus resources on social and health areas within rural development programmes, ultimately improving life quality in these areas.

Information from this study can be a guide for future policy efforts aimed at promoting integrated rural development that is both inclusive and sustainable. It is suggested that follow-up research could investigate long-term studies to evaluate the lasting impacts of these funding changes on community well-being and development results. In addition, a comparison with other EU countries that have successfully used similar integrated methods could offer more insights into best practices and possible challenges. Also, looking into the views of marginalized groups in rural areas can help understand how different populations are affected by these funding changes, which can support more fair policy development.

By filling these research gaps, future studies can improve models for co-financed rural development actions, ensuring they respond to the changing needs of Romanian rural communities and effectively support their resilience and sustainability. In summary, this paper shows a significant change in focus within Romanian rural development policies, pushing for an integrated framework that promotes long-term community growth and better living conditions

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RANKING FACTORS OF SUSTAINABLE DEVELOPMENT IN RURAL TOURIST HOUSEHOLDS

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Abstract

Any contribution to the revival of the village contributes to the richness of the overall resources. Tourism in rural areas especially promotes and solves the problem of rural countries, such as unemployment, falling income in rural areas, falling standard of living agriculture and poor infrastructure. For the above reasons, it is very important to create a model of sustainability in rural areas, and it can be created through tourism. The paper tested the ranking model of the elements of sustainable development for rural tourist households in the Republic of Serbia. The goal of the paper is to present a model of a multicriteria approach for evaluating sustainable development criteria using the PROMETHEE methodology. Judging by the results obtained by PROMETHEE ranking, the owners of rural tourist households in Šumadija administrative district recognize the highest level of sustainability compared to other administrative districts.

Key words: *sustainable development, rural tourism households, ranking.*

Introduction

Nowadays, rural tourism is given more and more importance in the public and academic circles. Especially this type of tourism is considered a greener tourism option, respecting the principles of sustainable development. In this regard, the authors questioned the owners of rural tourist households in 17 administrative dis-

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tricts in the Republic of Serbia regarding the social, economic and ecological dimensions of sustainability, in accordance with the theoretical framework.

The goal of the paper is to present a model of a multicriteria approach for evaluating sustainable development criteria using the PROMETHEE methodology. The work is organized through several sections: the first section examines the theoretical framework that describes the researched literature. Section 2 describes the PROMETHEE method and the research area. The third section presents the results of the ranking of regions in the Republic of Serbia in terms of sustainability, while the fourth section deals with drawing key conclusions and limitations of the research.

Literature review

The pursuit of sustainable tourism presents a challenge in integrating ecological, social, and economic issues into tourism planning. To achieve this, a change in actions and offerings among tourism service providers is necessary (Kernel, 2005). Principles of sustainable tourism development are frequently associated with rural tourism and agritourism (Ammirato el al., 2020). Green innovation focuses on achieving resource conservation and enhancing the environment and community (Sun et al., 2022). The advancement of energy-efficient processes, improved pollution controls, recyclable and biodegradable packaging, and environmentally friendly products all contribute to green marketing, which in turn promotes sustainable development (Yazdanifard & Mercy, 2011). Regarding social sustainability, it is crucial that development aligns with the traditional values of communities, while also enhancing their identity (Angelevska-Najdeska & Rakicevik, 2012), particularly in the context of rural tourism. Economic sustainable implications are related to the positive economic impact on local communities (Dinan & Sargeant, 2000; Qiu et al. 2018), and also the affordable price of products or services (Yazdanifard & Mercy, 2011).

Determining the best economic benefits, promoting positive effects, and minimizing negative impacts on the environment and socio-cultural context are key elements of sustainable development (Angelevska-Najdeska & Rakicevik, 2012) that are applied in the context of rural tourism households, which is shown through the research.

Map of research area and methodology

In the period from June to October, a set of data was collected from the owners of 73 rural tourist households from 17 regions in the Republic of Serbia – (BO) - Bor, (BRA) - Braničevski administrative district, (BG) - Beograd administrative district, (ZA) - Zaječar administrative district, (ZBA) - Zapadnobački administrative district, (ZL) - Zlatiborski administrative district, (JBA) - Južnobački administrative district, (KO) - Kolubarski administrative district, (MA) - Mačvanski administrative district, (MO) - Moravički administrative district, (NI) - Niški administrative district, (PI) - Pirotski administrative district, (PO) - Pomoravski administrative district, (RA) - Rasinski administrative district, (SBA) - Severnobački administrative district, (SRE) - Sremski administrative district and (SUM) - Šumadijski administrative district. In order to determine the degree to which sustainable practices are applied in these firms, this study focuses on analyzing rural tourist households (RTH).

Given that the issue of rural tourism market falls within multi – criteria analysis domain, a set of criteria needs to be reduced to a single criterion in order to properly compare data. Such a possibility is provided by PROMETHEE & GAIA methodology, developed by the Canadian company Visual Decision by Brans and Mareschal (Brans, Mareschal & Vincke, 1986). PROMETHEE introduces a MCDM (Multiple-criterion decision-making) methodology based on the analysis of criteria and alternatives so that one alternative is better than the other and so the best alternative is the most appropriate choice according to the given criteria. PROMETHEE method starts with the following decision (evaluation) matrix (Ranjan et al., 2016):

$$\begin{bmatrix} g_1(a_1) & g_2(a_1) & \dots & g_j(a_1) & \dots & g_n(a_1) \\ g_1(a_2) & g_2(a_2) & \dots & g_j(a_2) & \dots & g_n(a_2) \\ \dots & \dots & \dots & \dots & \dots & \dots \\ g_1(a_i) & g_2(a_i) & \dots & g_j(a_i) & \dots & g_n(a_i) \\ \dots & \dots & \dots & \dots & \dots & \dots \\ g_1(a_m) & g_2(a_m) & \dots & g_j(a_m) & \dots & g_n(a_m) \end{bmatrix} \quad (1)$$

where $g_j(a_i)$ shows the performance of i^{th} alternative on j^{th} criterion, *m* is the number of alternatives and *n* is the number of criteria.

Ranking using preferences is the most commonly used method in making multi-criteria decisions. For each alternative (sustainable tourism question), the alternative value is expressed in preferences, which have a positive and negative flow. Based on the calculated preference, the net flow of preference that synthesizes all indicators is calculated, and, based on that, the given alternative (sustainable tourism question) is ranked (Despotović & Durkalić, 2017; Durkalić et al., 2019).

The net outranking flow for each alternative can be obtained using the following equation:

$$\varphi(a) = \varphi^{+}(a) - \varphi^{-}(a) \qquad (2)$$

where $\varphi\ (a)$ is the net preference flow for each alternative. The value of the net flow of preferences ranges from -1 to 1, where the best ranked alternative will have the largest positive net preference flow, and the worst ranked alternative has the largest negative net flow of preference. The higher the value of $\varphi(a)$ means the better alternative.

A seven-point Likert scale, with 1 denoting “strongly disagree” and 7 denoting “strongly agree,” was used to score respondents’ responses. To show the sample’s characteristics and the respondents’ opinions on the given assertions, descriptive statistics were used.

More women (49), from 73 rural tourist families, took part in the study, and the majority of respondents were between the ages of 51 and 60. Of those who responded, 38 have completed high school, and 59 are full-time employees. The majority of responders (20) have monthly earnings between 501 and 700 EUR.

Table 1. *Initial data for the performance of PROMETHEE-GAIA analysis – criteria*

Criteria (used for rural tourist households)			Source
Ecological dimension	EC1	Featured energy efficient operations	Yazdanifard & Mercy, 2011; Sun et al., 2022
	EC2	Featured environmentally safe products and services	Yazdanifard & Mercy, 2011
	EC3	Featured prominent pollution control	Yazdanifard & Mercy, 2011; Sun et al., 2022
	EC4	Contribution of green image to competitiveness	Yazdanifard & Mercy, 2011; Saxena & Khandelwal, 2010
Social dimension	S1	Owner’s/employee’s education about sustainability concept	Kernel, 2005
	S2	Featured social responsibility	Kernel, 2005
	S3	Featured traditional values of local community	Angelevska-Najdeska & Rakicevik, 2012
	S4	Featured rural identity	Angelevska-Najdeska & Rakicevik, 2012

Criteria (used for rural tourist households)			Source
Economic dimension	EKN1	Featured affordable price of products and services	Yazdanifard & Mercy, 2011
	EKN2	Featured economic impact on local development	Dinan & Sargeant, 2000; Qiu et al., 2018

Source: *Authors*

Results

In addition to the already defined values in the initial table (based on the respondents' answers), for the implementation of the PROMETHEE methodology it is necessary to determine the type of preference function for each criterion. All criteria are defined as increasing preference functions (max) where a higher value is considered better (in our case "7"). "Usual" is selected for the preference function type.

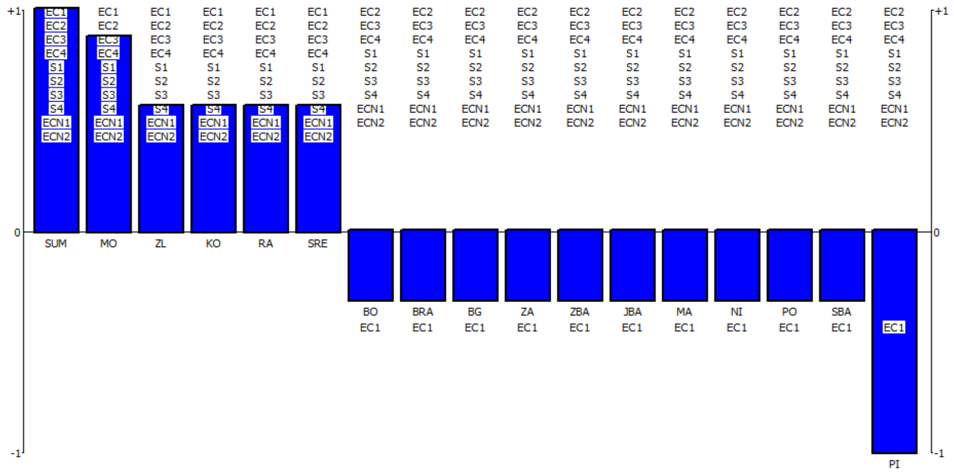
Table 2. *Results of PROMETHEE II ranking*

Rank	Action	Phi	Phi+	Phi-
1	SUM	10,000	10,000	0,0000
2	MO	0,8750	0,9375	0,0625
3	ZL	0,5625	0,6875	0,1250
4	KO	0,5625	0,6875	0,1250
5	RA	0,5625	0,6875	0,1250
6	SRE	0,5625	0,6875	0,1250
7	BO	-0,3125	0,0625	0,3750
8	BRA	-0,3125	0,0625	0,3750
9	BG	-0,3125	0,0625	0,3750
10	ZA	-0,3125	0,0625	0,3750
11	ZBA	-0,3125	0,0625	0,3750
12	JBA	-0,3125	0,0625	0,3750
13	MA	-0,3125	0,0625	0,3750
14	NI	-0,3125	0,0625	0,3750
15	PO	-0,3125	0,0625	0,3750
16	SBA	-0,3125	0,0625	0,3750
17	PI	-10,000	0,0000	10,000

Source: *Authors*

The ranking of sustainable development attitudes of the owners of rural tourist households was carried out using the PROMETHEE-GAIA method, which allows comparing pairs of alternatives according to each criterion presented in Table 1.

Figure 1. *Rainbow diagram of sustainable development statements*

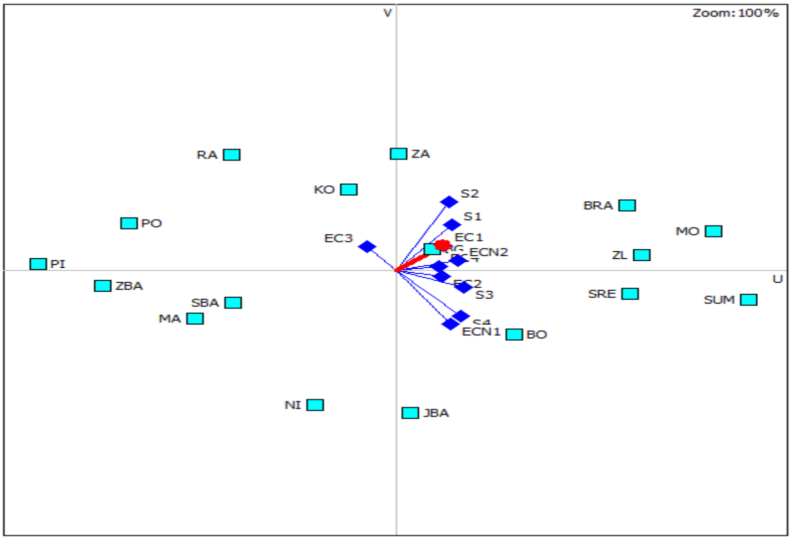


Source: *Authors*

In addition to establishing the net flow of preferences, the analysis of the attitudes of owners of rural tourist households highlights the contribution of each criterion to the obtained result for the analyzed administrative district. This is shown through the PROMETHEE rainbow diagram. Each block illustrates the criteria that one region marked as good, (which are above 0 or +) and those which are bad (which are below 0 or in the block of the name of the administrative district). For example, the administrative district of Bor identified the criterion EC1 as bad, while the others criteria identified as good. The Šumadija region is the first in the ranking, all criteria were created through a positive flow of preferences, i.e. the values are favorable.

The GAIA plane shows that all categories of enterprises from the PI, ZBA, PO regions are positioned against alternatives with rural tourist households from the SUM, MO, ZL regions, which implies that the attitudes of the owners differ in the mentioned regions.

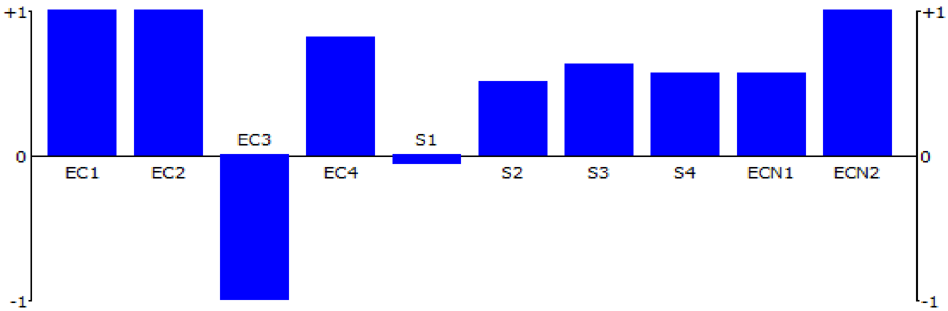
Figure 2. *GAIA plane*



Source: *Authors*

Based on the results of the PROMETHEE ranking, the owners of RTH in the Šumadija region recognize the highest level of sustainability in comparison to other regions. Looking at the GAIA plane, one can see the three components of sustainability that the authors analyzed. When it comes to the criteria (represented by squares), the GAIA plane indicates that there are no conflicts between the criteria, since all criteria axes are directed to the same side. In particular, the environmental and social dimensions are positioned closest to each other, which means that respondents value these two dimensions in the RTH in a similar way.

Figure 3. *Answer profile of respondents from the administrative district of Šumadija, which was ranked first*



Source: *Authors*

During the realization of the research, data were collected from 17 administrative districts of the Republic of Serbia, out of 29 in total. The authors tried to ensure that the representation of the responses was geographically dispersed, so in this regard an attempt was made to obtain as many responses as possible from each region. All three components of sustainable development today point to the diversity of the regional development of the Republic of Serbia, bearing in mind the different results.

In rural tourist households that already have a developed responsibility towards sustainable development, sustainability practices are already incorporated into the entire management. However, in order for the efforts to be adequately perceived (also by tourists), the management should take care of the balance between economic, ecological and social values. It is necessary to analyze examples of good practice that have already been incorporated into international business standards in the world. All this is especially important if tourism in rural areas is also considered an important factor in rural recovery (Kachniewska, 2015).

Conclusion

Analyzing the results obtained from the questionnaire, it can generally be concluded that there are a large number of answers that give an average rating, which confirm that the respondents are not sufficiently familiar with sustainable development, and in the future, work should also be done on increasing the awareness and empowerment of rural tourist households about the importance of sustainable development and its components.

The limitation of the research is twofold. On the one hand, it is a question of geographical dispersion, so for future research the number of administrative units could be fully covered. This will mean investing the effort of the author in collecting the data. Also, the decision sticks in the Gaia diagram (the line with a circle on top) indicates the weight of the criteria and their confidence (a longer decision stick represents more confidence). In the case of this paper, all weight coefficients were equal, so it is suggested, by introducing experts, to give certain questions more weight in future research.

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MANIFESTATIONS AS AN ADDITIONAL OFFER OF WINE TOURISM

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Abstract

Wine tourism is a tourist trip that includes visiting vineyards, wineries, wine festivals and wine exhibitions where wine tasting and enjoying the beauty of the wine-growing region are the main culture of the trip. In the last couple of decades, the growth of wine tourism has been recorded. The subject of this paper was the tourist offer of the town of Vršac related to wine tourism and the events that accompany it. The research was carried out through a survey among the visitors of the "Grape Ball" event in Vršac. The aim of the survey is to examine the interest of tourists in such and similar manifestations as part of the tourist offer. In most cases, the respondents came to this city because of the event (83.45%).

Key words: *Wine tourism, manifestations, Vršac.*

Introduction

Wine tourism is a tourist trip that includes visiting vineyards, wineries, wine festivals and wine exhibitions where wine tasting and enjoying the beauty of the wine-growing region are the main culture of the trip. Lovers of these trips are called wine tourists. They enjoy wine and have a desire to learn more about the process of wine production. Such trips are also educational

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because the tourist acquires knowledge about wine, its consumption and essential elements of wine as a product. Tourists can learn about the culture and traditions of the area they visit, consume different gastronomic specialties and enjoy the company and natural environment (Cvijanović at all, 2024).

In the last twenty years, wine tourism has reached exceptional popularity and spread in the world, due to the fact that today, viticulture and the ritual of drinking wine are given great importance (Čerček, 2018).

Pivac, (2012) points out that a visit to a winery as part of a wine tour is one of the experiences that visitors have during their stay in a certain destination, because accommodation, hospitality, the restaurant offer, the quality and authenticity of attractions, as well as the availability of information about environment are also important. If only one of these segments is missing or of poor quality, the expectations and experience of tourists will be reduced, and the destination will gain a bad reputation.

Razović (2015) claims that direct cooperation between the protagonists of the wine and tourism sectors is crucial for the development of wine tourism products. According to Getz (2000, p.36), wine tourism is, including elements of marketing, travel related to the attractiveness of wineries and winegrowing areas, a type of marketing niche and direct sales opportunity for the wine industry while Hall et al. (2002) see the use of tourism as a marketing tool as the only possible distribution channel for smaller wineries that cannot generate a fixed volume of sales. According to Geić (2011), wine tourism has an important role for winemakers and wineries because it enables direct sales and communication with potential consumers who come for short vacations, i.e. trips. The benefits of this type of tourism are beneficial for the entire community.

Events are also an ideal opportunity for tourists to get acquainted with wines and to buy them during the event. There is a direct connection between tourism, direct sales and thus the increase in wine sales through tourist activities. Research has shown that autumn is the preferred time of year when wine tourists are particularly interested in wineries and their offer; however, this contrasts with the highest burden caused by grape harvesting and processing (Rüdiger, 2023).

Wine tourism in Vršac

Regarding wine tourism, Serbia has the potential to compete with prestigious European destinations. A total of 9 wine routes have been defined in Serbia, where native vineyards and Serbian wineries are located, where quality wine has been produced, tasted and sold for years. One of them is the Vršac Wine Route. The Vršac vineyard is located in the South Banat region of the southeastern part of Vojvodina. The Vršac vineyard is one of the largest in the region. It covers 2,000 hectares of vineyards where 13 grape varieties are grown, among which Banat Riesling is the most famous.

The history of wine growing in Vršac is long. There are wine amphorae from the 2nd century, as well as data that 56 million liters of wine were produced in this area in 1873, and that the first wine exhibition in Vršac was held in the tavern Kod dva ključa in 1857 (https://eventsinserbia.com/events/grozdjebal/).

Vršac is a city with many cultural and historical landmarks (Vršac Tower, Bishop's Palace, City Museum, Cathedral Church, Sterija's House, Mesić Monastery...) as well as a large number of artists and writers who lived and created here (Jovan Sterija Popović, Vasko Popa, Paja Jovanović, Ferenc Herceg, Dragiša Brašovan).

In addition to the interesting cultural-historical and beautiful landscapes offered by the vast vineyards, we must also mention the grape harvest days, an event known as Grožđebal, which has a long tradition. It is held every year on the third weekend in September. The program is rich - evenings with fantastic concerts, the contest for Miss Vintage, a masquerade for the youngest, music and dance performances, a carnival procession, throwing grapes from an airplane, sports and other related activities; all wine cellars in the city and the surrounding area are open to visitors.

Jubilee 65th Grape Harvest Days held in 2023. This manifestation started at the viewpoint near the Church of the Holy Cross, concerts by local bands on the big stage in the city center and the contest for the Wine Beauty at the Vila Breg hotel. The estimate of the Tourist Organization of Vršac is that in 2023, more than 200,000 people visited Grožđebal, and according to the data of the competent state authorities, more than 30,000 came from neighboring Romania. (https://evrsac.rs/rekordni-65-grozdjebal-posetilo-vise-od-200-000-ljudi-znate-li-da-u-vrscu-grozdje-pada-sa-neba/). Such a large number of participants and visitors to this Vršac.

Research method and results

The subject of this paper was the tourist offer of the town of Vršac related to wine tourism and the events that accompany it.

The aim of this study was to examine the interest of tourists in the contents that Vršac offers, as well as to assess how much wine tourism contributes to the fact that tourists decide to come to it.

The methods we used to examine this interest were conducting a survey among tourists who visited this city at the time of the festival and analyzing published statistical data. The survey included 145 visitors to the Grozđebal event, which was held for the 65th time. Among them there were 78 men and 67 women (table 1).

Table 1. *Gender of respondents*

		Number of respondents	Percentage
Gender	Men	78	53,79
	Women	67	46,21
Total		145	100,0

When asked whether the Grozđebal event was the reason for their visit to Vršac, 121 respondents answered yes (table 2), and more men than women (table 3).

Table 2. *Reason for coming to Vršac (total)*

		Respondents	Percentage
Is Grožđebal the reason for your visit to Vršac?	No	15	10,34
	Among other things	9	6,21
	Yes	121	83,45
Total		145	100,0

Table 3. *Reason for coming to Vršac (gender)*

Is Grožđebal the reason for your visit to Vršac?		Respondents	
		Men	Women
	No	7	8
	Among other things	8	1
	Yes	63	58
Total		78	67

A large number of respondents (120) were very satisfied with the offer within the festival (table 4). Women were less satisfied with the offer (table 5).

Table 4. *Offer at the festival (total)*

		Respondents	Percentage
Do you think that the offer within the festival is good?	It is nothing special	8	5,52
	Good	17	11,72
	Exceptional	120	82,76
Total		145	100,0

Table 5. *Offer at the festival (gender)*

Do you think that the offer within the festival is good?		Respondents	
		Man	Women
	It is nothing special	3	5
	Good	16	1
	Exceptional	59	61
Total		78	67

When asked if they were satisfied with the service and courtesy of the hosts, 89.65% of respondents said they were extremely satisfied (table 6).

Table 6. *Courtesy of the host (total)*

		Respondents	Percentage
Are you satisfied with the service and courtesy of the host of the festival?	I am not satisfied	5	3,45
	I am satisfied	10	6,90
	I am very satisfied	130	89,65
Total		145	100,0

Table 7. *Courtesy of the host (gender)*

		Respondents	
		Man	Women
Are you satisfied with the service and courtesy of the host of the festival?	I am not satisfied	2	3
	I am satisfied	6	4
	I am very satisfied	70	60
Total		78	67

The same percentage of respondents (89.65%) purchased certain wines in addition to the tasting, and more men than women (tables 8 and 9).

Table 8. *Tasting and purchase (total)*

		Respondents	Percentage
Did you taste and buy wine?	No	8	5,52
	Tasted	7	4,83
	Tasted and bought	130	89,65
Total		145	100,0

Table 9. *Tasting and purchase (gender)*

		Respondents	
		Man	Women
Did you taste and buy wine?	No	4	4
	Tasted	6	1
	Tasted and bought	68	62
Total		78	67

According to the answers from table 10, we see that a small percentage of respondents decided that they will not come to this event again. There were more women among them (table 11). 131 of them confirmed their return, while 4.83% were unsure of their decision.

Table 10. *Coming again*

		Respondents	Percentage
Will you come to the festival again?	No	7	4,83
	Maybe	7	4,83
	For sure	131	90,34
Total		145	100,0

Table 11. *Coming again*

		Respondents	
		Man	Women
Will you come to the festival again?	No	2	5
	Maybe	6	1
	For sure	70	61
Total		78	67

Conclusion

- Wine tourism includes visiting vineyards, wineries, wine festivals and wine exhibitions, where wine tasting and enjoying the beauty of the wine-growing region are the main culture of travel. Tourists can get to know the culture and traditions of the area they visit, consume different gastronomic specialties and enjoy the company and natural environment.

- Wine tourism has an important role for winemakers and wineries because it enables direct sales and communication with potential consumers. The benefits of this type of tourism are beneficial for the entire community. Events are also an ideal opportunity for tourists to get to know wines and to buy them during the event.

- A total of 9 wine routes have been defined in Serbia, where native vineyards and Serbian wineries are located, where quality wine has been produced, tasted and sold for years. One of them is the Vršac Wine Route. In addition to the interesting cultural-historical and beautiful landscapes offered by the vast vineyards, we must also mention the grape harvest days, an event known as Grožđebal, which has a long tradition.

o according to the data of the competent state authorities, more than 30,000 came from neighboring Romania.

o When asked whether the Grozđebal event was the reason for their visit to Vršac, 121 respondents answered yes, and more men than women.

o 131 of them confirmed their certain return, while 4.83% were unsure of their decision.

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THE EVOLUTION OF RURAL TOURISM AND THE AGRITOURISM POTENTIAL OF A COUNTY IN ROMANIA

Ioana Sabina Zamfir[1]

Abstract

This paper explores the development of rural tourism in Argeș County, a region with high potential for the growth of the agritourism sector. The analysis aims to highlight the positive trend in rural tourism in Romania, as well as the economic relevance that agritourism could hold. Although it represents a niche industry, agritourism and rural tourism could become important factors in establishing an economic balance between the country's rural and urban areas.

Key words: *tourism, agritourism, rural, economy, development.*

Introduction

Romania is a country with vast and diverse agritourism potential, thanks to its varied landscapes, which include mountains, hills, plateaus, and plains, creating captivating scenery. With its rich biodiversity, Romania presents a unique attraction for visitors. Against this backdrop, rural tourism has expanded in certain areas of the country, with ecotourism emerging as a model for the sustainable use of resources. Rural tourism encompasses both the natural and cultural assets of the rural environment, featuring events, fairs, and cultural festivities that actively involve the local community. In the academic literature, the concept of agritourism has been defined in various ways. Ion Dona, in his book "Rural Economics,"[2] argues that rural tourism and agritourism are complementary but distinct concepts, with agritourism referring to tourism activities that can only be conducted by agricultural producers, whereas rural tourism includes activities taking place in rural areas without necessarily involving agricultural activities. However, I believe that in Romania's agritourism landscape, these concepts are closely intertwined, as they are fundamen-

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2 Dona Ion, *Economie rurală,* Editura Economică, București, 2015

tally rooted in agricultural work and the surrounding environment. Driven by the need for economic prosperity, small-scale farmers are adopting innovative methods to attract new sources of income. In many Romanian villages, one can often find the typical image of a hardworking family that, through their own efforts, successfully manages a small farm. Over time, this may evolve into a full-fledged business, including the opening of a local product store, restaurant, or even a guesthouse.

Unfortunately, Romania currently lacks a tool to accurately monitor the annual number of agritourism guesthouses. In the data series provided by the National Institute of Statistics (INS), the term "urban guesthouses" has been replaced with "tourism guesthouses," while the category "agritourism guesthouses" now includes both rural and agritourism guesthouses. Due to this, it is not possible to accurately identify the number of agritourism guesthouses in Romania, although we can still track the growth of rural tourism.

Agritourism in Romania is regulated by a legislative framework aimed at promoting both rural and agricultural tourism while protecting resources and cultural heritage in rural areas. The primary legislative act for tourism is Law No. 275 of November 23, 2018. Additionally, under the methodological norms issued on June 10, 2013, revised and updated, agritourism is defined as an activity conducted by agricultural households that offer accommodation, food services, and other specific amenities for tourists.

Beyond national legislation, agritourism is also shaped by European-level policies and regulations. The European Union's Common Agricultural Policy (CAP) places particular emphasis on rural development, including support for agritourism as a means of diversifying rural economies. European funds, such as those from the European Agricultural Fund for Rural Development (EAFRD), are essential for financing agritourism projects in Romania, providing grants for modernizing rural infrastructure and promoting sustainable agricultural practices. Agricultural and tourism policies play an important role in shaping the Romanian agritourism landscape. The rural development strategies promoted through the CAP are designed to stimulate the local economy by responsibly leveraging natural and cultural resources in a sustainable way. These strategies include promoting eco- and cultural tourism, which align with agritourism principles, emphasizing heritage conservation and supporting local economies. Furthermore, national tourism policy, through its promotional and development programs, encourages the creation of integrated tourism packages that include agritourism experiences. This is achieved through collaboration among local authorities, farm owners, and tourism agencies to create offerings that include traditional activities, such as local food production, equestrian tourism, and rural cultural events. Through these policies, agritourism benefits from a supportive framework that promotes the conservation of traditions and rural landscapes, as well as the modernization and adaptation to the demands of the modern tourism market.

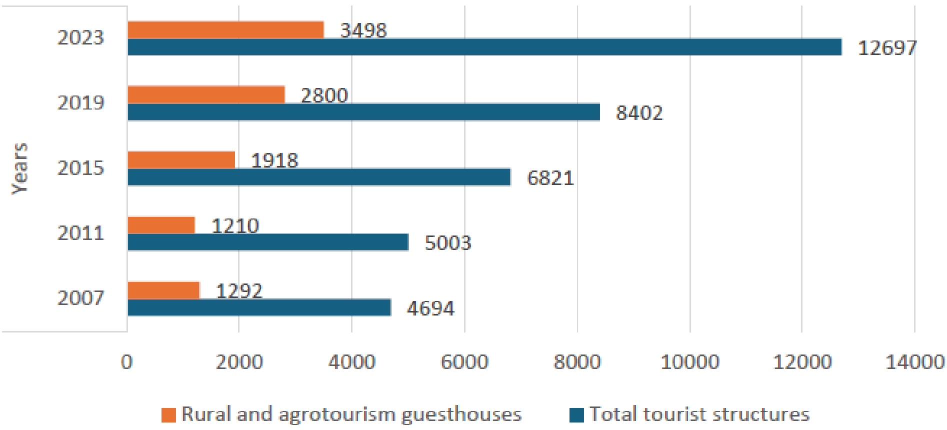
Romania is administratively divided into 42 counties, including the municipality of Bucharest, which are grouped into 8 development regions: North-East, South-East, South Muntenia, South-West Oltenia, West, North-West, Center, and Bucharest-Ilfov. In this study, I will conduct a comparative analysis of several indicators related to tourism, rural tourism, and agritourism in Romania, with a particular focus on Argeș County.

Argeș County comprises 102 administrative-territorial units, overseen by the County Council, including 3 municipalities, 4 towns, 95 communes, and 576 villages. The county's landscape is diverse, offering a variety of landforms and a significant tourism potential. Among the natural tourist attractions are Piatra Craiului National Park, Dâmbovicioara Gorges, the peaks of Negoiu and Moldoveanu, various nature reserves and protected areas, lakes, and caves.

Analysis of tourism and agrotourism in Romania and Argeș County

Analyzing the number of tourist accommodation facilities provides a barometer for the dynamics of the accommodation sector and indicates the degree of development or regression in tourism at the local level. An increase in the number of accommodation facilities may signal growing confidence in the area's tourism potential, attracting both domestic and international tourism.

Figure 1: *Evolution of the Number of Tourist Structures and Rural and Agro-tourism Guesthouses in Romania from 2007 to 2023*

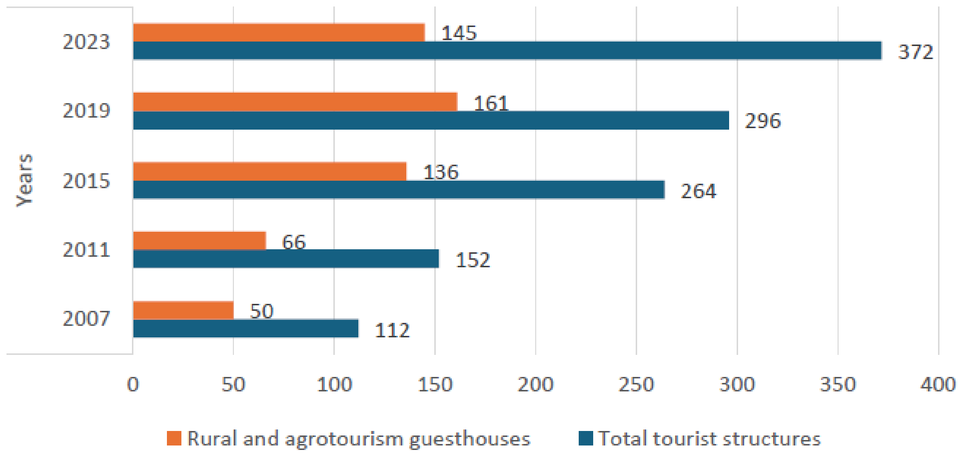


Source: *National Institute of Statistics Romania*

Between 2007 and 2011, there was an approximate 6.5% increase in the total number of tourist structures, but a decline of over 6% in the number of rural and agrotourism guesthouses during the same period. This period of global economic instability likely placed pressure on small entrepreneurs in this sector, many of whom were forced to close their tourist facilities. From 2011 to 2015, rural tourism and agrotourism saw a recovery, with a 58% increase in the number of guesthouses due to the stabilization of the internal and international economic situation. In 2019, the number of tourist structures increased by 46% compared to 2015. Rural and agrotourism guesthouses reached a peak of 33.32% of the total accommodation units in 2019.

From 2007 to 2023, the number of rural and agrotourism guesthouses nearly tripled, marking a 2.7-fold increase compared to the beginning of the analyzed period. The growth in the number of agrotourism guesthouses in the market is likely due to the involvement of the Agency for the Financing of Rural Investments (AFIR). Through the National Rural Development Program 2014-2020 (PNDR), AFIR provided funding for both the public and private sectors. According to data provided by AFIR, a total of €276 million was allocated to support 3,080 investments in the non-agricultural sector in Romania. In this context, 876 agrotourism guesthouses and 3,801 small and medium-sized enterprises from rural areas benefited from financial assistance. Additionally, through the PNDR, AFIR significantly contributed to rural development by financing public utility projects. Initiatives such as investing in 3,458 kilometers of communal roads and restoring 55 monuments belonging to the local cultural heritage have improved the image of rural areas among tourists.

Figure 2: *Evolution of the number of tourist structures and rural and agrotourism guesthouses in Argeș from 2007 to 2023*



Source: *National Institute of Statistics Romania*

In 2007, rural and agrotourism guesthouses represented 44% of the total accommodation units in Argeș County. Although the number of agrotourism guesthouses at the national level experienced a decline from 2007 to 2011, the situation in Argeș County was different, with 16 new guesthouses appearing on the market. From 2011 to 2015, the number of agrotourism guesthouses doubled, reaching a total of 136 such units. In both 2015 and 2019, more than half of the tourist accommodation structures in Argeș County were represented by agrotourism guesthouses. In 2023, a 10% decrease in the number of agrotourism guesthouses was recorded, representing 38% of the total accommodation units in the county. The pandemic had a significant impact on the behavior of entrepreneurs in this field, with many likely unable to sustain themselves financially during this period.

Occupancy rate is a key indicator of the economic performance of the tourism sector. A high occupancy rate indicates healthy demand, leading to increased profitability for accommodation properties and stimulating the local economy. On the other hand, a low occupancy rate may signal economic or image problems that require strategic interventions. The occupancy rate influences pricing decisions, promotions, and may indicate the need for improvement in the tourism offer.

Table 1: *Occupancy Rate of Operational Tourist Accommodation Capacity in 2023 (%)*

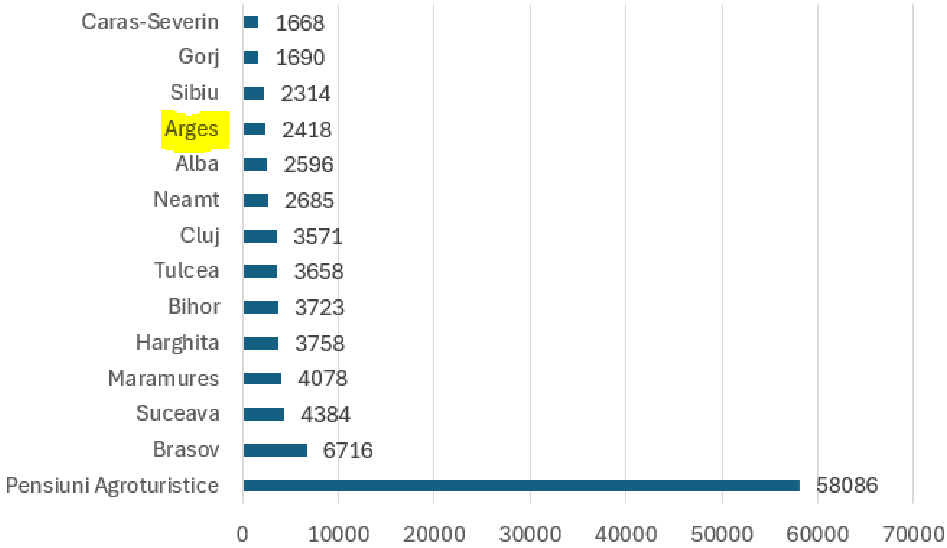
Types of turist structure	Area	Month												Average/ year
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	
Total turist structure	Romania	22	26	22,6	25	27	31	40	46	31	30	27	25	29,28
	Argeș	**19**	**18**	**18,2**	**25**	**27**	**32**	**36**	**40**	**30**	**27**	**28**	**29**	**27,4**
Rural and agrotourism guesthouses	Romania	13	15	11,3	15	16	21	26	32	19	15	14	17	17,94
	Argeș	**16**	**11**	**14,5**	**29**	**27**	**33**	**36**	**41**	**24**	**16**	**25**	**35**	**25,53**

Source: *National Institute of Statistics Romania*

The occupancy rate index of a tourist accommodation structure represents the number of overnight stays relative to the number of operational accommodation places. Using the previous table, we can make a comparative analysis of Argeș County with Romania regarding the occupancy rate of all operational accommodation structures and that of rural and agritourism guesthouses for each month of 2023. This analysis can help us better understand the behavior of tourism consumers.

All analyzed categories follow a seasonal pattern with variations throughout the year. Thus, there is an increase and decrease in values due to peak season and off-season periods. In the autumn and winter months, the values are quite low, which may indicate rather low tourist activity. Agritourism guesthouses in Argeș County stand out in our chart with values above the national average in April and December. These values can be explained by the fact that around Easter or Christmas, people feel the need to reconnect with the rural universe where most traditions and customs originated. The highest occupancy rate recorded by agritourism guesthouses in Argeș is in August, during the holiday and camp period. The chart also shows that agritourism guesthouses in Argeș have a higher occupancy rate than the national average for agritourism guesthouses.

Figure 3: *Ranking of Counties by Tourist Accommodation Capacity in Agritourism Guesthouses in Romania for 2023*

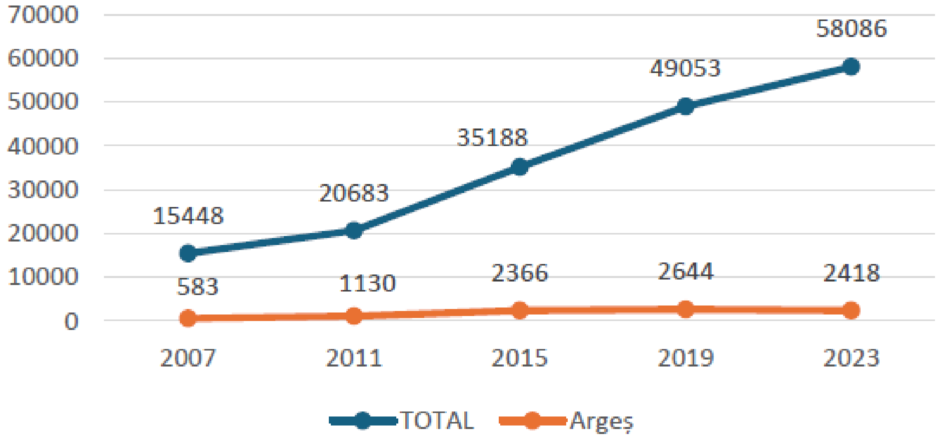


Source: *National Institute of Statistics Romania*

In Romania in 2023, there were 58,086 accommodation places in 3,498 rural and agritourism guesthouses, representing 13.40% of the total tourist accommodation places. Brașov County was at the top of this ranking, holding 11% of the total. This time, Argeș County ranked 10th, with a capacity of 2,418 accommodation places, or 4.16% of the total capacity. In 2007, Argeș County ranked 9th in the country for the capacity of agritourism guesthouses, representing 3.77% of the total national capacity.

Although the number of agritourism guesthouses decreased by approximately 6% from 2007 to 2011, the accommodation capacity increased by 33.9%. We can assume that this happened because the agritourism guesthouses that remained on the market expanded, or those that entered the market had a larger accommodation capacity than those that withdrew. Between 2007 and 2015, the growth rate was over 100% in Argeș, due to the fact that the number of agritourism guesthouses almost tripled, reaching 5th place in the country with a percentage of 6.72% of the tourist capacity, preceded by Neamț, Suceava, Harghita, and Brașov. However, from 2019 to 2023, the accommodation capacity of agritourism guesthouses in Argeș decreased by 7.35%, given that the number of agritourism guesthouses decreased by 10%, which could suggest a consolidation of the sector or changes in tourist preferences. In Romania, even though the growth rate is no longer as high, the accommodation capacity of agritourism guesthouses continues to increase.

Figure 4: *Evolution of Accommodation Capacity in Agritourism Guesthouses in Romania and Argeș County from 2007 to 2023*



Source: *National Institute of Statistics Romania*

SWOT Analysis of Argeș County from an Agritourism Perspective

The SWOT analysis of Argeș County reflects considerable tourism potential, but also a series of challenges that can influence the sustainable development of the region. The Strengths of the region include the diversity of the landscape, which is an important factor for attracting tourists interested in outdoor activities such as hiking, climbing, and cycling. The Făgăraș Mountains and the plains offer unique opportunities for varied natural experiences, being a magnet for ecotourism. Additionally, Argeș stands out for its significant cultural-historical wealth, with numerous attractions that draw visitors interested in the cultural and spiritual heritage of the area. The region is also blessed with natural resources and vast biodiversity, including national parks and nature reserves, elements that contribute to the development of agritourism and ecotourism.

However, the Weaknesses highlight significant obstacles. The tourism infrastructure in certain areas is underdeveloped, which limits the capacity to attract and retain tourists. Accommodation and public dining facilities are limited, and the available tourist packages often lack uniqueness, reducing the attractiveness of the tourism offer. Another problematic factor is the inefficient promotion of the destination. In the absence of a coherent tourism marketing strategy, the region fails to maximize its tourism potential. Additionally, professional training in the field of tourism and agritourism is limited, leading to services that fall short of modern tourists' expectations, affected by lower quality experiences.

The Opportunities available for the region underline positive prospects regarding the growing interest in rural and ecological tourism. Globally, tourists are increasingly seeking authentic and ecological experiences, and Argeș can capitalize on this trend by diversifying its agritourism and ecotourism packages. Furthermore, access to European funds for rural development opens up possibilities for improving tourism infrastructure and services, thus facilitating the attraction of a larger number of tourists. Another positive aspect is the possibility of collaborating with universities and research institutes. Partnerships with these institutions can contribute to improving management and marketing strategies through the application of advanced research methods.

The Threats to the development of tourism in the county include climate change, which can negatively affect agriculture and natural ecosystems, essential factors for agritourism. Additionally, tourism in Argeș is strongly influenced by seasonality, with peaks during summer and holiday periods. This seasonality dependence generates significant revenue fluctuations, contributing to economic instability for locals. At the same time, Argeș faces fierce competition from other tourist regions in Romania and Eastern Europe, which benefit from stronger promotion and a more diversified offer, potentially drawing tourists away from Argeș.

Although Argeș County has significant resources and competitive advantages, its tourism development depends on the ability to improve infrastructure and adopt an effective promotion strategy. Adapting to global trends in ecological tourism, attracting European funds, and partnerships with academic institutions can significantly contribute to leveraging its tourism potential and mitigating the impact of limiting factors.

Conclusions

Agrotourism and rural tourism are developing sectors in many counties in Romania, including Argeș County. However, these forms of tourism are still in their early stages, facing various challenges related to monitoring and performance evaluation.

Currently, there is no precise tool for monitoring agrotourism performance indicators. The National Institute of Statistics in Romania provides data series that include the indicator “Agrotourism Guesthouses,” but these data encompass both rural guesthouses and agrotourism guesthouses. This general classification complicates the monitoring process, as agrotourism guesthouses with a capacity of fewer than five sleeping places are not considered.

To stimulate the development of agrotourism and rural tourism, legislative and fiscal measures are needed to encourage the population to engage in entrepreneurial activities. These measures would not only contribute to the growth of the local economy but could also reduce the migration of young people from rural areas.

In conclusion, although agrotourism and rural tourism in Argeș County are still in their infancy, there is significant potential for development. With adequate support from authorities and the implementation of effective policies, these sectors can become important drivers of the local economy and contribute to the revitalization of rural communities.

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DYNAMICS OF SOYBEAN TRADE BALANCE IN ROMANIA AND SERBIA - INSIGHTS FOR FOOD SECURITY

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Abstract

The trade balance of soybeans is a critical indicator of agricultural performance and food security in Romania and Serbia, two key players in the soybean sector in Southeastern Europe. This study analyzes the dynamics of soybean trade between 2006 and 2021, utilizing data from external sources complemented by specialized literature. Romania, as a member of the European Union, faces restrictions on genetically modified organisms (GMOs), impacting its competitiveness. In contrast, Serbia leverages its non-EU status to capitalize on GMO soybeans. The findings highlight structural differences between the two countries, such as production capacities and export strategies. Recommendations include fostering regional collaboration, enhancing research on sustainable practices, and supporting farmers through targeted policies while contributing to regional food security and sustainable agricultural development.

Key words: *Soybean trade balance; Romania; Serbia; food security, sustainable agriculture.*

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Introduction

Soybean production in Romania and Serbia is of strategic importance for the agricultural economy of the Southeast European region, contributing significantly to ensuring food security and diversifying food and feed sources. [1,4] The cultivation of this oilseed crop is notable for its central role in agriculture due to its high protein and oil content, as well as its ability to fix nitrogen in the soil, improving its fertility. [5]

Romania benefits from favorable soil and climatic conditions for soybean cultivation, especially in the southern and western regions. In recent years, soybean production in Romania has experienced significant growth due to investments in modern agricultural technologies, access to genetically modified seeds (outside the European Union), and the adoption of sustainable agricultural practices. However, Romania must comply with strict European Union regulations on the use of genetically modified organisms (GMOs), which limits the widespread adoption of certain high-performance varieties. [2,3]

Serbia has a long tradition in soybean cultivation, being one of the leaders in the region in this field. Production areas are concentrated in the province of Vojvodina, characterized by fertile soils and a favorable climate. Unlike Romania, Serbia is not part of the European Union, which allows it to adopt genetically modified soybean varieties, thus favoring productivity and reducing production costs. [4,5]

Both Romania and Serbia play a crucial role in ensuring food security, through the production of soybeans as a major source of vegetable protein. Soy contributes to reducing dependence on imports for feed and food, promoting the sustainability and resilience of agricultural systems in the region. Although both countries have high potential, challenges such as climate change, rising production costs, and access to advanced technologies remain essential for increasing competitiveness in international markets. [3,4]

Materials and Methods

The analysis of the dynamics of the trade balance of soybeans in Romania and Serbia was carried out using external data provided by Our World in Data, as well as the Food and Agriculture Organization of the United Nations (FAO) and other relevant sources. The study was based on quantitative and qualitative methods.

Data and information sources

Quantitative data on soybean imports and exports for the period 2006-2021 were collected from international and national databases.

Specialized literature was used to contextualize the analysis, including sources indexed in Web of Science and Google Scholar, which provided insights into the economic, political, and climatic factors influencing the soybean market.

Analysis methodology

- *Data processing*. Raw data were organized and synthesized to identify trends and fluctuations in soybean trade in the two countries. These included the analysis of import and export volumes, as well as the calculation of the trade balance.

- *Data contextualization.* Based on the literature, the main variables affecting soybean production and trade were identified, such as regulations on genetically modified organisms (GMOs), agricultural policies, and climatic conditions.

- *Comparative analysis.* Romania and Serbia were compared according to trade dynamics, market structure, and the efficiency of the adopted strategies, in order to highlight the similarities and differences between the two countries.

- *Data visualization.* The results of the analysis were presented graphically to illustrate trends and fluctuations in imports, exports, and the trade balance.

Study limitations

The analysis depends on the quality and accuracy of the available data, as well as on the contextual variables that may influence the soybean market. Climatic factors, political changes, and economic developments were considered key variables that could affect the results obtained.

Objective of the methodology

The methodology used aims to provide a detailed understanding of the soybean market in Romania and Serbia, contributing to the formulation of strategic recommendations that support the improvement of the performance of the agricultural sector and strengthen food security in the region.

Results and Discussion

The analysis of the soybean trade balance for Romania and Serbia highlights the dynamism of the agricultural market in Southeastern Europe. Both countries play an important role in the regional soy trade, but their differences in approach reflect the influences of economic, political, and climatic factors. As an EU member, Romania complies with strict regulations on GMOs, which sometimes limits the competitiveness of exports. In contrast, Serbia, as a non-EU country, benefits from flexibility in the use of GMO technologies, achieving higher yields.

Dynamics of soybean exports and imports from Romania

The analysis of soybean imports and exports from Romania between 2006 and 2021 reveals significant fluctuations in domestic and international market dynamics. Imports and exports followed distinct trends, influenced by factors such as domestic market demand, climatic conditions, political changes and trade strategies. (Table 1)

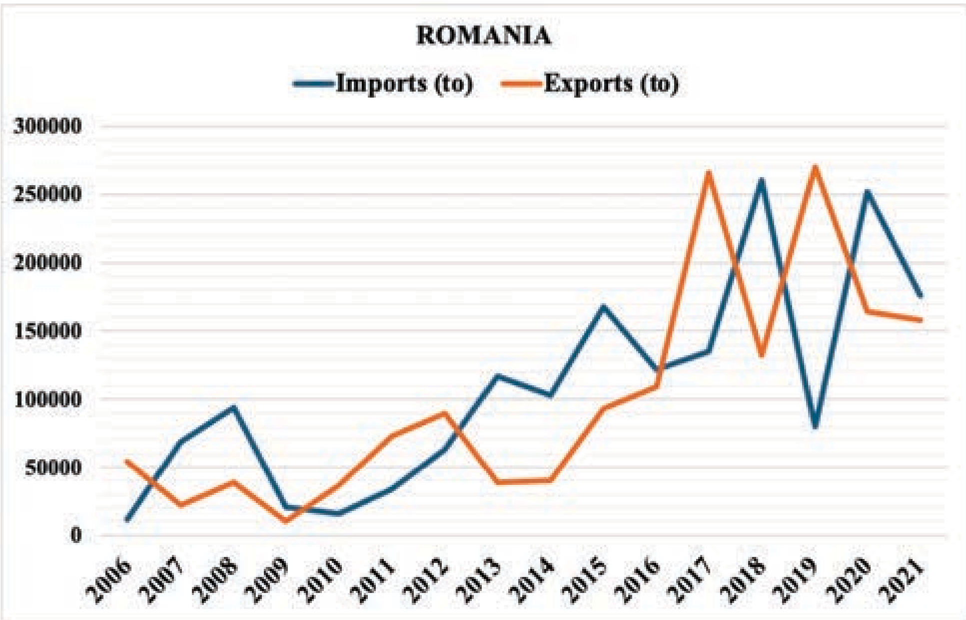
Table 1. *Soybean imports and exports from Romania (to) [6]*

Year	Import (to)	Export (to)
2006	12.000	54.000
2007	69.000	22.000
2008	94.000	39.000
2009	21.000	10.000
2010	16.000	37.000
2011	34.000	73.000
2012	63.000	90.000
2013	117.000	39.000
2014	103.000	40.000
2015	168.000	93.000
2016	122.000	109.000
2017	135.000	266.000
2018	260.000	132.000
2019	80.000	270.000
2020	252.000	164.000
2021	176.000	158.000

Soybean imports increased significantly during the period under review, from 12.000 tones in 2006 to a peak of 260.000 tones in 2018. This increase can be associated with the growing demand for soy-based feed and processed products, especially in the livestock sector. In the following years, imports stabilized at a high level, indicating an increased dependence on external sources to meet domestic demand.

Exports have shown different dynamics, oscillating depending on domestic production capacity and access to foreign markets. In 2006, Romania exported 54.000 tons, but volumes decreased significantly until 2009, when they reached only 10.000 tons. Subsequently, exports recorded a steady recovery, culminating in a peak of 270.000 tons in 2019, demonstrating the country's ability to adapt to international market demands. However, after 2019, exports decreased again, probably due to climatic factors or increased domestic demand. (Figure 1)

Figure 1. *Graphical analysis of the dynamics of soybean imports and exports from Romania (to)*



The dynamics of these figures highlight the strategic importance of soybean production for Romania, both as a domestic source of feed and food products and as a commercial opportunity in international markets. The increase in the volume of imports suggests the need to analyze domestic production capacity and invest in advanced agricultural technologies to reduce dependence on imports. At the same time, the volatility of exports highlights the need for better-coordinated trade strategies and an efficient logistics infrastructure to strengthen Romania's position on the global market.

Dynamics of soybean exports and imports from Serbia

Serbia's soybean imports and exports between 2006 and 2021 reflect variable dynamics, influenced by economic, agricultural, and political factors. Analysis of this data highlights both opportunities and challenges for the Serbian soybean market.

Soybean imports from Serbia have experienced significant fluctuations. In 2006, the import volume was 12.000 tons, followed by decreases in the following years. However, there have been substantial increases, such as in 2015, when imports reached 97.000 tons, indicating increased domestic demand. After 2020, imports rebounded, reaching 52.000 tons in 2021. These increases can be attributed either to a temporary deficit in domestic production or to the need to cover demand for industrial processing or feed. (Table 2)

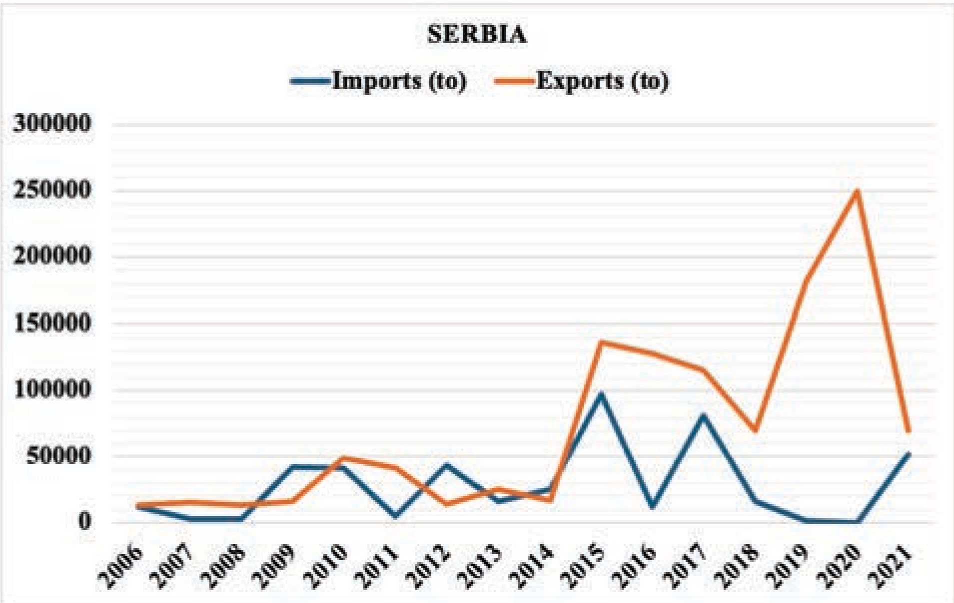
Table 2. *Soybean imports and exports from Serbia (to) [6]*

Year	Import (to)	Export (to)
2006	12.000	13.000
2007	3.000	15.000
2008	3.000	13.000
2009	42.000	16.000
2010	41.000	49.000
2011	5.000	41.000
2012	43.000	14.000
2013	16.000	25.000
2014	25.000	17.000
2015	97.000	136.000
2016	12.000	128.000
2017	81.000	115.000
2018	16.000	70.000
2019	1.000	182.000
2020	0	250.000
2021	52.000	70.000

On the other hand, soybean exports from Serbia have followed a different path, with marked variations from one year to the next. For example, in 2019, Serbia exported 182.000 tons, and in 2020 exports reached a record 250.000 tons. This indicates significant production capacity and efficient access to international markets. However, in 2021, exports decreased to 70.000 tons, suggesting either an increase in domestic consumption or logistical or trade challenges.

Serbia demonstrates considerable potential in the global soybean market, but variations in imports and exports highlight the need to develop a coherent strategy for this sector. Increasing domestic production through investments in modern agricultural technologies and optimizing production processes could reduce import dependence and increase exports. At the same time, diversifying export markets and improving logistics infrastructure would contribute to strengthening Serbia's position in the international market. (Figure 2)

Figure 2. *Graphical analysis of the dynamics of imports and exports of soybeans from Serbia (to)*



Therefore, the soybean market in Serbia represents a strategic element for agriculture, playing a key role in food security and the rural economy. Sustained efforts to increase efficiency and competitiveness could amplify the economic impact and sustainability of this sector in the long term.

Trade balance of soybeans from Romania and Serbia

The dynamics of the soybean trade balance for Romania and Serbia between 2006 and 2021 highlight the variability and influence of economic, agricultural and climatic factors on this strategic sector. Both countries have experienced significant fluctuations, reflecting both the challenges and opportunities of the regional and international market.

Romania has experienced a trade balance with strong fluctuations. In 2006 and 2017, Romania had a significant trade surplus of 42,000 tonnes and 131,000 tonnes respectively, highlighting the capacity to export considerable volumes of soybeans. However, 2013, 2014, 2015 and 2018 marked major deficits, with values such as -78,000 tonnes in 2013 and -128,000 tonnes in 2018. These deficits can be associated with insufficient domestic production, dependence on imports and challenges related to logistics infrastructure or adverse climatic conditions

Serbia, on the other hand, has shown a more consistent performance in recent years, especially after 2015. In 2016, Serbia recorded a notable surplus of 116.000 tones, and in 2020 this surplus reached a record 250.000 tones.

These results indicate improvements in domestic production capacity and a consolidated presence in international markets. However, the years 2009 and 2012 were marked by significant trade deficits, such as -26.000 tones in 2009 and -29.000 tones in 2012, suggesting temporary difficulties in adapting to market demand. (Table 3)

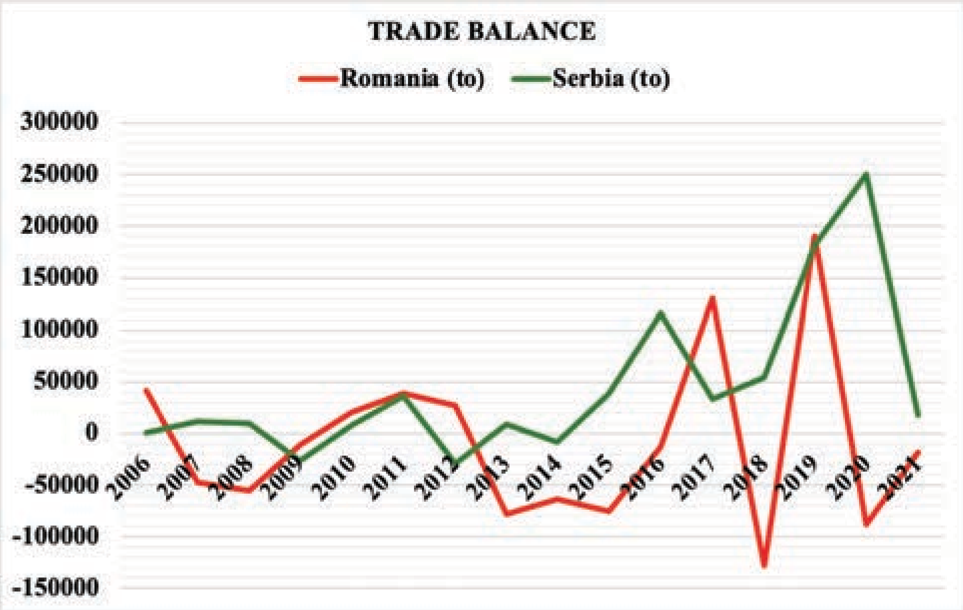
Table 3. Trade balance of soybeans from Romania and Serbia (to) [6]

Year	Romania (to)	Serbia (to)
2006	42.000	1.000
2007	-47.000	12.000
2008	-55.000	10.000
2009	-11.000	-26.000
2010	21.000	8.000
2011	39.000	36.000
2012	27.000	-29.000
2013	-78.000	9.000
2014	-63.000	-8.000
2015	-75.000	39.000
2016	-13.000	116.000

Year	Romania (to)	Serbia (to)
2017	131.000	34.000
2018	-128.000	54.000
2019	190.000	181.000
2020	-88.000	250.000
2021	-18.000	18.000

The comparative analysis shows that, while Romania has had both periods of surplus and deficit, Serbia has managed to gradually stabilize its trade balance, becoming a more consistent net exporter. This difference can be explained by the different efficiency of the production and export strategies adopted by the two countries. (Figure 3)

Figure 3. *Analysis of the dynamics of the trade balance of soybeans in Romania and Serbia (to)*



Therefore, the dynamics of the soybean trade balance underline the importance of investments in agriculture, infrastructure modernization, and adaptation to global market requirements. Both Romania and Serbia have the potential to consolidate their position in the regional and international markets through a coherent strategy and by exploiting agricultural resources in a sustainable way.

Conclusions

Food security remains a cornerstone for Romania and Serbia, carrying profound implications for economic and social stability across Southeastern Europe. Soybean production plays a strategic role in agriculture, being influenced by agricultural policies, supporting infrastructure, and integration into international trade. However, differences between the two countries are evident, especially in the context of regulations on genetically modified organisms (GMOs). [1,5]

Romania, as a member of the European Union, is subject to strict regulations on the cultivation and use of genetically modified soybeans. This sometimes limits competitiveness on the international market, but at the same time promotes a more sustainable agricultural model oriented towards quality standards. [4,5] However, fluctuations in the trade balance, especially between 2013 and 2018, highlight the need for strategic measures to improve production and exports.

Serbia, on the other hand, is not part of the European Union and is therefore not subject to the same restrictions on GMOs. This freedom has allowed it to use genetically modified soybeans to increase agricultural yields and reduce production costs, giving it a competitive advantage in certain markets. Trade surpluses in 2016 and 2020 reflect this flexibility, but periods of trade deficits show that challenges remain in infrastructure and adapting to the demands of international markets.

To improve the performance of the soybean sector and strengthen its competitiveness on international markets, strategic measures adapted to the specific context of each country are required. To address legislative differences, Romania could explore innovative solutions that would allow it to maintain its competitiveness in the context of European restrictions on genetically modified organisms (GMOs). These solutions could include the use of alternative technologies or diversification of the product range. At the same time, Serbia could capitalize on the advantages offered by the lack of GMO restrictions, continuing to increase its presence in emerging markets. However, this process requires significant investments in the modernization of agricultural infrastructure to support the expansion of international trade.

Farmers in both countries require subsidies and training to adapt to market demands and boost productivity. Enhanced collaboration between Romania and Serbia could foster the exchange of best practices and joint access to international markets. Investing in research and innovation is vital for developing climate-resilient soybean varieties and integrating modern technologies, enhancing sustainability and competitiveness in soybean production.

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SOLUTIONS FOR SOCIAL AGRICULTURE: HORTICULTURAL THERAPY

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Abstract

This paper is an attempt at promoting the practice of horticultural therapy in Romania. Raising awareness about this practice involves knowing the specific terminology in the field, knowing its definitions, its human issues, its defining elements, the categories of people who can implement horticultural therapy programmes, the types of settings where horticultural therapy programmes can be implemented, the types of effects and of benefits horticultural therapy has on clients' health, as well as the economic relevance of horticultural therapy.

Key words: *horticultural therapy, human issues, benefits, economic relevance*

Introduction

The practice of **garden / horticultural / horticulture / nature-assisted therapy**, **social and therapeutic gardening**, or **therapeutic horticulture** (Scott, 2017) requires adaptations / modifications allowing individuals with special

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needs (individuals with physical, mental, or socio-economic limitations) to "benefit from participation in horticultural activities or from viewing plants and landscapes" (Relf & Dorn, 1995). **Horticultural therapy** and **animal-assisted therapy** are components of **farm therapy** (Di Iacovo & O'Connor, 2009).

Horticultural therapy, which is about 50 years old, has been defined as: "one of the treatment modalities (including art therapy, music therapy, and recreational therapy) that form the adjunctive therapy treatment approach" (Relf & Dorn, 1995); "any gardening activity that helps anyone in any way" (Relf & Dorn, 1995); "The engagement of a client in horticultural activities facilitated by a trained therapist to achieve specific and documented treatment goals." (AHTA, 2012); "An active process which occurs in the context of an established treatment plan where the process itself is considered the therapeutic activity rather than the end product." (AHTA, 2012); "a relatively new discipline combining horticulture and rehabilitation disciplines, [which] employs plants and gardening activities in therapeutic and rehabilitation activities to improve human wellbeing" (Detweiler *et al*., 2012); "a process through which plants, gardening activities, and the innate closeness we all feel toward nature are used as vehicles in professionally conducted programs of therapy and rehabilitation" (Toyoda, 2012); and "a process, either active or passive, of purposefully using plants and gardens in therapeutic and rehabilitative activities designed to positively affect a set of defined health outcomes for individuals (e.g., improved mood, improved self-esteem, enhanced social interaction)" (Scott, 2015).

There are a few **human issues in horticulture**, i.e., the ***nature of influences of plants on people*** (Relf & Dorn, 1995): economic and marketing issues; ethnobotany considerations as they apply to horticulture; human dimensions in horticulture; people-plant interaction; "environmental and physical amelioration by plants: food and nutrition"; "role of horticulture in art, drama, music, and philosophy; social impact of horticulture."

Horticultural therapy has, like ***occupational therapy***, ***physical therapy***, and ***recreation therapy***, three main elements – *clients*, *treatment goals*, and *treatment activities* (Relf & Dorn, 1995; Aldous, 2000):

- ***Clients*** with disabilities such as: *economic and social "disability"* (disenfranchisement) (Relf & Dorn, 1995, Soga, Gaston & Yamaura, 2017); *geriatric disabilities* (frail and elderly) (McDowell, 1997; Detweiler *et al*., 2012; Soga, Gaston & Yamaura, 2017; Lo *et al*., 2018); *intellectual* *disability* (attention deficit hyperactivity disorder, hyperactivity, inattention, oppositional) (Kim *et al*., 2012; Soga, Gaston & Yamaura, 2017); *mental disability* (Lai *et al*., 2015; Seixas *et al*., 2017; Soga, Gaston & Yamaura, 2017); *mood disorder* (depression) (Alston, 2010; Soga, Gaston & Yamaura, 2017); *physical disability* (motor skills) (Jasmeen M., 2015; Soga, Gaston & Yamaura, 2017); *physical rehabilitation* (Soga, Gaston & Yamaura, 2017); *psychiatric disability* (Seixas *et al*., 2017; Soga, Gaston & Yamaura, 2017); *sensory impairment* (visual) (Soga, Gaston & Yamaura, 2017); *social deviation* (problem behaviour, socialization) (Jasmeen M., 2015; Soga, Gaston & Yamaura, 2017); *social disadvantage* (Soga, Gaston & Yamaura, 2017); *substance abuse* (Soga, Gaston & Yamaura, 2017); and *traumatic brain injury* (Soga, Gaston & Yamaura, 2017).

- ***Treatment goals*** depend on *client treatment* and *facility treatment* (Relf & Dorn, 1995): *client treatment goals* are circumstances under which the defined desired behaviour or response will occur, and minimum acceptable performance of the desired behaviour or response; *facility treatment goals* are: delayed progress of disability, maintenance of functioning level without institutionalization, "rehabilitation and return to the community at reduced functioning level," sheltered or supported employment, and vocational rehabilitation and placement.

- ***Treatment activities*** consist in (Relf & Dorn, 1995): arts arid crafts, cultivation of living plants, field trips, flower arranging, harvesting flowers, "learning to make terrariums and bonsai," "making dried flower arrangements," plant propagation, potting plants, producing greenhouse crops, pulling weed, reading, transplanting trees, etc.

Material and Method

The material used in this paper consisted in literature on horticultural therapy published in the last 30 years. The method used is the bibliographic one.

Results and Discussion

1. Horticultural therapy programmes can be implemented by three categories of people – *professional (horticultural) therapists*, *allied professionals,* and *volunteers* (Relf & Dorn, 1995):

- ***Professional (horticultural) therapists***: *horticulturist*, someone who "has a minimum of a bachelor's degree in horticultural therapy, or the minimum of a bachelor's degree with additional coursework in plant science, human science, and horticultural therapy; has completed a 480-hour internship in horticultural therapy; is professionally registered as a horticultural therapist" (AHTA, 2015); *landscapist* (professional making "make a garden or other area of ground more attractive by altering the existing design, adding ornamental features, and planting trees and shrubs" – *Oxford Languages*); *nursing staff* (licensed practical nurses, nurse aids, registered nurses, etc.); *occupational therapist* (assistive technology therapists, geriatrists, low vision therapists, mental health therapists, neurologists, oncological rehabilitation therapists, orthopaedists, paediatricians, physical rehabilitation therapists, etc.); *paramedical* (professions / services supplementing and supporting medical work but not requiring a fully qualified doctor – dietetics, emergency first aid, nursing, physiotherapy, radiography); *physiotherapist* (a person qualified to treat deformity, disease, or injury by physical methods – exercise, heat treatment, and massage); *special education* (education that accommodates students' individual differences, disabilities, and special needs); and *volunteers.*
- ***Allied professionals***: *occupational*, *physical*, and *recreation therapists*;
- ***Volunteers***.

2. Horticultural therapy programmes can be implemented in the following settings (Relf & Dorn, 1995; Aldous, 2000; Di Iacovo & O'Connor, 2009; Dietz, 2012; Brown, 2013; Hazen, 2024): *accessible / enabling gardens*, *adult training support services*, *care farms*, *children and school gardening*, *community centres and gardens, community gardening and urban greening*, *day centres, educational institutions, garden clubs*, *green social units*, *healing gardens / landscapes / spaces*, *horticultural therapy gardens*, *hospitals, inclusive farms*, *mental health facilities*, *nursing homes, prisons system*, *rehabilitation centres, restorative gardens*, *supported employment*, *therapeutic gardens* (characterized by a "profusion of plants and people/plant interactions," "benign supportive conditions," features modified to improve accessibility, recognizable placemaking, scheduled programmed activities, universal design, well-defined perimeters), and *therapeutic green units.*

3. Horticultural therapy has three types of effects on clients' health – *physiological*, *psychological*, and *social* (Toyoda, 2012):

- ***Physiological effects***: *improvement / preservation of ability of carrying, handling, and moving objects*; "*improvement / preservation of ability of changing and maintaining body position*;" "*improvement / preservation of ability of self-care (dressing, drinking, eating, looking after one's health, washing oneself)*"; "*improvement / preservation of ability of moving and walking*"; "*improvement / preservation of mobility*"; "*preservation of movement-related and neuromusculoskeletal functions and preservation of activities of daily living*"; *prevention of disuse syndrome of cardiovascular system function, hearing function, immunological system function, proprioceptive function, seeing function, sensory function related to temperature, smell function, taste function, touch function, vestibular function, etc.*; and *reduction of sensations of pain*.

- ***Psychological effects***: *preservation / recovery / stimulation of mental functions* "(attention functions – sustaining, dividing, and shifting attention; emotional functions; energy and drive functions; higher-level cognitive functions; memory functions; mental function of sequencing complex movements and experience of self; mental functions of language; orientation functions – orientation to time, place, person, etc.; perceptual functions; thought functions; and time functions)", *recovery of self-affirmation* (useful sense of self), *regain of confidence*, and *stress reduction*.

- ***Social effects***: *applying knowledge* (focusing attention, making decisions, solving problems, and thinking), *basic learning* (acquiring, copying, and rehearsing skills), *communication*, *conducting general tasks and demands* (handling stress, handling various psychological demands, "undertaking a single task, undertaking multiple tasks"), *interpersonal interactions and relationships*, and *purposeful sensory experiences* (listening, watching, and other purposeful sensing).

4. Horticultural therapy has five types of benefits – *cognitive*, *emotional*, *physical*, *physiological*, and *social* (Diehl & Park Brown, 2016):

- ***Cognitive benefits***: *attainment of new skills*, *encouragement of observation*, *increase of attention span and focus*, *increase of knowledge*, *increase of vocabulary*, and *stimulation of memory*.

- ***Emotional benefits***: *increase of feelings of confidence, self-esteem, and self-worth*; *promotion / satisfaction of creative drive*; *promotion of interest and enthusiasm*; and *relief of aggression or tension*.

- ***Physical benefits***: *development / increase of fine and gross motor skills*, *increase of activities of daily living skills*, *increase of eye-hand coordination*, and *provision of exercise*.

- ***Physiological benefits***: *decrease of cortisol level*, *lowering of blood pressure*, *lowering of heart rate*; and *relief of stress*.

- ***Social benefits***: "*increase of communication skills* and *increase of interaction within and outside of the group*."

5. Horticultural therapy is economic relevant. Even though, overall, "the reasons given for growing food crops [are] more for their noneconomic rather than their economic benefits" (Carman, 1987, in Aldous, 2000), **horticultural therapy** also has ***economic relevance*** as shown in literature: "Products or services that are a by-product of the treatment of a client (i.e., pot plants, vegetables, and grounds maintenance services) have *economic value* and are expected to contribute significantly to the budget of the program." (Relf & Dorn, 1995); "Economics will also play a major role in determining some of the most *cost-effective* ways to humanely care for the elderly, as the proportions of working individuals will greatly diminish in the future." (Detweiler *et al*., 2012); "Constructing rehabilitation centres, assisted living or dementia residence gardens that encourage autonomy and sensory stimulation is an *economically sound*, non-pharmacological *strategy* for improving the quality of life for persons needing these types of residences." (Detweiler *et al*., 2012)

Conclusions

The following conclusions can be drawn from the study of literature on **horticultural therapy**:

- Despite the long tradition of **horticultural therapy**, literature uses six synonyms for the same practice;

- **Horticultural therapy** (circumscribed to the cultivation of plants) has its animal counterpart (***animal-assisted therapy***) as part of **farm therapy**;

- **Horticultural therapy** has been defined in various ways (a relatively new discipline, active process, engagement of a client in horticultural activities, gardening activity, process, treatment modality);
- The practice of **horticultural therapy** needs to consider the ***human issues in horticulture***;
- **Horticultural therapy** is about three main elements – "*clients, treatment goals,* and *treatment activities*";
- **Horticultural therapy programmes can be implemented by three categories of people** – *professional (horticultural) therapists*, *allied professionals,* and *volunteers*;
- **Horticultural therapy programmes can be implemented** in over 26 types of settings;
- **Horticultural therapy has three types of effects on clients' health** – *physiological*, *psychological*, and *social*;
- **Horticultural therapy has five types of benefits** – *cognitive, emotional*, *physical*, *physiological*, and *social*;
- **Horticultural therapy** has ***economic relevance***.

Horticultural therapy has proved to be effective in health outcomes such as *anger*, *anxiety*, *body mass index* (in both men and women), *bone mineral density* (hip, spine), *chronic illnesses*, *cognitive function*, *confusion*, *depression*, *existential issues*, *fatigue*, *general health*, *general practitioner consults*, *health complains*, *heart rate*, *hope*, *life satisfaction, loneliness, mood, physical activity*, *physical constraints*, *positive affect*, *psychological wellbeing*, *quality of life*, *restorativeness* (being away, fascination), *rumination*, *salivary cortisol*, *self-esteem*, *sense of community*, *sociability, social contacts, stress, tension*, or *vigour* (Soga, Gaston & Yamaura, 2017) – which recommends it for implementation in Romania.

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THE ROLE OF THE LABOUR FORCE ON FAMILY AGRICULTURAL FARMS IN THE REPUBLIC OF SERBIA

Marija Popović[1]

Abstract

The aim of the work is to show the role of the labour force on family farms in the Republic of Serbia as one of the most important resources for agricultural production. The labour force is a key factor in the development of agriculture and rural areas. The unfavorable age structure affects the effective use of the labor force and the productivity of work in agriculture, where there is a pronounced decline in the participation of young people and an increase in the share of the elderly in agricultural production. According to the data of the Census of Agriculture from 2023, the number of members and permanent employees on agricultural farms in the Republic of Serbia is 1,134,999 people. Of the total number family farms, 506,736 (44.65%) are holders of the farms, 627,193 (55.26%) are members of the farms, while 1,070 (0.09%) are permanently employed.

Key words: *labor force, family farms, agriculture, Serbia.*

Introduction

In order to improve agricultural production, it is necessary to preserve two resources: labor force and agricultural areas. Some of the farms do not have enough arable land, fragmented property, there is a shortage of labor force, and because of this, these farms cannot be significant agricultural producers. As these resources decrease, which are the basic prerequisite for successful agricultural production, it is necessary to take a series of measures to slow down and stop negative trends (Rajić et al., 2007; Popović et al., 2024; Rajić and Popović, 2020).

There are 508,325 agricultural farms according to the data of the 2023 Census of Agriculture in the Republic of Serbia, and the largest part includes family agricultural farms, i.e. 99.61%, and agricultural production is carried out almost entirely on them. The total agricultural land which is used is

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3,239,373ha, and family agricultural holdings use 2,916,102, that is 90.02% (RZS, 2024). According to the number of members and employees on the farm, the largest number of agricultural farms are small and have one or two members (Stevanović and Milanović, 2014).

Labor force is the most important input in agricultural production and is an active factor in the use of land and capital in agriculture. Also, it is a significant factor in agriculture that consists of persons engaged in agricultural production with certain physical and intellectual abilities and experience (Subić, 2005; Subić, 2005).

The aim of the paper is to show the role and importance of the labor work on family agriculture holdings for agricultural production in the Republic of Serbia, their involvement and the age structure of the holders.

Material and working methods

For the research in this work, databases and publications of the Republic Institute for Statistics of the Republic of Serbia and other available and relevant literature were used. An analysis of the labor force on family farms according to data from the 2023 Census of Agriculture is presented. Based on the presentation of data in the table and graphs, it is pointed out the significant role of the labor force on family farms.

Research results

Ownership structure of family agricultural holdings according to the size of agricultural land that is used in the Republic of Serbia, according to the Census of Agriculture from 2023, indicates that the total number of family agricultural holdings is 506,323. Family farms with smaller holdings of up to 5ha make up the most dominant part, that is 68.33% of all family farms, and they have only 23.40% of used agricultural land at their disposal. Family farms with holdings from 5 to 30ha make up 29.57% of the total number of family farms, and they dispose of 54.47% of the total used agricultural land. Family farms with holdings over 30ha make up only 2.09% and include 22.13% of used agricultural land (table 1).

Table 1. *Structure of family agricultural holdings according to the size of agricultural land use in the Republic of Serbia, 2023*

Indicators	Total	< 1 ha	1,01-2 ha	2,01-5ha	5,01-10 ha	10,01-30ha	30,01-100ha	> 100 ha
Family agricultural holdings	**506.323**	**102.245**	**92.172**	**151.557**	**90.536**	**59.209**	**9.467**	**1.137**
%	100	20,19	18,20	29,93	17,88	11,69	1,87	0,22
Unilised agricultural area	**2.916.102**	**56.887**	**131.433**	**494.085**	**629.700**	**958.719**	**440.208**	**205.070**
%	100	1,95	4,51	16,94	21,59	32,88	15,10	7,03

Source: *RZS, https://data.stat.gov.rs/*

The agricultural labor force on family farms in the Republic of Serbia consists of family members, which indicates informal work and results in a large participation of unpaid labor. The largest number of members of family agricultural holdings work on family agricultural farms of 2 to 10 ha (Popović et al., 2024).

According to the results of the 2023 Census of Agriculture, the number of members and full-time employees on family farms in the Republic of Serbia is 1,134,999 people. Out of the total number of family farms, 506,736 (44.65%) are owners of farms, 627,193 (55.26%) are members of farms, and 1,070 (0.09%) are permanently employed on family farms (table 2). On average, one family farm in the Republic of Serbia employs 2.2 people.

Table 2. *Labor force in family farms by employment status by region in the Republic of Serbia, 2023*

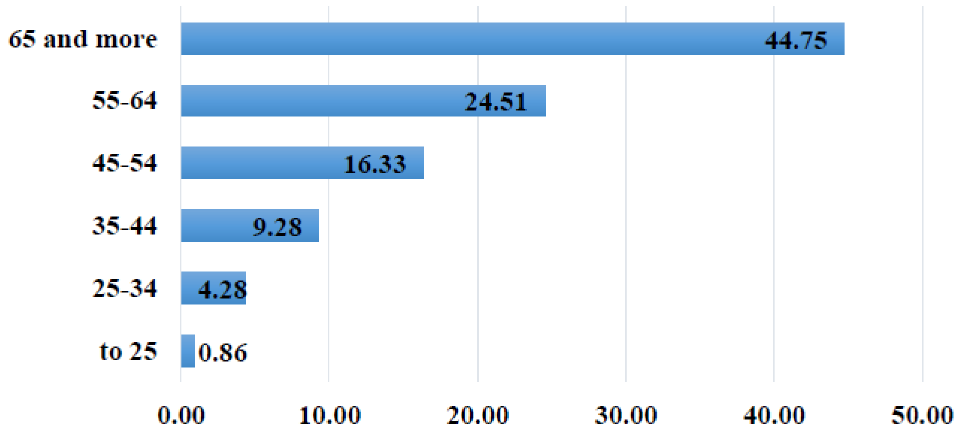
Region	Total	Holders farms		Members of the farm		Family farms – full-time employees	
		Number	%	Number	%	Number	%
Republic of Serbia	**1.134.999**	**506.736**	**44,65**	**627.193**	**55,26**	**1.070**	**0,09**
Belgrade Region	**59.409**	26.096	43,93	33.270	56,00	43	0,07
Vojvodina Region	**204.716**	111.099	54,27	92.912	45,39	705	0,34
Region of Šumadija and Western Serbia	**525.489**	224.047	42,64	301.305	57,34	137	0,03
Region of Southern and Eastern Serbia	**345.385**	145.494	42,13	199.706	57,82	185	0,05

Source: *RZS, https://data.stat.gov.rs/*

The increase in the number and share of the elderly in the total population is one of the basic characteristics of population changes in Serbia, which is also reflected in the changes in the average age of holders of households. Unfavorable age and educational structure of the agricultural labor force is a big problem for the development of agriculture. The growth in the number of carriers in the oldest age group is noticeable in all regions of Serbia. Women rarely appear in the role of caretakers of family farms, and it is very difficult to retain a highly trained workforce in rural areas (RZS, 2019; Trmčić and Jelić, 2015; Government of the Republic of Serbia, 2014).

The analysis of the age structure of owners of family agricultural holdings in the Republic of Serbia according to the Census data from 2023 indicates that the largest share is held by farms with 44.75% whose owners are 65 years old and older. Owners of farms under the age of 35 are 5.13%. Among the owners of family agricultural holdings, women make up 22.82% and are more represented as owners of small farms (graph 1). A slow ownership transformation is observed in terms of the transfer of ownership of the farm to younger owners (Bogdanov and Babović, 2014).

Graph 1. *Age structure of owners of family farms in the Republic of Serbia (%), 2023*



Source: *RZS, https://data.stat.gov.rs/*

The labor force expressed in annual work units gives a clear picture of the productivity and efficiency of the use of labor force on family agricultural farms. The total number of annual work units on family agricultural holdings in the Republic of Serbia is 480,266. When the number of annual work units is put into relation with the total number of persons active in agriculture, the available labor force on family agricultural holdings in the Republic of Serbia is engaged with 42.31% of capacity on average. The average number of annual work units per family farm is 0.95 (table 3).

Table 3. *Total employed workforce on family agricultural holdings in annual work units by regions, 2023*

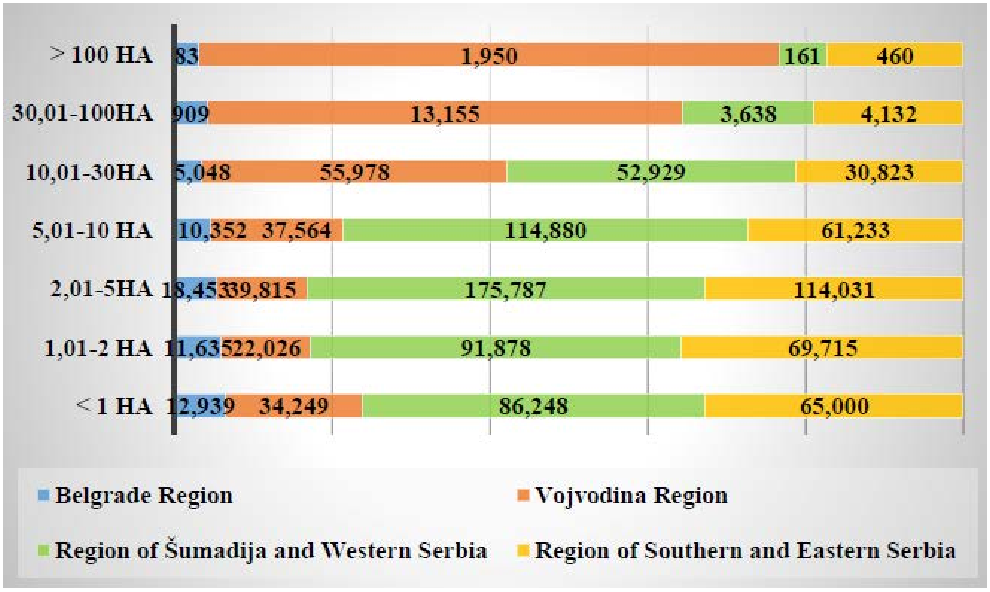
Region	Number of Family agricultural holdings	Number of members	Annual working unit (AWU)	AWU by:	
				holdings	**number of employees**
Republic of Serbia	**506.323**	**1.135.071**	**480.266**	**0,95**	**0,42**
Belgrade Region	**26.072**	59.419	23.791	**0,91**	**0,40**
Vojvodina Region	**110.982**	204.737	81.788	**0,74**	**0,40**

Region	Number of Family agricultural holdings	Number of members	Annual working unit (AWU)	AWU by:	
				holdings	**number of employees**
Region of Šumadija and Western Serbia	**223.850**	525.521	246.445	**1,10**	**0,47**
Region of Southern and Eastern Serbia	**145.419**	345.394	128.242	**0,88**	**0,37**

Source: *RZS, https://data.stat.gov.rs/*

The structure of the labor force according to the size of the agricultural land use indicates a high concentration of the labor force on small and medium-sized farms. 34.68% of the total number of persons involved in agricultural production on family agricultural holdings in the Republic of Serbia worked on farms up to 2ha (graph 2).

Graph 2. *Structure of the workforce on family agricultural holdings according to the size of the used agricultural land by regions in the Republic of Serbia, 2023*



Source: *RZS, https://data.stat.gov.rs/*

Conclusion

The unfavorable age structure of the population and members of family farms is a brake on the development of agriculture, and therefore of other settlements and the economy as a whole. There are more and more elderly holders of agricultural holdings. The age structure has an unfavorable effect on the effective use of the labor force and on the productivity of work in agriculture, where there is a pronounced decline in the participation of young people and an increase in the share of old people in the performance of agricultural work. The ownership structure of agricultural holdings shows that they are small, have small average sizes of used agricultural land, multiple plots and fragmentation, which limits their efficient use of land.

It is necessary to engage as many members of agricultural farms as possible and improve them through education, seminars, workshops, conferences, counseling, etc. Achieving greater cooperation of agricultural professional services of holders and members of agricultural holdings. It is necessary to take measures to slow down and stop existing negative trends.

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NEW APPROACHES TO STIMULATE ENTREPRENEURIAL INITIATIVES IN RURAL AREAS

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Abstract

This study examines the importance of promoting entrepreneurship in rural areas and proposes strategic measures to support this objective. The hypothesis suggests that entrepreneurship is essential for reducing economic and social disparities between rural and urban regions. Using a 20-question questionnaire as the primary research tool, the paper evaluates rural entrepreneurship in Romania and the EU, assesses financial support instruments, identifies challenges, and suggests strategies for business growth in rural areas. The study also developed a tool for assessing entrepreneurial skills, linking entrepreneurial motivation to business success. Findings highlight the need for Romania to invest in an entrepreneurial culture to drive economic growth, especially in rural areas.

Key words: *rural entrepreneurship, entrepreneurial spirit, business, economic disparity, social disparity, strategic measures.*

Introduction

In Romania, the concept of "enterprise" has evolved from a centrally managed unit in the 1950s to an independent, profit-oriented organization today, adaptable to competitive markets. Advances in technology introduced virtual enterprises—temporary, collaborative, and geographically dispersed structures. Social enterprises, now supported by the 2015 Social Economy Law, prioritize social over economic goals.

Romania classifies enterprises by size—micro, small, medium, large—based on employee count and turnover. SMEs, which make up 90% of global busi-

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nesses, drive economic growth due to their adaptability and innovation. In rural Romania, fostering SME growth is essential for revitalizing local economies and reducing urban dependency.

Rural entrepreneurship is key to revitalizing local economies. Governments and organizations support it through financing, training, and infrastructure improvements, bridging urban-rural divides. In Romania, with EU support, programs like grants and training foster rural business growth and innovation.

Rural development focuses on improving quality of life and fostering economic growth. In Romania, strategic policies promote sustainability, with EU support through the Regional Development Fund.

EU policies have supported entrepreneurship in Romania through various programs since its 2007 accession. Key initiatives include the National Rural Development Program, Startup Nation Program, and programs funded by the European Social Fund. These programs have provided financial support for business creation, especially in rural areas, and encouraged youth entrepreneurship.

The purpose of the article is to assess entrepreneurs' satisfaction with their business performance and to analyze their perceptions of entrepreneurial opportunities and challenges in rural areas. It also aims to investigate the entrepreneurial spirit of both entrepreneurs and non-business owners. Through the applied questionnaire, the article seeks to identify the main difficulties faced by rural entrepreneurs, intentions to start new businesses, and measures that could stimulate economic development in rural communities.

Literature review

The literature reveals the complexity and evolution of entrepreneurship, particularly within rural contexts. Entrepreneurship is often defined as a dynamic process requiring both intrinsic talent and skills, as well as practical steps to identify and exploit market opportunities (Mihalache, 2010). Entrepreneurial spirit, therefore, combines individual ability with educational influence; studies show that experience and education heighten one's capacity to innovate and spot business opportunities (Popescu, 2008). In line with these findings, several scholars advocate for integrating entrepreneurship education into formal curricula to bolster entrepreneurial skills nationally (Cojocaru, 2007).

While it is easy to define rural entrepreneurship, it is more difficult to explain why it is defined as such, as well as how rural entrepreneurship should be conceptualized. Rural entrepreneurship is often described as a form of entrepreneurship with an “added value” that relates to the socio-spatial context of rural areas (Korsgaard et al, 2015). Rural entrepreneurship is further differentiated from urban by its reliance on natural resources and the smaller scale of business operations (Philipson et al., 2011). This distinction is seen internationally, where researchers focus primarily on economic growth in developed nations, leaving gaps in studies on emerging regions (Pato and Teixeira, 2014).

Sustainability has recently emerged as a critical lens through which rural entrepreneurship is viewed, with emphasis shifting from resource utilization to environmental stewardship. Rural entrepreneurs now face a more complex ethical landscape shaped by global food trends and environmental concerns, moving beyond financial challenges to moral and societal obligations. Within post-communist nations, such as Romania, rural development faces obstacles rooted in past ideologies that limited individual entrepreneurial initiative, resulting in a slower adaptation of rural communities to market-oriented behaviors (Antonescu & Antonescu, 2013).

These multifaceted perspectives highlight that rural entrepreneurship is a field influenced by historical context, educational structures, societal values, and policy initiatives. The push toward sustainable and inclusive rural development reflects broader trends in global economic policy, yet challenges remain, particularly in bridging the rural-urban divide and fostering a culture of innovation in rural areas.

Rural entrepreneurs face specific challenges that are far less frequent or nonexistent in urban areas. For example, many rural communities are geographically remote from significant business networks, limiting access to suppliers, markets, and vital business services (Dabson, 2001). This isolation, coupled with small population sizes and limited local demand, makes it difficult for rural businesses to achieve economies of scale, which results in lower productivity and earnings when compared to urban areas (Goetz, 2006; Dabson, 2001). Moreover, rural economies are often dominated by one industry, typically agriculture, making them more vulnerable to sector-specific risks than urban economies (Dabson et al., 2003).

Additionally, the small size and geographic isolation of rural communities restrict access to a diversified labor pool and institutional support, which are critical for the success of small businesses (North & Smallbone, 2000). Furthermore, rural regions often have limited business financing options, including equity financing, which are essential for startups and business survival (Lichtenstein & Lyons, 1996). To survive, rural entrepreneurs frequently need to seek markets and services outside their region, which limits local business growth and resilience.

Economic disparities between urban and rural areas represent a significant social issue for the rural environment in Romania. Approximately 45.2% of the country's total population lives in rural areas, which accounts for about 9.8 million people. Studies show that the rural economy is largely dominated by agricultural activities, with the majority of the workforce concentrated in this sector, which poses a significant limitation to the development of both local and national economies (Chiripuci, 2019).

Supporting the development of rural entrepreneurship can contribute to increasing productivity in these areas and, implicitly, to improving the standard of living for rural inhabitants. A more efficient use of existing opportunities in rural areas can lead to higher profits for the economic activities in these regions. Although there is no universal solution to rural entrepreneurship, many successful cases demonstrate its potential, despite the challenges (Doltu, 2011).

Research methodology

The research methodology employed in this paper is a questionnaire survey, designed to assess entrepreneurs' satisfaction with their business performance, explore perceptions of entrepreneurial opportunities and challenges in rural areas, and evaluate the entrepreneurial spirit of both entrepreneurs and non-business owners.

The questionnaire consists of 19 closed-ended questions, divided into 6 parts, targeting 112 individuals from rural Braila County. It includes demographic questions, queries about existing businesses, assessments of entrepreneurial efforts, challenges in rural areas, and intentions to start a business. Additionally, it explores sources of business information, fears about entrepreneurship, and measures to stimulate rural business development.

Results of research

This research aimed to identify key prerequisites and measures necessary to stimulate entrepreneurial initiatives in rural areas as a catalyst for rural development. A questionnaire-based survey examined perceptions of entrepreneurs and non-entrepreneurs regarding business satisfaction, perceived opportunities, and challenges in rural entrepreneurship. Results indicated that weak entrepreneurial spirit in rural regions is largely due to financial concerns and inadequate infrastructure, including poor road quality and limited internet access. Nevertheless, a significant number of rural respondents expressed interest in establishing businesses. Recommended measures include infrastructure modernization, reduction of bureaucratic barriers, and targeted tax incentives for rural SMEs. Promoting entrepreneurship through sustainable investments in both agricultural and non-agricultural sectors may enhance rural quality of life and drive economic growth.

Table 1. *Last form of education graduated by the survey participants*

Master's degree	Bachelor's degree	Post-secondary school	Vocational School	High School
1.8%	32.7%	18.2%	18.2%	29.1%

Source: *Own conceptualization based on the questionnaire*

The results show a diverse range of education levels among respondents, with many holding a bachelor's degree or high school diploma, along with a notable number having post-secondary or vocational education.

Table 2. *Ocuppations of the respondents*

Student	Employed	Self-employed	Unemployed	Retired
2.7%	81.3%	11.6%	3.6%	0.9%

Source: *Own conceptualization based on the questionnaire*

The data reveals that most respondents are employed, with a smaller portion self-employed, a few seeking employment, and a very small number either students or retired.

Table 3. *Fields of activity of the businesses owned by respondents*

Agricul-ture, for-estry, and fishing	Financial interme-diation and in-surance	Real estate transac-tions	Profes-sional, scientif-ic, and technical services	Educa-tion	Trans-port	IT	Tourism
44.2%	7%	4.7%	7%	0%	23.3%	0%	14%

Source: *Own conceptualization based on the questionnaire*

Among respondents, 38.4% own a business. Among respondents who own businesses, most are in agriculture, forestry, and fishing, followed by those in transportation and tourism. Others are involved in financial services, professional and technical services, and real estate, with no participants operating in education or IT.

Table 4. *Time intervals since the business owned by the respondents have been active on the market.*

1-2 years	3-5 years	5-7 years	7-10 years
25.6%	46.5%	23.3%	4.6%

Source: *Own conceptualization based on the questionnaire*

Participants indicated a range of business durations: most have operated for 3-5 years, followed by 1-2 years and 5-7 years. A small percentage reported operating for 7-9 years or over 10 years, highlighting diversity in business experience and stability within the sample.

Table 5. *The number of employees that the respondents' businesses have*

1-3 employees	4-6 employees	7-9 employees	10-15 employ-ees	over 20 em-ployees
24.4%	46.3%	19.5%	4.9%	4.9%

Source: *Own conceptualization based on the questionnaire*

The majority of business owners surveyed have between 4 and 6 employees, followed by those with 1 to 3 employees. A smaller proportion reported having 7 to 9, 10 to 15, or over 20 employees, reflecting a diversity in business sizes within the sample.

Table 6. *Fluctuation of the economic and financial indicators of the respondents' business in the last 3 years of activity.*

Turnover increased	Turnover decreased	Turnover remains the same	No response
48.8%	11.6%	34.9%	4.7%

Source: *Own conceptualization based on the questionnaire*

These findings indicate that a significant portion of the respondents experienced growth in their net turnover, while a smaller percentage reported a decrease. A considerable number of respondents stated that their net turnover remained unchanged. It's important to note that a small percentage chose not to disclose their response.

Table 7. *The percentage of respondents who have considered opening a business in rural areas in the last 6 months*

Considering to open a business in rural ares	Not considering to open a business in rural areas
58%	42%

Source: *Own conceptualization based on the questionnaire*

58% of the respondents have considered opening their own business in the rural area in the last 6 months, while 42% responded that they haven't thought about it. These results suggest that there is a significant interest among a substantial percentage of participants in initiating their own business in the rural environment.

Table 8. *The fields of activity in which respondents intend to start a business in rural areas*

Agriculture, forestry, and fishing	Constructions	Transportation	Financial intermediation and insurance	Others
32.8%	17.9%	26.9%	6%	16.4%

Source*: Own conceptualization based on the questionnaire*

Only those who have considered opening their own business in the rural area in the last 6 months (58% of the total number of respondents) answered this question. The results reveal diverse entrepreneurial interests, with participants considering businesses in agriculture, construction, transportation, financial services, and tourism within rural areas.

Table 9. *Sources of information for respondents regarding the field of business and entrepreneurship*

Internet and social media	TV	Friends, relatives	Specialized magazines
33%	35.7%	25.9%	5.4%

Source: *Own conceptualization based on the questionnaire*

The respondents primarily gather information on business and entrepreneurship through the internet and social media, followed by television, friends and relatives, and specialized magazines.

Table 10. *Significant fears that respondents belive influence a person not to become an entrepreneur*

Fear of not generating income and profit in a short period of time	Fear of losing the invested resources in the business	Fear of change, of stepping out of the comfort zone
29.5%	56.3%	14.3%

Source: *Own conceptualization based on the questionnaire*

The main fears deterring individuals from entrepreneurship are the loss of invested resources, uncertainty about short-term profits, and fear of change or stepping out of their comfort zone. These concerns highlight financial risks and apprehension about business success as key barriers to entrepreneurship.

Table 11. *Measures that respondents consider as priorities in stimulating entrepreneurship and business development in rural areas*

Modernization and development of infrastructure	Reduction of bureaucracy	Granting special tax incentives for rural small and medium-sized enterprises (SMEs)	Conducting entrepreneurship courses in rural areas	Providing assistance and consultancy in entrepreneurial management	Improving communication between central and local authorities regarding the needs of rural entrepreneurs
71.4 %	60.7 %	52.7 %	29.5 %	46.4 %	35.7 %

Source: *Own conceptualization based on the questionnaire*

Each participant in the survey was asked to choose three measures they consider most important for stimulating entrepreneurial initiatives in rural areas. The top priorities identified include the modernization and development of infrastructure, such as improved roads, electricity, and internet access, followed by the reduction of bureaucracy to simplify administrative processes. Providing special tax incentives for rural small and medium-sized enterprises (SMEs) was also highlighted. Additional measures included offering entrepreneurship courses, providing consultancy in entrepreneurial management, and improving communication between central and local authorities to better address the needs of rural entrepreneurs.

Conclusions

The study reveals several key insights regarding rural entrepreneurship in Romania and its potential to foster economic growth and reduce the urban-rural divide. The findings underscore that although rural areas face significant barriers—such as inadequate infrastructure, financial concerns, and a lack of entrepreneurial culture—there is a substantial interest among rural residents in starting businesses. The perception of entrepreneurial success is hindered by financial risks and fears of instability, which are exacerbated by underdeveloped infrastructure, such as poor road conditions and limited internet access.

The research also highlights the importance of creating a more supportive environment for entrepreneurship in rural areas. Improving infrastructure, reducing bureaucratic obstacles, and offering targeted tax incentives for rural SMEs emerged as top priorities for stimulating business activity. Additionally, investing in education and training programs to foster entrepreneurial skills, particularly in rural communities, is vital for long-term success.

The integration of sustainable practices in rural entrepreneurship is increasingly important. Not only does sustainability align with global trends in environmental stewardship, but it also offers rural entrepreneurs opportunities for innovation and market differentiation. However, significant challenges remain in the form of limited access to capital, small labor pools, and a reliance on traditional industries, particularly agriculture.

Ultimately, the study advocates for a holistic approach to rural development that includes strategic policies, financial support, and infrastructure improvements. By creating a conducive environment for entrepreneurship, rural areas in Romania can harness their economic potential, improve the quality of life for their residents, and contribute to national economic growth. This approach will require collaborative efforts between local governments, educational institutions, and private sector actors to drive sustainable and inclusive rural development.

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THE ROLE OF NWFPs IN THE DEVELOPMENT OF ENTREPRENEURSHIP IN SOUTHEASTERN SERBIA

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Abstract

In the social context, forests have a significant role for many inhabitants, either in the form of livelihood, or income generated from a wide range of wood and non-wood forest products (NWFPs). In this research, NWFPs were analyzed as a component of rural entrepreneurship in southeastern Serbia. In this regard, 11 companies dealing with the purchase, processing, and marketing of mushrooms, forest fruits, and medicinal herbs were surveyed. The period considered is 2008-2017. The aim of the research was to familiarize with the elements of business related to the marketing mix (product, price, promotion, and distribution) in these companies, as well as to assess the possibilities for their improvement. In this way, it aimed to recognize the potential for the development of primarily small entrepreneurship in Southeastern Serbia through the use of NWFPs for commercial purposes.

Key words: *Southeast Serbia, NWFPs, companies, marketing mix.*

Introduction

Alongside the expansion of organic production and consumption, there is an intensive increase in interest in non-wood forest products (NWFPs) on a global level (Janse, Ottitsch, 2005; Marčeta, Keča, 2014; Keča et al., 2015/a; Недељковић et al., 2015; Tudor, Dincă, 2019; Sheppard et al., 2020). Their usage is multifaceted, and they represent a significant raw material base for a wide range of final products used in the pharmaceutical, food industry, etc. (Кеча, 2013; Abraham et al., 2020;

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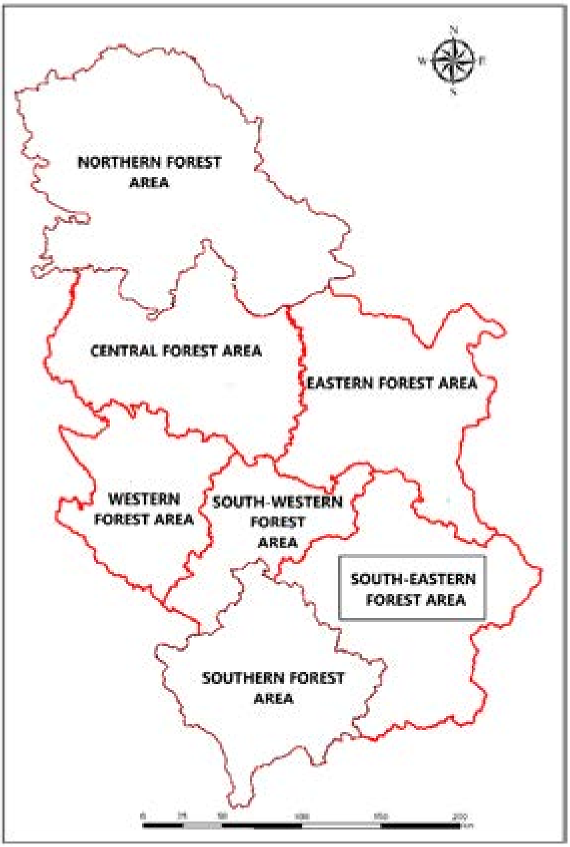
Górriz, 2019; Pettenella et al., 2020). Estimates indicate that over 150 species of NWFPs are present in international trade (Hinsui et al., 2008; Keča et al., 2015/a), among which traditional products can be highlighted, such as porcini mushrooms, chanterelles, oyster mushrooms, wild blackberries, raspberries, forest strawberries, etc. (Keča et al., 2013; Marčeta, Keča, 2014; Tudor, Dincă, 2019; Vacik et al., 2020; Lovrić et al., 2020; Sacchelli et al., 2021). Increased trends in the trade of forest products, particularly NWFPs, contribute to economic growth and consequently reduce poverty in many developing countries (Yadav, Kalpana, 2013). In Serbia, there is a long tradition of collecting NWFPs and using them, both for the personal needs of the local population and for commercial purposes. Considering exclusively the commercial aspect of NWFPs, this study analyzes 11 companies engaged in the purchase, processing, and placement of NWFPs in Southeastern Serbia, specifically the Southeastern forest region (Map 1).

Map 1. *Research area*



Source: *Original*

The aim of the research was to identify the marketing mix in the analyzed companies, as well as the possibilities for their improvement. In addition, growth rates in the placement of individual product categories were determined. The purpose was to identify commercially significant products within the product portfolio. The subjects of the research are companies (dealing with purchase, processing, and placement of NWFPs and the marketing mix of companies (product, price, promotion, and distribution). The period covered by the research is 2008-2017.

Material and method

For the purposes of the research, a special questionnaire was created for companies in the field of NWFPs. All questions were oriented toward the marketing mix. Questions related to the product are the structure and quantity of final products placed on the domestic and foreign markets. Within the framework of price, as an element of the marketing mix, the survey was oriented to finding information on the way and form of pricing of final products. For promotion, the questions were focused on the form and method of implementation and instruments of promotional activities, and for distribution, identifying the channels through which products are placed on the market. In the last part, the survey included questions that represent the expression of a subjective attitude in the context of business conditions and problems faced by companies on the market.

In addition, the flows and quantities of purchase, placement on the domestic market and export of NWFPs were analyzed by determining the average annual growth rate. The growth rate was calculated by obtaining chain indices in the first phase according to the following pattern:

$$\overline{Y}c = \frac{Y}{Y-_1} * 100$$

In this way, the value of the change in occurrence in the current year compared to the previous year (expressed in %) was obtained (Krstić, Šoškić, 2016). The geometric mean was calculated from these values (Excel function "*geomean*"). The obtained value was reduced by 100, determining the average annual growth rate for the purchase, placement on the domestic market, and export.

Table 1. *Territorial distribution and business orientation of the analyzed companies*

SOUTHEAST FOREST AREA	
CITY	COMPANY NUMBER
Leskovac	2
Vranje	2
Merošina	2
Surdulica	2
Vladičin Han	1
Svrljig	1
Crna Trava	1
TOTAL	11
BUSINESS ORIENTATION OF THE COMPANY	
Forest fruit	2
Mushrooms	1
Forest fruits and mushrooms	7
Medicinal herbs	1

Source: *Survey*

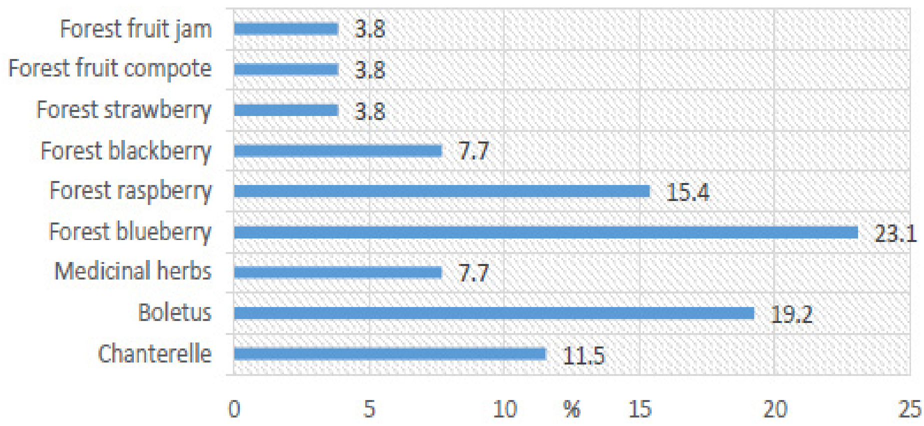
The survey was conducted in 11 companies. Of these, two companies were surveyed in each of cities: Leskovac, Vranje, Merošina and Surdulica. One company was surveyed in Vladičin Han, Svrljig and Crna Trava (Table 1).

Results and discussion

All analyzed companies from the field of NWFPs belong to the private sector. According to the number of employees, they mostly belong to the category of micro and small enterprises[4]. In the product range of the analyzed companies, the dominant products are those based on forest fruits and mushrooms (boletus). The structure of the product is shown in diagram 1.

4 According to the Republic Statistical Office, micro-enterprises have between 0 and 9 employees, small enterprises between 10 and 49, and large enterprises between 50 and 249 employees.

Diagram 1. *Representation of certain product categories in the assortment of analyzed companies*

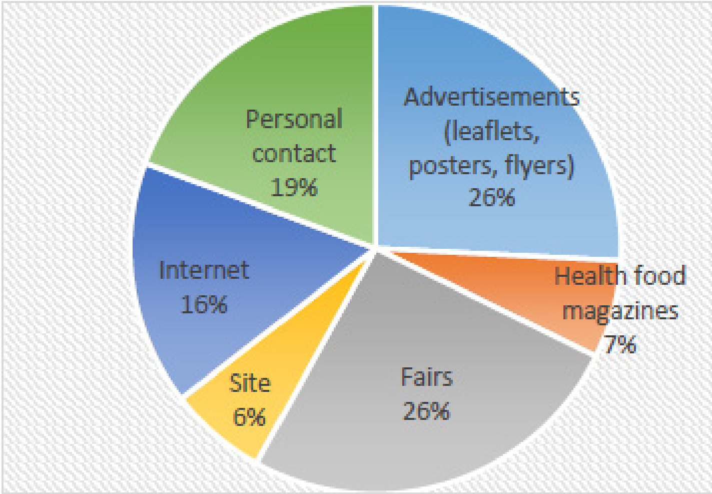


Source: *Survey*

The most represented individual products in the assortment of analyzed companies are forest blueberry, with a share of 23.1%, and boletus with 19.2%. Forest raspberry with 15.4% and chanterelle with 11.5% are less represented (Diagram 1).

The companies included in the analysis in the formation of sales prices have a cost-based approach. This means that the formation of prices is based on the "costs plus" model, which includes all costs (direct and indirect) while charging a certain percentage of profit (Marčeta et al., 2024). This model has been widely applied due to its methodological simplicity. Given that companies have precise data on the costs that arise in connection with the purchase of raw materials, and costs that accompany the production process, their simple addition leads to the lower limit of the price. To this price, companies independently add a certain percentage of profit (Milisavljević *et al.,* 2004; Njegovan, 2005).

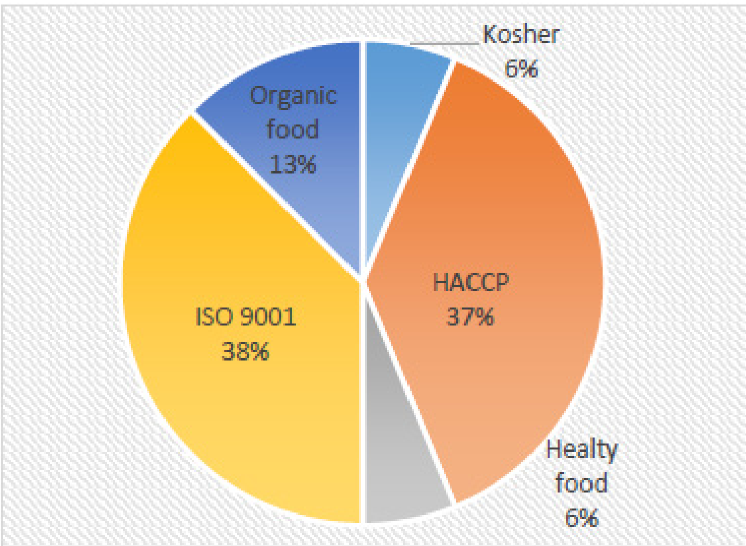
Diagram 2. Forms of promotional activities in the analyzed companies



Source: *Survey*

As a way of promotion, 26% of respondents highlighted participation in fairs and promotion in the form of printed materials (leaflets, posters, flyers, brochures, etc.). In addition, there is personal contact with 19% and promotion via the Internet with 16% (diagram 2).

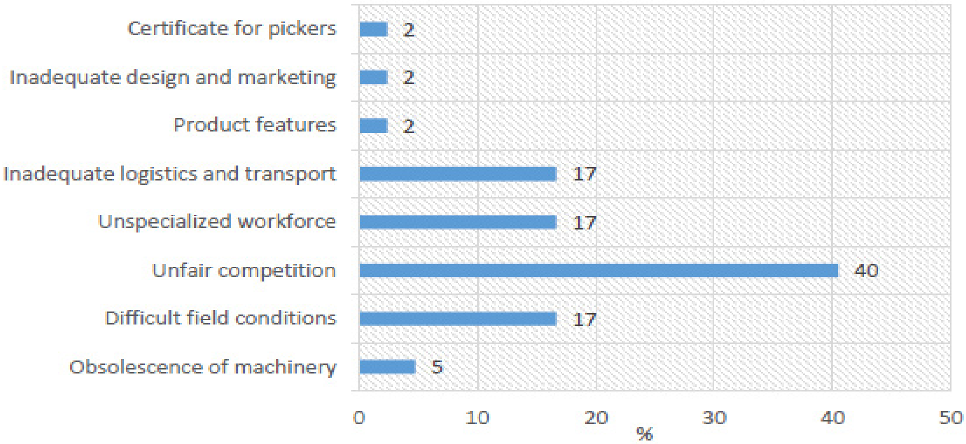
Diagram 3. *Representation of certain standards in the analyzed companies*



Source: *Survey*

Representation of ISO 9001 and HCCP standards is at approximately the same level, 38% and 37%, respectively. In addition, the share of the Organic food standard is 13%, while Healthy food and Kosher were implemented by 6% of the analyzed companies (Diagram 3).

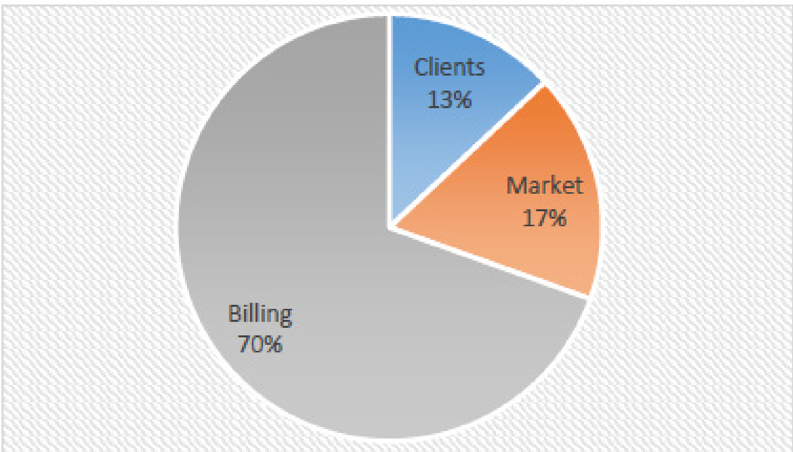
Diagram 4. *Problems in the business of the company*



Source: *Survey*

Unfair competition was recognized by almost 40% of analyzed companies. Inadequate logistics and transport, the problem with insufficiently qualified labor, and difficult field conditions were emphasized by 16.3% of respondents (Diagram 4).

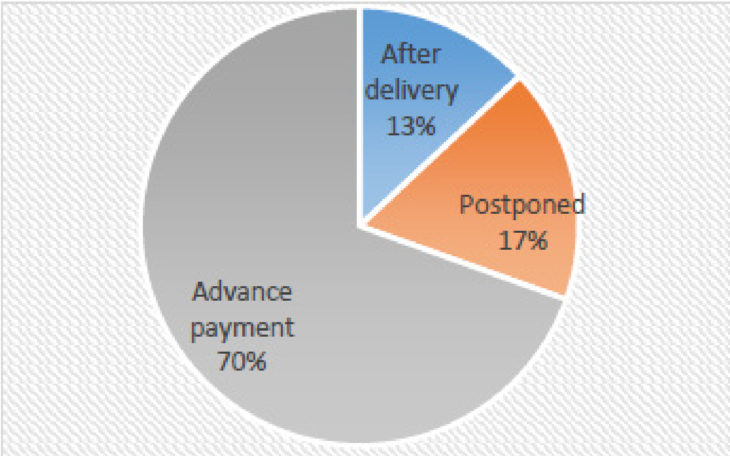
Diagram 5. *Immediate problems on the market*



Source: *Survey*

A total of 70% of the respondents in the analyzed enterprises of the Southeastern forest area pointed out payment as the primary problem they have in business, while the problems related to the underdeveloped market and the number of clients were recognized by 17% and 13% of the respondents (Diagram 5).

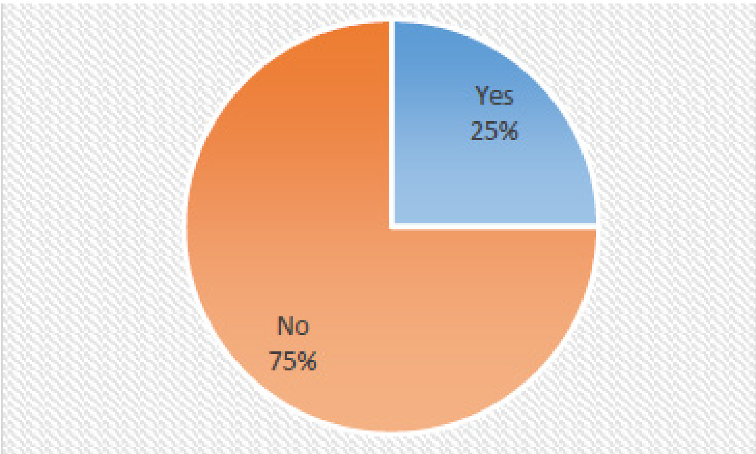
Diagram 6. *Forms of billing at the analyzed companies*



Source: *Survey*

The most common form of payment in the analyzed companies is advance payment (70%), while the forms of payment "postponed" and "upon delivery" are less common (Diagram 6).

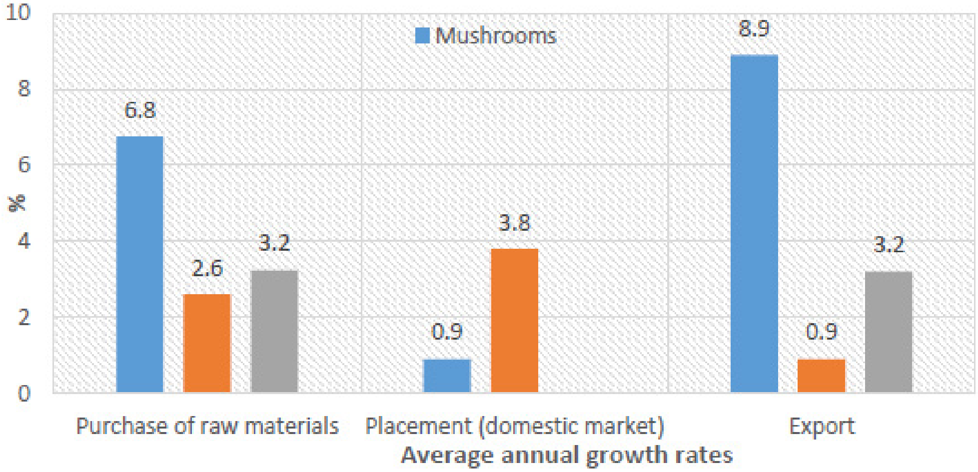
Diagram 7. *State support in the work of the analyzed companies*



Source: *Survey*

Of the analyzed companies, 25% used subsidies from the state to start business activities and purchase equipment (Diagram 7).

Diagram 8. *Average annual growth rates of purchase of raw materials, placement on the domestic market, and export of NWFPs*



Source: *Survey*

The average annual growth rate of the purchase of mushrooms was 6.8%, and the placement on the domestic market was 0.9%. A significant growth was achieved in the export of this category of NWFPs, by 8.9%. On the other hand, the purchase of forest fruits grew by 2.6%, and exports by 0.9%. Companies that deal with medicinal plants are mainly oriented towards the international market. For this reason, there was no placement on the domestic market. The growth rate for medicinal plants was 3.2%, both in the purchase of raw materials and in the export of final products (Diagram 8).

The length of the distribution channel is determined based on the perishability of the products. In the case of placing semi-finished products on the domestic market, such as forest fruits and mushrooms, distribution is usually done through retail outlets, restaurants, markets, health food stores, and the like. For products with a higher degree of processing, the placement is mainly carried out through intermediaries. These include trade chains, wholesalers, retail outlets, and pharmacies (Marčeta et al., 2024).

Table 2. *Export markets according to NWFPs categories*

TYPE OF NWFPs	EXPORT MARKETS
Mushrooms	• Hungary, Slovenia, Germany, Italy, Bulgaria, Austria, Poland
Forest fruit	• Germany, France, Belgium
Medicinal herbs	• Switzerland, Italy, Germany, Spain

Source: *Marčeta* et al.,2024

Based on the collected data from the analyzed companies, it was determined that the most important export markets for mushrooms are: Hungary, Slovenia, Germany, Italy, Bulgaria, Austria, and Poland. Forest fruits are mainly exported to Germany, France and Belgium, while medicinal herbs, in addition to Italy and Germany, are also sold on the markets of Switzerland and Spain (Table 2).

The opening of domestic companies to foreign markets, along with the expansion of demand for products of organic origin, created an opportunity to intensify exported quantities in all product categories.

Conclusion

- the most represented products in the assortment of the analyzed companies are wild blueberry, with a share of 23.1% and boletus with 19.2%;

- participation in fairs, as well as promotion in the form of printed materials (leaflets, posters, flyers, brochures, etc.) was emphasized by 26% of respondents;

- ISO 9001 and HACCP standards are represented at approximately the same level, 38% and 37% respectively;

- in business operations, almost 40% of respondents pointed out unfair competition as a problem, and billing was recognized as a market problem by 70% of analyzed companies;

- the most common form of payment in the analyzed companies is advance payment (70%), while the forms of payment “postponed” and “upon delivery” are less common;

- 25% of companies used subsidies from the state to start business activities and purchase equipment;

- the average annual growth rate of the purchase of mushrooms was 6.8%. Placement on the domestic market achieved a growth of 0.9%. Significant growth was achieved in the export of this category of NWFPs of 8.9%.
- purchase of forest fruit grew by 2.6%, and export by 0.9%;
- ompanies that mainly deal with medicinal plants in their business are exclusively oriented towards the international market. The growth rate for medicinal plants was 3.2%, both in the purchase of raw materials and in the export of final products.

Based on the research, it was recognized that the directions of action should be directed towards the improvement of the existing processing capacity, to increase the finalization of the product and create additional value. In addition, development potentials can be related to the introduction of new production lines and production diversification, which would contribute to greater competitiveness on the market. Adoption of product standards is key to entering the international market and meeting market demands.

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FUNCTION OF GENERAL ANXIETY, CORRELATION WITH NATURE AND PRO-ENVIRONMENTAL BEHAVIOR OF CITIZENS IN THE PREDICTION OF ANXIETY DUE TO CLIMATE CHANGES

Milivoje Ćosić[1] *Miroljub Ivanović*[2]

Abstract

The aim of this transversal research was to define the predictive contribution of: socio-demographic variables (gender, age, and financial status), perceived general anxiety, connection with nature and pro-environmental behaviors of citizens in predicting the proportion of variance of anxiety due to climate change. A total of 240 participants took part in the research (54% women and 46% men aged 18-62, with an average age (M = 43.88 years (SD = 2.86 years). Data were collected via the online method using five measuring instruments: Sociodemographic Data Questionnaire, Climate Change Anxiety Scale, Nature Relatedness Scale, Anxiety Scale and Proactive Environmental Behavior QuestionnaireHierarchical regression analysis revealed that the predictors of general anxiety and connection with nature explain 17% of the variance of the anxiety due to climate change criteria, where an increased level of general anxiety ($\beta = 0.41$, $p \leq 0.01$) and connection with nature ($\beta = 0.20$, $p \leq 0.01$) increases the level of anxiety of citizens due to climate change. The obtained values of standard Beta-coefficients in this study can significantly contribute to the planning of strategies to combat anxiety due to climate change. Methodological limitations, theoretical contributions and relevant implications of the results for future longitudinal studies for the assessment of the investigated relationships among the Serbian population were analyzed.

Key words: *Google forms platform, items, environmental knowledge, anxiety scale.*

Introduction

In the last two decades of the 21st century, due to increased global warming of the planet by 1.5° more than before the pre-industrial period, there has been an

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evident increase in researchers' interest in examining the relationship between climate change and the ecological crisis (Atadoga et al., 2024). The term *"climate change"* has various meanings in the literature, but it generally refers to changes in climate caused by direct or indirect human activity. The influence of the human factor significantly alters changes in the atmosphere over time, leads to damage to the ozone layer, and negatively affects the climate and all life on planet Earth (Eruaga, 2024). The consequences of global warming were not paid attention to until obvious negative changes in the lifestyle of modern society and its relationship with nature were observed. The burning of fossil fuels in industrial processes has the greatest impact on climate change, followed by the automotive industry, modern agricultural production, and deforestation (Okoro et al., 2024). Participants believe that climate change is a significant stress generator, and they are concerned about climate change. Climate change is manifested not only in the natural world, but also in the economic, political, cultural and health, e.g. through anxiety and fear of people (Wiedermann et al., 2023).

The modern lifestyle eliminates nature from everyday life so that people do not take into account their impact on the environment. The authors' study (Asgarizadeh et al., 2023) found that these unpleasant emotional and health conditions correlate with psychological stress, i.e. anxiety due to climate change. *Anxiety* is a psychologically unpleasant state characterized by physical symptoms and focus on future events, which prepares the individual for future events or takes precautionary measures against potential threats (Cenoz et al., 2024). Constant and acute exposure to the consequences of climate change puts an individual in a state of anxiety that disrupts their daily life and functioning, such as increased emotional, mental or somatic stress as a reaction to negative changes in the climate system.

Previous studies have shown that *socio-demographic variables* such as age, gender, and financial status are determinants of climate change anxiety (Eaton et al. 2023), emphasizing that women score higher on measures of pathological worry and a proactive ecological outlook on life. In addition, they are more likely than men to experience depression, anxiety, and impaired mental health.

The findings of the study (Naser et al., 2024) show that individuals with below-average *financia status* exhibit higher levels of anxiety about climate change. The explanation for this connection relates to the financial ability of individuals to provide themselves with better living conditions. Individuals who do not have the financial means to relocate to a region that is geographically not subject to extreme weather conditions and the impacts of climate change are mainly concerned about their safety. On the other hand, in a study where the sample consisted of households of different financial statuses, the findings showed that all households, regardless of their financial situation, are concerned about climate change (Younis et al., 2024). Participants who produced their own food, but it was not of good quality and varied, and therefore had to reduce the quantity of their meals, were classified as having a lower financial status. At the same time, the study (Harsono et al., 2024) concludes that not everyone is equally affected by the consequences of climate change, and the consequences are more evident among the population in countries with below-average financial status. Individuals with below-average financial status are more affected by the consequences of climate change due to underdeveloped infrastructure. In addition, extreme weather conditions can impair the mental health of people of lower financial status. In research on the relationship between climate anxiety and mental health, an interaction between general anxiety and anxiety due to climate change has been proven (Brophy et al., 2023). Individuals who exhibit general anxiety or have impaired mental health are more susceptible to the effects of stress due to climate change. The results of the study that individuals who scored higher on the connection to nature variable had higher levels of stress, depression, and anxiety, suggesting a direct correspondence with nature and climate anxiety. Additionally, people who identify with nature through emotional and cognitive interaction manifest greater concern for the environment and engage in more pro-environmental behaviors. Accordingly, the authors concluded that interaction with nature is correlated with higher levels of anxiety about climate change. Cohesion with nature has been shown to be a positive determinant of climate change anxiety (Raccanello et al., 2022).

The *aim* of this research is to examine the contribution of predictors: socio-demographic variables (gender, age and financial status), general anxiety, connection with nature and proactive ecological behavior) in predicting the variability of the criterion – anxiety due to climate change. In accordance with the research objective and the results of the criterion-predictor relationships of variables in previous studies, two *alternative hypotheses* were tested: H_1 – “It was hypothesized that general anxiety, connection to nature, and proactive environmental behaviors would be positive determinants, while younger age and below-average financial status would be negative determinants of climate change anxiety” and H_2 – “It is expected that increased self-perception of the level of predictor variables (general anxiety and connection to nature) will statistically significantly predict a relevant part of the variance of the criterion of citizens’ anxiety due to climate change.”

Method

Participants and research procedure

A total of (N = 240) participants from the territory of the Republic of Serbia participated in the research, namely: 54% female and 46% male. The age of the participants ranged from 18 to 62 years (M_{age} = 43.88 (SD_{age} = 2.86). The criterion for selecting citizens was the age above 18 years and that they use social networks.

The sample was pertinent, and after giving informed consent, the participants were asked to forward the online invitation with the measuring instruments to participate, via the platform (*Google forms*) and to other people from different districts of Serbia. The completed questionnaire and scales could not be correlated with the identity of the participants who filled them out, since instead of their names and e-mail addresses, they entered their passwords using the available characters.The research was completely anonymous and the participants could quit at any time without any consequences. Completing the scales and questionnaires took between 15 and 20 minutes. The research was conducted during December 2024.

Instruments

Sociodemographic Data Questionnaire on age, gender, and self-assessed financial status of the participants (below average, average, or above average financial status) was constructed for the purposes of this research.

Climate Change Anxiaty Acale

In order to measure the impaired psychological state of an individual as a result of climate change, the *Climate Change Anxiety Scale* (Clayton & Karazsia, 2020) was used. The measuring instrument consists of 13 items that assess the extent to which thinking about climate change makes it difficult for people to sleep (e.g., “Thinking about climate change makes it difficult for me to sleep”), socialize (e.g., “My concern about climate change makes it difficult for me to have fun with my family and friends”), regulate emotions, and concentrate on work or study (e.g., “Thinking about climate change makes it difficult for me to concentrate”). Participants were asked to rate their level of agreement with each item on a five point Likert-type scale (1 = *strongly disagree*; 5 = *strongly agree*). The total score is calculated as the arithmetic mean of responses to all items, with a higher score suggesting a higher level of anxiety about climate change. The reliability expressed by and in this study is (α = 0.89), indicating high internal consistency of the scale.

***Nature Relatedness Scale (NR-6*)**

To examine people's relatedness to nature, the short version of Nature Relatedness Scale (Nisbet et al., 2009) was used, which includes six items. The participants are asked to assess individual identification with nature, sense of interaction with nature, spirituality, mindfulness, and biased knowledge about the environment, e.g., „My relationship with nature is an important part of who i am". Participants assessed their agreement with each statement on a five-point Likert-type scale from 1 to 5 (1 = *never*, 5 = *almost always*). The total score on the scale is calculated as the arithmetic mean of all responses. A higher score indicates a greater relatedness of people with nature. The reliability of the scale in this research expressed through internal consistency is relatively high and amounts to (α = 0.85).

***Anxiety scale* (DASS-S)**

DASS-S (Lovibond and Lovibond, 1995) was used to measure the symptoms of anxiety. It consists of 14 statements that describe symptoms of physiological excitement and perceptions of panic and fear. Symptoms are distributed in the following four clusters: 1) autonomic excitement (e.g.: „I have problems with my heart (it beats fast or skips even when I am not physically active"), musculoskeletal experiences (e.g.: „My hands shake"), situational anxiety (e.g.: "I worry about situations in which I might panic or embarrass myself") and individual experience of anxiety (e.g.: „I feel like I am going to faint"). The participant is tasked with expressing the degree of agreement with the statement on a 3-point Likert-type scale (0 = *does not apply to me at all*; 3 = *applies to me completely*) by expressing how often during the past week he or she experienced the condition described in the statement. The total score on the scale is formed by adding the responses to the corresponding statements. A higher score indicates a greater degree of anxiety. The Cronbach's alpha coefficient on the examined sample is (α = 0.90), which indicates satisfactory reliability of the measuring instrument.

Proactive Environmental Behavior Questionnaire

To measure preventive environmental behaviors, the Proactive Environmental Behavior Questionnaire (Huang, 2016) was used, which contains 10 items. The statements indicate disruptive environmental behaviors that individuals can manifest at a personal level, e.g. recycling, composting, saving energy, reducing transportation use, buying local products. Participants assessed how often they exhibit the aforementioned behavior on a five-point Likert-type scale from (1 = *never*; 5 = *almost always*). The total score on the scale is calculated by adding up the responses to the corresponding items, where a higher score suggests more manifest proactive environmental behavior. The internal consistency coefficient for this questionnaire is $\alpha = 0.84$, which draws attention to its high representativeness.

Statistical analysis

When processing data and making statistical inferences, basic statistical descriptive parameters (arithmetic mean, standard deviation) and measures of distribution shape (skewness and kurtosis) were calculated for all research variables. To check the metric characteristics of the measuring instruments for reliability, Cronbach's coefficient was applied. Linear relationships between variables were estimated using the Pearson correlation coefficient, while hierarchical regression analysis was applied to define the relationships between the used variables. Statistical significance was tested at the significance level of $p \leq 0.01$ or $p \leq 0.05$. The results were processed using a software package (SPSS, version 26.0).

Descriptive statistics

Table 1 shows the basic descriptive parameters of measures of central tendency, variability, and coefficients of skewness and kurtosis of the distribution of measured variables.

Table 1: *Descriptive parameters and of normality of distributions for the examined distributions of variables (N = 240)*

Scales and questionnaire	*M*	*SD*	*Sk (SE)*	*Ku (SE)*
Anxiety due to climate change	1.40	0.72	0.53 (0.17)	0.79 (0.30)
Relatedness with nature	3.17	0.73	0.71 (0.13)	0.60 (0.30)
Proactive environmental behaviors	3.26	0.68	-0.42 (0.19)	0.89 (0.30)
General anxiety	0.85	0.54	-0.79 (0.16)	0.37 (0.30)

Legend. *M* = arithmetic mean; *SD* = standard deviation; *SK* = skewness *Ku* = kurtosis; *SE* = standard error. $p \leq 0.05$

In the total sample of participants, the maximum average score was obtained on the proactive environmental behavior scale, and the minimum score was obtained on the general anxiety scale. The normality of the distributions was treated using the criterion according to (Kline, 2023), whereby the obtained distribution values on the measuring instruments are considered statistically normal if the values range (for skewness ±3, and ±10 for kurtosis), which according to the aforementioned standards, at a statistical error level of 5%, indicates that all score distributions range within the range of conventionally acceptable values, and are therefore acceptable for further parametric analysis.

Correlation analysis

The linear relationship between the variables of age, gender, general anxiety, relatedness with nature, proactive environmental behavior, and anxiety due to climate change was examined using the Pearson correlation coefficient (Table 2).

Table 2. *Intercorrelation between the examined variables (N = 240)*

Variables	1	2	3	4	5	6
1. Age	–	-0.03	-0.01	0.05	0.13*	-0.01
2. Gender		–	0.28**	0.05	0.30**	0.02
3. General anxiety			–	0.17*	0.14*	0.42**
4. Relatedness with nature				–	0.53**	0.18*
5. Proactive environmental behaviors					–	0.14*
6. Anxiety due to climate change						–

*Annotation.** $p \leq 0.05$; ** $p \leq 0.01$

By looking into the values of the correlation coefficients, it is observed that their intensity ranges from weak to moderate. The maximum and positive statistically significant interaction is between the variables of the relatedness with nature scale and the variables of the proactive environmental behavior questionnaire. The general anxiety scale variable is positively and significantly bivariately in correlation to the variable of anxiety due to climate change. Of the remaining variables, relatedness with nature is positively and statistically significantly bivariately in correlation to the variable climate change anxiety, i.e., as relatedness with nature increases, so does climate change anxiety. In addition, the questionnaire variable proactive environmental behaviors positively and statistically significantly co-varies with the variables of the climate change anxiety scale, which suggests that individuals who manifest proactive environmental behaviors achieve higher scores on the climate change anxiety scale. In addition, with statistical significance set at the level of ($p \leq 0.01$), positive intercorrelations were established between the variables of the general anxiety scale, relatedness with nature, and proactive environmental behaviors and the variables of the climate change anxiety scale, which confirmed the tested alternative *hypothesis* H_1.

Predicting anxiety based on climate change

In order to examine the influence of predictor variables (general anxiety, relatedness with nature and proactive environmental behavior) on the variance of the criterion (anxiety due to climate change), a hierarchical regression analysis was conducted (Table 3).

Before applying this multivariate method, it was checked whether the conditions for its implementation were met. First, to check for multicollinearity, the variance inflation factor (VIF) and tolerance indices (TOL) were calculated. Based on the obtained tolerance values in the range of 0.194 - 0.876, and the variance increment factor (VIF test) in the interval of 1.107 - 4.521, it was concluded that there was no problem of multicollinearity among the analyzed predictors, and the reliability of the hierarchical regression analysis was not called into question (Miles, 2014).

Table 3: *Multiple linear regression model for predicting climate change anxiety (N = 240)*

Predictor variables	**Model I**	**Model II**	**Model III**
	β (SE)	β (SE)	β (SE)
General anxiety	0.41 (0.03)	0.02 (0.01)	0.03 (0.05)
Relatedness with nature	0.50** (0.02)	0.41** (0.03)	0.43** (0.01)
Proactive environmental behaviors	0.01 (0.02)	0.09 (0.01)	0.05 (0.003)
R	0.10	0.35	0.00
R^2	0.10	0.17	0.17

Legend. β = value of the standard Beta coefficient; SE = standard error of the estimate; ΔR^2 = changed coefficient of multiple determination, R^2 = coefficient of multiple correlation. $^{**}p \leq 0.01$, $^{**}p \leq 0.05$.

The general anxiety variable was introduced into the first model of the hierarchical regression analysis since it had the highest correlation with the criterion. The relatedness with nature variable was included in the second model, and the proactive ecological behavior variable was included in the third model. The value of the standard Beta-weight and the minimum standard error of estimate of the general anxiety variable in the first regression model accounts for 10% of the variability. The variable relatedness with nature in the second model additionally explains 3.5% of the variance, and in the third model the included variable of proactive environmental behavior does not statistically significantly affect the prediction of the variability of the dependent variable (anxiety due to climate change). The entire set of predictor variables of the regression equation, at the significance level of $p \leq 0.01$, with minimal standard errors of estimate accounts for 17% of the variance of anxiety due to climate change. In the 1st regression model of the analysis, the standard regression coefficient of the predictor *general anxiety* stood out as a positive and significant determinant ($\beta = 0.41$, $p \leq 0.01$), in the 2nd model, along with general anxiety, *relatedness with nature* stood out as a predictor ($\beta = 0.20$, $p \leq 0.01$), and in the 3rd and final model, general anxiety and relatedness with nature are still constant positive predictors of the criterion anxiety due to climate change. This suggests that increasing general anxiety and relatedness with nature increases anxiety due to climate change. Ultimately, based on these multiple parameters, the tested alternative hypothesis $H_{2.}$

Discussion

The aim of this research was to examine the influence of socio-demographic predictors (gender, height, financial status), general anxiety, relatedness with nature and pro-ecological behaviors in interpreting criteria climate change anxiety.

The study (Uysal et al., 2024) found that most people are more concerned about climate change than they were 10 years ago, and there is also a possibility that individuals who were previously depressed and anxious perceive climate change as a negative phenomenon, and therefore manifest symptoms of depression and anxiety. Climate anxiety is defined as unpleasant emotions associated with the environmental crisis, dominated by worry (Orazalin et al., 2024). The findings of this study draw attention to the fact that anxiety symptoms are less evident than worry, which has not yet reached a level that will interfere with people's functioning in everyday life. However, anxiety due to climate change in this study is more visible in participants who express general anxiety, relatedness with nature, and proactive environmental behaviors, which is in line with the first hypothesis tested.

Since this study found low levels of general anxiety, there was no correlation between gender and climate change anxiety. When examining financial status, previous research has had inconsistent results, suggesting that this connection should be further investigated. However, it is expected that people with above-average financial status are also more concerned about the negative consequences that climate change could generate due to their financial capabilities (Allen et al., 2021). In our sample, the majority of participants are of average financial status who do not emphasize the problem of climate change at a personal level, which is probably why no correlation was found between financial status and anxiety due to climate change.

In this study, in accordance with the hypothesis, a positive correlation was obtained between general anxiety and climate change anxiety, which shows that participants with higher general anxiety scores have higher scores on the climate change anxiety scale, which is in line with research (Gianfredi, et al., 2024). Relatedness with nature also interacts positively with climate change anxiety, which is in accordance with the findings of the study (Cianconi, et al., 2023). Definitely, the overall regression model explains a relatively minimal percentage of the variance, suggesting that the dependent variable is predicted by some other latent dimensions (e.g., personal experience of climate change consequences or exposure to climate change information), which were not examined.

The authors (Gunasiri et al., 2022) note that younger age is a determinant of climate change anxiety. The higher level of climate change stress in the younger population is explained by the fact that children are "bombarded" with information about climate change from pre-adolescence. This increases the likelihood that individuals who perceive natural disasters at a younger age will manifest climate change stress more prominently. The study also found that female gender is a predictor of climate change anxiety (Bratu et al., 2022). However, in this study, the predictor gender did not prove to be a determinant of climate change anxiety since the levels of both general anxiety and climate change anxiety constructs were low. The predictor *financial status* in our sample did not prove to be a predictor of climate change anxiety, identically to the study (Crandon et al., 2022).

In this study, the predictor *proactive environmental behavior* did not appear to be a determinant of climate change anxiety, which is contrary to the results of the study (Mouguiama-Daouda et al., 2022) where pro-environmental behaviors were manifested as a higher risk of perceiving climate anxiety. A likely explanation for why the variable proactive environmental behavior did not manifest itself as a determinant of climate change anxiety is that individuals who behave environmentally proactively experience surveillance and security related to the consequences of climate change, and therefore do not experience unpleasant emotions. In our sample, only general anxiety and relatedness with nature were found to be relevant determinants, with general anxiety predicting the highest percentage of variability in the dependent variable of climate change anxiety, i.e. participants with more manifested general anxiety also have more pronounced climate change anxiety. This finding is consistent with the results of a study which concluded that people with general anxiety are at greater risk of experiencing symptoms of climate change anxiety. The explanation is that current anxiety symptoms may correspond to the consequences of climate change, i.e. with concerns about climate change. The authors (Benoit, et al., 2022) emphasize that climate anxiety encompasses cognitive and emotional impairment that involves failure and repetitive thinking about climate change that represent symptoms of anxiety.

Relatedness with nature in this research is a positive predictor of anxiety due to climate change, as in the study (Galway et al., 2024). Individuals who identify with nature experience more symptoms of anxiety and stress. This means that people who interact with nature and often spend time in it, get stimuli from nature that can trigger climate anxiety because it warns them that nature is in danger. Finally, it should be borne in mind that climate change can also be a concern for the well-being of a person, and it is important to note that the emotional reaction to climate change is also conditioned by the social context that can generate pleasant or unpleasant emotions.

The obtained relations of the variables in the regression model should be analyzed by taking into account the *methodological limitations of this study*. The first limitation is the relatively minimal percentage of explained variance in climate change anxiety. This suggests that there are some other factors that influence climate change anxiety that are not included in this study, e.g. immediate direct exposure to information about climate change, immediate perception of the consequences of climate change and extreme weather conditions – floods, droughts and fires, which should be included in future studies to examine climate change anxiety. Also, a scale was applied that is oriented exclusively to anxiety symptoms, which is probably an insufficiently high-quality instrument for measuring the range of emotions correlated with climate change. Another limitation is the website, i.e. computer-assisted web interviewing, where the sample is limited to Internet users who want to respond to the survey, and among them there are fewer of lower social status and lower education who live in rural areas. In addition, bearing in mind the correlational and transversal character of the design used, the described results and offered interpretations represent only one of the possible, although logically and theoretically acceptable explanations of the direction and intensity of the connection between the examined predictors.

Conclusion

In this empirical study, the potential mediating roles of socio-demographic variables, general anxiety, relatedness with nature, and proactive ecological behavior in climate change anxiety were examined on a convenient online sample of citizens of the Republic of Serbia. The average age of the participants was 43.88 ± 2.86 years. The valid evidence collected in this cross-sectional study indicates satisfactory metric properties of the measuring instruments used, and the adequacy of their use among Serbian participants. A statistically significant positive correlation was found between the independent variables (general anxiety, relatedness with nature, and proactive ecological behavior) and the dependent variable (climate change anxiety). The findings of the hierarchical regression analysis, with a 17% proportion of variability, and minimal standard errors of the estimate, suggest their small dispersion from the regression line, and that only two mediators: perception of general anxiety and relatedness with nature are – significant positive determinants of the climate change anxiety criteria. However, the relatively large percentage of residual variance of climate change anxiety in the regression equation indicates that new mediator predictors should be included in future longitudinal studies on a larger and more age-heterogeneous sample. The lack of knowledge about the complex criterion-predictor relationships of the variables under investigation represents a relevant basis for the prediction of climate change anxiety criteria. Finally, the obtained correlation and multiple regression parameters have relevant practical implications because they indicate the need for public health guidelines, prevention and interventions that would address the climate change anxiety of the Serbian population.

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EXPLORING SUSTAINABLE TOURISM: ECOTOURISM, COMMUNITY ENGAGEMENT AND RURAL TOURISM

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Abstract

This paper addresses the critical issue of overtourism and its detrimental effects on global destinations and emphasizes the urgent need for sustainable tourism development as a viable solution. As the tourism sector has experienced significant growth in recent years, it also faces challenges related to mass tourism, which threatens the environmental and cultural integrity of popular destinations. By exploring sustainable tourism practices such as ecotourism, community-based tourism and rural tourism, this study aims to demonstrate how these approaches can mitigate the negative impacts of overtourism while increasing local economic benefits and preserving cultural heritage.

Key words: *sustainable forms of tourism, sustainable development, over-tourism, ecotourism, community-based tourism, rural tourism.*

Introduction

In recent years, tourism as an economic sector has made considerable progress worldwide. Tourism has enabled the economic development of many

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destinations that offer a variety of experiences to their visitors. However, this booming industry has a critical problem that threatens destinations that want to succeed in the tourism market: Overtourism. Overtourism, a term used to describe the massive influx of tourists to destinations, has caused worldwide concern (Vagena, 2021). The environment of destinations that attract visitors often bears the burden of their presence, leading to their degradation and the strain on natural and cultural resources.

The solution to the challenges of overtourism lies in the application of sustainable tourism development (Santos-Rojo et al., 2023). This is a holistic approach that aims to reconcile the economic benefits of tourism with the conservation of natural resources, cultural heritage and the well-being of local communities. Sustainable tourism seeks to mitigate the negative impacts of overtourism by promoting responsible practices when traveling and staying in destinations and managing destinations according to the economic, environmental and socio-cultural principles of sustainability (Bayuningsih et al., 2024). Tourism destinations are addressing the consequences of uncontrolled tourism development, making the pursuit of a harmonious balance between economic prosperity and environmental protection the main objective of tourism (Đorđević et al., 2024).

Sustainable tourism encompasses various approaches and practices that aim to minimize the negative impacts of tourism on the environment, culture and local communities while maximizing the benefits for all key stakeholders. Sustainable tourism not only benefits the present, but also ensures that future generations can continue to enjoy the beauty and cultural richness of tourist destinations. Ideally, tourism in all its forms should entail sustainable development, but certain types of tourism are recognized as inherently sustainable. It is believed that through various forms of sustainable tourism, tourists can contribute to environmental preservation of the environment, support local communities and enjoy authentic travel experiences (Kartika et al., 2024; Juganaru et al., 2008; Yanan et al., 2024). This paper will explore whether sustainable forms of tourism can lead to sustainable tourism development in destinations.

Sustainable tourism development

Rapid industrial development has led to the depletion of important resources and considerable damage to the natural environment (Vujović et al., 2012). In tourism, sustainable development is applied to conserve resources for future generations, contribute to the well-being of local communities and create long-term market benefits. It is an important solution for reducing the impacts of overtourism. Sustainable tourism development is an improved approach to tourism growth, and it is not a new type of tourism, nor does it apply only to certain parts of the tourism sector or certain tourism products. Rather, it is a specific development method that encompasses all components of the tourism system and involves all stakeholders in a destination. The basic principle of sustainable tourism development is to reconcile environmental, social and economic factors at all stages of tourism planning and decision-making (Emas, 2015). These three main factors of sustainable tourism development include the following (Kostić & Milićević, 2018; Maksin et al., 2009):

- Economic factor: sustainable tourism stimulates the local economy by supporting small businesses, local artisans, hotels and restaurants. Tourism can also create jobs and increase the income of the local community.
- Social factor: Sustainable tourism respects local cultures, traditions and customs. Tourism should contribute to improving the living conditions of local people, preserving cultural heritage and respecting human rights.
- Ecological factor: The preservation of the natural environment is a key element of sustainable tourism. This includes the protection of ecosystems, the preservation of biodiversity, the reduction of greenhouse gas emissions, waste management and the responsible use of resources such as water and energy.

To successfully coordinate these factors, it is necessary to organize effective destination management that works towards sustainable tourism development, including proactive planning, research to monitor and verify the results achieved, evaluation of tourism impacts and tracking of trends and changes in sustainable development (Holloway & Humphreys, 2012).

It is important for destination management to work with local communities, businesses and authorities to develop strategies that contribute to preserving natural and cultural heritage, reducing the negative environmental impacts of tourism and improving the living conditions of local people. Education and awareness-raising among tourists also play an important role, as tourists need to be informed about the importance of preserving the destination and encouraged to behave responsibly during their stay. The concept of sustainable tourism development should promote (Weaver, 2007):

- Improving the quality of life of locals and preserving the environment;
- The rational use of resources to minimize the negative impact of tourism on the environment;
- Equitable distribution of resources and benefits as a key element of sustainable tourism to ensure that the local population has access to the economic benefits of tourism;
- Sustainable tourism should ensure that future generations can enjoy the same resources as the present and that natural and cultural values are preserved for future generations;
- Sustainable development of a destination involves a balanced approach to development that takes into account economic, social and environmental factors in order to preserve the authenticity of the destination and enhance the tourist experience.

In this way, sustainable tourism development not only enables the economic prosperity of local communities by creating jobs and increasing income, but also protects natural resources and preserves biodiversity. At the same time, it promotes respect for different cultures and traditions and preserves the authenticity of destinations. The benefits that sustainable tourism development brings make it clear how important it is to find ways to implement such development.

Sustainable forms of tourism

When considering sustainable tourism development, it becomes clear that all forms of tourism should contribute to the overall sustainability of a destination. However, there are certain forms of tourism that develop in contrast to traditional mass tourism and overtourism and are often considered to be most in line with the principles of sustainable destination development. Sustainable forms of tourism primarily include ecotourism, community-based tourism and rural tourism (Juganaru et al., 2008).

Ecotourism is a form of tourism that focuses on protected natural areas and regions of great natural and cultural importance. Ecotourism develops in environments with ecological significance that are recognized as valuable by tourists.

The main goal of ecotourism and other sustainable forms of tourism, as Fennell (2008) points out, is to minimize negative environmental impacts, respect local culture, contribute to the economic benefits of destinations and provide enjoyment for tourists. This type of tourism plays an important role in tourism policy and in achieving the sustainable Development Goals. It encompasses the overall well-being of local communities, the protection of natural resources and the biodiversity of destinations (Das & Chatterjee, 2015). However, measuring the positive impacts of ecotourism can be challenging. Many of these benefits are often associated with ecotourism generating economic benefits that can later be used for environmental protection and conservation. In addition, ecotourism has an educational aspect, as it helps to raise the ecological awareness of visitors, which was highlighted in the study by Ramírez and Santana (2019).

Community-based tourism is a form of tourism in which local communities design and manage the tourism experience. This includes non-profit organizations, cooperatives and businesses owned by residents of the destination (The Global Community Tourism Network, 2022). Most importantly, this type of tourism ensures that the local community has full control over tourism development in their destination. Community-based tourism also involves residents as key decision-makers who set the boundaries of tourism development. In many cases, this form of tourism is about creating authentic experiences that showcase life in developing areas. One of the key features of this type of tourism is unique or unusual accommodation that contributes to the authenticity of the tourism offer (Revfine, 2022). Community-based tourism enriches tourists' experiences while promoting economic development and improving the quality of life in local communities.

Rural tourism is a form of tourism in which the tourist's experience is closely linked to nature, agriculture, rural lifestyle, local culture and traditions. Such rural tourism activities usually take place in rural areas characterized by low population density, agriculture and forestry, and traditional social structures and lifestyles (UNWTO, 2024). Rural areas are also characterized by a strong sense of community and authentic local culture, which contrast with urban environments. Life in rural areas moves at a slower pace and offers tourists the opportunity to experience a more temperate and relaxed way of life (Podovac & Jovanović Tončev, 2016). By attracting tourists to rural areas, this form of tourism also contributes to the protection and conservation of natural resources, which has a positive long-term impacts on the environment and biodiversity (Boz et al., 2017).

According to Illario et al. (2019), health tourism can also be considered a sustainable form of tourism. Spending time in a pleasant environment with clean air and intact nature can reduce stress, improve mood and increase general well-being. In addition, spending time in such a natural environment can have a healing effect on certain health conditions, improve quality of life and contribute to a sense of peace and tranquility. As the preservation of nature is a key element of health tourism, this type of tourism should also be directed towards sustainable tourism development.

Challenges in the implementation of sustainable tourism

When applying the principles of sustainable tourism, cooperation between key stakeholders is a major problem, with the socio-cultural impacts often being overlooked in comparison to the economic and environmental aspects of tourism. It is clear that if certain businesses in the tourism industry do not recognize that alignment with sustainable tourism principles is in their own interest, the efforts of other stakeholders will not be as effective. Furthermore, if sustainable tourism does not adequately meet the needs of tourists, they may choose to visit another destination that does not prioritize sustainability (Jovičić, 2014).

- The numerous challenges in implementing sustainable tourism can be summarized as follows:
- Economic priorities: In many cases, short-term financial interests and immediate economic needs take precedence over long-term sustainable practices. The focus on quick economic gains can hinder the implementation of long-term sustainable tourism strategies.
- Lack of control: Inadequate regulation and control can lead to overexploitation of natural resources and environmental degradation. Lack of regulations often contributes to irresponsible behavior by tourism operators.
- Lack of training/resources: Inadequate training and resources for local communities, entrepreneurs and tourism staff can limit the ability to implement sustainable practices. Education on the importance of preserving the natural environment is crucial for successful sustainable tourism.

- Insufficient government interest: If the government does not have sufficient interest in supporting sustainable tourism, there is a lack of political will and backing, which is critical to the implementation of sustainable policies and initiatives.
- Insufficient stakeholder involvement: Sustainable tourism requires the cooperation of all stakeholders in the tourism industry, including local communities, entrepreneurs, the government and non-governmental organizations. A lack of coordination and cooperation between these groups can limit the effectiveness of sustainable practices.
- Lack of understanding of Sustainable development: A lack of understanding of the importance and long-term benefits of sustainable development can reduce the support of local communities and entrepreneurs for the implementation of sustainable practices.
- Inability of certain destinations to develop Sustainable forms of tourism: The natural and cultural characteristics of some destinations may limit their ability to develop sustainable forms of tourism (e.g. ecotourism, rural tourism, community-based tourism). For example, fragile ecosystems or destinations with limited resources may face difficulties in implementing sustainable practices.
- Inequality in resources, infrastructure and overbuilding: Unequal resources and infrastructure across destinations can lead to unequal opportunities in the application of sustainable tourism development principles. This disparity can lead to an imbalance between destinations and hinder the implementation of coherent sustainable practices in a region or country.

Effective management, coordination between stakeholders and education on the long-term benefits of sustainability are essential to overcome these challenges and ensure that tourism contributes to both economic prosperity and environmental preservation of the environment and culture.

Conclusion

Given tourism growing concern about the negative impacts of overtourism on the natural and social environment, sustainable tourism is an important strategy for destination management. This approach is not just a business model, but embodies a philosophy that promotes responsible travel, supports local communities and preserves natural and cultural values for future generations. Sustainable tourism has the potential to create a harmonious balance between economic prosperity and environmental protection. It not only provides economic benefits for destinations, but also protects cultural heritage, biodiversity and natural resources for future generations.

Sustainable forms of tourism, such as ecotourism, community-based tourism and rural tourism, play a key role in achieving sustainable tourism development. These forms of tourism focus on conserving natural resources, supporting local communities and promoting cultural authenticity, creating lasting value for destinations. They offer a sustainable path to tourism development that is not only profitable today, but also viable in the long term. Their implementation requires careful resource management and extensive support, but it is possible to achieve sustainable tourism development with these approaches. Investing in sustainable forms of tourism is not just an investment in tourism, but an investment in the future, ensuring that destinations are preserved and remain attractive for generations to come.

However, the realization of sustainable tourism is a path that is associated with many challenges. Economic prioritization, lack of training and resources and insufficient government support are obstacles that need to be overcome. Different destinations have different resources and infrastructure capacities, which further complicates the implementation of sustainable practices. If a destination is aiming for sustainable tourism, developing sustainable forms of tourism would be a logical choice; however, in theory, only a small number of forms of tourism can be classified as exclusively sustainable. Since not all destinations have the same opportunities to develop ecotourism, rural tourism, health tourism or community-based tourism, they must integrate sustainable principles into other types of tourism they develop.

Considering that certain types of tourism are not usually associated with sustainable tourism, it is important to examine which characteristics of these types should be improved to contribute to sustainable tourism. By clearly articulating the application of sustainable principles at the level of each type of tourism, destination management can facilitate the process of sustainable tourism development.

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TOURISM, AN ESSENTIAL COMPONENT IN REVITALIZING THE ECONOMY OF THE RURAL AREA IN CARAȘ-SEVERIN COUNTY

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Abstract

From the comparative data (before the pandemic, 2017-2018-2019) of the South-East European studied countries (Romania, Bulgaria, Croatia, Slovenia and Serbia), it follows that the general tourist activity (qualitative and quantitative) of Romania is much below the level of competing neighboring countries, as well as below the natural potential offered by our country. Although all three EU member countries have a much smaller area and population, and GDP per inhabitant below the level of Romania (except Slovenia), they have double (Bulgaria and Serbia) or 3.5 times higher (Slovenia) tourist intensity, or 6.4 times more intense (Croatia). Even Serbia, a non-EU country, left without access to the sea (respectively coastline) after the dissolution of

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Yugoslavia, has indicators of tourist activity far above the level of Romania. Following the studies carried out, it was found that the forms of tourism practicable in the mountainous area of Caraș-Severin County, which can determine its economic development, are: mountain tourism, spa tourism, cultural tourism and agrotourism.

Key words: *tourism, rural area, rural economy, rural development.*

Introduction

The evolution of the tourism industry affects directly all sectors of the economy, generating fluctuations in both the employment rate and the national income, as well as all other economic and financial indicators. Currently, tourism is considered the main essential component from the economic and social point of view of contemporary society, which develops continuously under the influence of different factors, such as: the continuous desire to relax, the increase in time allocated to vacations, the demographic evolution, the development of means transport, etc. An area, such as the case of Caraș-Severin county, with an extraordinary natural tourist potential, has the chance of real tourism development only under the conditions of a strong economy and an infrastructure that facilitates and supports the tourism activity.

In turn, tourism, as an economic activity generating jobs and new added value, must contribute, through feed-back, to the general economic development of the county.

Methodology

In order to achieve the objectives proposed in this paper, we initially conducted the study and analysis of some bibliographic sources, taking into account the data related to the researched topic in order to deepen the proposed analysis. We resorted to the objective analysis of problems, opportunities and the tourism context in the area delimited for research. In this sense, we analyzed the economic-social situation of Caraș-Severin county, in a national and regional context, and the data obtained were compared with those of the South-Eastern European countries Romania, Bulgaria, Croatia, Slovenia and Serbia.

As a result of the analysis undertaken, the authors of the study proposed some solutions that can contribute to the revitalization of tourism in Caraș-Severin County.

Results and discussions

The economic and social development of a county, inclusively from a tourism point of view, is strictly linked to the general economic development and evolution of Romania, in a national and regional or international context. In order to position as correctly as possible, the contribution of tourism to the development of Caraș-Severin county, we briefly present the general economic state, including tourism, of Romania, by comparison with several neighboring countries and, at the same time, competitors from a tourist point of view: Bulgaria, Croatia, Slovenia and Serbia.

In a regional context, Romania, from the point of view of general economic development (GDP/capita, all economic data from national and European statistical sources are before the 2020-2021 Covid crisis), is in second place, after Slovenia, at equality with Croatia (entered the EU more than ten years after Romania) and above the development level of Bulgaria and Serbia (located outside the EU). (Tables 1, 2.)

Table 1. *National gross domestic product, millions of euros*

Countries	2017	2018	2019
Romania	***187772,7***	***204496,9***	***223162,5***
Bulgaria	52531,3	56224,7	61558,0
Croatia	49888,8	52688,8	55571,4
Slovenia	43011,3	45876,3	48533,1
Serbia	39235,3	42892,2	46005,4

Source: *Eurostat, INS*

Figure 1. *National gross domestic product, millions of euros*

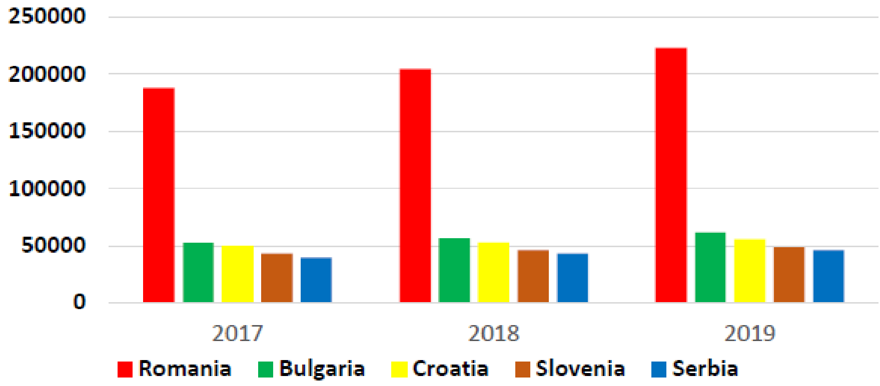
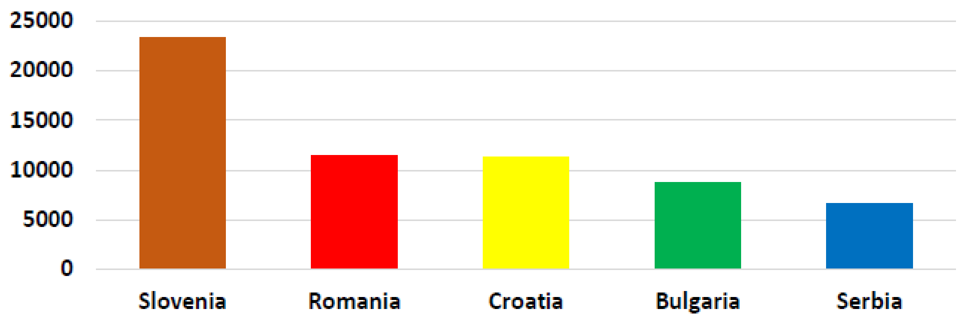


Table 2. *Gross domestic product, euro/capita*

Countries	2017	2018	2019
Romania	***9559***	***10469***	***11495***
Bulgaria	7397	7975	8794
Croatia	9445	10448	11286
Slovenia	**20820**	**22196**	**23323**
Serbia	5573	6126	6606

Source: *Eurostat, INS*

Figure 2. *Gross domestic product, euro/capita*



The tourism activity at the national level of the five countries is presented, for the beginning, by the indicators: a) total annual tourist arrivals, b) of which from abroad, c) the share of international arrivals in total arrivals and d) the share of tourism receipts in GDP.

Table 3. *The total annual number of tourist arrivals, number*

Countries	2017	2018	2019
Romania	***12056173***	***12815999***	***13277449***
Bulgaria	7461646	7799680	8187634
Croatia	**17409937**	**18648937**	**19553495**
Slovenia	4891986	-	6221841
Serbia	2101866	2409267	2723564

Source: *Eurostat, INS*

Figure 3. *The total annual number of tourist arrivals, number*

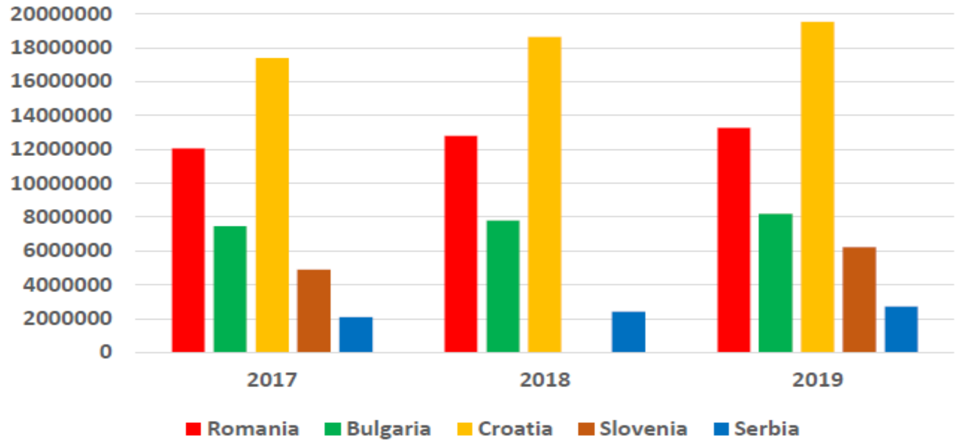


Table 4. *Annual total number of tourist arrivals from abroad, number*

Countries	2017	2018	2019
Romania	***2749258***	***2786468***	***2672887***
Bulgaria	3655830	3910159	4067350
Croatia	**15581704**	**16635013**	**17348056**
Slovenia	3543009	-	4694812
Serbia	976221	1127284	1277956

Source: *Eurostat, INS*

Figure 4. *Total annual number of tourist arrivals from abroad, number*

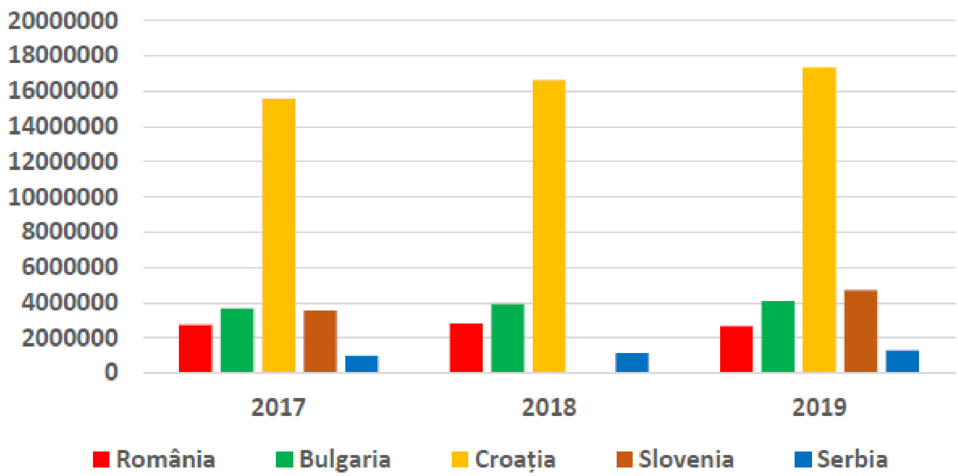
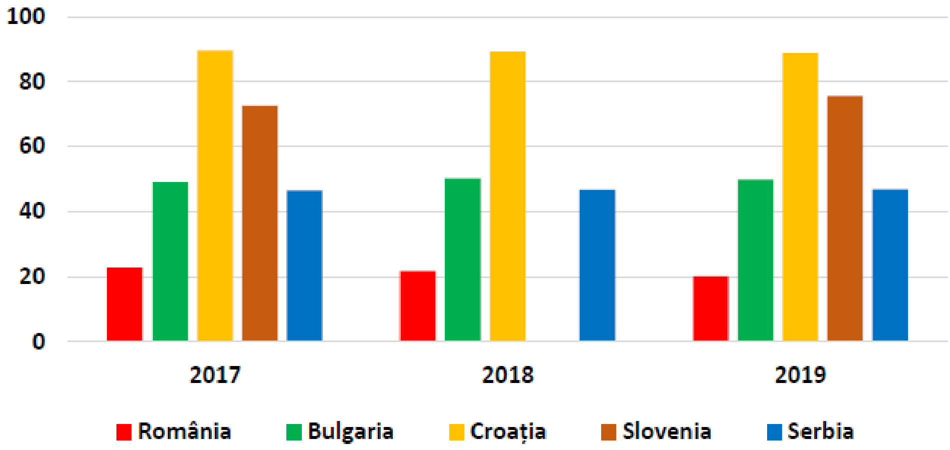


Table 5. *Share of tourist arrivals from abroad in total tourist arrivals, %*

Countries	2017	2018	2019
Romania	***22,8***	***21,7***	***20,1***
Bulgaria	49,0	50,1	49,7
Croatia	**89,5**	**89,2**	**88,7**
Slovenia	72,4	-	75,5
Serbia	46,4	46,8	46,9

Source: *own calculations according to Eurostat, INS, %*

Figure 5. *Share of tourist arrivals from abroad in total tourist arrivals, %*



In order to determine the intensity of tourism in each of the studied countries (including Caraș-Severin county), we calculated the indicators: a) the number of incoming tourists per 100 inhabitants and b) of which from abroad.

Table 6. *Number of tourists per 100 inhabitants*

Countries	2017	2018	2019
Romania	***62***	***66***	***67***
Bulgaria	126	127	131
Croatia	**425**	**455**	**477**
Slovenia	235	283	296
Serbia	123	127	128
Caraș-Severin	***116***	***118***	***126***

Source: *own calculations according to Eurostat, INS*

Figure 6. *Number of tourists per 100 inhabitants*

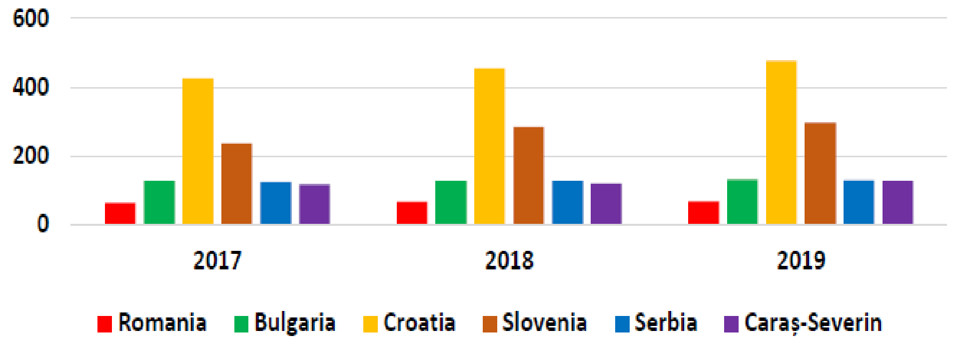
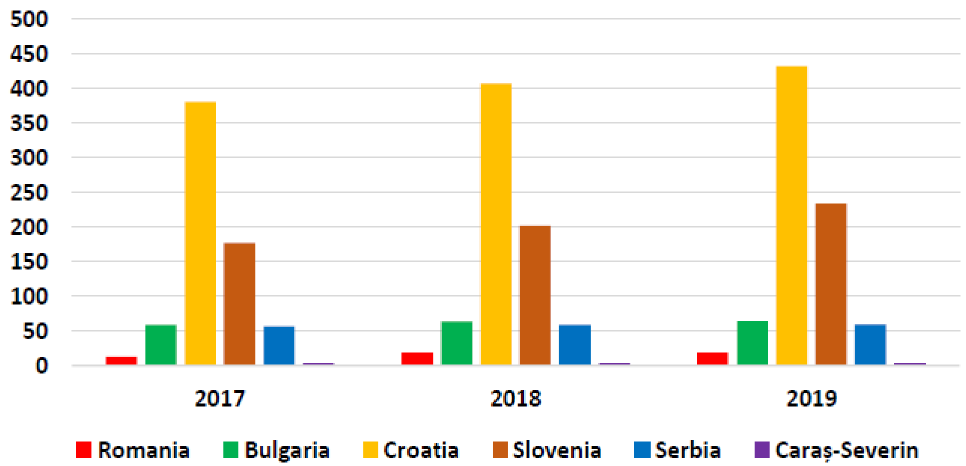


Table 7. *Number of tourists from abroad per 100 inhabitants*

Countries	2017	2018	2019
Romania	***13***	***19***	***19***
Bulgaria	59	64	65
Croatia	**381**	**408**	**433**
Slovenia	177	202	234
Serbia	57	59	60
Caraș-Severin	***4***	***4***	***4***

Source: *own calculations according to Eurostat, INS*

Figure 7. *Number of foreign tourists per 100 inhabitants*



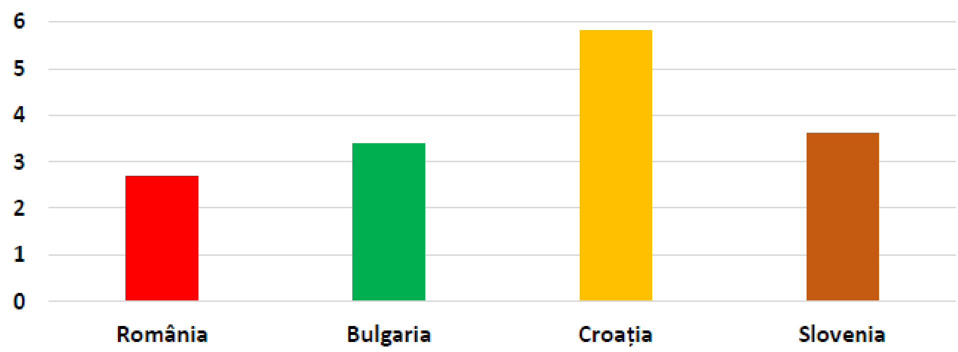
From the data provided by Eurostat, INS and from our own calculations, resulting from the indicators the number of overnight stays and the standard price of a tourist night, we present in table 8 and figure 8, the contribution of tourism to GDP (receipts from tourism).

Table 8. *Share of tourism in GDP (%)*

Countries	
Romania	***2,7*; 1,9****
Bulgaria	3,4***
Croatia	**5,8*****
Slovenia	3,6***

Source: ** INS; ** own calculations; *** Eurostat*

Figure 8. *Share of tourism in GDP (%)*



Conclusions

As can be seen from the national tourism intensity data (table 6.), Romania is far below the level of Croatia and Slovenia and even halfway between Bulgaria and Serbia. On the other hand, Caraș-Severin county, in terms of the total annual number of tourists entering the county per 100 inhabitants, has a higher intensity, even double compared to the national average of Romania, which expresses a higher tourist activity and county potential, compared with the average level of the country.

As a result of the studies carried out, the authors of the paper found that the most important forms of tourism that can be practiced in the mountainous area of Caraș-Severin County and that can determine its economic development are: mountain tourism, spa tourism, cultural tourism and agro-tourism.

In our opinion, knowing the forms and activities of tourism practiced in the mountain Banat, we appreciate that the most neglected of these by the authorities and investors, although extremely appreciated and sought after by tourists, is precisely the most appropriate form of tourism for rural communities, rural tourism and agritourism.

The research carried out in the field also highlights negative aspects of tourism in Caraș-Severin county, in general, and of local rural tourism, represented by the abandonment and loss of traditional culinary products, as well as local gastronomic points, which we did not encounter in county as a result of the research undertaken.

We also draw attention to the need for urgent intervention by the Romanian state at the Herculaneum Baths resort, because the rehabilitation and reconstruction of the Herculaneum Baths, at least in terms of their most important part, the old thermal establishments, historic architectural monuments, unique in Romania and Europe, cannot be fulfilled only through good intentions and voluntary activity. The Herculaneum Baths, at least for the historical part under dispute, in order to "restore" must be expropriated for cases of public utility, by law, by the Romanian Parliament and then subject to a vast investment program, national and European budget.

In conclusion, the forms and tourist areas of the Banat mountain offer an extremely wide range of tourist activities that the tourist can apply in the Caraș-Severin county, which are, in a word, of a completely exceptional potential. The essential problem of tourism in this area is, however, the valuing of this huge potential, which currently, we appreciate, is still too little used, as this research highlights.

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DIFFERENCES IN THE LEVEL OF PIG SUBSIDIES BETWEEN ROMANIA AND EU COUNTRIES

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Abstract

The proposed study explores the level of subsidies for pig farming is significantly lower in Romania compared to EU countries. This discrepancy creates a competitive disadvantage for Romanian producers, leading to higher production costs and less competitive prices for Romanian pork. Romanian producers struggle to access domestic and foreign markets because of higher prices. Decreased competitiveness could lead to a decrease in pork production in Romania, with an impact on the rural economy. Reduced domestic production could lead to greater dependence on pork imports, affecting Romania's food security. Research into the disparity of subsidies for pig farming is crucial for understanding the challenges faced by the Romanian sector and identifying effective support solutions. The implementation of strategies based on the research results will contribute to strengthening the competitiveness of the sector, boosting the rural economy and ensuring Romania's food security.

Key words: *Subsidies, pig farming, competitiveness, subsidy gap, impact.*

Introduction

Pig farming is an important branch of Romanian agriculture with a significant contribution to the rural economy. The sector faces a number of challenges, including competition from EU countries, high production costs and labor shortages. One of the factors affecting the competitiveness of the Romanian pork sector is the significant difference in subsidies between Romania and EU countries. Subsidies can play an important role in supporting pork producers by reducing production costs and making them more competitive on the market

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The aim of this research is to analyze the difference in the level of subsidies for pig farming between Romania and the EU countries and to assess its impact on the Romanian pig sector. The objective of the research is to identify and compare the level of subsidies for pig farming in Romania and EU countries. To analyze the impact of the difference in subsidies on the competitiveness of the Romanian pig sector. To identify solutions to reduce the subsidy gap and support the Romanian pig sector.

Official documents, reports and academic studies on pig subsidies in Romania and EU countries will be analyzed. Statistical data on pig meat production, production costs, prices and foreign trade in Romania and EU countries will be collected. Interviews will be conducted with agricultural experts, such as farmers, representatives of authorities and other specialists. The research on the difference in subsidies for pig farming between Romania and EU countries is important to contribute to a better understanding of the challenges facing the Romanian pig sector and to identify solutions to support it. Methodological, Institutional and Legislative Aspects in the field of subsidies: subsidies are a form of financial support granted by a public authority to a private entity in order to stimulate certain economic or social activities considered to be in the public interest. The awarding of grants is governed by a complex legal framework, comprising both national and European legislation.

Although the term subsidy is usually closely associated with government, it can refer to any type of support, including NGOs and related grants. Measure 14 - Animal Welfare Payments: it aims to improve animal welfare on farms by providing financial support to farmers who adopt more animal-friendly farming practices. The measure targets farmers keeping pigs, cattle, sheep, goats, sheep, goats and poultry. Types of support: payments for meeting minimum welfare standards: farmers who meet the minimum welfare standards set by EU legislation receive annual payments per head of animal; and payments for the implementation of welfare improvement schemes: Farmers who implement animal welfare improvement schemes that go beyond the minimum standards receive additional annual payments per head of livestock.

Presentation of the pig farming sector

At Romanian level

The domestic pig (Sus scroafa domesticus) is a species of omnivorous mammal native to Eurasia. A descendant of the European wild boar, the pig was domesticated about 10,000 years ago, becoming one of the most important domestic species in the world.Scientific importance of pigs: The pig is an important model for biomedical research, having significant genetic similarity to humans. Their physiological, anatomical and biochemical systems are similar, making them a valuable tool for the study of human diseases, the development of new drugs and therapies, and for xenotransplantation. The pig is a central topic in agricultural research aimed at improving meat production, feed efficiency, animal welfare and reducing environmental impact.

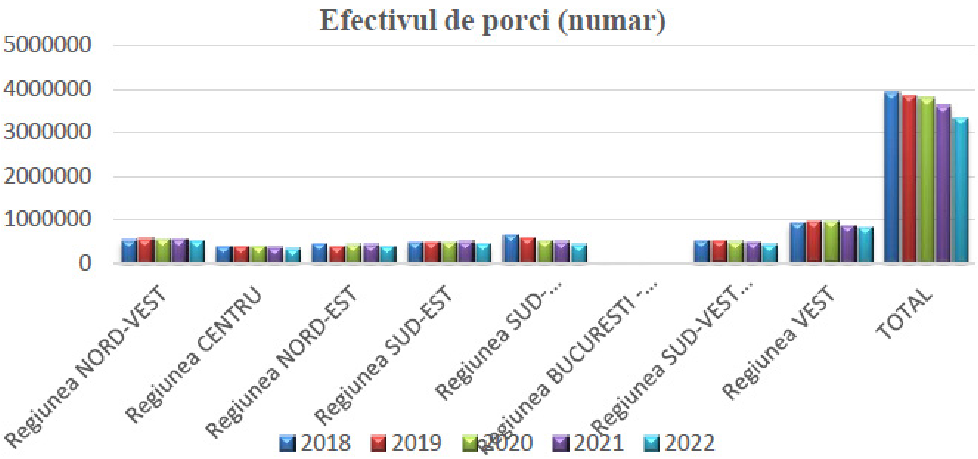
Evolutionary biology: Pigs provide important insights into the evolution of animal domestication, adaptability and genetic diversity.

Table 1. . Herds of pigs, total forms of ownership, regions of development at the end of the year

Categorii de animale	Forme de proprietate	Macroregiuni, regiuni de dezvoltare si judete	Anul 2018	Anul 2019	Anul 2020	Anul 2021	Anul 2022
			Numar	Numar	Numar	Numar	Numar
Porcine	Total	Regiunea NORD-VEST	526530	560871	547087	541799	507845
		Regiunea CENTRU	374759	372419	382534	357377	327550
		Regiunea NORD-EST	447482	381248	425284	428086	374602
		Regiunea SUD-EST	468624	482007	468669	483508	437676
		Regiunea SUD-MUNTENIA	649680	583808	515742	483125	429888
		Regiunea BUCURESTI - ILFOV	23610	10002	12144	5221	5026
		Regiunea SUD-VEST OLTENIA	519960	499081	483415	469426	430595
		Regiunea VEST	914638	944700	949632	851039	815552
TOTAL			3925283	3834136	3784507	3619581	3328734

Source: *U.M. Number*

Picture 1. *Pig herds, total ownership forms, development regions*



Source: *Own conceptualization, based on data from the TEMPO Online INSSE database*

According to Figure 1, the total number of pigs in Romania has shown a decreasing trend over the analyzed period. In 2018 there were 3,925,283 pigs, and in 2022 the number decreased to 3,328,734, representing an overall decreasing trend of about 15% The South-East region has consistently led in terms of pig numbers over the whole period. The number of pigs in this region ranged from 437,676 (in 2022) to 488,624 (in 2018).

The number of pigs in the Bucharest-Ilfov Region is significantly lower compared to the other regions. In 2022, there were only 5,026 pigs in the Bucharest-Ilfov Region. Data presented in the table refer strictly to pig herds and do not include information on other animals on farms in Romania.

Pig herds in Romania decreased steadily between 2018 and 2022. The South-East Region consistently had the highest herds, while the Bucharest-Ilfov Region showed the lowest values. For a more comprehensive analysis of the livestock sector in Romania, similar herd data and dynamics for other farm animal species would be needed.

At EU level

Pork is produced throughout the EU, with huge differences in the methods and sizes of farms in and across the EU. Between Member States, ranging from small, diversified farms with just one or two pigs to industrial factory farms with thousands of pigs, and from extensive organic farming to intensive organic, intensive intensive production and intensive conventional production.

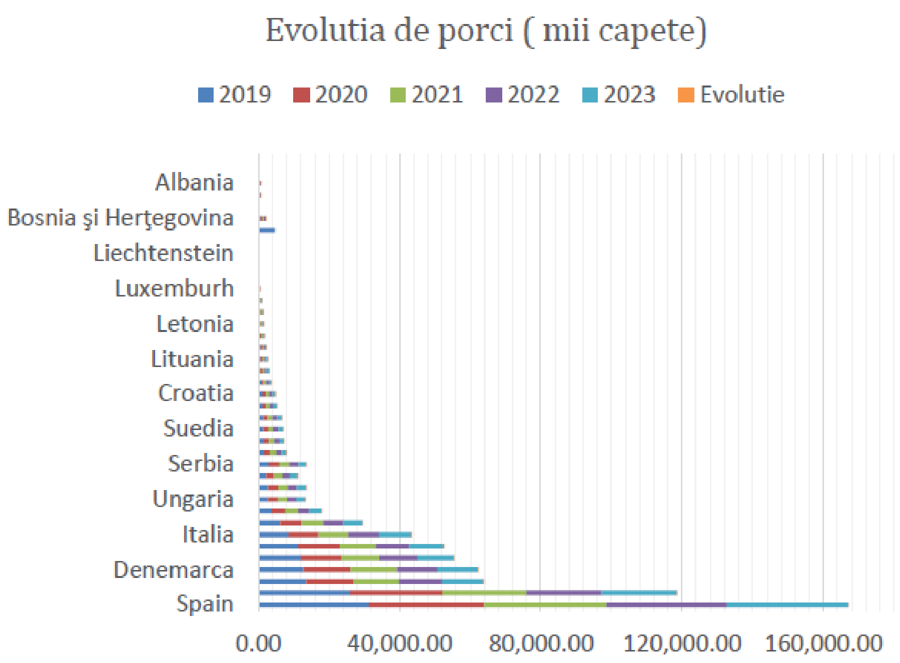
Table 2. *Herd of pigs, LU: THOUSAND HEADS*

Nr. Crt.	TARA	2019	2020	2021	2022	2023	Evolutie%
1	Spain	31.246,04	32.796,07	34.454,09	34.073,38	34.451,65	110,26
2	Germania	26.053,40	26.069,90	23.762,30	21.366,30	21.215,70	81,43
3	Franța	13.510,00	13.393,00	12.941,00	12.182,59	11.794,05	87,3
4	Denemarca	12.728,00	13.391,00	13.152,00	11.541,00	11.368,00	89,31
5	Olanda	11.921,00	11.541,00	10.872,00	10.706,00	10.471,00	87,84
6	Polonia	11.215,50	11.727,40	10.242,40	9.624,25	9.769,70	87,11
7	Italia	8.510,27	8.543,03	8.407,97	8.739,00	9.171,00	107,76
8	Belgia	6.085,10	6.218,27	6.042,15	5.751,18	5.404,14	88,81
9	Romania	3.834,10	3.784,50	3.619,60	3.328,70	3.200,10	83,46
10	Ungaria	2.634,00	2.850,00	2.725,90	2.558,10	2.607,70	99
11	Austria	2.773,23	2.806,46	2.785,59	2.650,15	2.516,46	90,74
12	Portugalia	2.255,87	2.251,97	2.221,02	2.183,32	2.174,82	96,41
13	Serbia	2.903,00	2.983,00	2.868,00	2.666,98	2.140,99	73,75
14	Irlanda	1.613,27	1.678,57	1.713,59	1.570,39	1.407,61	87,25
15	Cehia	1.508,91	1.546,02	1.493,44	1.328,82	1.362,28	90,28
16	Suedia	1.481,20	1.389,30	1.372,50	1.416,27	1.326,44	89,55
17	Elvetia	1.354,03	1.315,10	1.371,44	1.352,35	1.315,50	97,15
18	Finlanda	1.062,20	1.103,90	1.093,70	997,67	978,42	92,11
19	Croatia	1.022,00	1.033,00	972	945	847	82,88
20	Grecia	733	743	758,9	741,6	736,8	100,52
21	Bulgaria	491,81	592,1	694,66	601,7	726,94	147,81
22	Lituania	550,8	580,4	573,8	517,42	487,83	88,57
23	Slovacia	589,23	538,31	453,08	380,9	403,04	68,4
24	Cipru	351,76	359,06	360,59	330,87	309,76	88,06
25	Letonia	314,2	306,82	327,02	307,95	289,4	92,11
26	Estonia	301,6	316,6	308	269,38	272,23	90,26
27	Slovenia	240,14	229,48	215,71	202,15	196,14	81,68
28	Luxemburh	84,04	82,13	78,33	66,41	65,2	77,58
29	Malta	35,48	40,09	40,05	29,55	35,79	100,87
30	Islanda	35	0	0	24,3	0	69,43

Nr. Crt.	TARA	2019	2020	2021	2022	2023	Evolutie%
31	Liechtenstein	0	0	0	0	0	0
32	Norvegia	0	0	0	0	0	0
33	Regatul Unit	4.741,00	0	0	0	0	0
34	Bosnia şi Herţegovina	543	547	569,62	471,55	0	86,84
35	Muntenegru	23	25,81	24,33	24,51	0	106,57
36	Nord Macedonia	136	164	186	182	0	133,82
37	Albania	183,85	158,4	159,24	137,3	0	74,68
38	Turcia	0	0	0	1,65	0	1,65
39	Kosovo	40,53	45,39	47,38	45,42	0	112,07
TOTAL		153.105,56	151.150,08	146.907,40	139.316,11	137.045,69	3.243,32

Source: *Own conceptualization based on data from Eurostat website*

Figure 2. *Graphical representation of the pig herd in the period 2019-2023.*



Source: *Own conceptualization based on data from Eurostat website*

The total number of pigs decreased by 10.4% during the period under analysis, from 153,105.56 thousand head to 137,045.69 thousand head.

The leading decreasing countries: Spain, Germany and France show a reduction of more than 10%, Italy shows a significant increase of 10.76%. Steady downward trend in Romania, with an overall reduction of 16.54%.Dramatic decrease in Serbia: herd numbers fall by 73.75%, the largest decrease in the table.

Iceland and the United Kingdom have no pig herds in 2023. Turkey has a small herd of 1.65 thousand head in 2023. In Spain steady increase from 2019 to 2022, followed by a slight decrease in 2023. Germany has a steady downward trend since 2019. France shows a steady decrease from 2019 to present. Italy shows a slight decrease in 2019 and 2020, followed by a steady increase until 2023. Romania shows a steady fall every year. Hungary shows a slight decrease in 2019 and 2020, followed by a moderate increase until 2023. Serbia shows a steady decrease since 2019, with a dramatic decrease in 2023. A significant decrease in global pig herds can be observed between 2019-2023. Most of the countries listed have experienced a downward trend, with the exception of Italy. Romania ranks among the countries with the largest reduction in pig numbers, with a steady decrease. The specific reasons for the decline can be diverse and include economic factors, disease outbreaks, legislative changes, and many other factors that have led to the decrease in the pig herd.

Level of Pig Subsidies in Romania and EU Member States.

Subsidies in Romania

Table 3. *Sub-packages of welfare payments for pigs*

Nr. crt	Specify	Fat pigs	Sows	Scroafe
	UVM conversion factor according to Annex V of Regulation (EC) No 1974/2006	*0,3*	*0,3*	*0,5*
	Amount granted annually to cover additional costs and income foregone due to the application of animal welfare measures animal welfare measures	euro / UVM	euro / UVM	euro / UVM
1	Sub-package 1 - Increase by at least 10% the allocated space available per animal	41,40	165,00	23,30
2	Sub-Package 2 - Ensuring a minimum of 11 hours/day artificial light with an illuminance value of 50 lux	19,10	17,20	15,80

Nr. crt	Specify	Fat pigs	Sows	Scroafe
3	Sub-component 3 - Improved conditions for welfare of pigs during transport	4,80	4,80	5,40
4	Subpackage 4 - Correction of nitrite and nitrate levels in water	12,00	25,00	18,50
5	Sub-Package 5 - Reducing NOx by 30 of the mandatory minimum level by keeping microclimate parameters within optimal limits	16,80	48,00	22,90
6	Sub-component 6 - Improving rest area conditions	7,20	15,90	13,10
	TOTAL MEASURE 14 (euro / UVM / year)	101,10	275,90	99,00

***Source**: Own conceptualization based on data from Eurostat website*

Description of animal welfare packages

Sub-package 1 - increase by at least 10% the allocated space available for each animal. It consists of the following criteria, floor area available under superior welfare conditions, pigs with a live weight between 50-85 kg - 0.605 m2 , pigs with a live weight between 85-110 kg - 0.715 m2 , pigs with a live weight over 110 kg - 1.1 m2, sows and gilts kept in groups - 1.804 m2, respectively 2, 475 m2, these being indicator for the higher requirement, Indicator for the mandatory minimum requirement pigs with a live weight between 50-85 kg - 0,55 m2, pigs with a live weight between 85-110 kg - 0,65 m2, pigs with a live weight over 110 kg - 1m2, sows and sows kept in groups - 1,64 m2 and 2,25 m2 respectively.

Subpackage 2 - Provision of at least 11 hours/day of artificial light with an illuminance value of 50 lux/day. Indicator for superior requirement - Superior lighting conditions, these must be for a minimum of 11 hours/day of artificial lighting and illuminance of 50 lux (at least 1 bulb of 150W per 33 m2, in the hourly interval set by the commitment). Indicator for mandatory minimum requirement - Mandatory minimum lighting conditions, minimum 8 hours/day period of 40 lux lighting (at least 1 bulb of 100 W every 42 m2)

Sub-component 3 - Improvement of welfare conditions of pigs during transportation. Indicator for upper requirement - Density of pigs during transport must not exceed 165 kg/m2. Indicator for minimum requirement Mandatory - Density of pigs during transport must not exceed 235 kg/m2

Subpackage 4 - correction of nitrite and nitrate levels in water. Indicator for upper requirement, Nitrate - 50 (mg/l) and Nitrite - 0.5 (mg/l) [Nitrate / 50] +

[Nitrite /3] ≤ 1 Indicator for mandatory minimum requirement, Nitrate + Nitrite - 100 (mg/l) and Nitrite - 10 (mg/l).

Sub-package 5 - 30% reduction of nox emissions compared to the mandatory minimum level by keeping microclimate parameters within optimal limits. Indicator for the upper requirement, the level of nox levels in the shelter under superior welfare conditions in a range of max. 10.5 mg/m3 dust and max. 700 ppm CO2. Indicator for the Mandatory minimum requirement, the level of nox levels in the shelter under mandatory minimum conditions in a range of max. 15 mg/m3 dust and max. 1000 ppm CO2.

Subpackage 6 - Improvement of rest area conditions. Indicator for higher requirement, The resting area in improved welfare conditions shall be permanently dry through the use of suitable absorbent bedding materials. Indicator for the mandatory minimum requirement, The housing for pigs shall be constructed in such a way that the animals have access to a physically and thermally comfortable resting area that is adequately drained and cleaned and that allows all animals to rest at the same time. In press releases published on the APIA website, the authorized amounts for claims submitted for 2017 - 2020 APIA, for measure 14 - Animal Welfare Payments, were released.

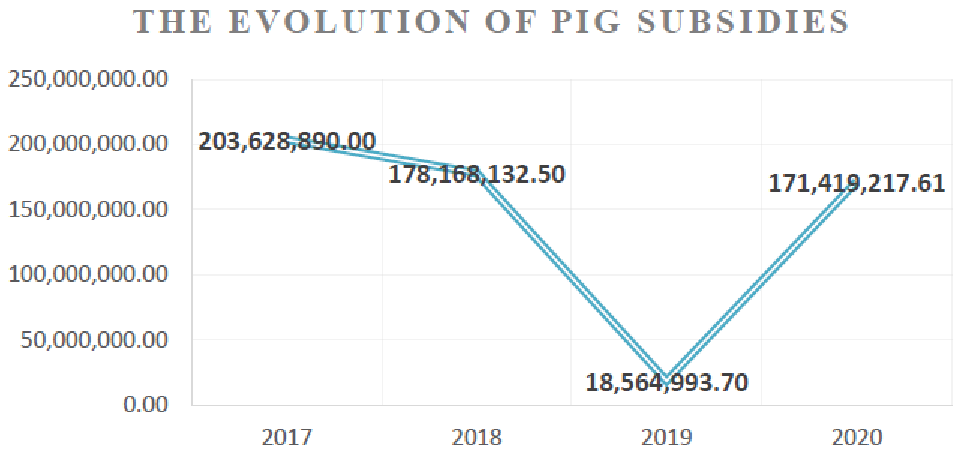
In this regard the payments for measure 14 for Package a - Pig Welfare Payments are presented as follows:

Table 4. *Amounts authorized on the basis of applications submitted for Package A*

	YEAR	BENEFICIARIES	AMOUNT IN EUR	SUM IN LEI
PACHET A	2017	131	43.700.000,00	203.628.890,00
	2018	124	38.245.815,71	178.168.132,5
	2019	24	3.980.914,27	18.564.993,70
	2020	214	35.839.267,71	171.419.217,61

Source: *Own conceptualization based on data from Eurostat website*

Figure 3. *Amounts authorized on the basis of applications submitted for package A*



Source: *Own conceptualization based on data provided on the APIA website*

According to figure number 3 and table number 4, in 2017 for a number of 131 beneficiaries for package A, subsidies amounting to 203.628.890,00 lei, equivalent in euro 43.700.000,00 were allocated. We can observe a slight decrease in 2018, this decrease is due to the fact that there were fewer beneficiaries, which resulted in a lower amount authorized on the basis of the applications. A significant decrease can very well be observed in 2019, this decrease being due to African swine fever in 2019. In year 2020, we have an increase from year 2019 by 923.35% and from year 2017 to year 2020 we have an insignificant decrease of 84.18%.

Total pig subsidies in Romania compared to EU member states

Government subsidies and support programs play a crucial role in supporting this sector, helping to cover the production costs and maintain the competitiveness of Romanian farmers on the European market.

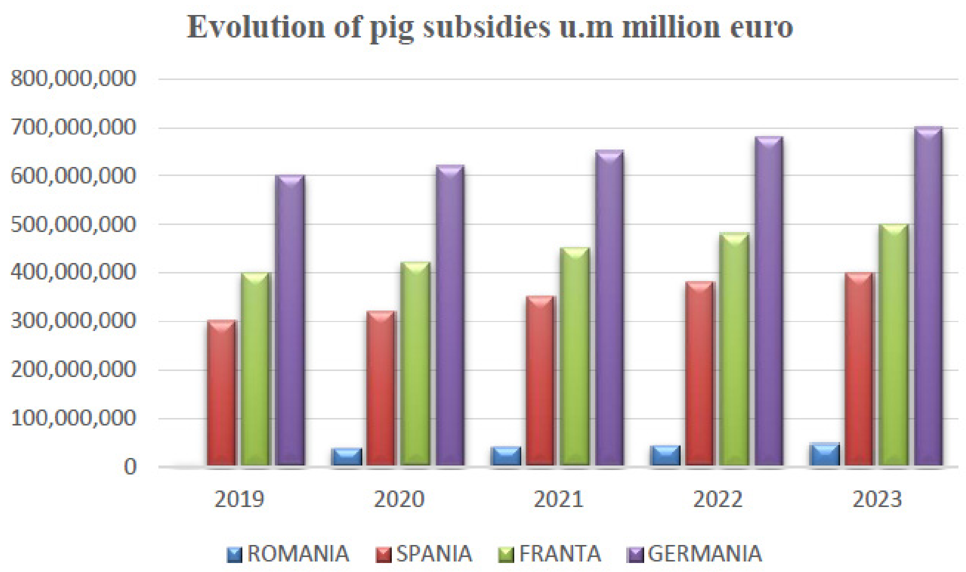
For this comparative study on the total subsidies granted to pigs in Romania and EU countries, data obtained from official sources were used. These were extracted from the database of the Agency for Payments and Intervention for Agriculture and the Gemini website, thus providing detailed and updated information on subsidies offered for pigs. The results are highlighted in the following table.

Table 5. *Total subsidies granted to pigs, m euro million*

Country	2019	2020	2021	2022	2023
ROMANIA	4.500.000	36.000.000	39.000.000	42.000.000	47.000.000
SPANISH	300.000.000	320.000.000	350.000.000	380.000.000	400.000.000
FRANCE	400.000.000	420.000.000	450.000.000	480.000.000	500.000.000
GERMANY	600.000.000	620.000.000	650.000.000	680.000.000	700.000.000

Source: *Own conceptualization*

Figure 4. *Evolution of subsidies granted to pigs*



Source: *Own conceptualization based on data from the APIA website and the Gemini website*

Looking at Figure 4, there is a general increase in subsidies granted to pigs in all four countries over the period analyzed. Romania had the lowest amount of subsidies granted to pigs in 2019, but showed an increase between 2019 and 2023, this increase is due to government support for the livestock sector, increased demand for pork and the development of the agricultural sector. Spain shows an increase throughout the analysis, this increase is explained by the economic crisis that has significantly affected the livestock sector and the government has implemented various support programs to help pig farmers. The increases in subsidies during the analysis are due to the competitiveness of the livestock sector, and pig farmers are constantly investing in modernizing their farms and increasing production efficiency. Germany had the highest amount of subsidies given to pigs throughout the period under analysis, as they have a long tradition in pig farming and on the other hand it is also the largest pork producer in Europe, these are due to the livestock sector constantly investing in modernization of farms and increasing production efficiency.

Examples Of Subsidies For Local Breeds Such As Mangalitza Pigs And Iberian Spanish Pigs

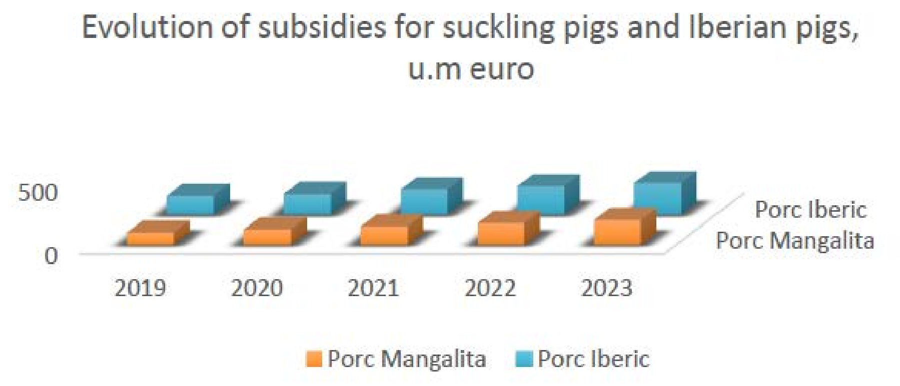
In order to carry out this comparative study on the subsidies granted to the Mangalitza and Iberian pig breeds in Romania and Spain, data obtained from official sources were used. These data were extracted from the database of the Agency for Payments and Intervention for Agriculture and the gemini chat website, thus providing detailed and updated information on the subsidies offered for the Mangalitza and Iberian pig breeds. MANGALITZA PIG: It is an indigenous breed of pig originating in Romania. The Mangalița is distinguished by its long and rich coat, which can vary from black to white. The meat is prized for its excellent taste and delicate texture and the fat is used for the production of lard and other traditional products. IBERIAN PIG : It is one of the best-known and most appreciated breeds of pig in Spain, famous for the production of jamon iberico, a particularly valuable culinary specialty. The Ibérico pig is reared mainly in the south-west region of Spain and is noted for its rich taste, distinctive marbling of the meat and intense flavor.

Table 6. *Subsidies granted for Mangalitza and Ibérico pig breeds. LU lei*

SPECIA	**2019**	**2020**	**2021**	**2022**	**2023**
Pig Mangalita	100	125	150	175	200
Pig Iberic	150	165	200	225	250

Source: *Own conceptualization*

Figure 5. *Evolution of subsidies for Mangalitza and Iberian pigs*



Source: *Own conceptualization based on data from the APIA and Agencia para el Desarrollo Rural websites*

Significant growth for both breeds, a total increase in subsidies of 49.4% for Mangalitza and 66.6% for Iberian between 2019-2023 is observed. Faster rate of growth for Mangalitza: Mangalitza subsidies increased at an average annual growth rate of 8.4% compared to 7.4% for Iberic. Steady upward trend: There has been a steady increase in subsidies for both breeds in each year over the period. Mangal Mangal pig: Moderate growth in 2019 and 2020, followed by an acceleration in 2021-2023. Iberian Pig: Steady growth each year, with a slight acceleration in 2022 and 2023. The subsidy amount exceeded 1 million lei in 2022 and reached 1,237.5 thousand lei in 2023. CAGR for 2019-2023: 7.4%. There is a significant increase in subsidies for Mangalitza and Iberian breeds of pigs in 2019-2023. This increase in subsidies can be due to various reasons, such as: stimulating the increase in the number of herds of these breeds, supporting pig farmers in the sector, promoting biodiversity and indigenous breeds, Mangalitza has benefited from a faster increase in subsidies, but Iberic has reached a higher level of subsidy value in 2023.

Comparison of subsidies per pig head between Romania and Germany

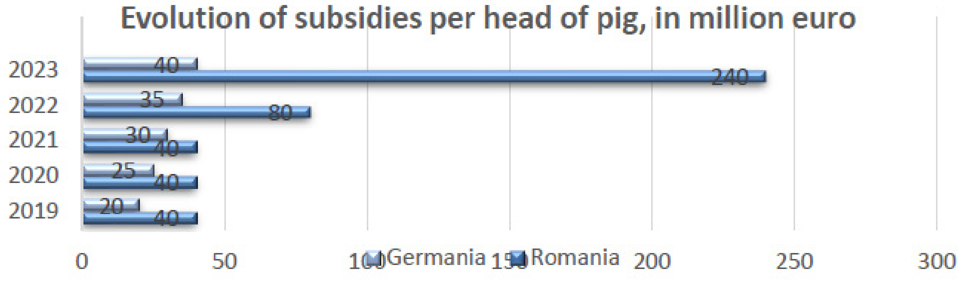
In order to carry out this comparative study on the subsidies granted to pig breeds, Mangalitza and Iberian in Romania and Spain , data obtained from official sources were used. These data were extracted from the database of the Agency for Payments and Intervention for Agriculture and from the database of the German Federal Office for Agriculture and Food (BLE), thus providing detailed and updated information on the subsidies offered per head of pig.The results are presented as follows.

Table 7. *Evolution of subsidies per head of pig between Romania and Germany. U.M. EURO*

TARA	**2019**	**2020**	**2021**	**2022**	**2023**
Romania	40	40	40	80	240
Germany	20	25	30	35	40

Source: Own conceptualization based on data provided on the APIA and Gemini websites

Figure 6. *Evolution of subsidies per head of pig*



Source: *Own conceptualization based on data from APIA and Gemini website*

According to figure number 6 and table number 7, a total increase in subsidies of 500% between 2019-2023 is observed. This significant increase indicates an important change in the subsidy policy for the pig sector. The accelerated rate of subsidy growth has been faster in recent years, with a 200% increase in 2023 compared to 2019. This trend indicates an increase in support to pig farmers. There is a steady increase in subsidies in each year over the period analyzed. This consistent development suggests a deliberate strategy to stimulate the pig sector. In Romania the subsidy reached a considerable level of € 240 per pig in 2023. This high value highlights a significant effort by the authorities to support domestic pork production. This trend points to an important shift in the subsidy policy of the pig sector, with a focus on stimulating domestic production and supporting pig farmers in the context of economic challenges.

Conclusions

This research has analyzed the significant difference in subsidies for pig farming between Romania and EU countries. The main findings highlight the negative impact of this discrepancy on the Romanian pig sector, affecting competitiveness, production, external trade and the rural economy.Romanian producers face significantly higher production costs compared to EU countries, affecting competitiveness on the internal and external market. Reduced competitiveness may lead to a decrease in Romanian pork production, negatively affecting food security and the rural economy. Dependence on pork imports may increase, affecting the trade balance and the vulnerability of the food sector.Research has identified a number of solutions to reduce the subsidy gap and increase the competitiveness of the Romanian pork sector: Negotiations at EU level: Support common positions at EU level to reduce the subsidy gap between Member States.National support programs Implement specific national support programs to compensate the subsidy gap and boost competitiveness. Measures to increase competitiveness: Investments in farm modernization, technology transfer, training programs for farmers. The final conclusion is that reducing the subsidy gap for pig farming is a necessity to ensure a competitive and sustainable Romanian pig sector, contributing to a prosperous rural economy and food security of the country.

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RURAL DEVELOPMENT THROUGH NATURE: THE POTENTIAL OF HIKING TRAILS ON THE MOUNTAIN STARA PLANINA

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Abstract

This article presents an analysis of the existing hiking trails leading to the falls at Stara Planina, identifying gaps in the mapped trails, specifically waterfalls in the basin of the Jelovac River. This study aims to propose an optimal route using a minimum cost route approach through integration of GIS and digital elevation models (DEM).The proposed route connects unidentified waterfalls from different river basins. It stretches for 5.04 km with an elevation difference from 1,356 to 1,769 m, effectively linking the Orlov Kamen waterfalls in the basin of the Dojkinci River and the waterfalls in the basin of the Jelovac River.

The method involves calculating distance and slope to determine possible walking trails. Analysis shows that many micro-watersheds in the basin of the Jelovac River in particular is often unmapped and disconnected from nearby watersheds. The maximum distance measured between the Orlov Kamen and the adjacent waterfalls is 2.3 km. This study emphasizes the importance of developing a trail network not only to promote public health and recreation, but also to enhance the quality of life. It also tried to bolster rural development by promoting the natural heritage of the area. This can lead to economic sustainability and community cohesion since investing on infrastructure and community engagement is critical to improving Stara Planina's accessibility and conserving its natural resources.

Key words*: development, hiking trail, Jelovac-Dojkinci rivers, Stara Planina, tourism potential, waterfalls.*

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Introduction

With the increasing interest in cultural and historical heritage, hiking tours have become an important form of tourism, especially among local communities (Veverka, 1998). Organizing hiking tours in nature, similar to trekking and backpacking, is often done by specialized professional or commercial tour agencies. The origins of this form of tourism dates back to the 18th Century.

What makes hiking attractive for every hiker is the simplicity of walking, the pleasantness of walking, the perception of attractiveness, comfort, convenience, etc. (Moudon & Lee, 2003). Today, hiking tours generally refer to walking over long distances. The most famous routes are found in England and Wales (The National Trails), the United States (The National Trail System), France (The Grande Randonnée), the Netherlands (Lange-afstand-wandelpaden), Portugal (Grande Rota), and Spain (Gran Recorrido).

The Alpine mountain range is one of the most important tourist destinations, attracting millions of visitors each year. Such tourist destinations provide significant benefits to both the tourism industry and local communities (Kelfaoui et al., 2021; Petrevska & Dimitrov, 2018). In 2016, the Alpine region recorded 508 million overnight stays, with approximately 7.5 million beds available for tourists. These figures highlight the dominance and importance of attracting visitors to mountain areas (BAK Economics AG, 2018; Tempesta & Vecchiato, 2018). Through the development of hiking trails, outdoor recreation, sports, and leisure activities, both the natural and cultural landscapes of the region can be explored. Increasingly, the focus is placed on ecological tourism, which can directly contribute to rural development (Datta & Banerji, 2015; Kling et al., 2017). Moreover, hiking trails can help alleviate poverty in disadvantaged communities by utilizing local cultural and natural resources for community-based tourism (CBT), a strategy that has shown positive results when properly implemented (Mnguni & Giampiccoli, 2017; Tempesta & Vecchiato, 2018).

A good example of how hiking trails play an important role in rural development and attracting tourists is the Veneto Region in Italy. In 2001, the region recorded around 9 million recreational activities. By 2015, this number increased to nearly 13 million, indicating a growing demand for recreational activities in Alpine areas (Tempesta, 2004; Petrevska & Dimitrov, 2018). On the contrary, there are regions where natural conditions, terrain topography, and landscape features allow the development of hiking trail networks, but the lack of financial resources and insufficient commitment from local communities limit the potential of these areas. In North Macedonia, many hiking trails lack adequate facilities and resources, as well as infrastructure, to meet the needs of the growing number of visitors (Petrevska & Dimitrov, 2018). Local authorities need to focus their efforts on developing and promoting new tourism offerings. Additionally, it is essential to invest in trail maintenance and the construction of necessary facilities to ensure sustainable tourism development in rural areas (Kelfaoui et al., 2021).

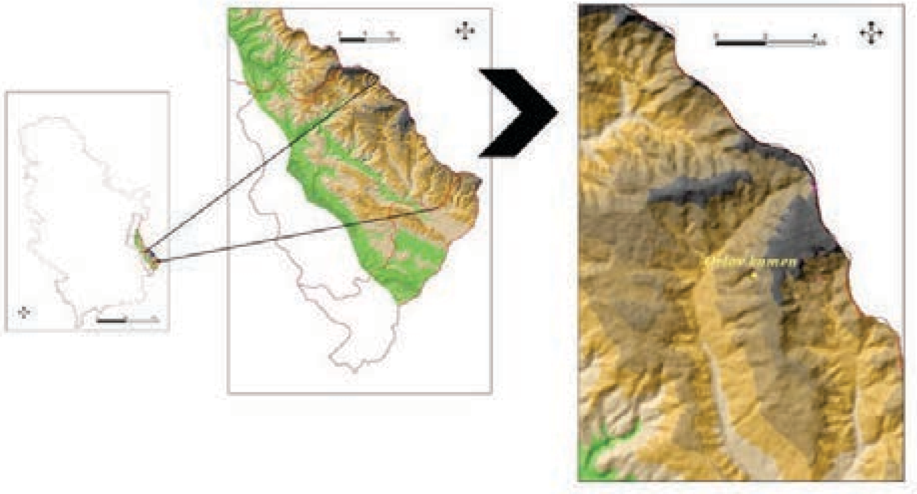
However, the scene has dramatically changed over the last decades due to abandonment of agricultural activities and reforestation, enhancing the aesthetic and recreational values for these areas too (Thiene & Scarpa, 2009; Tempesta & Vecchiato, 2018). These impacts are countered by the Common Agricultural Policy of the European Union to aid in the development of mountain areas by way of restoring hiking trails and meadows, among others, through funding and infrastructure development programs provided for under Regulation (EU) No. 1303/2013 of the Commission (Tempesta & Vecchiato, 2018).

The main objective of the paper is to determine the hiking trail of waterfalls belonging to different watersheds of Dojkinci and Jelovac rivers. The hiking trails are designed around attractive scenic spots and connected to each other, forming a network of trails (Li, Ge, & Liu, 2005). The most attractive part is certainly the waterfalls, of which there are many on Stara Planina, and the network of hiking trails began to form only at the beginning of the last century, when most of the waterfalls on this mountain were discovered.

Study area

Stara Planina spans the southeastern part of Serbia, part of the Carpathian-Balkan system, with a natural border towards Bulgaria along the ridge of Stara Planina. The highest peak is Midžor (2,165 m), and the lowest point is the exit from the valley of Prlitski Stream. The northernmost point is in the valley of Prlitski Stream, the southernmost in the valley of Nišava, the westernmost at the confluence of the Trgoviški and Svrljiški Timoks, while the easternmost point is the summit of Srebrna Glava (1,933 m above sea level) (Milovanović, 2010).

Map 1. *Geographic location of the study area*



Source: *Elaborated by Authors*

This area was analyzed in the 19th Century by Jovan Cvijić, who studied the tectonics and geology of this region (Cvijić, 1896), particularly the area from Temska to Topli Do and Midžor. The route from Temska to Topli Do is the location with the highest number of identified waterfalls, but Cvijić, from that period, described Ripaljka (Ozren mountain, Soko Banja) as the highest waterfall with a height of 420m. Based on recent measurements from the Faculty of Mining and Geology, University of Belgrade, the highest waterfall in Serbia today is the Kopren waterfall (103.5m) on Stara Planina (Map 1).

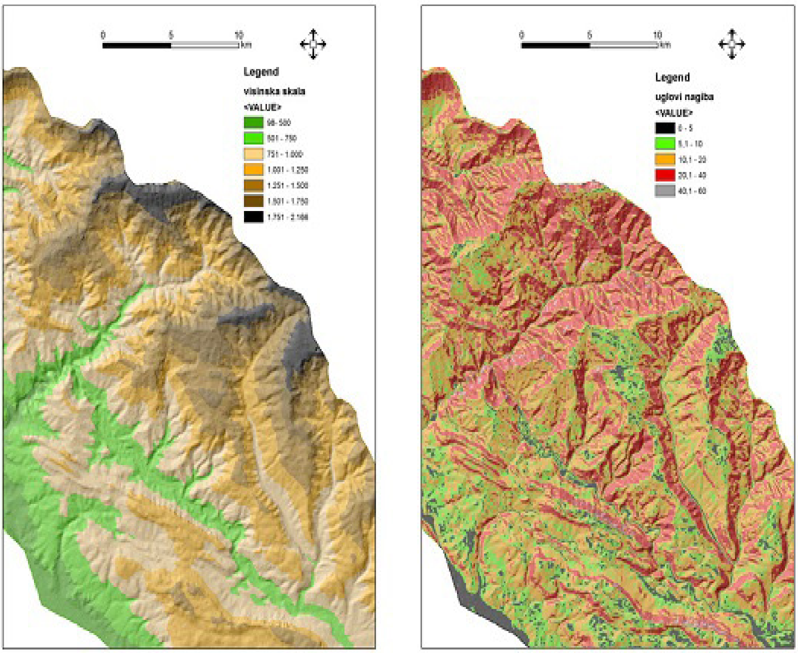
Methodology

The least-cost method is based on the definition of “cost surface,” which represents a raster map where each cell is assigned values reflecting the “costs” of passing through them. These costs are not necessarily of an economic nature (Bagli et al., 2011). Instead, they may encompass various factors, such as terrain slope, transportation infrastructure, and land use. This method is often applied in the planning of infrastructure projects such as roads, pipelines, canals, and power lines, as well as for recreational purposes, such as the development of hiking trail systems. The least-cost method is used to determine the optimal path between two points, taking into account various possible routes and minimizing the overall costs, which may include factors defined by the user (Kim, 2012).

The starting criteria for determining the hiking trail of the waterfall were the terrain elevation and slope angle within the study area. Calculating the optimal hiking trail using the least-cost method represents the most efficient approach, utilizing Geographic Information Systems (GIS). Hypsometric and slope angle maps were obtained by combining the Digital Elevation Model (DEM) with GIS technologies (Map 2). Through further analysis and the application of the least-cost method, the most favorable route, i.e., the hiking trail, was defined.

The starting point was taken as the point of interest, which is closest to the hiking trail Jelovica – Široke Luke – Kopren waterfall. Based on the slope angle map and further reclassification, distance costs for each raster cell were obtained. The necessary costs determine the best path, which is related to the direction depending on the slope, through a predefined function. The distance cost values were lowest closer to the source, i.e., the starting point of interest, and as the distance increased, the costs grew (Map 3).

Map 2. *Hypsometric map and slope angle map of the analyzed area*

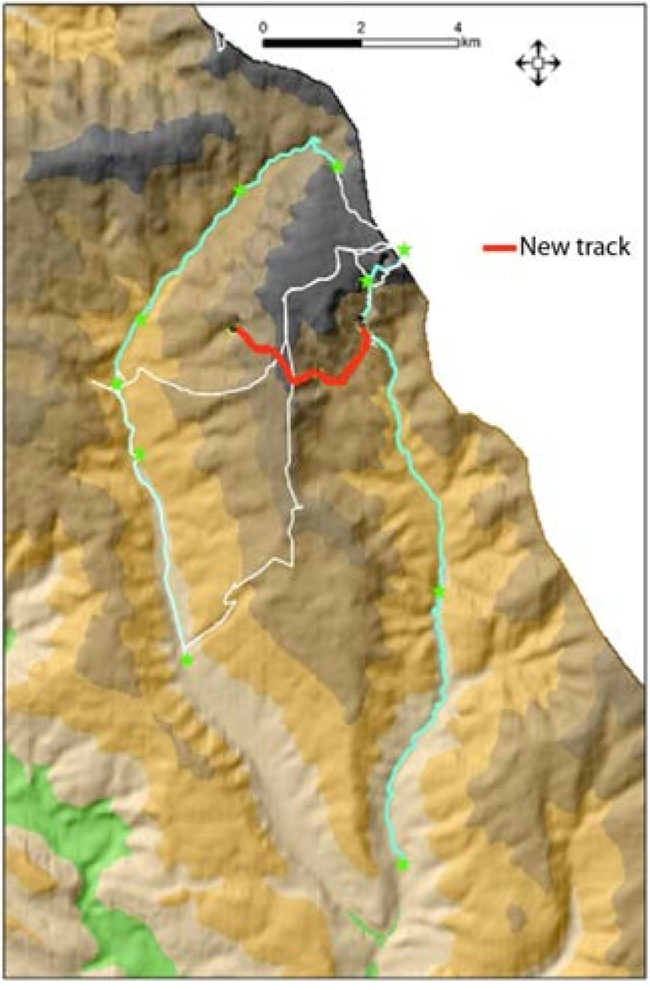


Source: *Elaborated by Authors*

Results

After analyzing the existing trekking routes and the cartographic representation of the waterfalls on Stara Planina, it was observed that the majority of waterfalls that are not mapped within the hiking trails belong to the route from Jelovica to Široka Luka. The only waterfall that does not belong to the Jelovac River basin is the Orlov Kamen waterfall, which is part of the Dojkinac River basin (Map 3).

Map 3. *The new hiking route obtained using the least-cost method from the Jelovac River waterfall to the Orlov Kamen waterfall*



Source: *Elaborated by Authors*

The obtained hiking trail connecting the waterfalls of Jelovac River with the Orlov Kamen waterfall is 5.04 km long, with an elevation difference ranging from 1,356 m to 1,769 m. GIS analysis showed that the greatest distance was measured between the Orlov Kamen waterfall and the Upper Šošina Vunija waterfall, at a distance of 2.3 km. All subsequent distances are less than 1 km, with the distance between the Lower Šošina Vunija waterfall and the Upper Šošina Vunija waterfall being 0.65 km. The shortest distance was measured between the Javorski Do River waterfall and the Lower Šošina Vunija waterfall, at a distance of 0.2 km (Map 3 and Map 4).

Map 4. *Visualization of the obtained trail via Google Earth*

Source: *Elaborated by Authors*

The potential development of this mountain could be focused on expanding the network of hiking trails. This paper presents only some of the mapped walking trails located in the part of Stara Planina that belongs to Pirot. On the Knjaževac side, there are trails around the newly built hotel complex and future ski trails. The Pirot part of Stara Planina is richer in waterfalls, many of which are relatively new and have not been fully explored yet. Some of these waterfalls are located in inaccessible areas, and some dry up during the dry season, making them both inaccessible and invisible. By locating, mapping, and marking them in the field, these waterfalls can become accessible to every hiker. Some information is already available to tourists and hikers through the internet, but with economic investment from local communities into infrastructure and greater promotion, Stara Planina could, over time, evolve from its current level of recognition into a region known for its hiking routes, similar to destinations like the Great Smoky Mountains (USA), Cinque Terre (Italy), etc.

Conclusion

Through such research, rural areas can benefit from enhanced tourism, creating jobs and economic opportunities while preserving their natural heritage. This is particularly important for regions with limited economic perspectives. The integration of geospatial technologies, local knowledge, cultural practices, and community decision-making is crucial to ensure that the benefits of tourism are fairly distributed and that natural resources are managed sustainably. The hiking trail connecting the Jelovac River waterfalls and the Orlov Kamen waterfall, 5.04 km long with an elevation difference of 413 m, illustrates how such projects can contribute to sustainable development. GIS analysis revealed that the greatest distance is between the Orlov Kamen waterfall and the Upper Šošina Vunija waterfall, measuring 2.3 km, while all other distances are less than 1 km. This data allows for effective planning and sustainable management of natural resources, which is key to the long-term sustainability of rural tourism. Future research can significantly contribute to strengthening rural development through sustainable tourism, using hiking trails as an important resource for revitalizing rural communities and preserving cultural heritage. However, current research suffers from a lack of data on actual number of tourist visits and their impacts. Furthermore, there is potential to improve route efficiency. Research should focus on preserving natural resources and improving the quality of life for local communities, while involving all relevant stakeholders in the planning and implementation of strategies.

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IS RURAL TOURISM AN OPPORTUNITY FOR THE DEVELOPMENT AND REVITALIZATION OF THE MUNICIPALITY OF ARANĐELOVAC?

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Abstract

The Municipality of Aranđelovac, with Bukovička Banja, boasts a tradition of spa and health tourism spanning more than two centuries. Covering an area of 376 km², Aranđelovac is the third largest municipality in the Šumadija District and the second most populous, with 41,297 residents according to the 2022 census. Its relatively favorable traffic and tourism position along the regional road M4 is expected to significantly improve with the construction of the "Vožd Karađorđe" highway, which will undoubtedly enhance connectivity with major emitting markets and contribute to tourism development. Surrounded by the Bukulja and Venčac mountains, with 25.2% of its territory covered by forests, the municipality of Aranđelovac enjoys a temperate-continental climate that is particularly beneficial to human health in the higher altitudes. Aranđelovac is a well-known destination on Serbia's tourist map, recognized for the Bukovička Banja Park (Special Hospital, Staro Zdanje, natural springs), the Risovača Cave, the "Marble and Sounds" art festival, the "Izvor" hotel, as well as the nearby historic site of Orašac, home to Marićevića Jaruga, where the First Serbian Uprising began. In recent years, the efforts of the Tourist Organization of the Municipality of Aranđelovac have been directed toward developing niche tourism forms, including wine and gastronomy routes, adventure tourism, fishing, events, and cultural-historical tours. A particularly notable aspect of these efforts is the promotion of rural tourism, which represents a significant opportunity and a growing trend in the tourism market. Rural tourism holds great potential not only as a driver

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of economic growth but also as a key strategy for revitalizing the municipality of Aranđelovac.

Key words: *Revitalization, tourism, rural areas, development, municipality of Aranđelovac.*

Introduction

Rural tourism is a broad concept that encompasses not only rural leisure but also all other tourist activities in rural areas (Todorović, Bjeljac, 2007). Derek H. and Greg R. (2002) particularly emphasize the existence of a pressure between successful tourism development (which generally means more visitors) and the attractiveness of rural regions (which implies peace and quiet). Tourism is one of the activities that can have a significant impact on the economic, social, functional, and physical structure of rural areas. The tourism function plays a significant role in the transformation of the physical appearance and functions of rural settlements. This phenomenon is the result of the growing need of urban populations for recreational stays in a different, rural environment (Stanković, Ćirković, 2003).

Tourism in rural areas represents a significant multifunctional space for rural development. Within the methodology of the "multifunctional scheme", which outlines functional interrelations within the process of rural development and provides insight into specific reconfigurations in resource use such as land, labor, knowledge, and nature (Knickel, 1990), four distinct levels of rural development are identified: farm, agricultural household, region, and global space. Ružić (2009) states that rural tourism began developing in the 11th century. However, its growth accelerated significantly in the 18th century when wealthy residents could afford vacations in small settlements near cities, in well-maintained villas and houses. Switzerland became a major rural tourism destination during this period. The key characteristics of the development of rural tourism to date place Serbia in areas with significant resources but lacking sufficient tradition in tourism development. The development of rural tourism as an organized activity in Serbia began in the late 1970s. The beginnings of rural tourism are linked to intense urbanization and the spontaneous movement of tourists from urban, ecologically damaged areas to ecologically preserved rural environments. Initially, this form of tourism was practiced only by individual households (Čomić, 2002).

The term rural tourism has been adopted by the European Union and refers to all tourism activities in rural areas. Specific forms of rural tourism can include: agritourism, hunting, fishing, ecotourism, health tourism, sports and recreational tourism, residential (holiday homes), educational tourism, adventure tourism, transit tourism, camping tourism, continental nautical tourism, gastronomic and ethnogastronomic tourism, tourism in protected natural areas, cultural tourism, religious tourism, and other special forms (Košić, 2009).

Rural tourism implies a series of tourist activities taking place in the countryside. Rural tourism expanded in many parts of the world from the 1970s to the 1980s, both in terms of demand and supply. It happened due to the rise of a society led by lifestyle and leisure and the widespread mobilization of tourism as a strategy for rural development and revitalization (Silva, 2021). Due to their backwardness, the villages have preserved a significant part of their characteristic material and spiritual culture. It is partially maintained: in the form of village memorial buildings, traditional objects, traditional handicrafts, agricultural products, folk costumes, customs and the like (Štetić, Cvijanović and Šimičević 2014).

A prerequisite for the development of tourism is a well-developed agricultural production. (Stanić Jovanović, Vuković, Miletović). In the rural area of the Šumadija district there are many tourist attractions that can represent the unique tourism product of the tourist region Šumadija, which is the basis for the development of rural tourism, among many Aranđelovac municipality villages Garaši, Vrbica, Orašac, etc. (Matić, Djordjević, Vujić, 2019).

Municipality Aranđelovac

The municipality of Aranđelovac is one of the most attractive tourist destinations in the Šumadija District. Its rich cultural and historical heritage, along with spa tourism, occupy an important place in the municipality's tourism offerings. The most attractive tourist sites include: Orašac, the Risovača Cave, the park of Bukovička Banja with its springs, and the building of the Staro Zdanje (Dimitrovski, 2013).

Figure 1. *Park of Bukovička Banja*

Source: *Tourist Organization of the Municipality of Aranđelovac*

The Municipality of Aranđelovac is one of the seven municipalities in the Šumadija Administrative District. It covers the northwestern part of the district and spans 375.89 square kilometers, representing 15.75% of the total area of the Šumadija District. In addition to the administrative center of Aranđelovac, the municipality includes 18 rural settlements. The relief of this area is dominated in height by Bukulja (696 m) and Venčac (658 m), connected by a ridge with an average elevation of about 500 m. The territory of the Aranđelovac municipality is characterized by the regional climate type of the central part of Šumadija, namely a temperate continental climate, ranging from variable to the most pleasant moderate. The higher parts of its territory (Bukulja and Venčac) have a specific variety of milder, altitude-based subalpine climate, with relatively stable temperature conditions. The Aranđelovac climatic region is characterized by relatively cold winters, warmer autumns than spring, and moderately warm summers. The municipality of Aranđelovac is home to several mineral and thermomineral springs. Of particular significance are the mineral waters of Bukovička Banja, which are classified as rare cold waters and hypothermic (warm) healing waters (Program of Measures for Implementing Agricultural Policy and Rural Development Policy of the Municipality of Aranđelovac, 2018).

The favorable conditions for the development of spa tourism are largely due to its proximity to major emitting areas and its good connectivity. Health tourism is based on the use of waters for prevention, treatment, and rehabilitation. The mild natural resources of the surrounding environment are well-suited for recreational activities, while cultural content is linked to events such as the “Marble and Sounds” artistic manifestation (Marinoski, Stamenković, Ilić, 2015). Nestled in the greenery of the Bukovička Banja Park, the “Staro Zdanje” is undoubtedly the most impressive building in Aranđelovac and perhaps one of the most beautiful architectural gems in the country. The construction of this building began in 1868. It became the summer residence of the Obrenović dynasty, whose members frequently visited Aranđelovac. In honor of its rich culture and tradition, several interesting events are held in Aranđelovac every year. The largest and most famous of these is the “Marble and Sounds” art festival, which takes place from early June to the end of September. This festival has a long tradition dating back to 1966 and consists of three forms of cultural and artistic activity: the “White Venčac” Sculpture Symposium, the “Marble and Sounds” Manifestation, and the International Festival of Ceramic Art. The significance of the “Marble and Sounds” symposium is emphasized by UNESCO, which ranks it among the most important global events in the field of visual arts. The National Museum preserves and displays numerous exhibits from the fields of paleontology, archaeology, ethnology, history, and art history, as evidence of the material and spiritual culture that developed in the Šumadija region. The village of Orašac, located near Aranđelovac, is best known as the site where the First Serbian Uprising was planned and where Karađorđe Petrović was declared the supreme leader (vožd) on Sretenje, February 15, 1804 (https://arandjelovac.org/o-arandjelovcu/accessed: 09.12.2024.).

Tourist Traffic

As demonstrated in Table 1, the tourist traffic of the Municipality of Aranđelovac has fluctuated over the past six years, with 2023 marking the highest recorded tourist activity during the observed period. Expectedly, 2020 saw a decline in tourist traffic due to the global COVID-19 pandemic. By contrast, 2021 showed significant recovery, largely driven by international travel restrictions, which compelled tourists to explore domestic destinations. That year, Aranđelovac recorded 75,809 overnight stays, representing notable growth compared to 2020, though still not matching the figures of 2018. The surge in tourist traffic in 2023, which stands as the highest recorded during the analyzed period, can be attributed to enhancements in the local tourism offering and increased efforts by the Aranđelovac Tourism Organization, the Municipality of Aranđelovac, and other public institutions in the region. These initiatives aimed to improve tourism infrastructure and create favorable conditions to attract tourists and encourage longer stays. A crucial point to consider is that official statistics on arrivals and overnight stays in Aranđelovac/Bukovička Banja do not include data from the Special Rehabilitation Hospital "Bukovička Banja" or the Children's Holiday Center "Bukulja." Annually, these two facilities account for between 30,000 and 40,000 overnight stays—a substantial figure that significantly alters the overall representation of tourist traffic in the Municipality of Aranđelovac.

Table 1. *Number of Overnight Stays in Aranđelovac (2018–2023)*

Yeat	**Number of overnight stays**
2018.	88.553
2019.	86.662
2020.	52.975
2021.	75.809
2022.	62.034
2023.	91.520

Source: *Statistical Office of the Republic of Serbia*

The Tourist Organization of the Municipality of Aranđelovac (TO Aranđelovac) has maintained successful collaboration for many years, serving as an intermediary with private accommodation facilities. TO Aranđelovac collaborates with approximately 100 privately-owned accommodation providers through promotion and by acting as an intermediary, issuing invoices for tourist accommodations in rooms, apartments, and rural tourism households. Annually, more than 10,000 overnight stays are facilitated through the Tourist Organization, with the majority being realized via vouchers for subsidized vacations in Serbia. These vouchers are granted by the Government of the Republic of Serbia to Serbian citizens who meet the eligibility criteria defined by the government as a form of support for both tourists and accommodation providers. The year 2022 set a record for the number of overnight stays using government vouchers compared to previous years. Table 2 presents a comparison of the last six years in terms of overnight stays facilitated through these vouchers.

Table 2. *Number of Overnight Stays Using Government Vouchers in Aranđelovac (2018–2023)*

Year	Number of realized vouchers	Number of recorded overnight stays through vouchers
2018.	264	1.320
2019.	235	1.175
2020.	672	3.360
2021.	579	2.895
2022.	1461	10.227
2023.	728	3.640

Source: *The Tourist Organisation Municipality Aranđelovac*

As shown in Table 2, the number of overnight stays facilitated through TO Aranđelovac using vouchers issued by the Republic of Serbia has fluctuated over the past six years. Notably, 2022 recorded the highest number of overnight stays, which is significant from an economic perspective for TO Aranđelovac, considering that the commission charged for its intermediary role amounts to 5% of the total invoice for a given accommodation facility. However, a decline in the number of overnight stays was observed in 2023 compared to the previous year. This decrease can be attributed to the reduced value of vouchers; in 2022, the vouchers were worth 15,000 RSD, whereas in 2023, their value was reduced to 5,000 RSD.

Rural Tourism as an Opportunity for Development and Revitalization of the Municipality of Aranđelovac

The current state of tourist demand in Aranđelovac is far below the levels it reached in the 1980s and even the 1990s. The reasons for this include outdated infrastructure, inadequate accommodation capacities, disorganized ownership structures, and many other factors. However, the new circumstances that have led to a sudden increase in tourist traffic in Serbia, primarily from domestic tourists, over the last three years have also influenced tourism in Aranđelovac. The interest in the tourist offer of Aranđelovac and Bukovička Banja is growing, and the Aranđelovac Tourism Organization, as the umbrella organization for the city, is actively working on promoting Aranđelovac as an attractive tourist destination. Therefore, over the past three years, the number of privately-owned accommodation facilities has significantly increased, and a number of new projects have been initiated, which will greatly impact the tourism industry in Aranđelovac.

Figure 2. *Rural Tourism Household "Vajati Bosutica"*

Source: *https://bosutica.rs/*

In addition to spa tourism, which has been prominent in Aranđelovac for more than two centuries, new forms of tourism are constantly being developed. Recreational, cultural-historical, and event tourism are also well-represented in Aranđelovac, with congress tourism, urban and rural tourism, as well as gastronomic and wine tourism, experiencing significant growth in recent years. In the Municipality of Aranđelovac, the offer of rural tourism is quite modest, consisting of a small number of ethnic houses, ethnic restaurants, and a few individual rural tourism households. Despite the fact that the number of households engaged in rural tourism does not exceed ten, it should be noted that this form of tourism has been attracting increasing attention in recent years, both in Serbia and in Aranđelovac. For this reason, the number of rural tourism households increases every year, and the services offered by these households are also expanding.

Currently, six rural tourism households collaborate with the Aranđelovac Tourism Organization in the Municipality of Aranđelovac, namely: "Paunove stene" and "Garaške breze" in the village of Garaši, "Bukovički mir" in the village of Bukovik, “Gajića konak” in the village of Orašac, “Vajati Bosutica” in the village of Bosuta, and “Kuća za odmor Gornja Trešnjevica” in the village of Gornja Trešnjevica. Implemented projects by the Aranđelovac Tourism Organization (such as the construction of an observation point at the top of Bukulja, the installation of recreational furniture along the Bukulja hiking trail, and the reconstruction of tourist signage, among others), as well as a total of nine wineries from the Venčac wine region (wineries: “Tarpoš,” “Eden,” “Matijašević,” “Vladimir,” “Blagojević,” “Veličković,” “Legat 1903,” “Trilogija,” and the wine cellar “Grb”), along with well-known barbecue spots and ethnic restaurants in the municipality, contribute to enhancing the experience of tourists who choose to stay at rural households in the Municipality of Aranđelovac.

Conclusion

The opportunities that the Municipality of Aranđelovac offers as a tourist destination are significant for both domestic and international tourist markets. Favorable climatic conditions, along with interesting geomorphological features (such as the Risovača Cave and Bukulja Mountain), whose exploration and visits are ideal for various sports and recreational activities, along with the rich cultural heritage and long tradition (Orašac, the “Izvor” building, the “Marbe and Sounds” festival, sculptures in the Bukovička Banja park, etc.), as well as the recognition of spa tourism, contribute to the popularization of Aranđelovac. Šumadija’s hospitality, local culinary specialties, and quality indigenous wines are just a few of the reasons why more and more tourists are eager to visit Aranđelovac or choose to stay in rural households in this municipality, where, when you order a traditional coffee, it is served with mineral water (“Knjaz is not just water, it’s our pride”).

The significance of developing rural tourism in the Municipality of Aranđelovac lies in the fact that it creates opportunities for self-employment within one’s own household, as well as generating additional income. Hosts, through rural tourism services, have the opportunity to sell surplus agricultural products, often at significantly higher prices than market rates. Another positive aspect of the development of rural tourism in the Aranđelovac municipality is that it contributes to the retention of young people in rural areas, prevents the aging of villages, and influences the development of infrastructure, primarily roads, water supply, and sewage networks.

The development of rural tourism is gaining increasing importance due to its potential contribution to the social and economic renewal of rural areas and the revitalization of villages. Investment in the offer and promotion of rural tourism in the Aranđelovac municipality, through family farms and rural households, aims to attract as many tourists as possible and generate revenue. This form of tourism is based on sustainability principles, offering tourists elements of rural life, nature, and traditional hospitality. As such, rural tourism should serve as the foundation for economic development and improving the standard of living in the rural communities of Aranđelovac villages.

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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 European Union wine sector dynamics from the Romanian perspective. 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

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euros to destroy surplus wine reserves to support producers. Initially, at the 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 the development of an analysis regarding the overall assessment of the dynamics of the wine sector in the European Union from the Romanian perspective. 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

Vineyards in the European Union (EU) have stabilized in size, standing at 3.3 million ha in 2021 for the eighth consecutive year. This stability can be attributed to the EU regulations (European Parliament, 2013) because the European Union, starting in 2016, allowed the member states to authorize new plantings with an annual increase of up to 1% of the areas already planted by each member state.

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. In 2022, it decreased by 0.8%, reaching 955 thousand ha. France, the second largest country of wine plantations, continuously increased its wine area by 0.2% in 2021 compared to 2020 and by 0.8% the following year, reaching 812 thousand ha in 2022 (Roca, 2022). Italy, with 718 thousand ha of surface cultivated with vines, after five years of positive growth, has maintained the same level since 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).

Among the other EU countries, Germany and Hungary are the only countries that recorded decreases in wine production in 2021. At 7.9 million hl, Germany's wine production is 5% lower than in 2020 due to the spring frost episode in some of its vineyards. 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. In 2021, the production levels were Portugal (7.3 mil hl, +14%), Romania (4.5 mil hl, +16%), Austria (2.5 mil hl, +3%), and Greece (2 .4 million hl, +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 48% of the world's consumption. This figure is 3% higher than the level estimated in 2020, hit by the Covid crisis (110.5 million hl, one of the lowest volumes ever recorded), but 2% below the value of 2021 (114 million hl) (Pirvutoiu & Popescu, Study concerning the EU Position in the World Wine Production, 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 combined effect of the growth of new markets, but also of the reduction of traditional wine consumption in producing countries within the EU 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 (Ugaglia, Jean-Marie 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). Italy, the second largest market in the EU and the third in the world, estimated wine consumption in 2022 was 23 million hl (5% below that of 2021 when the highest level of wine consumption in Italy 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.

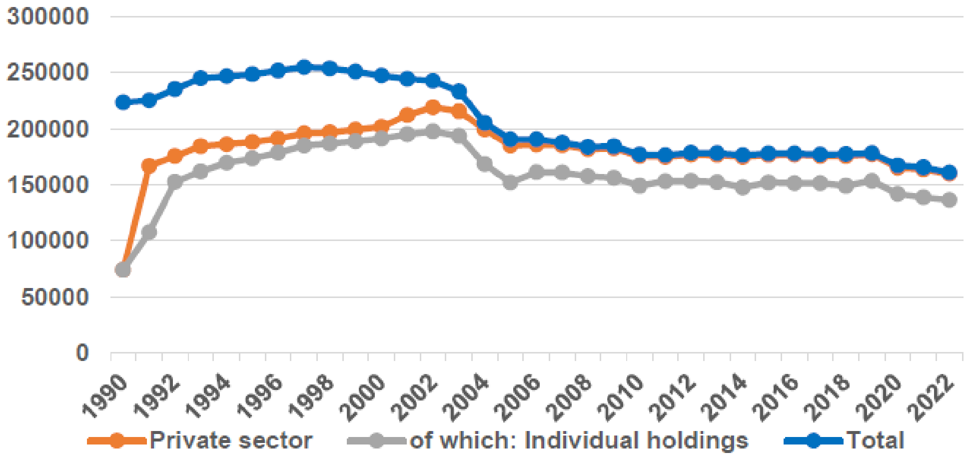
Developments in the production of grapes and wine and the specialization of farms

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 pandemic, changes in agricultural policies in the EU, inflationary dynamics or other noteworthy economic changes.

In 2021, Romania owned 2.6% of all the area cultivated with vines worldwide. This value places the local market tenth in the world, close to Portugal and Chile, but far from the leaders - Spain, France, China and Italy, each with over 700,000 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)*

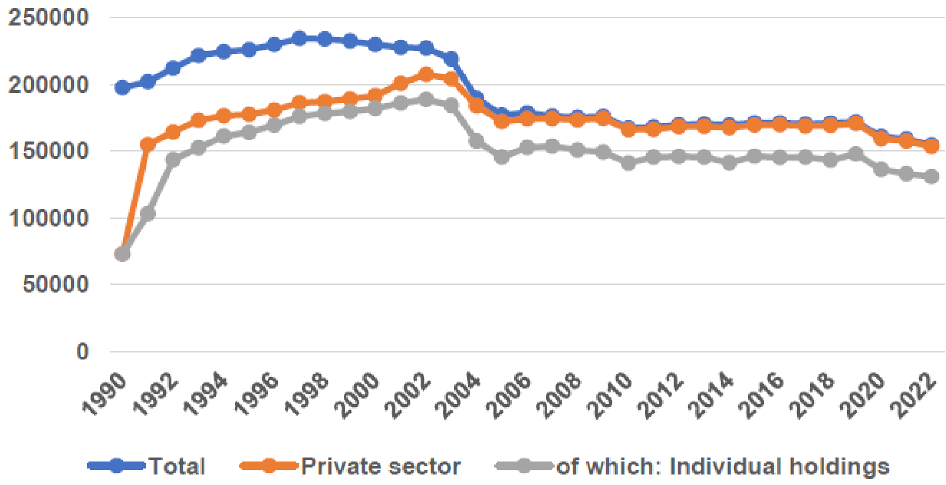
Chart 2 shows the evolution of *the areas of the wine grape vineyards in bearing by ownership form in Romania*. They increased during 1990-2002, the growth being more robust in the first three years. A steeper decline occurred in 2003-2005, followed by a period of relative stability until 2019, after 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)*

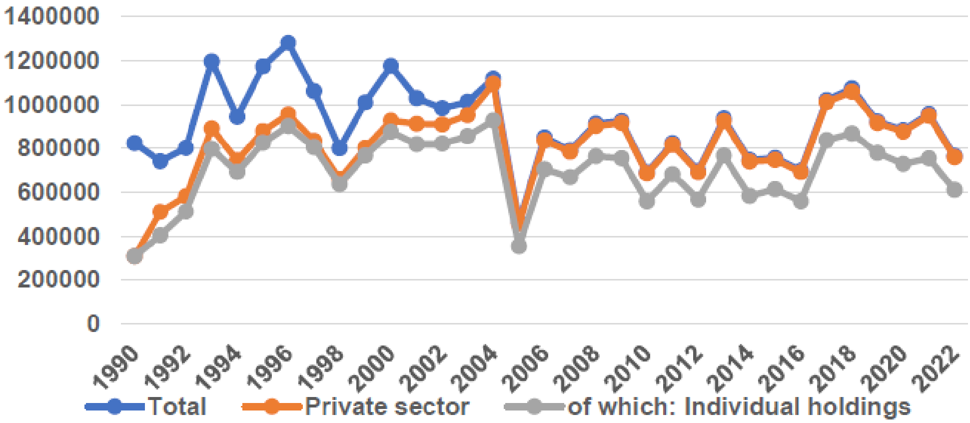


Source: *National Institute of Statistics of Romania (online data code: AGR111A)*

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.

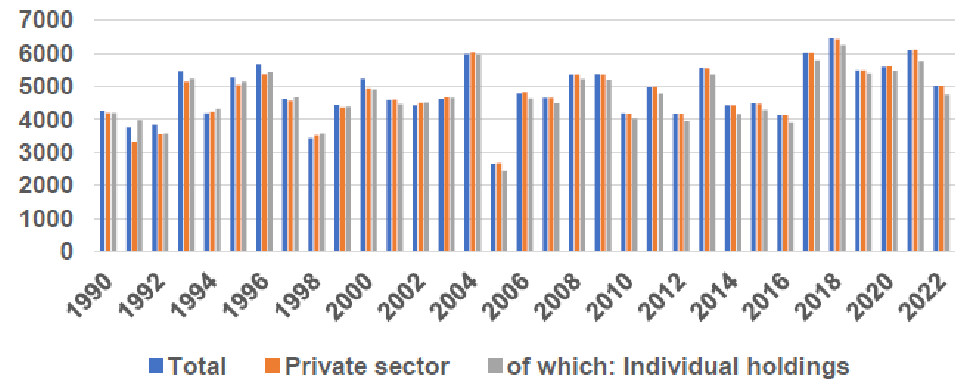
Chart 3. *Evolution of the production of wine grapes by ownership form in Romania (to)*



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)*



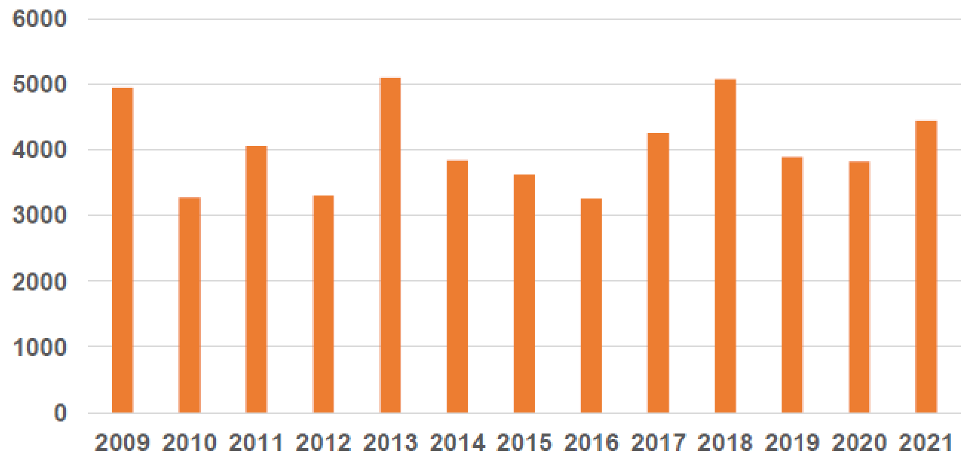
Source: *National Institute of Statistics of Romania (online data code: AGR113A)*

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.

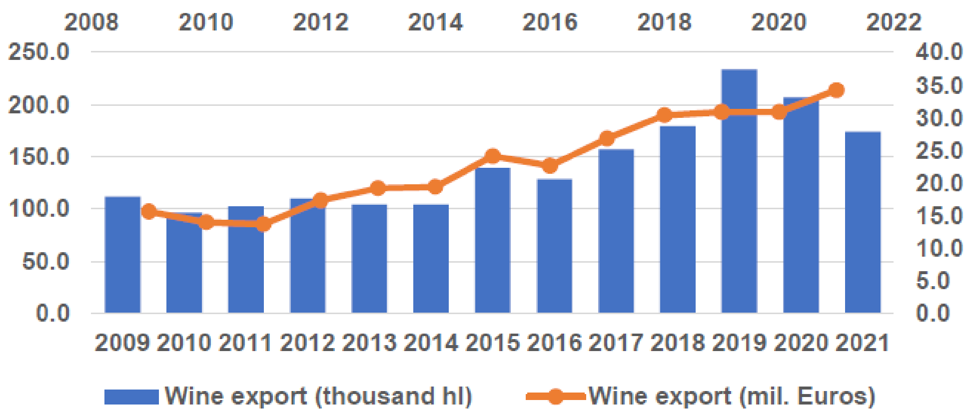
Until 2018, Romania did not exceed more than 3-4% of production for export.

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 neighbors 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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REVITALIZATION OF RURAL AREAS THROUGH THE APPLICATION OF THE "SMART VILLAGE" CONCEPT

Suzana Lazović[1], *Drago Cvijanović*[2]

Abstract

The revitalization of rural areas represents a very important segment of the overall development at the national level and should be based on knowledge and new technologies. The paper aims to analyze the significance of the application of the "smart village" concept in rural areas, which would contribute to the formation of new use values and the solution of current problems related to economic and cultural backwardness, depopulation, migration to urban areas, departure of young people abroad, abandonment of engaged in agricultural production, lack of application of modern technological solutions and insufficiently educated staff in providing services in rural areas.

Key words: *"smart village", rural areas, revitalization.*

Introduction

Rural areas with preserved nature and traditions of different rural areas have always attracted people to stay and vacation (Đenadić et al., 2016). The fact that 85% of the territory of the Republic of Serbia consists of rural areas, great geographical diversity, a wealth of natural and anthropogenic resources, multiethnic population, indicates that rural areas and more intensive development of tourism could play a key role in the future economic development of the Republic of Serbia (*Tourism Development Strategy of the Republic of Serbia 2016-2025)*. However, despite the numerous potentials for the development of rural tourism, there are numerous problems that rural areas face. Cvijanović (2014) states that in the 20th century, Serbia was an agrarian country with a large share of the population employed in agriculture. After the crisis of the 1990s, people lost their jobs and moved to the cities. This tendency is still present today, where in addition to depopulation, abandonment of agricultural

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production, lack of motivation to provide services in rural households, etc., population migration from rural to urban areas is still present. According to the *National Rural Development Program from 2018 to 2020* (2018), as a consequence of the intensive processes of urbanization and industrialization in the post-war period, depopulation and unfavorable aging of structures are observed in the rural areas of the Republic of Serbia.

The paper aims to analyze the significance of the application of the "smart village" concept in rural areas, which would contribute to the formation of new use values and the solution of current problems that contribute to economic and cultural backwardness.

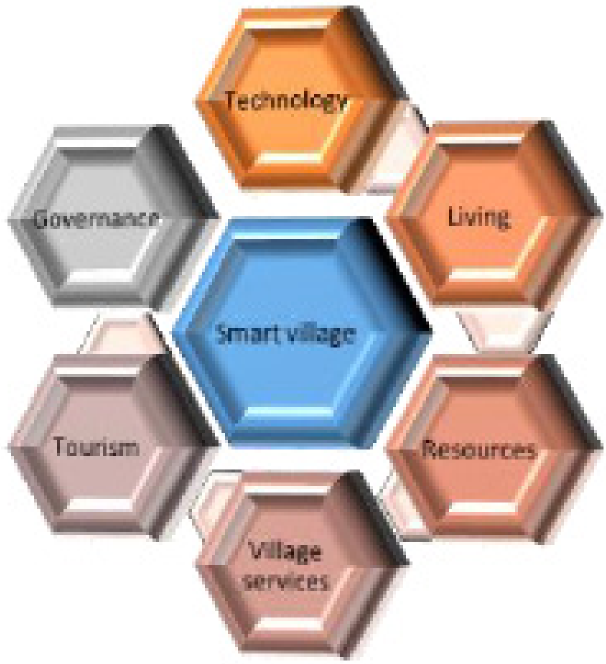
The term and concept of "smart village"

When defining smart villages, the European Commission focuses on rural communities that use their current advantages and strive for their digital development, while supporting daily activities related to increasing the quality of life and living standards, reviewing general public services, and considering environmental aspects in every action. UNWTO (2017) defines smart tourism villages as "intelligent, sustainable and competitive rural tourism destinations that use data-related resources, such as georeferenced data, big data and the Internet of Things (IoT).

Numerous authors in their research analyzed the concepts of "smart village" and "smart destination" (Viswanadham & Vedula, 2010; Buhalis & Amaranggana 2013; Thorpe et al., 2016; Slee, 2019; Adamowicz & Zwolińska, 2020; Stojanova et al. al., 2021). The idea of a "smart village" relies on the presence of rapid access and application of digital technology to support business innovation and wider community development (Slee, 2019). By applying the "smart concept" destinations could increase their level of competitiveness (Buhalis & Amaranggana 2013). It can be said that the benefits of investing in the development of smart villages are twofold.

This concept benefits residents, making their lives more comfortable and simpler, and also makes the community stronger, more resilient, independent, and connected (Stojanova et al., 2021). A smart village can be defined as a set of services that are provided to its residents and businesses efficiently. They include services related to construction, agriculture, electricity, health care, water, retail, manufacturing, and logistics, which are needed to make the construction of a smart village possible (Viswanadham & Vedula, 2010). In their research conducted on the example of Poland, Adamowicz & Zwolińska (2020) dealt with ways of sustainable development in rural areas, they point out that the concept of a smart village can be useful in facilitating the sustainable development in rural areas. Crucial factors for the development of smart and competitive villages according to Thorpe et al. (2016) are considered: broadband connection of rural areas, to overcome their isolation and increase accessibility; use of modern services; digital access to the market; diversification of the rural economy, modernization of farms and sustainable use of rural resources. The implementation of smart concepts in regional, both rural and urban contexts must be adapted to socio-cultural and environmental circumstances. In the context of digital transformation, which is the focus of this concept, it means that digitalization requires customized concepts, business models, and solutions that must strive for the general improvement of the well-being of the rural population (Zavratnik et al., 2018). Viswanadham & Vedula (2010) in their paper, on a case study of a village "Banyuwangi Regency" created a smart concept starting from a rural area, called "smart kampung". Based on the data of their research, the authors proposed a smart village model (Figure 1).

Figure 1. *Predloženi model pametnog sela*



Source: *Adapted from Viswanadham & Vedula, 201*

In Figure 1, it can be seen that the proposed model consists of six dimensions. The Smart Village Model consisted of six dimensions: 1) Governance, 2) Technology, 3) Resources, 4) Village Services, 5) Living and 6) Tourism.

Ristić & Bošković (2020) conclude that there is no unique model for the development of a "smart village", because all villages have a chance to be smart, if they develop with their resources, while the traditional elements of development must be supplemented with digital information and communication technologies and social innovations.

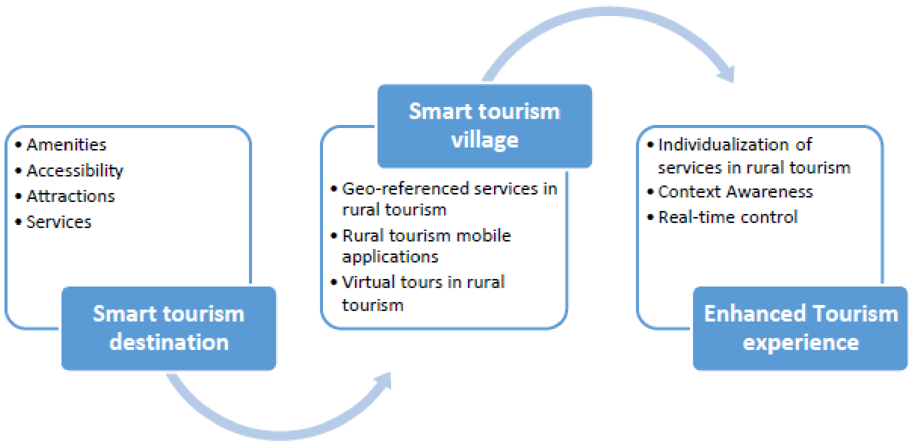
Implementation of the "smart village" concept in rural areas

The importance of Internet information technologies is evident and strategically important in rural development. Tourists are provided with a wide range of information available to potential tourists, as well as easier access to information and other actions related to the departure of tourists to a certain rural destination (Todorović & Štetic, 2009). Čomić et al. (2001) point out that the Internet enables activities that are important for the development of rural tourism, and provides the possibility of searching for information related to rural tourism, interactive communication, virtual education programs, consulting services, and electronic business. A similar view is expressed by the authors Zhu et al. (2014), who state that the development of smart tourism destinations contributes to the tourism industry by providing convenient access to information for both tourism organizations and tourists through an integrated and centralized data platform.

The application of the concept of "smart" development in rural areas is gradually receiving increased attention (Zhang & Zhang, 2020). Based on research in which they examined the possibilities for improving the tourist experience and personalizing services through the concept of a smart destination, the authors Buhalis & Amaranggana (2015) state that introducing "smartness" into tourist destinations requires a dynamic interconnection of interested parties through the technological platform on which they are located information related to tourism activities could be exchanged immediately. According to Ella & Andara (2018), if a village has potential for tourism, a smart village should provide services in tourist facilities, accommodation, and related facilities for the development of a tourist resort.

In a smart tourism destination, tourism service providers can use a centralized information platform to make better business decisions. On the other hand, Ristić & Bošković (2020) indicate in their analysis in this paper that not all rural areas are ready for the realization of the concept of "smart villages". Rural communities in underdeveloped countries are the least prepared since implementing any strategy at the local level requires adequate funding sources for the application of ICT and the readiness of the population to master new knowledge and skills in using it. Also, the motives for launching new models of development of rural communities, and applying the concept of "smart villages", are precisely the answers to the depopulation and demographic aging of villages, through the use of modern technologies, the improvement of e-literacy and e-skills of the inhabitants of rural areas, and with the aim of improving the quality of their life and work. The main goal of a smart tourism village should be to create a smart experience for rural tourists and improve service quality (Huang et al., 2012). According to Vuković et al. (2022), the "new normal" offer of rural tourism could be based on the use of mobile virtual tours and mobile applications, enabling the realization of the "smart village" concept (Figure 2).

Figure 2. *Improving the tourist experience through the creation of a smart tourist village*



Source: *Adapted from Vuković et al., 2022*

Figure 2 illustrates how it is possible to improve the tourist experience through the creation of a smart village. Developing and implementing the concept of a smart village, it is of utmost importance to create a smart experience for tourists. Buhalis and Amaranggana (2013) point out that the smart experience is enhanced by individualization, contextual awareness and real-time observation, while providing new and improved services to rural tourists.

An example of good foreign practice – Germany

The concept of “smart village” is characterized by sustainability, innovation, connection of the local community, an integrated approach and an adequate strategy.

New village concepts are widespread in the world and are characteristic of economies at a higher level of development. The pilot project in Germany “digital villages” indicates the importance of digitization in opening up new opportunities for the development of rural areas. The project was designed with the aim of improving the quality of life in rural areas with the help of providing digital services. Bearing in mind that German villages also have the problem of population depopulation, the task of the project was to revive villages and rural areas, keeping them attractive for their residents, especially young people (Jovanović & Gavrić, 2018).

Implementation of “smart village” in the Republic of Serbia

According to Ristić & Bošković (2020, p. 40), the model of development of rural areas through the concept of “smart villages” is only in the first stages of development in the Republic of Serbia, and it is desirable to direct this concept through the following strategic directions: “development of “smart villages” with small businesses and households that produce healthy food and specialized products of high value; to base its business on the local offer and the markets of the surrounding cities; connecting local food businesses with consumers, while organizing training for the application of digital technology and the Internet; solving the mobility of the elderly, by organizing public transport well; enabling young people to start a new business, to develop precision agriculture and circular economy, while strengthening intergenerational cooperation; development of socio-innovative services in the field of financing, healthcare, education, child protection and for people with special needs; establishment of various types of cooperatives, especially energy cooperatives for the production of solar and other alternative forms of energy, with an integral approach to waste disposal; development of all types of rural tourism, along with spiritual revival, preservation of manifestations and traditions with pride that “it’s my village”.

In the Republic of Serbia, there are almost no examples of smart villages. However, a village that can represent an example of good practice is the village of Seča Reka. Seča Reka is a village in Serbia in the municipality of Kosjerić in the Zlatibor district, and is considered a pioneer in the development of rural tourism in the Republic of Serbia. The village has considerable potential for the implementation of the "smart village" concept, bearing in mind that based on the completed road, electricity and water supply network, as well as telecommunications, the village has become a sustainable community, which is one of the characteristics of the implementation of this concept.

In addition to the above, Radosavljević (2017) points out that most of the roads in the village are asphalted, or made with high-quality macadam embankments to distant points. In addition, the village is located on a road of national importance that connects Kosjerić with Bajina Bašta and the Drina river valley, which indicates a good infrastructure connection. Already in the 70s and 80s, in the 20th century, the village of Seča Reka became one of the villages where the development of rural tourism began, however, it was only in the 21st century that the tourist offer gained relevance, with changed contents on offer. A special attraction in the tourist offer is the manifestation "Čobanski dani", which was traditionally held every year in July, and which was visited by several tens of thousands of visitors. It is important to note that in addition to the above, the village is an ecologically healthy environment, suitable for starting the production of healthy food.

Conclusion

Studying domestic and foreign literature, it can be seen that a large number of foreign authors dealt with the topic of "smart villages" in the field of development and revitalization of rural areas. Unlike foreign literature, there is a very small number of scientific works on the implementation of the concept of "smart villages" in domestic literature. This work, which is based on the collection of available secondary data, can complement the existing literature and leave room for more detailed research and analysis of this concept.

The proposal for future research is reflected in the consideration of the possible application of this concept at the level of the Republic of Serbia, or a specific place. In addition, possible research directions can be reflected in answering the following questions:

1. Is the local community interested in the development and implementation of the "smart village" concept and in what way?
2. To what extent are we using technology to improve the quality of life in rural areas and make them more attractive to residents and tourists?

3. Are there grounds and possibilities for the implementation of this concept in the rural areas of the Republic of Serbia?

The aim of the paper was to analyze the importance of applying the “smart village” concept in rural areas. Based on the review of the available literature, it can be concluded that investing efforts in the development of this concept can significantly contribute to solving the current problems that occur in rural areas. While the long-term goal of this concept is to improve the quality of life in rural areas, using digital services, which would contribute to the revival of villages and the revitalization of rural areas, while making them attractive for their residents, especially the younger population. In addition to the above, the problem is also insufficiently educated personnel in the provision of services in rural areas, as well as the lack of application of modern technological solutions. Bearing in mind that rural areas make up a large part of the territory of the Republic of Serbia, the development of these areas represents a very important segment of the overall development at the national level. Rural tourism must be based on knowledge and new technologies, which is confirmed by modern models and approaches in the development of rural areas.

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THE INFLUENCE OF VINE GROWING AND WINE PRODUCTION ON THE DEVELOPMENT OF RURAL TOURISM IN SERBIA[1]

Zoran Simonović[2], Vuk Miletić[3]

Abstract

In this paper, we want out the influence that viticulture and the production of wines can have on developing rural tourism in Serbia. The value of grapes is seen when there is not enough of them and when there is a shortage of them, which in practice leads to an increase in prices. The value of grapes comes to the fore even more when it is related to wine production because viticulture and wine production are the face and the reverse of the same production-processing policy. Apart from providing grapes for wine production, it is also a key element that can contribute to rural development. Rural policy is for Serbia due to depopulation trends and the rapid evacuation of the population from rural areas. In this sense, the development of tourism in Serbia should be headed towards finding mechanisms to prevent the deterioration of villages and rural areas in the concept of tourism development (strengthening of infrastructure, increasing the attractiveness of the rural regions, enrichment of tourist content, diversification of the rural economy). The standardization implemented within the rural tourism sector and under wine tourism should lead to better integration of agriculture and tourism in planning documents. In that process, greater participation of the owners of rural households and wineries is necessary. Finally, it is vital to raise the education and awareness of the local population about the possibilities of rural and wine tourism (education continuously, not sporadically).

Key words: *viticulture, wine production, rural tourism, wine tourism, Serbia.*

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Introduction

The document Tourism Development Strategy of the Republic of Serbia, under the term rural tourism, emphasizes that rural tourism implies and includes a range of activities and services add content organized by the rural population on family farms to attract tourists and generate additional income while respecting the principles of sustainable development and conservation of natural resources.[4]

The National Programme for the Integration of the Republic of Serbia into the EU, adopted by the Government (2008), highlights the section entitled Agriculture and Rural Development, which speaks of our clear commitment, both to this integration and to this concept. (Pejanovic et al., 2008, p.6). Accordingly, we emphasize that rural areas occupy about 85% of the territory of Serbia and that the rural population makes up more than half of the total population. This certainly creates a need for further investment in this area to improve social and economic conditions, both in isolated rural areas facing a tendency to depopulation and in suburban areas. Investing in the development of the rural economy and local communities is a vital factor in improving the quality of life in rural areas, primarily through better provision of public services, infrastructure development, and a more favourable business environment.

Creating conditions for better competitiveness in rural areas requires sustainable development and the creation of new employment opportunities, especially for the younger population, as well as providing access to modern information and communication technologies. Diversification of activities in rural areas into agricultural and non-agricultural activities, support for non-agricultural activities, and strengthening the connection between different spheres of rural development play a significant role in all this. (Roberts et al., 2004, p.253-263).

Rural areas suitable for tourism development in Serbia

Rural areas in Serbia are different in economic, social, and demographic. In the first place, these are geomorphological differences (mountainous, hilly, and plains areas), differences in population, economic structures, infrastructure, environmental conditions, transport accessibility, etc. Rural areas contain most of the country's natural resources: agricultural land, forests, and waters with rich ecosystems and biodiversity, including significant human

4 Стратегија развоја туризма Републике Србије, 2005, 69.

resources and economic activities, as well as important natural, cultural, and historical heritage. The diversity of rural areas of Serbia is a good opportunity but creates main problems for the planning of rural development and support as a whole.

Serbia's terrain ranges from the rich, fertile plains of the Pannonian Plain in the north, through limestone mountain ranges and basins in the east and west, to ancient volcanic massifs in the south. The north is dominated by the Danube River, the south is divided by the Sava River, and the Morava River basin reaches deep into the mountainous wilderness of the south. (Đorđević-Milošević, et al., 2013, p.33).

The northern plains of Vojvodina administratively belong to the Autonomous Province of Vojvodina, which accounts for 28% of Serbia's total area and 26% of its total population. It is the wealthiest region and had a net population inflow for 1995–1999.

The hilly and mountainous regions of Central Serbia account for 29% of Serbia's total area and 44% of its population. It is the most diverse and densely populated of the three regions, partly due to the influence of Belgrade. The capital is an important market and source of employment. This region has the most developed infrastructure in the country. However, this does not mean that this infrastructure is complete and functional.

The mountains and valleys of Southern Serbia account for 44% of Serbia's total area. Southern Serbia is the largest of the three regions and the poorest and most underdeveloped region. Most of the area is mountainous, with 37% covered by forest and only 55% by agricultural land. The soil, except the valleys, is often poor and shallow, much of it on steep slopes. The head resources that sustained the local rural economy were the vast highland grasslands suitable for extensive livestock farming and the valley areas just for vegetable growing. Single parts of the region farm crop, fruit, and vines.

Serbian wine tourism relies on 17 wine routes that reveal the richness and diversity of Serbia's historical and wine traditions.

Serbia consists three regions: of Central Serbia, Vojvodina Kosovo, and Metohija. Within them, there are 22 wine-growing regions, which include 77 vineyards.

The Central Serbia region has 13 regions, 55 vineyards and the following 10 wine routes: Šumadija, Pomoravlje, Župa, Toplica, Leksovac, Vranje, Niš-Knjaževac, Negotinska krajina, Pocerina-Valjevo, Belgrade, Podunavlje.

The Vojvodina region has seven regions, 15 vineyards and five wine routes: Srem-Fruška gora, Bačka, Subotica, Vršac, Banat.

The Kosovo and Metohija region has two districts, seven vineyards, and two wine routes: Northern Metohija and Southern Metohija. In the wine regions of rural areas, especially in developed countries, tourism is highlighted as a product of rural tourism. Most wineries in Serbia are also trying to innovate by introducing new technologies and attractions into wine tourism. The wine tourism offer can be considered a complementary element of the tourist offer. Serbia has the potential to develop wine districts as attractive tourist destinations; most of these areas are in the zone of poor potential share of 46.88%. The areas of wine districts with good potential make up only 1.10% and need to be further improved. (Jovanović et al., 2023, p. 245).

The advantages of rural tourism, and therefore wine tourism, relate to the preservation of numerous natural resources, rich cultural and historical heritage, the number and diligence of rural settlements, the richness of local traditions, traditional hospitality, and diversification of the tourist product. The disadvantages are inadequate rural infrastructure, an "archaic" tourist product, an underdeveloped information system, an unsatisfactory level of quality of mixing and other services, a lack of training programs for farmers to ensure adequate quality of services, a lack of experience, a lack of motivation, and an underdeveloped awareness in rural areas of the economic and other benefits of the development of rural tourism. (Vuković, 2017, 55-56).

Development of wine tourism in rural areas

More reasonable familiarization of all those involved in agricultural production with this is significant and productive for the development of wine tourism. Rural areas of Serbia must respond to the many challenges that await it on its path to the EU. Therefore, a reform of the agricultural policy in Serbia should be implemented by including technical-technological and environmental standards. Agrarian reform should enable the creation of modern farm producers and entrepreneurs who would be competitive and equal with the same in the European Union.

Perhaps a solution for domestic agricultural producers who want to develop wine tourism would be their joint organization in the form of cooperatives or other associations of agricultural producers, all to make it easier to place their households on the tourist services market. Currently, cooperatives in Serbia are practical organizations. Most cooperatives in the modern way of doing business tend to think about fulfilling their current obligations. This way of thinking influences the cooperative movement to see the way forward. Today, the cooperative movement is introduced towards pragmatic turning off, reacting to given opportunities to adapt to changes. (Simonović et al., 2016, p. 275-293).

The development of rural tourism in Serbia should be organized on a sustainable basis. The sustainable development of rural tourism means development that meets the needs of current tourists while preserving the natural, social, cultural, and anthropogenic values of a tourist destination, but also enabling future generations to continue using these resources at the same, and if possible, at a higher level. Sustainable development of rural tourism has a significant impact on the development of agriculture, given that these activities are interconnected. The considering importance of the sustainable development of rural tourism and the large number of stakeholders participating, the Republic of Serbia must adopt a Rural Tourism Development Strategy based on the current Tourism Development Strategy and the Master Plan for the Sustainable Development of Rural Tourism. Development and successful operation of each rural area are significant to creating a Strategy development of rural tourism. The strategy should clearly define the mission, vision, and goal, as well as the necessary steps for the development and progress of rural tourism in that area. (Njegovan et al., 2015, p. 53). We believe that at this stage of the development of winemaking in Serbia, it is necessary to create a strategy that would relate to the development of wine tourism.

It is also necessary to develop a concept for managing the sustainable development of rural and wine tourism, the framework of which is in the Master Plan for the Sustainable Development of Rural Tourism in the Republic of Serbia. Specifically, the Master Plan should define the management obligations for each of the proposed clusters with all significant functions, i.e., planning, organizing, decision-making, and control. In Serbia, the proposed management concept should enable the transformation of comparative advantages (the potential for rural and wine tourism) into competitive ones in both the domestic and international tourist markets. In particular, attention should be to the quality of accommodation and food services and the offers of tourist content and tourist products. Among the above functions, the most complex is the function of the organization, through which the work of several direct and indirect subjects participating in the development of rural tourism in the territory of the Republic of Serbia should be coordinated. Also, territorial, structural, and functional connectivity and cooperation of all relevant participants are necessary. Sustainable development of rural, though also wine tourism, is a continuous process that requires constant monitoring, i.e., control, and taking the necessary corrective or preventive measures. (Košić et al., 2013, p. 231-241).

On the potential opportunities for the development of gastronomic and wine rural tourism

Gastronomic and wine tourism has emerged as an area of interest in tourism studies, especially in rural regions. (Hall et al., 2001, p. 307-329). Food at a gastronomic event served as the strongest predictor of brand equity. The exception is the impact of event content, which destination image. Food at a gastronomic event has a forceful impact on destination loyalty. This suggests that this is the most significant component of attraction and repeat visits. (Čavić et al., 2023, p. 43). Part of this interest is connections to the increased awareness of the cultural importance of food in everyday life. Writing about wine and gastronomic tourism has also contributed to this interest, along with the measures taken in parallel by rural areas to innovate and diversify their rural tourism base. Since the early 1970s, rural regions in industrialized countries have been significantly affected by successive rounds of economic restructuring within the new globalized economy and society. In response to the abolition or privatization of government-provided services, the changed access regime to “traditional” markets, and the removal of tariffs and regional support mechanisms, rural areas have sought to diversify their economic base, with new agricultural products and tourism being two responses. Food tourism strategies are a significant instrument of regional development, in particular, because of the potential leverage between products from the two sectors. (Hall et al., 2003, p. 22-59).

In the increasingly competitive world of tourism, each region is constantly searching for a unique product that would differentiate itself from the products of competition. Local gastronomy and food are unique to a particular destination of the resources whose characteristics can be used to attract more visitors.

The focus of wine and gastronomic tourism is on new product development at the company and regional levels. For example, specialized products offer the possibility of growth through services to visitors in village tours, direct purchases from the farm, specialized restaurant menus with an emphasis on local food, and homestays on such estates. (Bessière, 1998, 21-34). Indeed, in these circumstances, the interest of visitors, i.e., tourists, in local products can also serve to stimulate local awareness and interest and help not only in diversifying and maintaining plant and animal diversity but can also encourage community pride in strengthening local identity and culture. Therefore, some agencies and stakeholders see wine and food tourism as an important element in provincial economic development strategies due to the potential relationships between different industrial sectors, thus ensuring the long-term circulation of money in local economies and the development of new added value. (Hall, 2005).

Therefore, each region has authentic agricultural and food products, dishes, and wines that may be of interest to foreign tourists. These products are the fruit of producers who produce high-quality products with a protected brand based on traditional technologies and their raw materials, such as dairy and meat products, freshwater fish, compotes, candied fruits, fruit teas, natural fruit juices, select fruit brandies, grape products, primarily and indigenous wines, grape juices with added natural fruit aromas, products from various types of vegetables produced by hot and cold processing. (Simonović et al., 2024, p. 125).

Then, authentic agricultural and food products can also include products from manufacturers engaged in the production and processing of "ecological" products, i.e., healthy food and other products such as wholemeal flour and baked goods made from them, grainy "instant food" made from cereals with various additives such as dried fruit, honey, walnuts, hazelnuts, almonds, etc., natural honey and honey products, teas, medicinal herbs, etc.

When it comes to authentic agricultural and food products, it is worth mentioning the production of chicken eggs, broilers, the production of yeast, early fruits and vegetables in a protected area, special types of confectionery products, the production and processing of mushrooms, chickens, pheasant game and the breeding of other game, e.g. fallow deer for hunting tourism purposes, production and processing of snails and frogs, collection and processing of forest fruits such as boletus and chanterelles, and breeding and processing of fattening horses. (Maletić et al., 2011, p. 121-131). It is precisely the production of these products and their placement in the tourism market that can influence the development of underdeveloped regions in the country. (Kalenjuk et al., 2012, p. 136-146).

Conclusion

Serbia has significant natural and social resources that can contribute to the development of rural and wine tourism. Numerous existing tourist products such as farms, ethno-houses, wineries, wine fairs, and events provide tourists with a unique experience. However, despite all the predispositions, rural and wine tourism in Serbia still does not have an adequate position on the market.

For rural and wine tourism to develop further, the active involvement of social, political, and other institutions and individuals is necessary. Also, for adequate valuation of cultural and historical heritage, efforts should be increased to restore numerous sites and buildings, which requires the community to its area, customs, and heritage. The development of rural and wine tourism in Serbia must be on the principles of sustainable development. If a tourist destination decides to use rural and wine tourism as a development basis it must carefully plan and manage that will not only meet the needs of tourists but also ensure the sustainable development of the local community.

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SECTION IV

DIGITALIZATION IN AGRICULTURE

THE POLITICS OF DIGITAL AGRICULTURAL TECHNOLOGIES: A PRELIMINARY REVIEW

Alexandra Mîț, Lorena Cristina Pîrvu[1]

Abstract

From farm to fork, digital technologies are being created and embraced throughout the agro-food system. Yet, political considerations brought about by these technological advancements are not given much thought in decision-making settings. This paper examines new technologies and big data systems in agriculture and evaluates some of the major problems that are emerging in the industry by drawing on critical social sciences. After providing an overview and introduction to the so-called „digital revolution," we quickly discuss how political economy might be used to comprehend the main issues facing the regulation of agricultural technologies and data systems. Data ownership and control, technology development and manufacturing, and data security are some of these issues. Then, using examples and literature, we examine how much the political and economic environment.

Key words: *digital revolution, agri-food system.*

Introduction

Environmental challenges, such as climate change and water scarcity, are expected to complicate and increase the costs of food production in the future. Experts believe that sustainably producing enough healthy food will be one of the century's most significant challenges. One proposed solution is "digital agriculture," defined as the integration of big data and precision technologies in farming. This digital revolution aims to produce food more efficiently, using less land and resources. Emerging technologies like yield monitors, GPS systems, and variable rate application help farmers customize their practices by collecting biophysical and production data. Despite growing interest in the ethical and social implications of big data, research specifically addressing its impact on agriculture remains limited. Current discussions primarily

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focus on scientific and economic dimensions, with emerging concerns about power inequalities in the food system. A comprehensive review of the political economy of agricultural digitalization is lacking, and some critical scholarship suggests that these technologies may not provide significant benefits, advocating instead for agroecological solutions to transform the food system.

Material and metods

This review article examines the relationship between digitalization and agroecology, addressing concerns about corporate concentration in ag-tech. The authors argue that digital technologies can coexist with agroecological practices, potentially benefiting both large-scale and small-scale farmers. Using a political economy framework, the article explores the power dynamics at play in agricultural technology adoption, assessing who gains and who loses from these advancements. The review is structured into three main areas: defining the political economy lens and current trends in digital agriculture; analyzing key issues such as data ownership, technology production, and data security; and considering how digital technologies can evolve in a more equitable manner.

By situating the discussion within a broader political context, the article highlights underexplored issues in the field. Methodologically, it draws on insights from an interdisciplinary workshop and a systematic literature review, contributing a vital perspective to the intersection of food studies and big data, and advocating for equitable agricultural technology development. The literature on digital agriculture predominantly spans from 2010 to 2018 and includes white papers and selected media articles. The research team categorized readings into broad fields: agriculture 4.0, data governance, and precision agriculture. Agriculture 4.0 defines digital agriculture, while the other fields address data challenges and precision tools for data collection. Key themes identified included data ownership and control, technology production and data development, and data security.

The political economy dimensions emerged as a significant gap in the literature. Digital agriculture involves various technologies, such as sensors and intelligent machinery that collect real-time data. For instance, smart tractors can utilize GPS and algorithms to optimize planting and fertilization, minimizing pollution and crop loss. Automatic milking systems are also becoming prevalent, particularly in North America, enhancing dairy farm productivity and cow health while reducing resource inputs. These technologies have led to improved animal health and lower environmental impact. The uptake of precision agriculture is growing globally, with significant advancements observed in countries like the Netherlands, where precision techniques manage a substantial portion of arable land. At the herd scale, advanced technologies such as sensors, microfluidics, sound analysis, and biosensors are increasingly used to monitor animal health, detecting environmental risks and physiological changes that may signal disease.

For example, sound analysis helps identify respiratory diseases in pigs and stress in laying hens, while biosensors facilitate early disease detection in livestock. Big data enhances veterinary epidemiology by targeting high-risk populations for surveillance, supported by mandatory animal traceability programs in many countries. These technologies have attracted significant interest from companies, policymakers, and investors due to their potential profitability. For instance, Canada and the UK have recommended investing in agro-food innovation, and global investments in agricultural technologies have surged. The precision agriculture market is projected to exceed $10 billion by 2025.

However, the actual benefits for farmers remain unclear. Many are skeptical about the value of these expensive technologies, especially given their lack of control over crop prices, which raises affordability concerns. Additionally, the digital divide between technologically advanced and less advanced farmers may exacerbate economic inequalities, particularly affecting small- and medium-sized farms. Even for those adopting these technologies, challenges around data access, management, and analysis persist. The political economy framework helps analyze changes in agriculture, particularly in understanding the power dynamics among agriculturalists, agribusinesses, the state, and other institutions. This lens allows for an examination of how digital agricultural technologies are influencing these relationships and the motivations behind their development.

Key issues, such as data ownership, technology development, and cybersecurity, highlight the political nature of digital agriculture and its implications for power relations in the agro-food system. The digitalization of farming is seen as a significant shift, comparable to the Green Revolution. This transition has been driven by increasing corporate power, leading to higher on-farm costs and stagnant commodity prices. Consequently, many farmers in North America and Europe have had to either expand production or exit the industry, resulting in fewer, larger farms and a decline in rural communities. The review questions whether digital agricultural technologies continue historical trends of market integration and corporate concentration, which could further exacerbate the income crisis for farmers and marginalize small and agroecological farmers.

This ongoing process of "elite capture" suggests that powerful actors are more likely to benefit from these technologies, raising concerns about equity and sustainability in agricultural practices. Market integration, exclusion, concentration, and elite capture are ongoing issues in agriculture, but new digital technologies introduce unique economic factors that influence these dynamics across various agro-food sectors. For example, expensive technologies like precision tractors pose risks for farmers in volatile markets. In contrast, the Canadian dairy sector benefits from supply management, stabilizing prices and enabling farmers to adopt costly technologies like automatic milking systems more sustainably.

Results and discussions

The average herd size in Canada allows for effective use of such technologies, unlike larger herd sizes in the U.S. However, while the promise of increased profitability and labor savings may motivate farmers to adopt digital technologies, challenges such as rising farm debt and concerns about technology applicability complicate this process. Smaller-scale farmers face significant barriers due to asset constraints, limiting their access to the necessary infrastructure and resources for digital agriculture.

The article identifies three key issues in digital agriculture shaped by political and economic forces: data ownership and control, technology production and data development, and data security. These issues highlight the concentration of corporate power, as major corporations dominate the agricultural input market, developing technologies primarily for large-scale, capital-rich farmers. This concentration impacts farmers of all sizes, as well as farm laborers and food workers. Addressing these dimensions is crucial for promoting a more equitable and sustainable development of digital technologies in agriculture.

Data ownership and control are central to the digital agricultural revolution, as data collection drives management decisions across the sector. Various stakeholders—including private companies and agencies—collect and process data in different forms, leading to disparities in empowerment among them. Farmers face substantial costs and risks when adopting new technologies in agriculture, with benefits often favoring corporate developers over farmers themselves. The current political and economic climate tends to minimize the benefits of ag-tech advancements for farmers, particularly those practicing agroecology.

Ag-tech companies profit from data and equipment sales, exploiting agricultural data to develop products prescribed to farmers rather than collaborating with them. Open-source models of digital agriculture could empower farmers by granting them ownership of their technology and data, leading to financial independence and control. However, challenges such as cybersecurity threats and corporate dominance persist. Policies promoting scale-appropriate technologies and community-based food systems are emerging, but significant work is needed to prioritize small and agroecological farmers in the digital age. Addressing broader political and economic structures reinforcing corporate control is essential, even as open data platforms offer improved access and control over digital farm equipment components.

Technical interoperability challenges are concerning in rural areas with limited infrastructure, affecting the sustainability of communities amid digitalization. Data integrity discussions often exclude broader conversations on control and ownership. Farmers and consumers should shape regulations on data management. Data justice involves fair treatment of individuals regarding digital data. Corporate consolidation limits farmers' access to and control over their data, impacting smaller farms disproportionately. The dominance of large-scale industrial operations in digital technologies marginalizes smaller producers. Agroecological producers are underrepresented in agricultural data development. Farmer-driven digitalization is crucial for data justice and societal fairness. More research is needed to address the impact of big data on vulnerable populations in agriculture. Bottom-up, locally oriented digitalization can support fair agricultural practices and justice discussions within society. Continuing dialogue and investigation are key to integrating fairness and social justice into digital agricultural practices.

Conclusion

In the coming generation, we face a major challenge: how to feed a growing population sustainably, safely, and nutritiously while tackling significant environmental issues such as climate change and water scarcity. Although technology can play a role, many of the proposed technological solutions tend to empower corporate entities rather than support independent farmers in making informed decisions about the agroecological systems they manage. The current trajectory of agricultural technology may deepen inequalities among marginalized food system participants, particularly between farmers of different sizes and between farmers and agro-food corporations.

This article examines the political economy of digital agriculture, focusing on three critical challenges in the sector: data ownership and control, the production of technologies and data development, and data (cyber) security. Our exploration of these challenges is not exhaustive; rather, it aims to highlight and clarify some of the most pressing political economic issues within the sector for a diverse audience of decision-makers and scholars. We underscore the importance of open, cooperative, publicly funded, and locally relevant technology and data systems as initial steps toward promoting data justice for farmers.

However, we also acknowledge that larger political economic barriers in agriculture limit the potential for digitalization to serve the interests of marginalized farmers and food producers. Therefore, substantial scholarly and practical efforts are needed to better understand what data justice means for the agricultural community and how it can be achieved in the future.

Acknowledgments

This research was partially conducted as a result of the Erasmus+ mobility of Mîț Alexandra and Pîrvu Lorena Cristina at the Institute of Agricultural Economics, Belgrade, Serbia. The mobility took place from December 8, 2024, to December 14, 2024.

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FORMS OF ENTREPRENEURIAL EXPRESSION IN INTERNATIONALIZED AGRIFOOD MARKETS

Alexandra-Ștefania Ilie[1], *Răzvan-Ștefan Nițu*[2]

Abstract

How does the international environment influence the efficiency and global economic performance of a business, and what are the strategies for maximizing it? The topic, refers to the research and understanding of the various ways entrepreneurs conduct their activities and adjust their strategies to successfully operate in global markets. This process is based on the discovery of business opportunities outside the country, the development and implementation of entry strategies into foreign markets, modifying products or services to meet local demands and preferences, managing the risks specific to the international environment, and establishing relationships with certain partners and clients from different countries. The research objective is to investigate and understand the success factors, effective strategies, and the impact of the international environment on entrepreneurial expression. In conclusion, to maximize global economic performance, businesses must effectively manage regulations, currency fluctuations, cultural differences, and political risks through diversification, hedging, local adaptation, and innovation.

Key words: *internationalization, agrifood entrepreneurship, sustainability, digital platforms, global agribusiness.*

Introduction

In the current era of globalization, the international environment significantly impacts the efficiency and economic performance of businesses operating on a global scale. Entrepreneurs and companies are continuously seeking ways to navigate the complexities of foreign markets, requiring a deep understanding of various external factors that influence their operations. This research to examine and comprehend the key factors driving success, the most effective

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strategies, and the influence of the international environment on entrepreneurial activities and decision-making.

To succeed, entrepreneurs must first recognize and evaluate potential business opportunities outside their domestic markets. This involves conducting comprehensive market analyses to identify regions with favorable economic conditions, emerging demand, and potential competitive advantages. Once opportunities are identified, businesses must develop and implement tailored market entry strategies, which can range from exporting and franchising to establishing joint ventures or wholly-owned subsidiaries. The choice of strategy is influenced by factors such as market size, trade regulations, political stability, and local competition.

Entrepreneurs must modify their offerings to align with the unique demands of each market, whether through design alterations, product localization, or adapting marketing strategies to reflect local norms and values. Failure to consider these differences can lead to misalignment with consumer expectations and, ultimately, business failure.

Moreover, businesses operating internationally face a variety of risks specific to the global environment. These include economic fluctuations, exchange rate volatility, regulatory changes, and political instability. Effective risk management strategies, such as currency hedging, diversification of investments, and political risk insurance, are essential to safeguarding business operations. Entrepreneurs must also navigate complex regulatory frameworks, ensuring compliance with local laws and trade policies to avoid legal and financial repercussions.

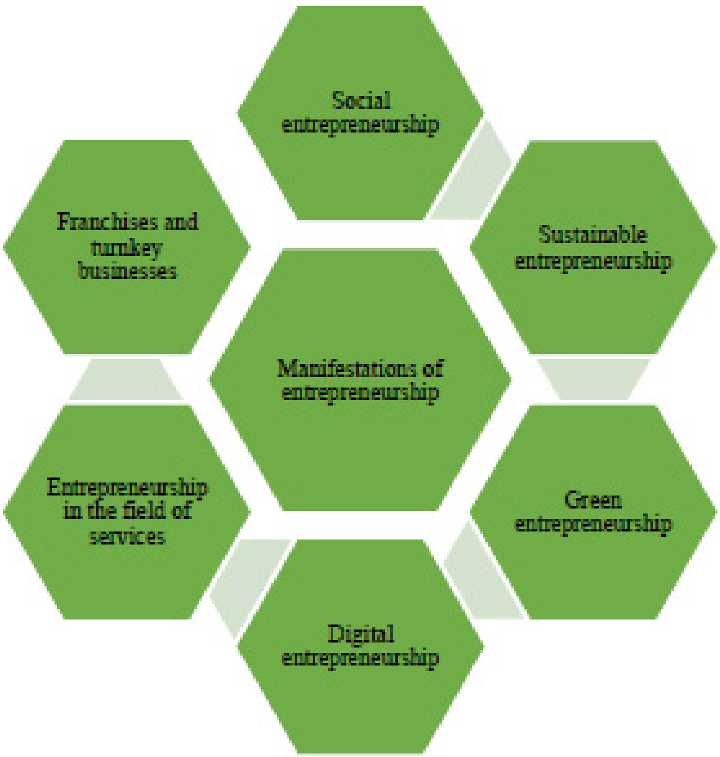
The research aims to investigate the key success factors and strategies that enable businesses to maximize their global economic performance. It explores how companies can overcome the challenges of operating in diverse and unpredictable international environments. Ultimately, businesses that effectively manage regulations, currency fluctuations, cultural differences, and political risks through diversification, hedging, local adaptation, and innovation are more likely to achieve sustained success in the global market. Understanding and mastering these strategies is vital for entrepreneurs looking to thrive in an increasingly interconnected and competitive global economy.

Business models – Conceptual and practical approaches

Entrepreneurship is the process through which a business opportunity is identified and pursued, allowing entrepreneurs or companies to transform ideas into profitable products or services (Gartner, 2004). Different forms of entrepreneurial activity highlight the creativity and problem-solving abilities of entrepreneurs in addressing modern challenges and seizing business opportunities (Nicholls,A.,010). These forms include social entrepreneurship, service-based ventures, franchising and turnkey businesses, digital entrepreneurship, as well as green and sustainable entrepreneurship.

The concept of a "business model" refers to the strategic approach a company uses to organize, acquire, and manage its economic, social, and operational aspects. This concept is widely applied in organizational management to offer a structured way of understanding and evaluating how a business functions (C.M. DaSilva, P. Trkman, 2014).

Table 1. *Trends in entrepreneurial expression*



Source: *Personal conceptualization*

Comparative study on international business models

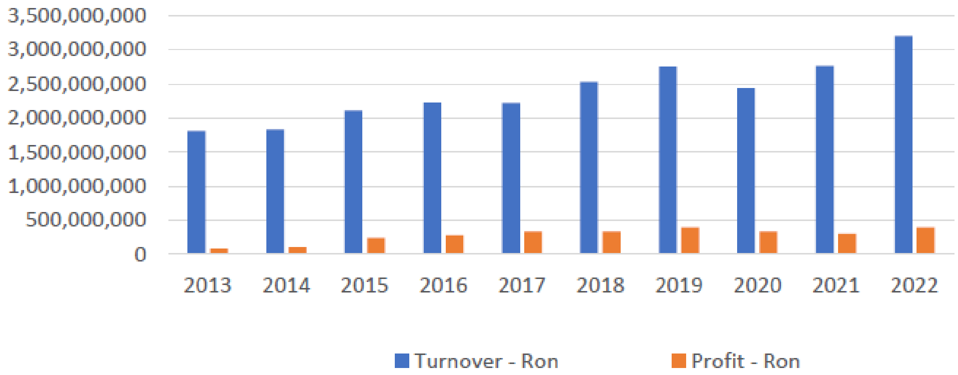
American models

The business model in the United States promotes innovation and entrepreneurship through accessible resources, mentoring programs and diverse financing options, backed by flexible regulations that facilitate market entry.

The Coca-Cola Company

The Coca-Cola Company is an American multinational corporation founded in 1892, known for producing the Coca-Cola beverage. In addition to Coca-Cola, the company markets and promotes a variety of non-alcoholic beverages, syrups, and alcoholic drinks. Its shares are listed on the New York Stock Exchange (NYSE) and are part of the DJIA, S&P 500, and S&P 100 indices.

Table 2. *Charting net profit and turnover*



Source: *own interpretation of data from RisCo and Listafirme websites*

Turnover grew significantly between 2013 and 2022, by an annual average of 5%. Net profit grew faster than, averaging 7% annually.

Table 3. *SWOT Analysis*

Strengths	Weaknesses
• It is one of the most recognized brands • Diversity of product portfolio • Extensive global distribution	• Negative environmental and health impacts • Addiction to carbonated drinks
Opportunities • Product diversification • Expansion into emerging markets • Packaging innovation	**Threats** • Competition • Changes in consumer preferences

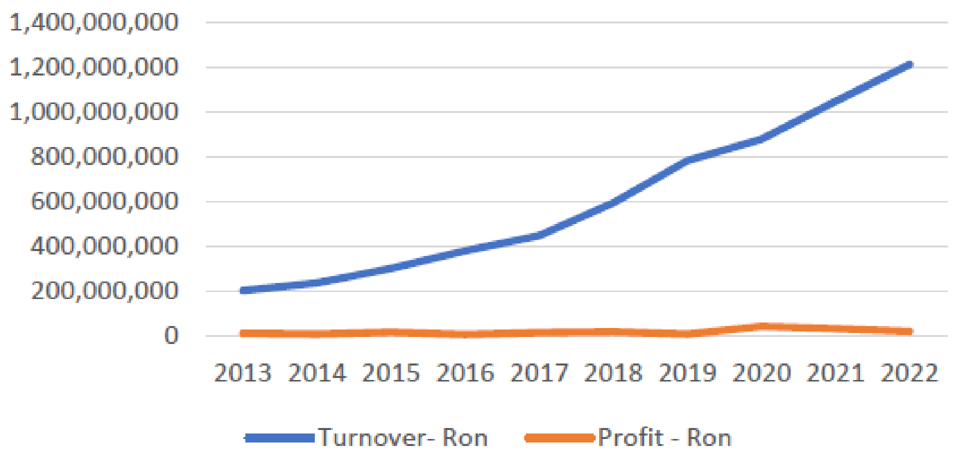
European models

In Europe, work-life balance is promoted through paid leave and flexible schedules, and companies adopt sustainable and socially responsible policies, stimulating innovation and economic development through public-private partnerships.

Ferrero SpA

Ferrero is an Italian company, founded in 1946 by Pietro Ferrero, specializing in chocolate and sweet products. Still owned and managed by the Ferrero family, it has become a key player in the global confectionery industry, known for its quality and innovation.

Table 4. *Charting net profit and turnover*



Source: *own interpretation of data from RisCo and Listafirme websites*

Between 2013 and 2022, Ferrero's turnover grew steadily at an annual average of around 4%, reaching over RON 800 million in 2022. Net profit has averaged annual growth of around 6%, reflecting a stable and positive long-term financial performance.

Table 5- *SWOT Analysis*

Strengths ● Strong brand image ● Product innovation ● Geographical diversification	**Weaknesses** ● Brand addiction
Opportunities ● Expanding the product range ● Innovation in ingredients and packaging	**Threats** ● Price ● Competition

Asian models

Asian businesses prioritize long-term strategies, sustainable development and strong business relationships, emphasizing a conservative and prudent approach to stable growth, while family businesses, whether small or multinational, often remain owned and controlled by a single family or group of families, playing a central role in the regional economy.

Want Want China Holdings Limited

Want Want China Holdings Limited is a leading Chinese food company, specializing in dairy products, snacks, and beverages. Founded in 1962 and based in Taiwan, it has grown significantly over the years, becoming a major player in the Asia-Pacific food industry. Want Want is well-known in China and other Asian markets for its high-quality products and aggressive marketing strategies.

Table 6. *SWOT Analysis*

Strengths ● Various products ● Innovation and adaptability	**Weaknesses** ● Dependence on Chinese market
Opportunities ● Innovation and product development	**Threats** ● Price ● Competition

Romanian forms of entrepreneurial expression

Entrepreneurship began with the economic activities of the church and merchants in the Middle Ages, characterized by opportunity assessment, risk-taking and innovation.

After the 1989 Revolution, the private sector in Romania started to develop, favored by the legislative framework and the needs of the population for consumer goods.

Romania's accession to the European Union in 2007 brought a stable legislative framework and financial support from EU funds, facilitating innovation and business development.

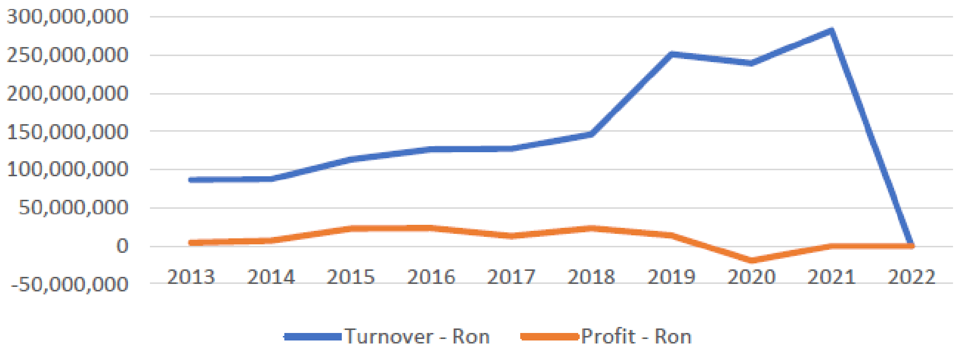
Unstable government policies, bureaucracy, poor infrastructure, limited entrepreneurship education and limited access to finance represent significant challenges for Romanian entrepreneurs.

Low operating costs, a talented workforce, financial support from government and EU funds, and potential in sectors such as technology, tourism, agriculture and e-commerce offer favorable prospects for entrepreneurs.

Betty Ice's innovative business model

Betty Ice was founded in 1991 by Vasile Armean, who returned to Romania after gaining experience in the gelato business in Austria. With initial support from an Austrian supplier, he quickly established a successful ice cream venture in Suceava. Over time, he shifted from small-scale production to an industrial model, co-founding Betty&Cris in 1994. By 1998, he became the sole owner and renamed the company Betty Ice. The company has since experienced rapid growth and is now a leading ice cream producer in Romania, competing with major brands like Nestlé.

Table 7- *Graphic representation of turnover and net profit from 2012 to 2022*



Source: *own interpretation of data from RisCo and Listafirme websites*

The company's turnover has increased during the analyzed years with a growth rate of about 3%. We can observe a significant growth in the period 2018-2021. Similar to the turnover, the growth in net profit was steady until 2020 where it showed a small loss.

Conclusions

In conclusion, the international environment significantly impacts the efficiency and global economic performance of businesses, making it essential for entrepreneurs to adopt strategic and informed approaches. Successful internationalization begins with identifying viable business opportunities beyond domestic borders, supported by thorough market analysis to understand regional demands and competitive advantages.

Entrepreneurs must adapt their products and services to meet local preferences, employing tailored market entry strategies such as exporting, franchising, or forming joint ventures. Additionally, effective risk management is crucial due to the economic volatility, exchange rate fluctuations, and political uncertainties encountered in global markets. Strategies like currency hedging and diversification are vital for safeguarding operations.

The research highlights the importance of understanding diverse business models across regions, which reflect different cultural, economic, and social dynamics. For instance, American models prioritize innovation, European models emphasize sustainability, and Asian models focus on long-term relationships. In Romania, the entrepreneurial landscape has evolved significantly since 1989, benefitting from EU support and a favorable legislative framework. However, challenges like bureaucracy and limited access to finance remain. Opportunities in sectors like technology, agriculture, and e-commerce present avenues for growth.

Ultimately, effectively navigating the international business environment and implementing adaptive strategies are critical for enhancing global economic performance. By leveraging insights from various business models and fostering innovation, companies can achieve sustained success in a competitive global economy.

Acknowledgments

This research was partially conducted as a result of the Erasmus+ mobility of Ilie Alexandra-Ștefania and Nițu Răzvan-Ștefan at the Institute of Agricultural Economics, Belgrade, Serbia. The mobility took place from December 8, 2024, to December 14, 2024.

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COMPARATIVE BIBLIOMETRIC INSIGHTS: SUSTAINABILITY RESEARCH IN SERBIA AND ROMANIA

Cristiana-Adriana Dragodan[1] *Irina Puiu*[2]

Abstract

This study aims to evaluate the current state of sustainability research, highlighting trends, key terms, and their interconnections while identifying potential gaps in the scientific literature. A comparative analysis between Romania and Serbia is conducted to assess the level of research development in both countries. Data was retrieved from the Web of Science database using the keyword „sustainability," resulting in 505,154 records globally, of which 6,455 pertain to Romania and 2,094 to Serbia. Specific filters, detailed in the methodology, narrowed the dataset to 2,000 entries, including the most cited articles. A bibliometric analysis was performed using VOSviewer software, providing insights into publication trends, collaboration networks, and research impact in sustainability.

Key words: *sustainability, bibliometric analysis, comparison, scientific literature, Serbia, Romania.*

Introduction

This paper aims to evaluate the current state of sustainability research, highlighting the main trends, themes, and connections within the scientific literature, as well as identifying existing gaps. The comparative analysis between Romania and Serbia provides a detailed perspective on scientific contributions in this field, emphasizing differences in terms of international and interdisciplinary collaborations. In a global context where countries like the United States, China, and Germany lead sustainability research, the study highlights the efforts of the Balkan region to align national priorities with global challenges such as climate change and resource management.

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Focusing on a bibliometric analysis of data from **Web of Science** and using the **VOSviewer** software, the article explores collaboration networks, academic impact, and the evolution of specialized terms. By visualizing keyword clusters and collaboration patterns, the study identifies five distinct thematic clusters and key global trends. The results indicate a significant intensification of interest in sustainability, especially after 2010, and emphasize the complexity of this field, which requires transdisciplinary approaches and international cooperation.

Literature Review

Bibliometric analyses have become an essential tool in contemporary scientific literature due to their ability to process large volumes of data, provide interdisciplinary perspectives, and identify research trends (Ellili, 2024[1]; Khan et al., 2022[2]). Studies in the field of sustainability indicate a growing academic interest across diverse sectors, such as energy, agriculture, circular economy, biodiversity, and food security (Fito & van Hulle, 2021[3]; Yasmeen et al., 2022[4]).

The literature emphasizes the relevance of sustainability in ecology, economics, and management, highlighting the need for interdisciplinary approaches (Bettencourt & Kaur, 2011)[5]. Recent studies have highlighted the importance of corporate sustainability, financial performance, and ecological strategies in various industries (Zaharia et al., 2019[6]; Kates et al., 2001[7]). Highlighting interdisciplinary interest, tools such as VOSviewer have identified gaps in the literature, supporting the development of more detailed future research.

In Romania, recent studies have focused on the impact of climate change on agricultural structures (Stoian et al., 2023)[9], the promotion of sustainable agriculture (Ion, R., 2011)[10], and the analysis of the relationship between ESG practices and the financial performance of firms in the energy sector (Hurduzeu, G., 2022).[11]

Materials and Methods

The bibliometric analysis was conducted using the **Web of Science** database, which provided a total of 505,154 global publications associated with the term “sustainability” for the period 1977–2024. Romania contributed 6,455 articles (1995–2024), while Serbia had 2,094 articles (2003–2024). A subset of the 2,000 most cited articles was selected for detailed analysis, including the visualization of collaboration networks and thematic clusters, offering an interdisciplinary perspective on sustainability research.

The **VOSviewer** tool was used to generate graphical representations of keyword connections, identifying five major thematic clusters, such as renewable energy, biodiversity, and circular economy, further emphasizing the interconnectedness of this field.

The methodology presents several significant limitations. The exclusive use of the **Web of Science** database may exclude relevant research available in other sources, such as Scopus or Google Scholar. Focusing solely on the most cited articles may reduce thematic diversity, limiting access to less commonly addressed but potentially important perspectives. The emphasis on the 2010–2024 period may overlook older but foundational contributions, while incomplete data for 2024 affects the interpretation of recent trends, which have influenced current research directions.

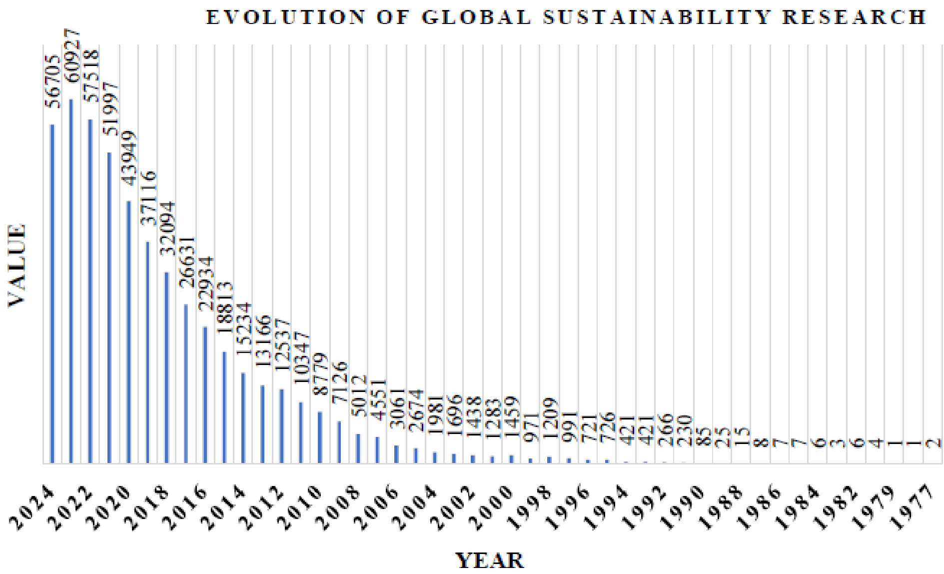
Results

The study highlights an upward trend in sustainability research, analyzing data from the Web of Science for the period 1977-2024. The term "sustainability" first appeared in 1977, with Romania and Serbia registering their first publications in 1995 and 2003, respectively, showing a notable increase in interest after 2007, when Romania joined the EU.

In the keyword analysis, five major clusters were identified: renewable energy, circular economy, biodiversity, corporate sustainability, and agriculture. Romania and Serbia reflect these themes, with differences in focus on renewable energy in Romania and climate change in Serbia.

International collaborations show a higher interest from Romania towards Germany and Poland, while Serbia collaborates more with countries from Southeastern Europe and Asia. In conclusion, the research trend is upward in both countries, but diversifying collaborations is essential for advancing sustainable solutions.

Figure 1. *The evolution of global research in sustainability*

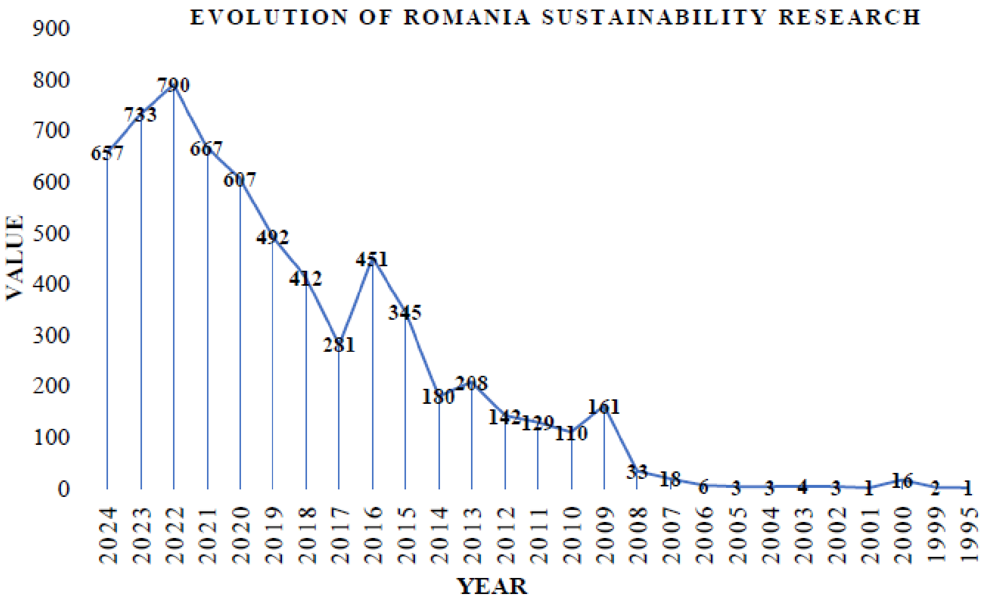


Source: *Authors' own conceptualization. The data were accessed on November 18, 2024, from the Web of Science platform.*

Based on the **Figure 1**, the evolution of sustainability research between 1977 and 2024 is depicted, totaling 505,154 articles. The keyword "sustainability" first appeared in the Web of Science in 1977, marking the start of documented research in this field. Notably, no articles were found for the year 1980.

Until 2010, growth was slow, with only 85 articles published in 1990 and 991 in 1997. Between 2004 and 2010, the number of publications grew rapidly, reaching 8,779 in 2010, driven by interest in circular economy and climate change. After 2010, research accelerated: 10,347 articles in 2011, 22,934 in 2016, and a peak of 60,927 publications in 2023. Key topics include circular economy, renewable energy, and climate change adaptation. In 2024, 56,705 articles have been recorded, though this number is partial due to incomplete data updates. This trend highlights the expansion of global research and the growing focus on sustainability.

Figure 2. *The evolution of research in Romania on sustainability*

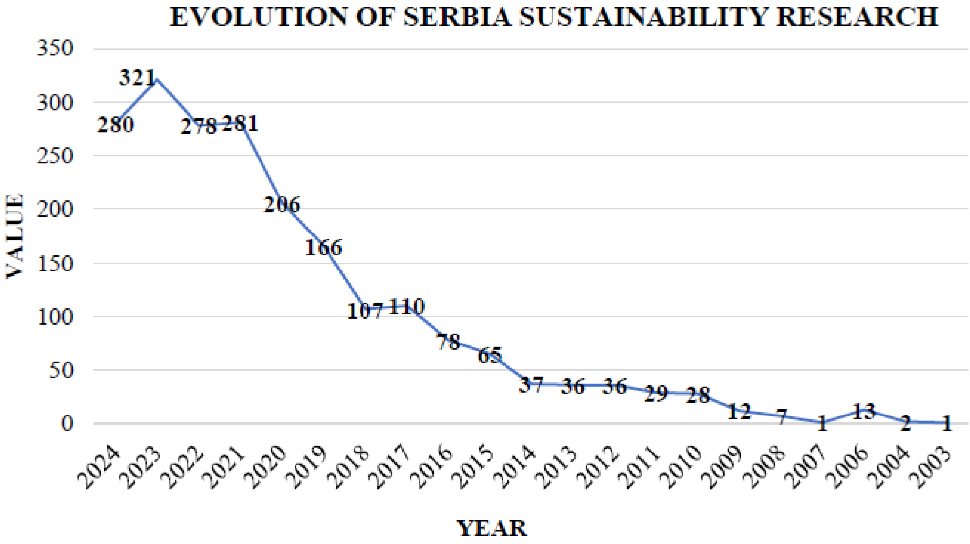


Source: *Authors' own conceptualization. The data were accessed on November 18, 2024, from the Web of Science platform.*

The graph highlights the evolution of publications from Romania with the keyword "sustainability" between 1995 and 2024, based on Web of Science, totaling 6,455 articles. The first publication appeared in 1995, and between 1995 and 2007, the number of articles grew slowly, reaching 18. Romania's accession to the European Union in 2007 accelerated research through access to funding and international collaborations. In 2010, the number of articles reached 110, and between 2010 and 2016, it grew significantly, reaching 451 publications due to participation in European projects such as Horizon 2020. Between 2016 and 2022, growth continued rapidly, culminating in 790 articles published in 2022.

For 2024, 657 articles have been recorded, but this figure is influenced by incomplete data updates. The trend reflects Romania's alignment with global tendencies and its commitment to sustainability research.

Figure 3. *The evolution of research in Serbia on sustainability*



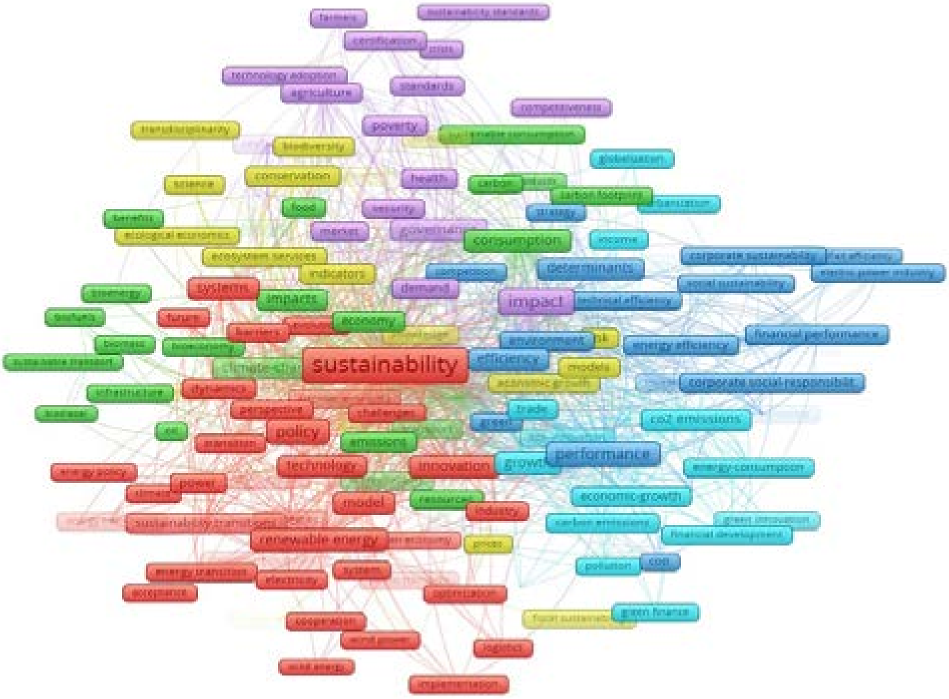
Source: *Authors' own conceptualization. The data were accessed on November 18, 2024, from the Web of Science platform.*

The graph shows the evolution of publications from Serbia in the field of sustainability between 2003 and 2024, according to Web of Science, totaling 2,094 articles. Research in this field has experienced significant growth, especially after 2010, despite Serbia not being a member of the European Union.

Between 2003 and 2009, the number of articles remained low, increasing from 1 article in 2003 to 13 in 2006 and 12 in 2009. This period reflects economic constraints and limited access to European funding, which restricted the development of research in this area. The period 2010–2016 marks moderate growth, with the number of articles rising from 28 in 2010 to 78 in 2016. This growth was supported by involvement in international projects that encouraged research in sustainability.

Between 2016 and 2023, there was accelerated growth, with 107 articles in 2018, 166 in 2019, and a peak of 321 in 2023. This progress reflects the adaptation of Serbian researchers to global themes such as renewable energy, circular economy, and sustainable agriculture. In 2024, 280 articles have been recorded, but this figure is influenced by incomplete data updates. This evolution highlights Serbia's increasing involvement in sustainability research, demonstrating a consistent commitment to this field on a global scale.

Figure 4. *Interdisciplinary insights into global sustainability research*



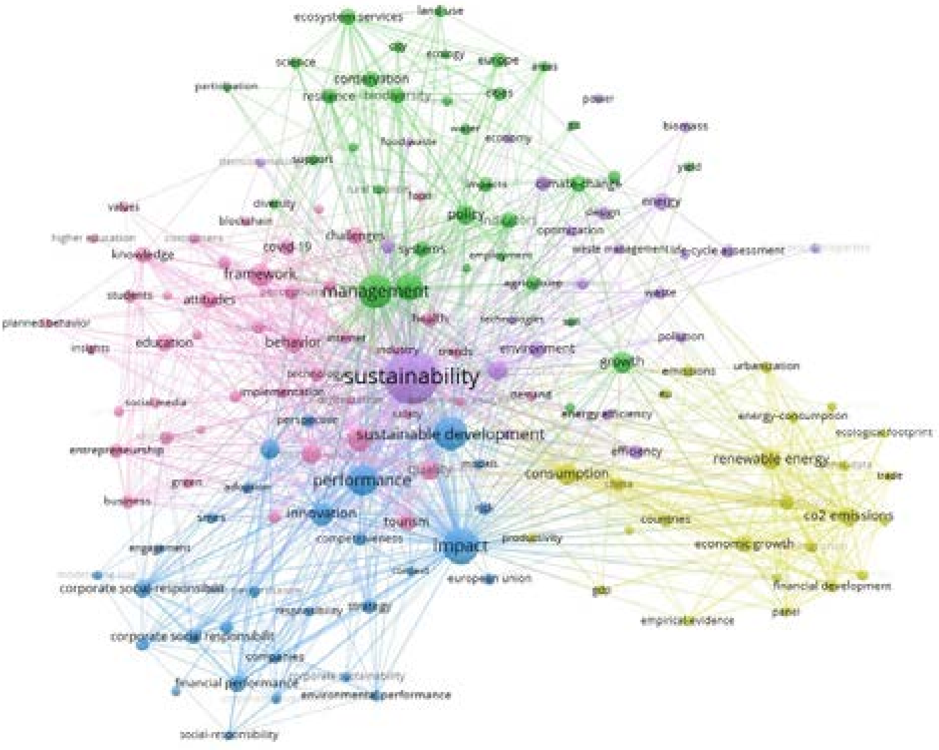
Source: *Authors' own conceptualization, using VOSviewer based on data retrieved from the Web of Science database as of November 18, 2024.*

This image illustrates an analysis of keywords associated with the term "sustainability," conducted using the VOSviewer software, based on 505,154 articles from the Web of Science database for the period 1977–2024. The keyword network analysis highlights five distinct thematic clusters that dominate international research in this field. For this analysis, only the top 2,000 most cited articles were selected.

The keyword network analysis for "sustainability" highlights five distinct thematic clusters. **The red cluster** focuses on "renewable energy," "policy," and "innovation," emphasizing energy transitions and technological innovations. **The green cluster** highlights the responsible use of natural resources and environmental conservation, with representative terms such as "impacts," "economy," and "resources." **The blue cluster** explores corporate sustainability and economic efficiency through concepts like "corporate sustainability," "efficiency," and "financial performance." **The yellow cluster** centers on biodiversity and ecosystem services, with terms such as "biodiversity" and "ecosystem services." Finally, **the purple cluster** addresses the role of agriculture and modern technologies in food security, with key terms including "agriculture," "technology adoption," and "security."

These clusters emphasize interdisciplinary collaboration and connections between fields such as energy, agriculture, economy, and environment. The dense interconnections between nodes reflect the complementarity of these subdomains, offering valuable insights into emerging trends and opportunities for collaboration in sustainability research.

Figura 5. *Interdisciplinary perspectives on sustainability research in Romania*



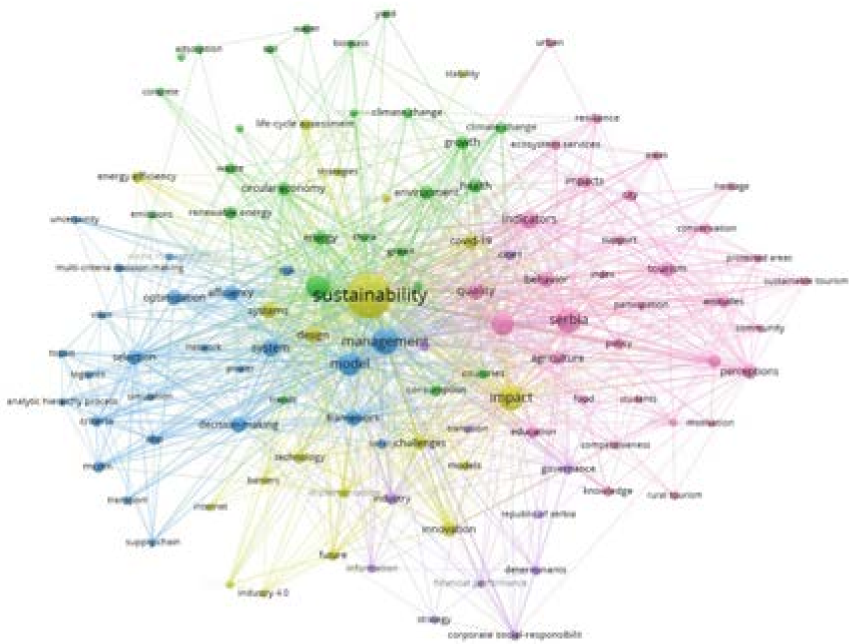
Source: *Authors' own conceptualization, using VOSviewer based on data retrieved from the Web of Science database as of November 18, 2024.*

This image presents a network of keywords associated with the term "sustainability," created using the VOSviewer software, based on the top 2,000 most cited articles selected from a total of 6,455 articles available in the Web of Science database for the period 1995–2024. The network highlights five distinct thematic clusters that reflect the main research directions in Romania.

The term “sustainability,” located at the center of the network, reflects the main research directions in Romania, with each color in the network representing a distinct theme, such as: **The green cluster** focuses on ecology and environmental protection, with terms such as “biodiversity,” “climate change,” and “agriculture,” emphasizing the importance of conserving natural resources. **The yellow cluster** explores the connections between energy and the economy, including terms such as “renewable energy” and “economic growth,” highlighting the transition to a low-carbon economy. **The blue cluster** analyzes corporate sustainability, with terms such as “corporate social responsibility” and “financial performance,” and their impact on the economy. **The purple cluster** emphasizes the role of education and behavioral changes, with terms such as “education” and “behavior.” **The pink cluster** focuses on resource management and waste reduction, including terms such as “waste management” and “biomass.”

These clusters highlight the interdisciplinary nature of research, shedding light on the connections between energy, economy, environment, and education, providing a clear perspective on priorities and opportunities for future research.

Figura 6. *Interdisciplinary perspectives on sustainability research in Serbia*



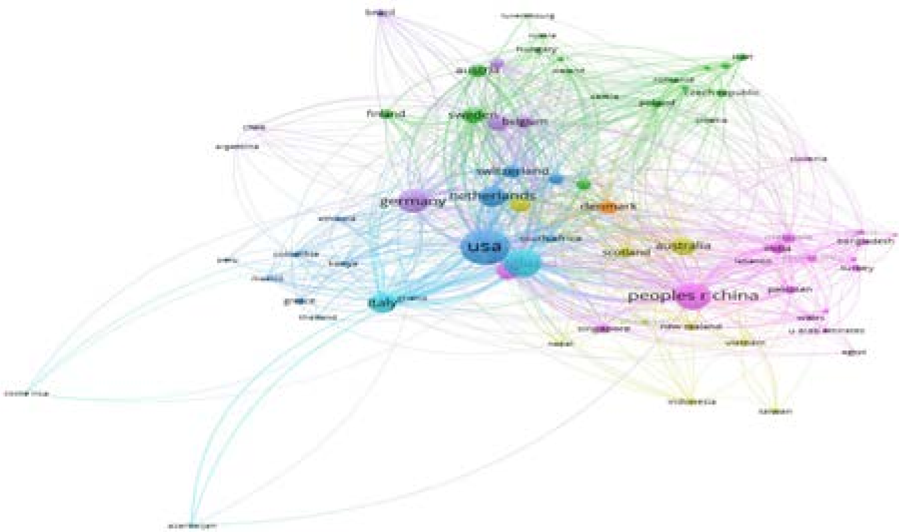
Source: *Authors’ own conceptualization, using VOSviewer based on data retrieved from the Web of Science database as of November 18, 2024.*

This image illustrates a network of keywords associated with the term “sustainability,” generated using the VOSviewer software, based on the top 2,000 most cited articles selected from a total of 2,094 articles available in Web of Science for the period 2003–2024. The network highlights the main research directions in Serbia, organized into distinct thematic clusters.

The term “sustainability,” located at the center of the network, reflects the main research directions in Serbia, with each color representing a distinct theme. **The green cluster** focuses on “climate change,” “ecosystem services,” and “energy,” highlighting biodiversity conservation and adaptation to climate change. **The blue cluster** analyzes “decision-making,” “efficiency,” and “supply chain,” focusing on resource and logistics optimization.**The yellow cluster** reflects “innovation,” “industry 4.0,” and “technology,” emphasizing the modernization of industrial processes. **The purple cluster** explores “corporate social responsibility,” “financial performance,” and “strategy,” highlighting the integration of sustainability into corporate strategies. **The pink cluster** centers on “education,” “knowledge,” and “students,” emphasizing the role of education in promoting sustainability.

This analysis highlights the interdisciplinary nature of sustainability research in Serbia and emphasizes collaborations across various fields to promote sustainable development.

Figura 7. *The global network of collaborations in sustainability research*



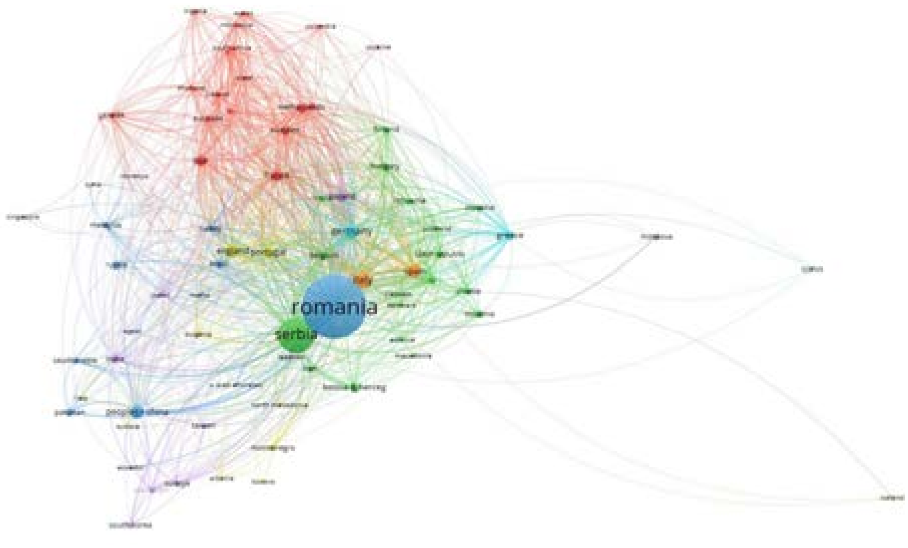
Source: *Authors’ own conceptualization, using VOSviewer based on data retrieved from the Web of Science database as of November 18, 2024.*

This image illustrates the global network of collaborations in sustainability research, based on data from VOSviewer software. The United States (USA) is the central node, with the highest number of connections to countries in Europe, China, and Australia, demonstrating its dominant role in international collaborations. China is also a significant hub, with extensive partnerships across Asia, Europe, and the Pacific.

Europe is well-represented, with Germany, the United Kingdom, and the Netherlands as key centers of influence, maintaining strong links with Eastern European countries (Romania, Poland) and Southern European countries (Italy, Greece). Australia has strong collaborations with countries in the Pacific region and major global powers, while Romania maintains significant regional partnerships, especially with Germany and Poland.

Countries in Latin America and Africa are less connected, with limited links to major research hubs. This global network highlights the central role of developed countries in fostering international collaborations, which are essential for advancing sustainability research and global solutions.

Figura 8. *Scientific collaboration between Romania and Serbia*



Source: *Authors' own conceptualization, using VOSviewer based on data retrieved from the Web of Science database as of November 18, 2024.*

This image highlights the network of scientific collaborations between Romania and Serbia in the field of sustainability, generated using the VOSviewer software. Romania is a central node with extensive connections to Serbia and other European countries, indicating a significant volume of research and cooperation.

The relationship between Romania and Serbia is strong, reflecting frequent collaborations, particularly within the Balkans and Eastern Europe. Romania maintains important ties with countries such as Poland, Hungary, and the Czech Republic, while Serbia has close links with North Macedonia, Bosnia and Herzegovina, and Montenegro, strengthening regional cooperation.

Beyond regional collaborations, Romania has significant international partnerships with Western European countries, such as Germany and Italy, as well as with the United States. Serbia also collaborates with non-European countries, including China and Turkey.

This network underscores the role of Romania and Serbia in fostering interdisciplinary and collaborative research, contributing to both regional and international sustainability initiatives.

Conclusions

Sustainability research has significantly increased globally since 2010, with a focus on renewable energy, circular economy, and biodiversity. Publications reached a peak of 60,000 articles in 2023, highlighting the global interest in sustainable solutions. In Romania, research accelerated after 2007, focusing on renewable energy and corporate sustainability, supported by EU funding.

In Serbia, research has evolved steadily, concentrating on climate change and adaptation strategies. Despite lacking European financial support, Serbia has advanced through international collaborations, particularly with countries from Southeastern Europe and Asia, in contrast to Romania, which has strong partnerships with Germany and Poland.

In conclusion, sustainability research is growing both globally and in Romania and Serbia. Romania benefits from greater EU support, and both countries significantly contribute to sustainable solutions through international collaborations. Diversifying these collaborations will be essential for advancing research and implementing sustainable solutions.

Acknowledgments

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SMART FARMS AND PROJECT MANAGEMENT IN SUSTAINABLE AGRO-TOURISM

Dragana Vuković[1], Marica Milošević[2], Tamara Popović[3]

Abstract

This paper explores the concept of smart farms and their application in managing sustainable agro-tourism projects. As an innovative form of agriculture, smart farms integrate advanced technologies such as the Internet of Things (IoT), sensors, and digital analytics to enhance efficiency and productivity. This research analyzes their impact on agro-tourism development aligned with sustainability principles. The paper also examines project management strategies in this sector, including resource optimization, improvement of tourism offerings, and enhancement of environmental awareness. Through case studies and data analysis, the paper provides insights into the key benefits and challenges associated with implementing smart technologies in agro-tourism and demonstrates the potential for the long-term sustainable development of rural communities.

Key words: *smart farms, sustainable agro-tourism, project management, digital transformation, rural development.*

Introduction

Modern challenges in agriculture demand innovative approaches to achieve greater efficiency, productivity, and sustainability. One of the most significant responses to these challenges lies in the concept of smart farms. Smart farms represent the integration of advanced technologies such as the Internet of Things (IoT), sensors, artificial intelligence (AI), and remote sensing systems to enable precise resource management and optimize agricultural production. In addition to increasing yields and reducing negative environmental impacts, smart farms transform agriculture into a knowledge-based industry where data play a crucial role in decision-making.

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In the context of agro-tourism, these technologies offer numerous applications. On smart farms, visitors can not only participate in food production activities but also learn about sustainable practices and technologies used in modern agriculture. These farms provide a unique opportunity to promote sustainability by combining ecological, educational, and tourism components. For example, smart farms can showcase the use of solar panels, soil moisture sensors, or waste recycling systems, which simultaneously attract tourists and raise awareness of the importance of protecting natural resources.

Efficient project management is essential for the successful implementation of smart farms in agro-tourism. Project management facilitates the planning, organization, and control of all activities, from establishing infrastructure to training staff and promoting tourist offerings. Moreover, a focus on sustainability requires detailed planning to ensure responsible resource use and maximize benefits for the local community.

The aim of this paper is to explore how smart farms can contribute to the development of sustainable agro-tourism, with an emphasis on project management as a critical factor for success. By analyzing the application of modern agricultural technologies and their integration with the tourism industry, the paper offers insights into the potential for advancing sustainable development in rural communities.

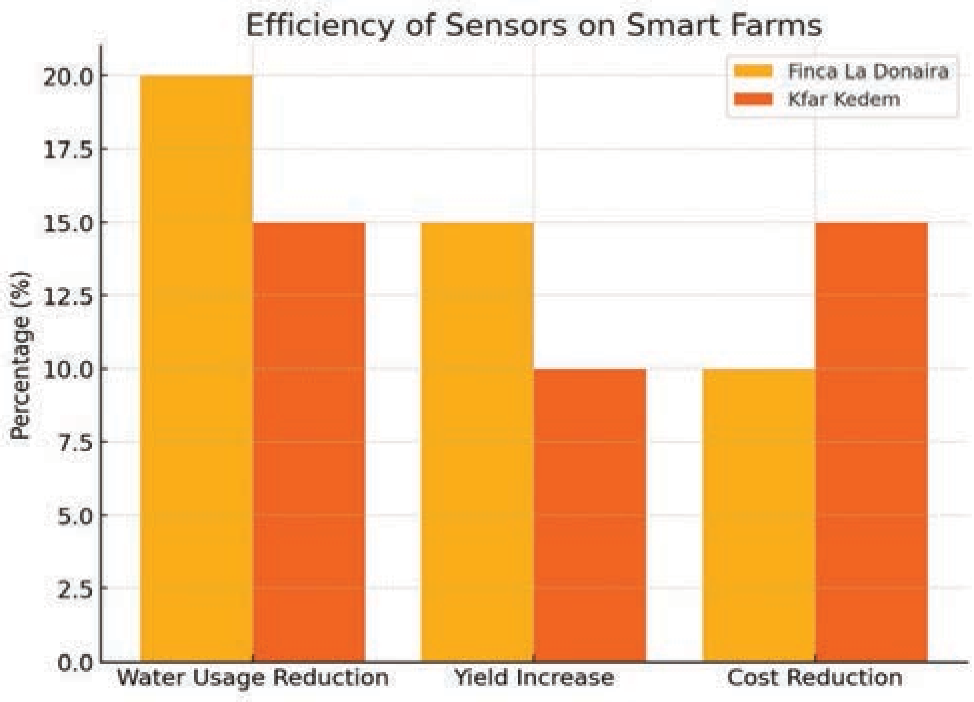
Smart Farms

Smart farms represent a modern concept in agriculture that integrates information-age technologies with traditional methods of food production. This concept is based on the application of advanced technological solutions to optimize agricultural processes, increase production efficiency, and reduce negative environmental impacts (Bach and Mauser, 2018). Smart farms transform agricultural practices into data-driven systems, enabling informed decision-making in real time.

The core technologies that define smart farms are the Internet of Things (IoT), sensors, and big data analytics. The Internet of Things (IoT) facilitates the connection of various devices and systems into a unified network to enable data exchange and process automation. On smart farms, IoT is used to collect and exchange data from various sources, including sensors installed in fields, machinery, and storage facilities (Gyamfi et al., 2024). For example, soil moisture sensors can transmit real-time data, allowing for precise irrigation and reduced water consumption.

Sensors are fundamental components of smart farms, as they gather data on critical parameters such as temperature, humidity, soil nutrient levels, pest presence, and plant health. These devices provide detailed information about current farm conditions, enabling timely and accurate interventions.

Figure 1. *Efficiency of Sensors on Smart Farms*



Source: *https://digital-strategy.ec.europa.eu/en*

Figure 1 clearly illustrates how sensors contribute to resource optimization and sustainable development on the farms Finca La Donaira and Kfar Kedem across the following categories:

- Reduction in water usage: Finca La Donaira (20%), Kfar Kedem (15%).

- Increase in yield: Finca La Donaira (15%), Kfar Kedem (10%).

- Reduction in costs: Finca La Donaira (10%), Kfar Kedem (15%).

Large amounts of data collected from smart farms are analyzed using algorithms and software tools for big data analytics. These tools identify patterns and trends, predict yields, and optimize resource allocation. For example, by analyzing weather data and historical yield information, it is possible to forecast the optimal time for planting or harvesting.

The advantages of technologies on smart farms include more efficient resource usage, increased yields, reduced negative environmental impacts, and real-time decision-making (Shepherd et al., 2018). Through precise monitoring of conditions, smart farms enable the optimization of water, fertilizer, and energy use, reducing production costs. The use of sensors and data analysis allows agricultural practices to be tailored to the specific needs of each plant, resulting in higher yields. Precise resource usage minimizes greenhouse gas emissions, soil erosion, and water pollution. Smart farms also allow farmers to respond quickly to changing field conditions, reducing the risk of losses.

Smart farms represent a significant advancement in the modernization of agriculture, enabling not only higher productivity but also a more sustainable approach to food production (Bach and Mauser, 2018). These technologies play a crucial role in addressing global food security challenges and adapting agriculture to changing climatic conditions..

Sustainable Agro-Tourism

Sustainable agro-tourism represents a combination of agricultural activities and principles of sustainable development, aiming to preserve natural resources, improve the environment, and support local communities. This form of tourism focuses on providing tourists with authentic experiences while simultaneously contributing to the economic and social development of rural areas.

The principles of sustainable tourism in agro-tourism include the preservation of natural resources, cultural heritage conservation, economic sustainability, and community involvement (Swarbrooke, 1999). Agro-tourism entails the responsible use of land, water, and energy to minimize the negative impact on ecosystems. Practices such as organic farming, recycling, and the use of renewable energy sources are essential for sustainability. Promoting local traditions, gastronomy, and customs plays a significant role in connecting tourists with rural areas and preserving cultural heritage. Sustainable agro-tourism contributes to stable incomes for local communities through the sale of local products, accommodation services, and activities such as workshops and farm tours. Active participation of local residents in planning and implementing agro-tourism activities ensures equitable distribution of benefits and enhances support for sustainable development.

Local communities are key drivers of agro-tourism initiatives, as they possess the knowledge, resources, and authentic values necessary to attract tourists. Their involvement is critical in developing tourism offerings, supporting sustainability efforts, preserving cultural identity, and creating employment opportunities. Local farmers can adapt their agricultural operations to include tourism-related activities, such as organizing educational tours, offering tastings of locally produced goods, and conducting interactive workshops. By adopting and promoting ecological practices, local communities contribute to the conservation of natural resources and establish a strong foundation for the long-term development of agro-tourism. Moreover, by emphasizing the promotion of local culture and traditions, these communities strengthen their identity while appealing to tourists seeking genuine and immersive experiences. Agro-tourism not only creates new employment opportunities in rural areas, particularly for younger generations, but also helps reduce migration and revitalizes local economies.

Sustainable agro-tourism serves as a development model that balances current resource utilization with the preservation of opportunities for future generations. This approach integrates the active involvement of local communities and adherence to sustainability principles, ensuring the successful convergence of agriculture and tourism. By prioritizing the preservation of natural landscapes and cultural heritage, sustainable agro-tourism enhances the quality of life in rural areas while fostering economic stability and environmental stewardship.

Project Management in Agro-Tourism

Project management in agro-tourism requires a holistic approach that integrates the specificities of the agricultural sector and the tourism industry. The core phases of project management in this field include planning, implementation, monitoring, and evaluation. Each of these phases presents specific challenges arising from the complexity of agro-tourism projects.

The key phases of project management in agro-tourism are as follows:

- Planning. This phase involves defining project goals, identifying necessary resources, and analyzing local potentials. Understanding local agro-ecological conditions, available capacities, and the needs of the tourism market is essential. Planning must also consider sustainability principles, such as preserving natural resources and supporting the local community.

- Implementation. This phase encompasses the realization of planned activities, such as building infrastructure (accommodation, educational centers), implementing smart farming technologies, or training employees. The success of this phase lies in resource coordination and timely problem resolution.
- Monitoring. Monitoring involves the continuous tracking of project progress through predefined success indicators. This may include analyzing tourist visits, visitor satisfaction, or financial performance. The goal is to identify and correct potential shortcomings promptly.
- Evaluation. The evaluation focuses on assessing achieved results against initially set goals. In agro-tourism, this may involve analyzing the project's impact on the local economy, resource preservation, and community satisfaction.

Project management in agro-tourism requires the integration of strategies aimed at efficient resource utilization, enhancement of tourism offerings, and raising environmental awareness. These strategies are crucial for achieving sustainable outcomes that benefit farmers, tourists, and local communities.

One of the primary goals of project management in agro-tourism is the rational use of natural, financial, and human resources. Smart farming technologies, such as sensors for monitoring soil moisture and nutrient levels, enable farmers to reduce water, fertilizer, and energy consumption. Using these resources efficiently not only lowers costs but also contributes to protecting natural ecosystems. For example, installing solar panels on farms can reduce energy dependency and lower carbon dioxide emissions. Agro-tourism provides a unique opportunity to educate tourists about the importance of environmental awareness.

Specific issues in agro-tourism include seasonality, preserving authenticity, financing, involving the local community, and maintaining infrastructure. Most agro-tourism activities are tied to seasonal agricultural processes, which can limit continuous tourist inflow and revenue. Planning off-season events, such as winter workshops or tastings, can help overcome this challenge. There is a risk that the commercialization of agro-tourism could compromise the authenticity of the experiences offered to tourists. Striking a balance between modernization and tradition preservation is critical for success. Many agro-tourism projects face challenges in securing initial capital. Access to subsidies, loans, and public-private partnerships can provide solutions. Insufficient involvement of local residents in decision-making processes can lead to resistance against the project. Transparent communication and active community engagement increase the chances of success. Agro-tourism infrastructure must be environmentally friendly and tailored to local conditions, which can raise construction and maintenance costs.

Project management in agro-tourism demands careful planning, adaptation to local conditions, and the integration of modern technologies to achieve sustainable results.

Case Studies - Successful Smart Farms in Agro-Tourism

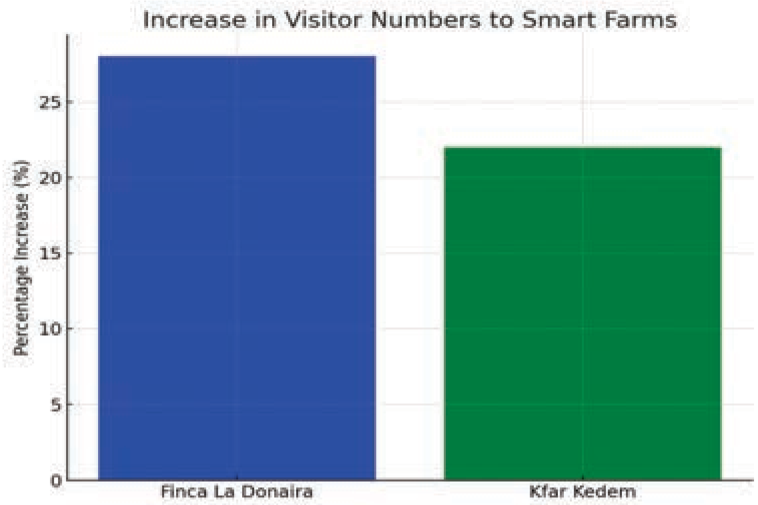
The development of smart farms in the context of agro-tourism offers numerous opportunities to connect agricultural production with the tourism industry. By integrating advanced technologies, these farms not only enhance the efficiency and sustainability of agricultural practices but also create unique experiences for tourists. Below are two examples of successful smart farms that have excelled in agro-tourism. Finca La Donaira in Spain and Kfar Kedem in Israel are prominent examples of smart farms that successfully integrate technology into agro-tourism, providing visitors with unique experiences.

Example 1 - Finca La Donaira located in Andalusia, Finca La Donaira is a biodynamic farm and luxury eco-retreat that combines sustainable agriculture with tourism amenities. The farm utilizes advanced technologies for monitoring soil and water quality, automated irrigation systems, and solar panels for energy production. Visitors can participate in interactive tours, observe the application of technologies in agriculture, and join workshops on sustainable practices. These approaches contribute to an increase in tourist visits and raise environmental awareness.

Example 2 - Kfar Kedem situated in Galilee, Israel, Kfar Kedem recreates daily life from the Mishnaic period, offering visitors the chance to engage in traditional agricultural activities. Although focused on historical practices, Kfar Kedem uses modern technologies for managing visits and education, including interactive guides and digital tools to enrich the experience.

Graph 2 illustrates the increase in the number of visitors during the project implementation phase (two years after introducing advanced agricultural technologies). Finca La Donaira recorded a 28% increase, while Kfar Kedem attracted 22% more visitors.

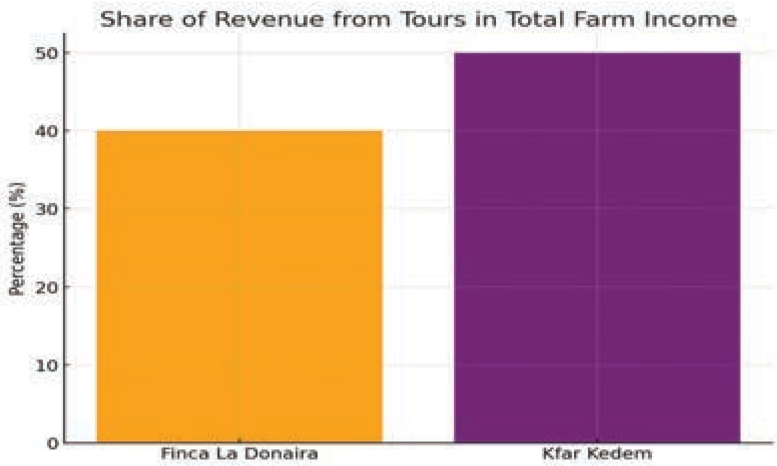
Graph 2: *Increase in Tourist Visits to Smart Farms*



Source:https://digital-strategy.ec.europa.eu/hr/policies/digitalisation-agriculture?utm_source

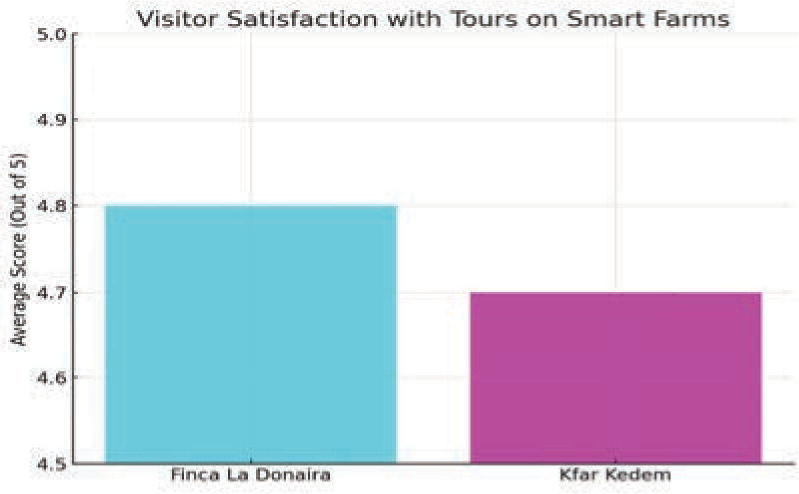
Chart 3. represents the share of revenue from tours in the total farm income. Finca La Donaira - Tour revenues account for 40% of the farm's total income, based on data recorded over the past two years, following an increase in visitor numbers and diverse educational offerings. Kfar Kedem - Tour revenues constitute 50% of the total income, with trends showing growth over the past five years, attributed to the introduction of new activities and increased tourist interest.

Chart 3. *Share of Revenue from Tours in the Total Farm Income*



Source: https://digital-strategy.ec.europa.eu/hr/policies/digitalisation-agriculture?utm_source

Chart 4. *Visitor Satisfaction with Tours on Smart Farm*



Source: *https://www.ine.es/ https://www.gov.il/en/ departments/central_bureau_of_statistics/govil-landing-page*

On Graph 4, visitor satisfaction with tours at smart farms is displayed. The average satisfaction score for visitors at Finca La Donaira is 4.8/5, based on surveys conducted over the past two years. At Kfar Kedem, a satisfaction score of 4.7/5 has been recorded over the past three years.

Table 1. *Core Indicators of Smart Farms and Their Analysis*

Indicator	Description	Impact Analysis
Resource Optimization	Precise monitoring of conditions (moisture, nutrient levels) using IoT sensors.	Reduces costs and usage of water, fertilizers, and energy, enhancing economic sustainability and reducing ecological impact.
Yield Increase	Application of sensors and data analysis enables adjustment of farming practices to plant needs.	Increases farm productivity and enhances profitability in both agriculture and tourism activities.
Sustainability Awareness	Organization of educational tours and workshops for tourists.	Promotes ecological education among tourists, raises awareness of sustainable practices, and increases the attractiveness of smart farms.
Tourism Offer Enhancement	Incorporation of interactive technologies (drones, AI) in tourist activities.	Enhances tourist engagement through unique experiences, such as observing drone operations or sampling farm-produced goods.

Indicator	Description	Impact Analysis
Revenue Diversification	Combination of income sources from agriculture and tourism.	Reduces dependence on seasonal production and enables farmers to achieve more stable year-round income.
Community Involvement	Creation of new jobs and promotion of local products and traditions.	Strengthens rural economies, reduces migration, and preserves the cultural identity of the community.

Source: *Analysis based on data from smart farm practices at Finca La Donaira and Kfar Kedem.*

Based on everything written so far in the paper, Table 1 highlights the key indicators illustrating how smart farms leverage technologies to optimize resources, increase yields, enhance tourism offerings, and diversify income streams. The indicators also emphasize the role of local communities and sustainable practices in achieving long-term benefits for agriculture and tourism.

Conclusion

Smart farms and their application in agro-tourism represent a significant step toward modernizing agriculture and advancing sustainable development in rural communities. Through the analysis of technologies such as IoT sensors, artificial intelligence, and big data analytics systems, this study has demonstrated how these innovations can optimize resource use, increase yields, and reduce the environmental footprint. At the same time, smart farms play an important role in providing authentic and educational experiences for tourists, enhancing tourism appeal and diversifying farmers' income.

Case studies of Finca La Donaira and Kfar Kedem confirm the potential of smart farms to integrate advanced technologies to improve tourism offerings. The increase in visitor numbers, high tourist satisfaction ratings, and a significant share of income from tours in the total revenue of these farms underscore the success of combining agriculture and tourism. These examples also highlight the importance of involving local communities in agro-tourism initiatives, ensuring sustainability and economic stability in rural areas.

Efficient project management in agro-tourism, coupled with the adoption of modern technologies and adherence to sustainability principles, is critical for achieving long-term benefits. This paper demonstrates that smart farms can serve not only as tools for improving agricultural productivity but also as models for integrating tourism and environmental conservation, creating new value for farmers, tourists, and local communities.

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THE IMPACT OF DIGITALIZATION IN AGRICULTURE IN ROMANIA AND SERBIA

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Abstract

This paper examines the impact of digitalization in agriculture within Romania and Serbia, focusing on the adoption and integration of advanced technologies such as precision farming, IoT, and data analytics. The study highlights how these digital tools enhance productivity, optimize resource management, and promote sustainable agricultural practices. By comparing the implementation strategies and outcomes in both countries, the paper identifies key challenges and opportunities faced by farmers. The research also explores the role of government policies and support in facilitating the digital transformation of the agricultural sector. Findings suggest that while both countries have made significant strides, further investment in infrastructure and education is essential to fully realize the benefits of digital agriculture.

Key words: *digitalization, agriculture, Romania, Serbia, precision farming, IoT, sustainability.*

Introduction

The contextual background of digitalization in agriculture we observe the global trend towards digitalization in agriculture, with an emphasis on its increasing importance due to the need for efficient use of resources and sustainable practices. Below we outline major technological advances in agriculture, including precision agriculture, the Internet of Things (IoT), data analytics and artificial intelligence (AI).

Insufficient access to internet networks in rural areas of Romania and Serbia represents a significant barrier to agricultural digitalization, preventing farmers from fully adopting and utilizing modern technologies. While digital connectivity is essential for benefiting from IoT (Internet of Things) solutions, precision agriculture, data platforms, and other digital tools, many rural regions in these countries still suffer from inadequate coverage and low internet speeds.

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Insufficient access to internet networks in rural areas of Romania and Serbia represents a significant barrier to agricultural digitalization, preventing farmers from fully adopting and utilizing modern technologies. While digital connectivity is essential for benefiting from IoT (Internet of Things) solutions, precision agriculture, data platforms, and other digital tools, many rural regions in these countries still suffer from inadequate coverage and low internet speeds.

Current Challenges in Internet Access in Rural Areas are isolation and limited infrastructure, low internet speeds and high implementation costs. Now we will briefly describe each of them:

Isolation and Limited Infrastructure: Many rural areas are geographically isolated, with poorly developed digital infrastructure. This includes weak internet connections or even a complete lack of fiber optic networks, which are essential for high-speed internet access.

Low Internet Speeds: In some cases, farmers who have internet access experience speeds too slow to support complex applications like satellite crop monitoring, data analytics, or real-time weather updates.

High Implementation Costs: Establishing internet infrastructure, such as telecommunications towers and fiber optic networks, requires substantial investments. Internet providers may be hesitant to invest in sparsely populated areas, where returns may be lower than in urban regions.

To expand internet networks in rural areas, Romania and Serbia have implemented several government initiatives, supported by EU funding, national programs, and partnerships with local providers. Both countries have accessed European funds through projects like the Connecting Europe Facility and Horizon Europe, which aim to improve digital infrastructure and internet access in underserved regions. National programs in Romania focus on installing fiber optic networks in isolated areas and providing subsidies to encourage private internet providers to invest in rural infrastructure. Serbia is also expanding its internet network through government-backed projects, offering financial support to operators and exploring alternative solutions like satellite internet for remote areas. Additionally, both governments encourage local internet providers to join these efforts by offering grants or access to necessary network equipment, enabling them to provide essential internet services to rural communities. These initiatives aim to create a more connected agricultural sector, enhancing access to digital tools and data-driven farming.

Impact of Slow Progress on Agricultural Digitalization there are 3 directions:

Delays in Technology Adoption - Due to limited internet access, farmers in these areas struggle to use essential digital tools for modern agriculture. For example, crop monitoring solutions, resource management applications, and online commerce platforms all require reliable connections, which many farms lack.

Limitations on IoT Use and Precision Agriculture - The internet is crucial for IoT devices (such as moisture and temperature sensors) and precision agriculture equipment. Without reliable internet, farmers cannot receive real-time data or effectively analyze collected information, impacting their productivity and farm sustainability.

Reduced Competitiveness of Rural Farmers - Farmers without digital technology access face challenges in increasing their productivity and efficiency, putting them at a disadvantage compared to urban competitors or those with internet and digital technology access. As a result, rural farmers may miss important opportunities, such as accessing new markets and improving production techniques.

Recommendations to Accelerate Rural Internet Expansion:

To accelerate rural internet expansion, Romania and Serbia could benefit from additional public investments and fostering public-private partnerships to fund network expansion, sharing costs, and offering incentives for internet providers. In remote or isolated areas where installing fiber optics is costly, governments could promote alternative technologies such as satellite or 5G internet, which provide wide coverage without extensive physical infrastructure. Direct subsidies to farmers for purchasing connectivity equipment like routers and signal boosters would also enhance internet access for small-scale farms, ensuring they can use digital tools. By implementing these initiatives, both countries could address current connectivity barriers, enabling more farmers to adopt modern technologies, which would improve agricultural efficiency, productivity, and sustainability.

The Agricultural Landscape in Romania and Serbia:

While specific farm names are often not disclosed in public reports, there are documented instances in Romania and Serbia where the adoption of digital tools has led to significant improvements in agricultural practices:

Romania - A study highlighted that the implementation of precision agriculture technologies resulted in a 20% increase in crop yields. This improvement was attributed to the use of advanced data analytics and precision farming techniques, which optimized resource utilization and enhanced productivity.

Serbia -Research indicated that the adoption of IoT-based smart irrigation systems led to a 15% reduction in water usage. These systems utilized sensors and real-time data to manage irrigation more efficiently, thereby conserving water resources and reducing costs.

These examples underscore the tangible benefits of integrating digital technologies into agricultural operations, including increased efficiency, resource conservation, and enhanced productivity.

Digitalization Technologies in Agriculture:

Precision farming, also known as precision agriculture, is a modern farming approach that leverages advanced technologies such as GPS, sensors, and data analytics to optimize crop production. This method tailors farming practices to the specific needs of each area within a field rather than treating the entire field uniformly. By collecting and analyzing real-time data, precision farming enables farmers to make informed decisions about where, when, and how much to apply resources like water, fertilizers, and pesticides.

The main components of precision farming include GPS, sensors, drones, and Variable Rate Technology (VRT). GPS allows for accurate field mapping and guides tractors to plant, fertilize, and harvest in precise rows, reducing overlap and ensuring uniform application. Sensors measure conditions like soil moisture and temperature, helping farmers target water and resources exactly where needed to avoid overuse. Drones and satellites capture aerial images that reveal crop health and stress patterns, helping farmers quickly identify areas needing attention. VRT systems, informed by sensor and GPS data, enable farmers to apply fertilizers and pesticides at varying rates, minimizing waste and enhancing crop health.

By leveraging real-time data from precision farming technologies, farmers can manage their fields with exceptional accuracy, optimizing resource use and reducing waste. This approach enhances crop health and productivity by applying inputs like water and nutrients only where needed, leading to higher yields and lower environmental impact. Additionally, precision farming minimizes chemical runoff and conserves water, contributing to more sustainable agricultural practices.

Precision farming has had a positive impact on agriculture in both Romania and Serbia, leading to increased crop yields, improved soil health, and reduced environmental impact.

Precision farming allows Romanian and Serbian farmers to use data-driven tools like GPS, sensors, and satellite imagery to assess the specific needs of each part of their fields. Variable rate technology (VRT) enables precise application of fertilizers and pesticides, ensuring that each area receives the optimal amount. This has led to higher crop yields, as plants get exactly what they need to grow.

With real-time monitoring through IoT devices and sensors, farmers can detect issues such as pest infestations or nutrient deficiencies early on, allowing them to address problems quickly and prevent yield losses.

Precision farming applies fertilizers and pesticides only where they are needed, preventing excessive chemical buildup in the soil and promoting a balanced nutrient profile, which leads to healthier soils in Romania and Serbia. Minimal tillage practices preserve soil structure, reduce erosion, and maintain organic matter, enhancing the soil's ability to retain water and nutrients, which supports long-term productivity. Precision irrigation, informed by soil moisture sensors and weather data, helps farmers apply water only where and when necessary, conserving water—a critical benefit for Serbia, where resources may be limited. This approach also reduces nutrient runoff, protecting local ecosystems and supporting environmental sustainability. By optimizing machinery use, precision farming lowers fuel consumption and greenhouse gas emissions, contributing to cleaner water sources and a healthier environment.

Precision farming has enabled farmers in Romania and Serbia to increase their crop yields, sustain soil health, and reduce the environmental footprint of their operations. These outcomes support both higher agricultural productivity and long-term environmental sustainability.

IoT devices like weather stations, moisture sensors, and livestock trackers have become essential in modern farm management. Weather stations provide real-time data on conditions like temperature, humidity, and wind, helping farmers make timely decisions on planting and harvesting while also sending alerts about frost or storms to protect sensitive crops. Moisture sensors measure soil water content at different depths, allowing farmers to apply irrigation precisely where needed, reducing water waste and promoting healthy crop growth. Livestock trackers monitor animal health and location, providing insights into behavior patterns and helping farmers detect early signs of illness while keeping track of animals on large grazing lands, saving time and improving welfare.

The integration of IoT devices in farm management allows for a more efficient, data-driven approach to agricultural operations. By using real-time data from these devices, farmers can reduce input costs by applying resources like water, feed, or care only when necessary, optimizing conditions for both crops and livestock. This timely, precise management helps prevent issues from escalating, leading to healthier plants and animals and ultimately increasing productivity and yield quality. Additionally, IoT devices enhance sustainability by conserving water, reducing chemical use, and supporting responsible livestock practices, thereby lowering the environmental impact of farming operations.

IoT devices like weather stations, moisture sensors, and livestock trackers have transformed farm management, enabling farmers to make data-informed decisions that enhance productivity, reduce costs, and support sustainable practices.

Data analytics is essential for helping farmers interpret the vast amounts of data produced by IoT devices and precision farming tools. Technologies like sensors, GPS, and monitoring devices continuously collect information on soil moisture, weather, crop health, and livestock behavior. Data analytics tools process this data, organizing it into patterns, trends, and actionable insights that guide better farm management decisions. By compiling data points like soil moisture levels, crop growth, and animal health metrics, analytics systems provide farmers with a clear overview of field conditions. Advanced algorithms can also detect subtle patterns, such as correlations between soil conditions and yield or the impact of temperature changes on pest populations, enabling more informed, precise actions.

By analyzing historical and current data on weather, soil, and crop health, predictive models can forecast potential yield outcomes. Farmers can use these predictions to make decisions on resource allocation, planning their harvesting, and marketing efforts.

Data analytics helps farmers anticipate pest infestations or disease outbreaks by analyzing temperature, humidity, and plant health data, allowing for timely and targeted interventions that reduce crop loss and minimize chemical use. By using moisture sensor data and weather forecasts, analytics tools determine the best irrigation schedules, ensuring water is applied efficiently and only where needed, thus preventing over-irrigation that can cause nutrient leaching or root diseases. Additionally, by examining soil conditions and plant health, data analytics supports the precise application of fertilizers and pesticides through variable rate application (VRA), providing each part of the field with exactly what it requires and reducing environmental impact. Real-time monitoring capabilities in data analytics systems can also detect sudden changes, such as drops in soil moisture or unusual livestock behavior, instantly alerting farmers to potential issues. These immediate notifications enable farmers to respond promptly, adjusting irrigation or addressing animal health, ensuring optimal farm management and productivity.

Over time, data analytics builds a historical record of field conditions, crop performance, and resource usage. Farmers can use this data to evaluate which crops and practices work best under certain conditions, supporting more effective long-term planning.

Data analytics helps farmers analyze the costs and efficiencies of various farm operations, allowing them to evaluate profitability and pinpoint areas for improvement. For instance, they might find that reducing fertilizer in specific areas doesn't affect yield, leading to cost savings. By turning complex data into actionable insights, data analytics enables farmers to allocate resources precisely, optimizing costs and increasing yields. This precise approach minimizes waste, reduces environmental impact, and promotes sustainable practices, ultimately boosting profitability through lower input costs and maximized yields. With data-driven decision-making, farmers can enhance productivity, improve sustainability, and increase their farm's overall profitability.

Implementation Strategies and Comparative Analysis

Adoption Rates in Romania and Serbia: As of recent assessments, the adoption rates of digital technologies in agriculture in Romania and Serbia remain relatively low, particularly among small-scale farmers. In Romania, approximately 15–20% of farmers are expected to adopt technologies such as barn robotics, section control, and variable-rate applications within the next five years. Springer Link

In Serbia, while specific statistics are limited, the overall digital adoption index is 0.5 on a scale from 0 to 1, indicating moderate digital adoption across various sectors, including agriculture.

World Bank

Both countries face challenges such as limited infrastructure, high costs, and a lack of digital literacy, which hinder the widespread adoption of digital technologies in agriculture.

In both **Romania** and **Serbia**, significant disparities exist in the adoption of digital technologies between urban and rural areas, as well as between large-scale and smaller farms. These gaps limit the full impact of digitalization on the agricultural sectors in both countries. Rural areas in Romania and Serbia often have limited access to high-speed internet, essential for many digital farming tools. Urban areas, on the other hand, generally have better connectivity, enabling more efficient and reliable digital technology use.

Farmers in rural areas typically have less access to digital literacy programs, technical support, and training on modern agricultural technologies. Urban regions or areas closer to universities and research institutions benefit more from workshops and resources that foster digital adoption. Large-scale farms usually have greater access to funding and can more easily afford the costs associated with implementing digital tools, such as IoT devices, GPS-guided machinery, and data analytics platforms. Small-scale farms, however, often face financial limitations, making it harder for them to invest in these technologies. Large farms have better access to digital technology providers and service contracts, which offer essential support for maintaining and upgrading equipment. These farms also experience more immediate benefits from digital technologies, as even minor efficiency improvements can result in substantial gains across large areas. For smaller farms, however, the benefits may be less pronounced, and the high initial investment often poses a barrier to adoption.

These disparities mean that while digitalization has the potential to revolutionize agriculture, its benefits are unevenly distributed in Romania and Serbia. Larger, well-connected farms in urban-adjacent areas can take advantage of precision agriculture, IoT, and data analytics, while smaller farms in remote areas lag behind. Uneven adoption of digital tools in agriculture prevents the sector from fully realizing potential gains in productivity and efficiency. While widespread use of these technologies could greatly reduce resource consumption and environmental impact, the limited uptake constrains these benefits. Additionally, the divide between large, digitally advanced farms and smaller, traditional farms grows, making it harder for small farmers to compete and achieve similar productivity and profitability. To address these disparities, both Romania and Serbia would benefit from policies and initiatives focused on expanding digital infrastructure, providing financial assistance for small-scale farms, and enhancing training programs in rural areas. This approach would promote a more balanced and inclusive digital transformation across the agricultural sector.

The *digitization of agriculture and rural areas* in the EU aims to modernize and enhance the competitiveness and sustainability of the agricultural sector while improving the quality of life in rural communities. By integrating digital technologies and data-driven approaches, EU agriculture can undergo transformative changes, making farming more efficient and eco-friendly. Information collection, automation, and robotics contribute to sustainable agricultural practices, enabling farmers to optimize their resources and reduce waste. Digital tools also boost efficiency and competitiveness, lowering the sector's environmental impact. Additionally, digitization helps develop rural areas by improving accessibility and connectivity, aligning with the EU's long-term vision for vibrant rural communities.Digital technologies can act as enabling tools for all specific objectives of the Common Agricultural Policy (CAP), in particular economic, environmental, climate and rural objectives. Digitization includes the adoption of digital technologies by farmers and rural communities, as well as improving access to knowledge and training. This also means modernizing the sector in terms of infrastructure and governance. Outline investment trends, both public and private, in Romania and Serbia aimed at supporting agricultural digitalization. The digitization of agriculture in Romania and Serbia has become a priority, both for public and private investments. Here are some relevant trends in this area:

In **Romania** are:

- EU Funding: Romania has taken advantage of financial resources from European Union initiatives, such as the National Rural Development Program (PNDR), to enhance digital transformation in agriculture. These resources are directed towards implementing digital innovations and upgrading equipment.

- Collaborative Initiatives: There has been a rise in partnerships among research institutions, universities, and private enterprises. These collaborations are focused on creating tailored digital solutions for agricultural producers.

- IT Infrastructure Investments: Both the government and private sectors are making investments to broaden high-speed internet access in rural regions, which is crucial for the effective use of digital technologies.

- Education and Training Initiatives: Programs designed to enhance farmers' understanding of digital tools are becoming increasingly prevalent, offering training sessions and workshops.

In **Serbia** are:

- Government Initiatives: The government of Serbia has launched programs to promote digital transformation in agriculture by providing grants and financial aid for the integration of modern technologies.

- Investment in Agricultural Technology: The private sector is showing a growing interest in funding startups and businesses that create digital agricultural solutions, including platforms for farm management and mobile applications.

- Development Projects: Joint efforts between universities and research organizations have facilitated the creation of innovative technologies, such as drones for monitoring crops and intelligent irrigation systems.

- Legal Framework and Data Governance: There is an increasing focus on developing a legal structure to support digitalization in agriculture, which includes regulations on data protection and technology usage.

Both **Romania** and **Serbia** are channeling investments into the digitalization of their agricultural sectors through funding, partnerships, and improvements in infrastructure. These efforts aim to boost efficiency and sustainability within agriculture. Public and private sector collaboration is vital for the successful realization of these initiatives.

In Romania, there are workshops organized by universities that offer training in the use of digital tools, aimed at young farmers.

In Romania, universities and various organizations offer training programs for farmers in the use of digital tools. A notable example is the "Digital Farmer" project, funded through the Erasmus+ program, which provides free courses for farmers and educators from agricultural education units. These courses cover digital education in agriculture, including technologies such as blockchain, drones, and e-commerce software.[1]

Additionally, the *Agrinnovator* think tank, formed by young farmers who graduated from the "Young Leaders for Agriculture" program organized by the Romanian Farmers' Club, launched Romania's first "Guide for the Digitalization of Agriculture." This guide offers farmers practical information on available digital solutions and how these can be implemented on their farms.[2]

These initiatives reflect ongoing efforts to support Romanian farmers in adopting digital technologies to improve the efficiency and sustainability of agricultural practices.

In Serbia, the government has implemented several initiatives to support farmers in adopting digital technologies, including the Internet of Things (IoT) and precision agriculture. A notable example is the "Digital Agriculture of Serbia" program, which develops technologies in areas such as in-situ nano and microelectronic sensors, robotic platforms, genotyping/phenotyping, remote sensing (UAS, satellites), IoT and big data analytics. These technologies are meant to create new information and knowledge for farmers

Also, the digital platform *"AgroSense"* was launched for public use and has been widely accepted, with a large number of large, medium and small farmers registering with the system. This platform brings the benefits of information technology to end users by providing free and paid (for advanced users) tools for better decision making.

These programs reflect the Serbian government's ongoing efforts to support farmers in adopting digital technologies to improve the efficiency and sustainability of agricultural practices. Examples of successful digitalization in both countries highlight the tangible benefits of digital tools. In Romania, a large-scale farm reported a 20% increase in crop yield after implementing precision farming techniques, while a Serbian farm saw a 15% reduction in water usage with IoT irrigation sensors. Limited access to internet networks in rural areas of Romania and Serbia is a significant barrier to the digitization of agriculture, preventing farmers from fully adopting and using modern technologies. Although digital connectivity is essential to benefit from IoT (Internet of Things) solutions, precision agriculture, data platforms and other digital tools, many rural regions in these countries still suffer from inadequate coverage and slow internet speeds.

Challenges and Opportunities

In Romania and Serbia, several technical challenges hinder the widespread adoption of digital technologies in agriculture, particularly affecting rural and small-scale farmers. Key issues include lack of infrastructure, high costs of digital tools, and limited internet access in rural areas.

In Romania and Serbia, several challenges hinder the adoption of digital tools in agriculture. Many rural areas lack the necessary broadband infrastructure, which restricts farmers from using data-driven technologies like IoT sensors and cloud platforms that rely on stable, high-speed internet. Consistent access to electricity and cell networks is also limited, making it even harder to use advanced tools essential for efficient farm management. Additionally, the high costs of digital equipment—such as GPS-guided tractors, drones, and soil moisture sensors—pose a financial barrier, especially for smaller farms that struggle to afford these technologies and their ongoing maintenance and updates. Small-scale farmers often have limited access to loans or subsidies, further preventing them from investing in new tools, particularly when returns on investment are uncertain. Moreover, slow or inconsistent internet in rural regions hampers real-time data use, making it difficult for farmers to implement precision agriculture effectively. Some turn to satellite or mobile internet as alternatives, but these options are often costly and may lack the stability needed for reliable, continuous monitoring. Addressing these technical challenges will require collaborative efforts from government agencies, internet providers, and agricultural organizations. Solutions like subsidized internet expansion in rural areas, financial support for technology purchases, and shared digital infrastructure could help improve access to digital tools for all farmers, fostering a more equitable and sustainable agricultural sector.

Both **Romania** and **Serbia** have implemented government policies to support the digital transformation of their agricultural sectors. These initiatives include subsidies, tax incentives, and research funding aimed at enhancing productivity, sustainability, and competitiveness.

In Romania:

- **National Rural Development Programme (NRDP):** Funded by the European Union and the Romanian government, the NRDP offers financial support to farmers and agribusinesses for adopting modern technologies, including digital tools. This program aims to improve the competitiveness of the agricultural sector and promote sustainable practices.

- **Young Farmers Scheme:** This initiative provides grants to young farmers for setting up and developing modern, technology-driven agricultural enterprises, encouraging the adoption of digital solutions among the younger generation.

- Romania offers a 150% super deduction for qualifying R&D expenditures, effectively reducing the taxable income of companies investing in research activities, including those related to digital agriculture. Deloitt

- Companies can apply accelerated depreciation for equipment and machinery used in R&D activities, allowing for a faster write-off of investments in digital technologies.

In Serbia:

- Instrument for Pre-Accession Assistance in Rural Development (IPARD): In collaboration with the European Union, Serbia provides non-refundable funds to support the agricultural sector, including investments in digital technologies. The IPARD program offers financial assistance for purchasing new equipment, machinery, and implementing modern agricultural practices. Gecic Law

- **National Agricultural Subsidies:** The Serbian government offers subsidies for investments in agricultural production, aiming to improve competitiveness and achieve quality standards. These subsidies support the adoption of digital tools and technologies in farming operations. Seerural

- Serbia provides tax incentives for investments in agriculture, including deductions and exemptions for expenditures on modernizing agricultural practices and implementing digital technologies.

- The Serbian government funds research projects focused on technological advancements in agriculture, promoting the development and application of digital tools to enhance productivity and sustainability.

To accelerate ***agricultural digitalization***, governments should increase funding for digital tools, provide low-interest loans for equipment, and expand high-speed internet access in rural areas to ensure connectivity for advanced technologies. Additionally, they should implement regular training programs for farmers on digital literacy and technology use, fostering confidence and skills to adopt and benefit from digital solutions.

Conclusion

The research highlights that digitalization in agriculture significantly boosts productivity by enabling precision in resource management, such as optimized use of water, fertilizers, and pesticides, leading to increased crop yields. Additionally, the use of digital tools promotes sustainability by reducing waste, conserving resources, and minimizing environmental impact, creating a more efficient and resilient agricultural sector.

Both Romania and Serbia face shared challenges in agricultural digitalization, including limited rural internet access and high costs for small farmers, yet Romania's EU-supported funding provides broader financial resources, while Serbia leverages targeted government initiatives to enhance local adoption of precision technologies.

Further research should explore the transformative potential of AI and machine learning in optimizing crop management and yield predictions, as well as examine the long-term socio-economic impacts of digitalization on rural community development and resilience.

Governments should provide subsidies and infrastructure grants, the private sector can offer affordable, scalable digital tools, and educational institutions should develop accessible training programs to equip farmers with the skills needed to adopt and effectively use digital agriculture technologies.

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AUTOMATION IN AGRICULTURE: THE ROLE OF ADVANCED TECHNOLOGIES AND ARTIFICIAL INTELLIGENCE IN INCREASING EFIICIENCY

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Abstract

The modernization of agriculture through advanced technologies and artificial intelligence (AI) brings concrete solutions for [4]*process efficiency. Precision technologies, such as drones and sensors, enable detailed monitoring of soil and crop conditions, reducing excessive use of water and fertilizers. AI algorithms, integrated into climate prediction systems and agricultural software, can analyze complex data to determine the optimal time for sowing and harvesting. Autonomous machines, such as smart tractors, can perform mechanized tasks without human intervention, increasing productivity and reducing errors. Automated harvesting robots enhance efficiency by lowering labor costs. Additionally, AI facilitates the real-time detection of diseases and pests, preventing crop losses. These technologies allow farmers to manage large farms more efficiently, optimize resources, and address global challenges, such as climate change and the growing demand for food.*

Key words: *agriculture, artificial intelligence (A.I.), sustainability, efficiency.*

Introduction

Nowadays, field work in agriculture is carried out by manpower and machinery with different tried and true methods of obtaining yield. On the other hand,

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modern agriculture seeks to optimize every aspect of culture and technology, so to achieve this, a multitude of hardware and software solutions have been created.

Methods of remote analysis can help in precision farming with gathering data of plant growth during the season, such as satellite imagery provided by Sentinel-2 satellites, which is available and provided by the European Space Agency (ESA). (Drusch et al., 2012)

Drones are another way of remote analysis that can gather data in conditions where satellite imagery is not available. In cloudy conditions, for instance, drones can gather information and usually at a much higher resolution (down to centimeters) than a satellite-based imaging system (down to meters). The downsides of drones are the difficulties in operating and processing images that have been collected. (Matese et al., 2015; Bu et al., 2017)

Remote analysis of soil temperature and humidity is also important to establish if the conditions for sowing are right, and to help with that, there are a plethora of devices that can do that job, such as Soil Scout, which can create a 3D weather map remotely. (https://soilscout.com/)

Analyzing soil nutrients after processing an agrochemical map enables farmers to use variable-rate fertilizer, which distributes the precise amount of nutrients needed by the soil in nutrient-deficient areas, making fertilization more efficient.

Numerical weather prediction (NWP) combined with different AI techniques helps with gathering weather and agriculture data in order to facilitate a more precise decision-making process for the process of sowing and harvesting. (https://climavision.com/blog/precision-agriculture-empowered-by-better-weather-data/)

Remote analysis of plant growth during the season

Interaction between plants and sunlight emits electromagnetic radiation that can be observed by satellites and drones, which can indicate their biophysical composition and physiological status. Chlorophyl absorbs radiation on the visible spectrum in the ranges of 400–700 nm, the range where energy is used in photosynthesis. In near infrared (700–1300 nm), leaves emit values that are related to their biomass and structural properties. In the shortwave infrared region (1300–2500 nm), we can observe the water and biochemical components that are present in leaves. This data helps in figuring out the different phenological stages of plants or the status of plants health by observing the quantity of chlorophyll, which is responsible for photosynthesis and for different ranges of stress. (Segarra et al. 2020)

Remote analysis of soil qualities

Analyzing soil moisture and temperature is a key part in determining the optimal sowing and harvesting period. Devices like soil scouts can be buried underground at a depth of 2 meters and transmit data about soil moisture, temperature, and salinity in real time, storing it in cloud servers and creating a soil behavior view over a longer period of time. (https://soilscout.com/solution/wireless-soil-moisture-sensor)

After the processing of an agrochemical mapping, a variable fertilizer rate can be applied in order to fertilize to the specific needs of every area within a field. By recognizing soil fertility and plant response, it can address the heterogeneity of the land, distributing an optimal amount of nutrients with minimal waste. (https://eos.com/blog/variable-rate-fertilizer/)

Numerical weather prediction and AI

By getting timely data about precipitations, storms, and severe weather conditions, farmers can make decisions regarding harvesting, crop protection, and irrigation patterns. This can mitigate risks, minimize crop losses, and optimize their technology. Taking in account atmospheric variability and using algorithms for simulated weather conditions, farmers get a generated forecast to aid in their decision-making. With AI technologies, farmers can leverage weather and all the soil dates in order to facilitate a precise decision-making process. AI models can generate recommendations for specific farms with high accuracy, facilitating optimal irrigation schedules, fertilizer application rates, and different crop protection measures that facilitate less waste and achieve higher yields. (https://climavision.com/blog/precision-agriculture-empowered-by-better-weather-data/)

The Role of Autonomous Machines in Modern Agriculture

In recent decades, agriculture has seen major advances thanks to automated and autonomous technologies. Autonomous machines, especially smart tractors, the key component of modern agriculture, significantly contributing to increasing productivity and reducing human error.

Autonomous Tractors: Technology and Functionality

Autonomous tractors are equipped with an advanced combination of sensors, GPS, cameras and artificial intelligence (AI) software that enables them to perform a variety of complex agricultural tasks without human intervention. These machines can plow, plant, fertilize and even spray crops over vast areas, guided by precise navigation maps and AI algorithms that allow them to adjust their route and tasks in real time.

Components of Autonomous Tractors:

Advanced GPS system – Uses satellites to obtain an exact location, allowing the tractor to follow a pre-set route with centimeter deviations to ensure full ground coverage.

Proximity sensors and cameras – Detects obstacles and prevents collisions, ensuring safe and efficient operation even in complex terrain conditions.

Artificial Intelligence (AI) software – Analyzes data from sensors and cameras to make real-time decisions. For example, it can adjust plow speed and depth based on information about soil density and moisture.

The benefits of Autonomous Tractors

Increased operational efficiency – Autonomous tractors can work continuously, without being limited to a certain time of day or affected by human fatigue. This allows farmers to cover large areas in a shorter time.

Resource saving – Computer systems can optimize the amount of fertilizer or water used, adapting in real time as needed according to soil characteristics. This precise application reduces costs and minimizes environmental impact by avoiding excessive use of chemicals.

Automated Harvesting Robots: Innovation in Harvesting

Another cutting-edge area in agricultural automation is automated harvesting robots. These robots, designed to pick fruits, vegetables and other crops, are equipped with visual recognition technology and artificial intelligence that allows them to identify and harvest plants at optimal maturity.

The Technology of Harvesting Robots

Harvesting robots are equipped with computer vision and AI systems that allow them to analyze the structure and color of fruits and vegetables, determining the optimal time to harvest. Technologies used include:

High-resolution cameras – Detect the color, size and texture of fruits and vegetables to identify their ripeness and quality.

Proximity and pressure sensors – Ensures gentle harvesting so as not to damage crops. These sensors help the robot apply for proper handling of the fruit or vegetable.

Machine learning algorithms – These algorithms are trained to recognize different stages of maturity of crops, and through continuous learning, they can become more efficient in the process of recognition and culture.

Advantages of Automated Harvesting Robots

Reducing dependence on seasonal labor – Harvesting is a labor-intensive activity, especially during peak harvest periods. Automated harvesting robots can replace seasonal workers, effectively responding to labor shortages.

Efficiency and precision – Harvesting robots can work consistently with high precision, reducing losses by avoiding harvesting too early or too late. This ensures efficient use of crops and maintains their quality.

Cost reduction – Using automated harvesting robots helps lower operational costs by eliminating costs associated with hiring, training and supervising labor.

Challenges and Prospects for Autonomous Machines and Harvesting Robots

While robot and autonomous tractor technology is promising, there are challenges to overcome:

High implementation costs – The initial investment is considerable and this can limit the access of smaller farms to these technologies.

Need for special maintenance – Self-driving cars require regular maintenance and calibration to maintain accuracy and efficiency.

Integration with other farm management systems – To achieve maximum efficiency, autonomous machines and harvesting robots must be effectively integrated with farm management and monitoring systems, which may involve software adaptations and IT infrastructure.

Automation through self-driving tractors and self-harvesting robots offers farmers possibilities for efficient utilization and reduction of their operational costs. As technologies evolve, they will become more accessible and efficient, contributing to a more sustainable agriculture capable of meeting the challenges of climate change and increasing global food demand.

Automation in Agriculture: The Role of Advanced Technologies and Artificial Intelligence in Increasing Efficiency

Modern agriculture stands at a crossroads, as farmers must meet the global demand for food amid climate change and the growing world population. Artificial intelligence (AI) is one of the technologies bringing significant transformations to this sector, supporting farmers in facing modern challenges and improving crop management. Real-time detection of diseases and pests using AI, with the help of sensors, drones, and imaging, allows farmers to protect crops efficiently, reducing resource wastage and contributing to agricultural sustainability.

AI-based Disease and Pest Detection Technologies

Today, AI utilizes advanced image recognition systems and sensors to analyze the condition of plants with high accuracy, quickly identifying possible infections or pests. Platforms like Fermata Croptimus and FarmSense FlightSensor are specifically designed to monitor crops around the clock. These systems can detect subtle changes in color, shape, or texture on plant leaves and stems, which signal diseases like fungal or bacterial infections. This enables farmers to receive real-time alerts and intervene before the issue spreads.

Moreover, farmers use satellite images and drones with high-resolution cameras to gather detailed data about crop health. These data are processed using machine learning algorithms that learn and improve in disease identification, reducing the need for manual inspections. An innovative approach is the use of drones to apply pesticides directly to affected plants, saving time and resources and minimizing chemical use in areas where it is unnecessary.

Resource Optimization for Large Farms

For large-scale farms, resource management is essential to minimize costs and reduce environmental impact. AI technologies enable monitoring soil moisture to automatically determine optimal irrigation times and the required water quantities. For example, soil sensors connected to IoT networks transmit real-time data that is analyzed and used to control irrigation systems. Google's AI for Agriculture is an example of how algorithms can anticipate the water and nutrient needs of plants, maximizing yield without affecting the environment.

In addition to water resources, AI optimizes fertilizer and pesticide use. AI-based analysis systems can detect nutrient deficiencies or the presence of pests, providing farmers with valuable information about the ideal time for applying fertilizers. This helps minimize soil and water pollution, a crucial factor for sustainable agriculture. In the future, these systems are expected to expand, becoming the norm in large farms and helping reduce ecological impact.

Benefits for Small and Medium-Sized Farms

While large farms benefit significantly from AI, small and medium-sized farms also have advantages through the use of this technology. Solutions like FieldNET Advisor allow farmers to optimize irrigation, leading to more efficient resource management on a smaller scale. Additionally, accessible mobile applications enable farmers to use AI to monitor diseases and receive personalized recommendations on necessary treatments.

In regions with limited access to resources, AI facilitates the precise use of water and fertilizers, allowing farmers to achieve more with fewer resources. These technologies democratize access to advanced solutions, reducing costs and increasing the competitiveness of small and medium-sized farms.

AI Optimizing Harvesting and Logistics

One of the biggest challenges for farmers is managing harvesting at the optimal time to minimize quality losses and maximize profitability. AI supports this process by continuously monitoring weather conditions and crop growth parameters. Machine learning algorithms can accurately predict the optimal harvest time based on weather data, soil moisture content, and specific plant characteristics. Through platforms like John Deere's Operations Center and Agri-Tech East, farmers receive personalized alerts indicating the ideal harvest time, even on extensive fields.

AI optimizes not only the harvest timing but also the logistics of transporting and storing crops. By analyzing data from multiple locations, AI-based software can suggest optimal routes for transporting crops, reducing time and fuel consumption. This is especially important for perishable crops, where time is a critical factor for maintaining quality and reducing losses. Blue River Technology, part of John Deere, develops AI solutions that monitor harvesting and coordinate autonomous agricultural machines, ensuring efficient logistics from the field to storage centers.

Smart Storage Management with Intelligent Sensors

Another AI application in agriculture focuses on the smart storage of crops. IoT sensors installed in silos monitor humidity, temperature, and CO2 levels, maintaining optimal conditions for crop preservation. AI processes this data and alerts farmers if conditions in the silos change, preventing crop degradation. Solutions like GrainSense and Taranis are already widely used in farms across Europe and the USA to optimize storage and maximize agricultural product quality.

Automating Operations with Smart Agricultural Machines

Another area of application is using autonomous agricultural machines equipped with sensors and AI algorithms that allow them to perform complex tasks, such as sowing, harvesting, and field maintenance, without human intervention. Autonomous tractors developed by companies like John Deere and Case IH can operate independently, saving time and resources and enabling farmers to focus on other strategic activities.

These machines are connected to central control systems, allowing farmers to monitor progress in real time. Based on collected data, AI can adjust the speed and efficiency of operations, increasing productivity and reducing operating costs. This not only streamlines field activities but also reduces carbon emissions, contributing to more sustainable agriculture.

Artificial intelligence is revolutionizing agriculture, bringing significant benefits to both large and small farms. From the rapid detection of diseases and pests to resource management and adaptation to climate change, AI supports farmers in increasing efficiency and meeting global challenges. In the future, we can anticipate even greater integration of AI in agriculture, ensuring a safer and more sustainable food supply for the global population.

Acknowledgments

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STUDIES WITH REFERENCE TO THE IMPLEMENTATION OF THE SMART VILLAGE CONCEPT IN ROMANIAN VILLAGES

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Abstract

Currently, rural areas are undergoing rapid changes. The idea of smart villages is a response to current rural development problems stemming from ongoing demographic changes, mainly the aging population and an exodus of young people from rural areas, low population density, fewer and fewer jobs, an insufficient and decreasing range of services offered in these areas or the lack of funds for investment. Digitalization has become an essential aspect of modern society, being present in all activities of daily life. The article aims to highlight the importance of implementing the Smart Village concept for the viability of villages in Romania. Smart Village is a relatively new concept that refers to the development of rural communities through the use of technology and innovation. In conclusion, the purpose of digitalization is to create value and bring significant benefits to organizations, communities, and society as a whole through the use of digital technologies, to improve existing processes and services or to develop new solutions and innovations, and the digitalization of public and social services can bring significant benefits to rural areas,

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contributing to improving access to essential services, the efficiency of public administration and stimulating economic and social development.

Key words: *Smart Village***,** *digitization, villages, development.*

Introduction

The idea of smart village, although having all the attributes of a scientific concept, is very often described without any reference to theory, research, or scientific publications. It is based on practical solutions, which makes many scientists believe that it does not have a solid theoretical basis. Among others, *Bill Slee* questioned, in 2019, the theoretical aspect of the idea, writing that the evolution of development support for the local community and, more generally, of what is called a smart village, has occurred almost without reference to theory. However, in recent times, there has been an increase in research for this concept, which translates into a growing catalogue of publications containing both theoretical and inductive considerations, in which "smart villages" has become one of the key phrases.

The smart village concept is still in its early stages of development. This is confirmed by the search for a definition of smart villages that corresponds to the specificities of rural areas and its real field of interest. Studies on this concept are carried out at different area levels that include entire continents, individual countries, or smaller administrative units. The subjects addressed by them are very diverse. Works from Asia, Africa, and the Americas focus mainly on energy systems, climate, and sustainable agriculture, while European studies explore the topic mainly in the context of revitalizing local communities through the improvement of public services and the use of new technologies.

The notion of smart village has been used for a while, but changes in its scope can be observed. It was, originally, used to refer to aid programs in Africa and Asia. The vision of smart villages was first presented in 2015 by Van Gevelt & Holmes. It focused mainly on issues related to access to modern energy sources, food security, primary education, and healthcare. An important moment for the development of the smart village in the European Union was the declaration of 2016, *"A better life in rural areas"* (commonly known as the *Cork Declaration 2.0*). The document was the result of a meeting of several hundred participants at the *European Conference on Rural Development in Cork, Ireland*, during which the directions for rural development and agricultural policy were set. One of the points of the declaration emphasized that special attention should be paid to overcoming the digital deadlock and developing digitization opportunities in rural areas.

In 2017, the European Network for Rural Development (ENRD) proposed the *"EU Action for Smart Villages"*. The document refers to the debate process on the villages of the future and the need to centralize different programs to build a strategic approach to promote smart villages, including support for knowledge, investments, and connectivity. The document establishes the initial definition of the concept of smart villages: *"Villages (local communities, regions) that use digital technologies and innovations in everyday life, thus improving the quality of life, the standard of public services and making better use of local resources."*

Entrepreneurship and digital innovation play a vital role in the revitalization and development of rural areas. In the context of an increasingly digital global economy, the use of software technologies and the development of entrepreneurship can bring new opportunities and economic growth in rural communities. The importance of entrepreneurship and digital innovation in rural areas and the ways in which they can boost economic and social development are as follows:

- ✓ *Increasing access to technology and connectivity* as one of the major challenges in rural areas, since access is limited to technology and connection to the online environment. Promoting digital entrepreneurship and innovation can help expand Internet infrastructure and increase access to digital technologies in rural communities. Initiatives that provide high-speed Internet access and technology training programs can stimulate the development of digital entrepreneurship in rural areas.

- ✓ *Fostering entrepreneurship*, since it plays an important role in diversifying rural economy and in creating jobs and local business opportunities. Encouraging local entrepreneurs to develop their businesses in areas such as precision agriculture, rural tourism, handicrafts, and online commerce can increase the competitiveness and economic sustainability of rural areas.

- ✓ *Innovation in agriculture and natural resource management,* since digital innovation can revolutionize agricultural practices and natural resource management in rural areas. The use of technologies such as precision agriculture, drones, and data analytics can help farmers optimize their agricultural production, reduce resource consumption, and manage environmental impact more effectively.

- ✓ *Promoting rural tourism and e-commerce* through digital entrepreneurship that can stimulate the development of rural tourism and e-commerce in rural areas. Creating online platforms to promote local tourism and traditional produce and products can attract tourists and customers from around the world, thus contributing to economic growth and to the preservation of cultural traditions.
- ✓ *Supporting digital education and innovation through investments in digital education and innovation*, which are essential for boosting entrepreneurship and innovation in rural areas. Technology training and education programmes, as well as support for business incubators and digital innovation hubs, can encourage the emergence and development of start-ups and innovative enterprises in rural communities.

Materials and methods

To reach the goal of this paper – that of highlighting the importance of implementing the concept of Smart Village for the viability of Romanian villages – a study and an analysis of existing bibliographic sources in the literature were carried out, considering the data related to the research topic to deepen the analysis. An objective analysis of problems, opportunities, and context in which digitization can be implemented in different activities of rural areas in Romania was also carried out. As a result of the analysis, the authors of the paper propose several actions in the field of digitization that could contribute to the efficiency of activities in rural communities.

Results and discussions

The development of the smart village concept is seen as an opportunity for a better life for rural residents. At the same time, the need to respond to the problems related to the aging of the population and to the decline of public services are emphasized. An essential aspect of the concept is territorial sensitivity, which allows the adaptation of the projects implemented within it to local conditions. The indispensable elements of the concept are smart initiatives, smart community, smart services, smart institutions, and smart infrastructure. Smart initiatives should be understood as any local activities aimed at meeting the specific needs of the residents, carried out or initiated by them and supported by new technologies to the greatest extent possible.

Regarding smart services, it should be considered that they are not only public and social services based on technological innovations, but also services necessary for a certain area (i.e., adapted to needs). At local level, the administration is responsible for providing most of these services, but it is desirable that it cooperates with other administrative units – the non-governmental sector and businesses.

As for smart institutions, it should be remembered that they are public institutions, for example, town hall, school, or a cultural centre, which use modern solutions, while making such technologies available to the inhabitants. Equally important in the concept of smart villages is smart infrastructure, as the material basis necessary for any human activity. In the case of rural areas, it is primarily about the transport infrastructure allowing the mobility of the inhabitants and significantly influencing the living conditions of the rural population and the ICT infrastructure allowing the residents to deal with problems more quickly by using public communication services in an efficient way.

Smart Village is a relatively new concept that refers to the development of rural communities through technology and innovation. The idea is to improve the lives of people in rural areas through the intelligent use of available resources and digital technology. A Smart Village can be defined as an innovative village, connected to the Internet, and sustainable.

According to statistical data in Romania, there are more than 140 communes that are implementing more than 220 smart village initiatives, including schools with distance education systems, digitized town halls, public transport, and waste collection, according to information from the Romanian Association for Smart City (RASC).

There are also nine localities where several smart village projects have been implemented, three of which are in Mureș County and six in Alba, Sălaj, Galați, Timiș, Sibiu, and Ilfov counties: *Ciugud*, Alba County (eight projects); *Aluniș*, Mureș County (seven projects); *Boghiș*, Sălaj County (five projects); *Saschiz*, Mureș County (five projects); *Bălășești*, Galați County (four projects); *Corunca*, Mureș County (four projects); *Mânăștiur*, Timiș County (four projects); ***Şelimbăr***, Sibiu County (four projects); *Snagov*, Ilfov County (four projects).

One of the key objectives of a smart village is to provide access to quality services and facilities for its residents. In addition, smart villages can be used to develop a smart infrastructure to help improve access to the Internet and other facilities needed for economic development. Another important feature of this concept is economic development through innovation. This can be achieved by attracting investments to rural areas and by creating new business opportunities. In addition, digital technologies can be used to help develop precision agriculture and improve production processes.

Another important aspect of the smart village concept is sustainability. This can be achieved by using renewable energy, by increasing energy efficiency, and by promoting a more sustainable lifestyle. In addition, these smart villages play an important role in protecting the environment through conservation measures and the development of sustainable agriculture.

In agriculture, digitization represents an increasingly visible trend in recent years, which has the potential to revolutionize this sector and bring numerous benefits to both farmers and consumers. In addition, digitization can contribute to improving product quality and increasing transparency in the supply chain, through produce / product tracking and electronic certification systems. The digitization of agriculture is necessary due to the need to increase the quantities of agri-food products to cope with the sharp increase in the consumption of products in the conditions of the reduction of agricultural areas as a result of urbanization and industrial areas, the increase in the demands of farmers, and the need for sustainable, higher crops on smaller areas, and the reduction of costs and risks because of the extreme climate conditions and, last but not least, compliance with legal requirements regarding pollution reduction, environmental conservation, and the control of change climate and desertification.

An example of start-up and digital innovation in the rural area is the *establishment of a company that offers services in the field of precision agriculture and viticulture using drones and the autonomous mobile robot VinBot* used on most of the land within wine-growing areas, equipped with a set of sensors capable of capturing and analysing vine images and 3D data using cloud computing applications, thus evaluating plants and determining vineyard yields, helping wine growers with essential information (Figure 1).

Figure 1. *VinBot*

Source: *https://robotnik.eu/projects/vinbot-en/*

VinBot responds to the need to increase the control process that leads to the implementation of precision viticulture, to estimate the yield (the amount of fruit per square meter of vine area – kg/m²). Winegrowers should be able to estimate yield accurately to make annual report management plans.

Figure 2. *VinBot- distribution of components*

Source: *https://robotnik.eu/projects/vinbot-en/*

The VinBot robot is composed of a sensor mast that integrates a Kinect V2 RGB-D device, an RTK-DGPS antenna, two external Hokuyo sensors (one used for navigation, one for 3D plant scanning) and a communication system with dual interface using Wi-Fi and Radio. Radio devices (920 MHz/2.4 GHz) allow communication up to 50 km away, while Wi-Fi devices – up to 75 m (Figure 3). When the rover uses RTK localization, either NTRIP or base corrections can be radioed to the rover. All measurements are geo-referenced and stored on the local hard drive, the robot starting uploading data to the cloud automatically when it detects that it is connected to the Internet.

Among the services offered by the company are also those of crop management using GPS guidance, RTK station, and precision antennas on agricultural machinery. GPS PILOT is the first GPS guidance system from CLAAS. Controlled by GPS and correction signals, GPS PILOT can follow the trajectory with a high accuracy of ± 2 cm, even in foggy conditions or at night. This guidance system for tractors and other agricultural machinery reduces the operator's burden and working time, ensures high quality of work performed, and reduces operational costs.

The trends from the perspective of digitization and technology in the agricultural field offered to farmers are generalization of self-guidance, control of applied doses, application of variable doses and control of sections, optimization of automatic adjustments, development of autonomous and robotic machines, widespread use of satellite or drone photos, expansion of the use of plant health sensors, crop sensors and soil quality sensors, development and use of multispectral maps that overlap information of various types, transfer of data, data selection and analysis, creation of multi-disciplinary software, public platforms data, and training operators and farmers to make the right decisions (Figure 3).

Figure 3. *Use of drones in agriculture*

Source: *https://agrointel.ro/*

The main goal regarding the use of drones in agriculture and viticulture is to obtain maps based on which foliar diagnosis can be made later related to and nitrogen, phosphorus, and potassium deficiency. The footage taken with the drone is later analysed on the computer with the help of specialized software. Depending on the colour of the vine leaf, one can determine the area where there is a need to reduce or increase the level of fertilization, where there is a problem with a disease, a pest, or the irrigation system (Figure 4).

Figure 4. *Use of drones in viticulture*

Source: *https://agrointel.ro/*

Also, by using drones in agriculture, farmers can benefit from maps that contain information related to vegetation indices. Based on the maps obtained, farmers know where to spray fertilizers, where the soil is poorer, where irrigation is needed because the area is dry, and where it is necessary to treat the plants because they are affected by pests.

Entrepreneurship and digital innovation have huge potential to transform rural areas and make them more competitive and prosperous in the digital age. Promoting access to technology, connecting to the online environment, stimulating entrepreneurship, innovating in agriculture and natural resource management, promoting rural tourism and e-commerce, as well as supporting education and digital innovation, farmers can develop significant opportunities for economic and social development in areas rural.

Conclusions

Smart Village is an innovative approach to the development of rural communities, which aims to use technology and smart solutions to improve the quality of life in these areas. This concept focuses on sustainable development by integrating a variety of technologies and services into the local ecosystem.

Romania has the potential to become one of the most digitized countries in the region, given that 50% of villages can become smart by 2030, according to the estimates of the Romanian Smart City Association (ARSC). The purpose of digitization is to create value and bring significant benefits to organizations, communities, and society, using digital technologies; to improve existing processes and services; or to develop new solutions and innovations.

The digitization of public and social services can bring significant benefits to rural areas, contributing to improving access to essential services and the efficiency of public administration, and to stimulating economic and social development. It is essential that governments, non-governmental organizations, and other stakeholders invest in digital infrastructure and promote the use of digital technologies for the benefit of rural communities.

However, the digitization rate depends on several factors, such as degree of involvement of local authorities, access to finance, degree of technology adoption in rural areas, and development of the necessary digital skills.

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PROCESS CONTROL IN AGROINDUSTRY

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Abstract

Process control in agroindustry encompasses measurement and control systems that optimize agricultural operations through precise and accurate measurement, monitoring, and automation. Precise and accurate measurement serves as the function of quality, which is a key competitive factor in sustainable development conditions. The implementation of smart farming solutions with process control enables real-time monitoring and control of critical parameters, including irrigation, heating, cooling, and air quality management. Modern metrological services provide necessary calibration of temperature measuring instruments, which further enable adequate temperature regulation in grain silos, sugar warehouses, flour mills, and other agricultural storage facilities. System integration extends to measuring truck scales at agricultural farms, customs terminals, and logistics centers, ensuring accurate and precise mass measurements throughout the entire supply chain. Advanced monitoring solutions help reduce operational costs, minimize losses, and reduce environmental impact through automated control systems. Quality control systems in the food industry maintain strict standards through accurate and precise measurements and regulatory protocols. Implementation of these control processes, although initially requiring significant investments and training, results in increased productivity and operational efficiency. Regular maintenance and calibration of measuring equipment, although time-consuming, are key to maintaining accuracy, precision, stability, and reliability of systems, and compliance with regulations in agroindustrial operations.

Key words: *Metrology, agriculture, agroindustry, quality, accuracy, precision, reliability.*

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Introduction

Agroindustry represents an economic activity that, with the industrial revolution, has transformed from ordinary agricultural production and traditional farming and management activities into an industrial activity, thus becoming an entire industrial branch. Agroindustry encompasses economic activities whose key characteristics are: industrialization, commercialization, professionalization, and value addition to products from both the food and non-food sectors.

Regarding food products in agroindustry, it includes domains of agriculture, livestock, and fisheries. In terms of the non-food sector of agroindustry, it encompasses economic activities such as forestry, as well as agriculture, livestock, and fisheries, since many non-food products are derived from these economic activities. Agroindustry, which includes the fields of agriculture, livestock, forestry, fisheries, as well as the food (processing) industry, does not refer only to production but to the entire chain through which a product passes from production through markets to the consumer. It is based on the motto of more efficient, more productive, and more rational agricultural production known as "From Farm to Table," founded on efficient and effective production, distribution, transport, logistics, and supply networks, ensuring the supply of supermarkets and stores, all the way to the consumer's home. In recent decades, agroindustry has gained a new dimension through the development of the fourth industrial revolution in the form of industrialization and commercialization of products, as well as through automation and resource optimization via smart and precise agriculture.

Measuring information holds significant importance in modern scientific and technological disciplines, as it deals with quantitative values used to assess the state of the research object [4]. In contemporary science, these measuring information is digitized, or converted into electrical signals [4]. They are obtained through sensors, various instruments, amplifiers, transmitted remotely, and processed via complex algorithms and analyses [4]. This enables a high level of accuracy, sensitivity, and reliability in modern science and technological disciplines, which are the characteristics that form the foundation of metrology and measuring information since their inception [4].

Metrology is the science of measures, methods, means of measurement, and the procedures for achieving the necessary measurement accuracy [4]. With the development of technology, metrology as a science that permeates all other sciences, and particularly stands out in synergy with philosophy, mathematics, physics, and electrical engineering, introduces cybernetics as a key discipline of modern metrology, along with information technologies, measuring information systems, digital measuring techniques, and stochastic procedures [4]. These new disciplines give a new dimension to metrology, further developing methods of analysis and synthesis in both science and practice [4].

Application of Metrology in Agroindustry

With the worsening of climate change, agriculture, and consequently agroindustry, is at risk of reduced yields on agricultural land, as well as a decrease in the supply of agricultural and food products in the market [3]. As one of the potential solutions to overcome this significant problem, metrology stands out as a science that can contribute to a more robust, resilient, and climate-flexible agricultural production, as well as agroindustry.

For example, the assessment of soil moisture, which is a key factor in agriculture, can significantly enhance the awareness of farmers and agricultural producers during the production process [1]. Measuring soil moisture through metrology and the information it provides can greatly improve the optimization of irrigation timing and quantity, the precise timing of fertilizer and pesticide application, optimal harvest timing, as well as contribute to yield prediction [1].

It enables stability, robustness, and scalability in unfavorable conditions due to climate change, while preserving the principles of sustainable development and ecological responsibility in areas such as agriculture, livestock, forestry, and fisheries.

Metrology in agroindustry has numerous applications, and modern research places special emphasis on the calibration of sensors in the agricultural field, precise monitoring of environmental conditions, primarily temperature and humidity, contributing to better optimization and allocation of resources, such as critical resources like drinking water, and enabling the application of calibration methods and techniques not only on agricultural equipment but also in the field of meteorology and the use of modern techniques and mathematical models for predicting both yields and weather conditions.

The implementation of smart agriculture solutions with metrology allows for real-time monitoring and control of critical parameters, including irrigation, heating, cooling, and air quality management. Modern metrological services provide the necessary calibration of temperature measurement instruments, which further enables adequate temperature regulation in grain silos, sugar warehouses, flour mills, and other agricultural storage facilities.

The integration of systems encompasses the measurement of truck scales at agricultural farms, customs terminals, and logistics centers, ensuring accurate and precise mass measurements throughout the supply chain. Advanced monitoring solutions help reduce operational costs, minimize losses, and decrease environmental impact through automated control systems. Quality control systems in the food industry maintain strict standards through accurate and precise measurements and regulatory protocols.

Measurement as a Reflection of Equipment Value

Does the value of equipment really decline [2]? In the case of workers, years of experience add depth and value to the worker within the company [2]. A machine, which lacks human qualities, is discarded after prolonged use [2]. Like workers, machines that have operated for decades should be used with significant care [2].

The language of business economics refers to “depreciation,” “residual value,” or “book value”—artificial terms used for accounting and tax purposes [2]. Unfortunately, it seems that people have forgotten that such terms have little to do with the actual value of a machine [2]. For example, we often hear: “This machine is fully depreciated and paid off, so we can discard it at any time without loss,” or “The book value of this machine is zero; Why spend money on a major overhaul when we can replace it with a new, more advanced model?” [2].

Such thinking may represent a significant mistake [2]. If a piece of equipment was purchased in the 1920s, maintained well, and can currently guarantee an operational rate close to 100 percent while handling the production load placed upon it, the value of the machine has not diminished at all [2]. On the other hand, if a machine was purchased last year, poorly maintained, and operates only at half of its capacity, we should consider that its value has dropped by 50 percent [2].

The value of a machine is not determined by its years of service or age [2]. It is determined by the potential contribution to profit that it still retains [2]. So, how should one decide whether to replace an old machine [2]? If adequate maintenance has been performed, replacing it with a new machine is never cheaper, even if maintaining the older one incurs some costs [2]. If we decide to replace it, we should understand that we have either been misled by our calculations and made a wrong decision, or that our maintenance program was inadequate [2]. When replacing old equipment, decisions should always be made on a case-by-case basis.

Thus, metrology should determine how capable or able a piece of equipment is to continue serving its intended function effectively and efficiently, as well as to be calibrated to maximize its current capabilities. This is also the case with equipment and infrastructure in the agroindustry, whether it concerns silos, weighing scales, various equipment in processing, food industry, or logistics during transport from farm to table.

The role of metrology in agroindustry is even more significant not only due to the increasing population on planet Earth and their needs for increased food production (it is projected that by 2050, the global population will rise from the current approximately 8.2 billion to around 10 billion) but also in terms of minimizing, overcoming, and mitigating the risks that accompany this sector—production under the sky—which are present in every agricultural production and agroindustry, making it less attractive for larger investments, yet still extremely significant and ultimately necessary, especially in the future.

Additionally, metrology, through monitoring and improving the precision, accuracy, reliability, and continuity of measuring devices in agroindustry, contributes to alleviating the negative consequences of climate change that reduce food yields. Namely, metrology enables the full capacity of agricultural and agroindustrial infrastructure to be utilized in order to overcome the given risks and consequences of climate change.

It is rightly said that a country, and thus its economy and industry, is only as strong as the appreciation and representation of metrology as a science within that country, not only in academic circles but particularly in business practice. Furthermore, metrology is not only essential as an integral element and aspect of agroindustry as a sector but also for all sectors of the economy and society as a whole.

Conclusion

Metrology permeates numerous sciences, from philosophy, physics, mathematics, electrical engineering, and computing, to social sciences such as economics, agriculture, agroindustry, and others. To fully understand the significance of metrology and the benefits it brings in modern conditions, especially in the context of the negative effects of climate change on agriculture and humanity as a whole, we must recognize the great need for rational, intelligent decision-making and optimized management of the resources available to us.

In this regard, metrology can significantly contribute as a science that inherits fundamental principles of establishing and achieving precision, accuracy, sensitivity, continuity, and reliability. In contemporary conditions of dynamic changes, climatic disasters, numerous armed conflicts, and disruptions in the supply chains of agricultural and food products, introducing the values and axioms that metrology addresses as a science—not only in agroindustry but also in all other areas of economic activity—represents a crucial step toward establishing a more stable and certain future for humanity as well as harmony with the environment and nature.

Therefore, metrology plays a role not only in science and the industry but also, in addition to improving product quality, assessing the capacity, potential, and capabilities of equipment, it offers a brighter future by emphasizing measurement or measuring information as a fundamental value that will be appreciated and valued in modern society.

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THE CHALLENGES OF DIGITIZATION IN AGRICULTURE FOR SUSTAINABLE RURAL DEVELOPMENT

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Abstract

The aim of this research is to identify and analyze the challenges and opportunities that digitization brings to agriculture, in the context of sustainable rural development. The methodology used is a systematic literature review, which synthesizes recent studies to highlight the main challenges, solutions and impacts of digitization in agriculture. The gap identified in the existing literature is the lack of an integrative approach that correlates the specific challenges of infrastructure, skills and public policies with the impact of digitization on smallholder farmers and vulnerable rural communities.

The main findings highlight that digitization in agriculture is limited by poor access to digital infrastructure in rural areas and the costs associated with modern technologies, which impose an urgent need for investment and public-private partnerships. Also, the lack of digital skills among farmers is an important barrier, suggesting the need for educational programs to facilitate the adoption of advanced technologies. From an ecological point of view, digital technologies such as "digital twin" and "smart farming" present significant opportunities for ecologically responsible agriculture, optimizing resource use and reducing environmental impact.

The added value of this research lies in the systematic and integrative approach to digitization in agriculture, providing an in-depth understanding of the interplay between challenges, opportunities and policies. Limitations of the study derive from the focus on existing literature, which may limit the direct applicability of the results to empirically unexplored contexts.

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The findings suggest that although digitization presents many challenges, it has the potential to support sustainable rural development through technological solutions and adequate public support. Future research directions include empirical studies to test proposed solutions in different rural contexts and the development of integrated strategies to support the adoption of digital technologies among smallholder farmers.

Key words: *digitization in agriculture, sustainable rural development, digital infrastructure, digital skills, ecological agriculture, public policies, organizational resilience.*

Introduction

The digital transformation of agriculture has become a topic of major interest, given the potential of modern technologies to address the economic, social and environmental challenges facing rural communities. Digitization in agriculture, often described by concepts such as "Agriculture 4.0" or "smart agriculture", includes the use of advanced technologies – from sensors and drones to artificial intelligence and real-time data analysis – to optimize agricultural processes and increase productivity. In the context of sustainable rural development, digitization offers multiple advantages, but also significant challenges for farmers, public administrations and the rural environment.

Literature Review

The challenges and opportunities of digitization in agriculture have captured the interest of researchers due to its potential to support sustainable development in rural areas. Abbasi, Martinez, and Ahmad (2022) provide a detailed insight into digitization in the industry, exploring the transition to "Agriculture 4.0" and highlighting gaps in research on the integration of advanced technology systems. Alt, Isakova and Balushkina (2020) address the difficulties of digitization in modern agricultural production, highlighting technological and financial barriers to the application of digitization in traditional agriculture. On the other hand, Amirova and colleagues (2021) discuss the implementation of digitization in agriculture, highlighting the practical challenges faced by farmers and the role of technological infrastructure. In the same direction, Bakulina et al. (2020) explore how digitization affects the accounting profession in agriculture, looking at the changes from the perspective of professionalization and workforce training.

An important aspect of digitization in agriculture is organizational resilience. Burlacu, Mocanu, Gomboș and Dobre (2022) emphasize the importance of organizational resilience through digitization, necessary to ensure the continuity of activities in conditions of economic uncertainty. In another paper, Burlacu and colleagues (2022) examine the impact of digitization in public administration and the prospects for sustainable development in Romania. Under global challenges, Izuogu et al. (2023) study the digitization of agriculture in Nigeria, while Sadjadi and Fernández (2023) discuss digitization in agriculture in Spain, identifying specific local challenges and opportunities. Also, Klerkx, Jakku and Labarthe (2019) propose a research agenda focused on the social contributions of digital agriculture and its impact on rural communities. Latino et al. (2022) conduct a global bibliometric analysis on the digitization of agriculture, illustrating the importance of comparative studies to understand global trends. To emphasize the relevance of digitization at the level of human resources, Faskhutdinova and colleagues (2020) examine the role of digitization on the agricultural workforce, discussing the need to develop employees' digital skills to adapt to new technologies.

Romera, Sharifi and Charters (2024) propose an integrative approach to digitization in agriculture, emphasizing the importance of a holistic vision that includes both technological innovation and social and economic sustainability.

In a broader context of digitalization, the research carried out by Burlacu, Crețu, Potcovaru and Călin (2024) explores the role of public administration in supporting sustainable development through post-pandemic technological innovations.

The impact of digitization on the economy and society, outlined by Burlacu, Diaconu, Mocanu and Gombos (2022), provides a global perspective on the effects of digitization in different sectors, including agriculture. For increased organizational sustainability, Burlacu, Mocanu, Gomboș and Dobre (2022) emphasize organizational resilience through digitization, highlighting that the agricultural sector must adapt and become more flexible in the face of rapid external changes. Another relevant study, by Burlacu, Negescu, Patarlageanu and Vasilescu (2021), examines the impact of digital globalization on economic and social life. In agriculture, digital globalization can facilitate access to new markets and technologies, but it also requires adjustments at the local level to encourage balanced and sustainable development. Burlacu, Pargaru, Iacob and Gombos (2022) provide a perspective on digital public administration and its implications for sustainable development in Romania, emphasizing that digital policy plays a crucial role in supporting agriculture. In another paper, Burlacu, Popescu, Diaconu and Sârbu (2021) analyze digital public administration in the context of sustainable development. Also, Burlacu, Ciobanu, Troaca and Gombos (2021) discuss digital finance as an opportunity for development in the new economy, emphasizing the importance of farmers' access to financial resources through digital platforms, which can support investments in precision technologies and the efficiency of agricultural operations.By introducing digital public governance, Calin, Burlacu, Mocanu and Popescu (2022) discuss the role of governments in promoting sustainable management in agriculture. In another study, Ciobanu, Burlacu, Bodislav and Oancea-Negescu (2019) highlight the role of regional and rural digitization as an opportunity for access to information, jobs and economic growth. This is an essential premise for rural development, providing farmers with the digital tools needed to improve operations and access markets and educational resources.

Research by Dibirov and Dibirova (2021) highlights both the prospects and problems of digitizing the agricultural economy, showing that the digital transition is often hampered by economic and infrastructural barriers, especially in less developed regions.Similarly, Izuogu et al. (2023) examine the digitization of agriculture in Nigeria, focusing on local challenges such as limited access to technology and digital infrastructure, but also potential benefits such as increased efficiency and increased income for local farmers.

Adusumalli (2018) highlights the ecological challenges of digitization in agriculture, emphasizing the need to balance technological innovation with ecological conservation to support sustainable development.From the perspective of organizational resilience, Burlacu, Mocanu, Gomboș and Dobre (2022) discuss digitization as a tool to strengthen the adaptability of agricultural organizations, especially in the face of rapid and unpredictable changes, a crucial aspect for the long-term sustainability of farmers and communities rural.

Hilbeck and Tisselli (2020) warn of emerging issues related to the digitization of agriculture, including its effects on small farmers and digital equity challenges. Similarly, Lioutas, Charatsari and De Rosa (2021) bring up the dilemma between food security and digital development, asking whether digital technologies could solve food problems or whether they generate additional risks by marginalizing small farmers.

Klerkx, Jakku and Labarthe (2019) present an analysis of the social contributions of smart agriculture and identify the need for a research agenda focused on the social and ethical impact of digitization in rural areas.. Kitole, Mkuna and Sesabo (2024) study digital agricultural transformation in developing countries, highlighting that digitization has the potential to boost economic growth, but also highlights obstacles such as poor infrastructure and lack of digital skills. Similarly, Izuogu et al. (2023) explore the digitization of agriculture in Nigeria and reveal the difficulties related to access to the technology, but also the benefits it can bring to farmers in vulnerable backgrounds. Kuzmich (2021) emphasizes the impact of digitization on the sustainable development of rural areas, stressing that technological integration in agriculture can reduce economic disparities between rural and urban regions. This idea is also supported by Lovkova et al. (2022), which examines the main digitization trends in agriculture and highlights their role in promoting economic equity.

Mohr and Höhler (2023) analyze how the digitization of agriculture is presented in the media, showing that public perception can influence the implementation of new technologies. Nasirahmadi and Hensel (2022) propose an innovative vision of digitization through the concept of the "digital twin," which promises to revolutionize the monitoring and optimization of agricultural resources.

On the other hand, Popescu, Gomboș, Burlacu and Mair (2021) discuss the impact of the COVID-19 pandemic on digital globalization, revealing that digitization has been accelerated in several sectors, including agriculture, in response to new social and economic challenges.

In a theoretical framework, Ulezko, Reimer and Ulezko (2019) explore the methodological aspects of digitization in agriculture, arguing that the development and application of innovative digital models can improve both production processes and the management of agricultural resources.. Adusumalli (2018) explores digitization in an ecological context, drawing attention to the fact that technological innovations in agriculture require a responsible ecological approach in order not to compromise the sustainability of the rural environment. Klerkx, Jakku and Labarthe (2019) propose a social analysis of digital agriculture and smart agriculture, suggesting that digital transformation not only optimizes production, but also changes the social structure of rural communities. In another direction, Rolandi et al. (2021) provide a taxonomy of the impacts of digitization on rural areas, noting that digitization can increase economic opportunities and encourage young people to stay in agriculture. Lioutas, Charatsari, and De Rosa (2021) address the trolley dilemma from the perspective of the digitization of agriculture, arguing that while digital technologies can contribute to solving food problems, they can create new challenges, such as the exclusion of small farmers from modern production chains.

Lovkova et al. (2022) analyze the main trends of digitization in agriculture, emphasizing that innovative technologies can fundamentally transform agricultural processes. Nasirahmadi and Hensel (2022) propose the concept of a "digital twin" as an advanced method of agricultural resource management, facilitating increased control over production and real-time optimization. In his analysis of Nigerian agriculture, Izuogu et al. (2023) identify challenges faced by Nigerian farmers in adopting digital technologies such as limited access to infrastructure and high costs. Negescu et al., (2021) investigate the paradigm of digitization of public administration in the context of the COVID-19 pandemic, highlighting that digital administration can facilitate the adoption of innovative solutions in agriculture.. Zhumaxanova and colleagues (2019) analyze the state of digitization in agriculture in Central Asia, noting the fundamental obstacles to the adoption of digital technologies, including the lack of digital infrastructure and skills. In another paper, Sulimin, Shvedov and Lvova (2019) explore innovative models and emerging technologies in agriculture, suggesting that the adoption of digitization can streamline agricultural processes and stimulate innovation in this sector. Ognivtsev (2019) discusses the relationship between the digitization of the economy and the economics of digitization in agriculture, emphasizing that this process is essential to increase the competitiveness of agriculture globally.

Similarly, Smagulova (2020) examines the experiences and issues of digitizing agriculture in Kazakhstan, identifying local barriers and emphasizing the importance of infrastructure investment and the promotion of government policies to support farmers in adopting digital technologies.

Radulescu, Dobrea and Burlacu (2018) explore crisis management in business and draw attention to the importance of good digital preparation for organizational resilience. In the context of sustainability, Shamshiri et al (2024) present an analysis of digitization for sustainable agricultural production, highlighting case studies from various regions that demonstrate how digital technologies can optimize production while reducing negative environmental impacts. On the other hand, Phillip and Ndirpaya (2020) examine the digitization of agriculture in Nigeria, focusing on the challenges and opportunities encountered in the process of adopting digital technologies for food security. Burlacu, Popescu, Diaconu and Sârbu (2021) provide a perspective on digital public administration and sustainable development, emphasizing that digital governance can play an essential role in supporting farmers and promoting sustainable agriculture through effective measures and regulations. Similarly, Nezamova and Olentsova (2022) analyze the main trends of digitization in agriculture, highlighting the role of policy drivers and public-private partnerships in accelerating the adoption of digital technologies.

Methodology

This research uses a systematic literature review to analyze the challenges of digitization in agriculture and its contribution to sustainable rural development.

The research aims to:

1. Identify and classify the challenges of digitization in agriculture, both globally and regionally.

2. Analyze the solutions proposed in the specialized literature and how they support sustainable development.

3. Assess the impact of digitization on the economic, social and ecological sustainability of rural communities.

To ensure the relevance and timeliness of the data, only studies published in the last 10 years, available in academic databases such as Scopus, Web of Science and JSTOR, were included. They were selected based on the inclusion criteria: direct relevance to the digitization of agriculture, analysis of the impact on rural development, and offering applicable solutions. Papers that did not focus on challenges in agriculture or rural development were excluded.

Data analysis was performed by thematic coding, using qualitative analysis software (NVivo), allowing the classification and comparison of information extracted from each study. Thus, an overview of the challenges and solutions encountered, but also of their impact on sustainable rural development, was obtained.

Findings

The literature review highlights a number of key challenges and opportunities associated with the digitization of agriculture and its impact on sustainable rural development.

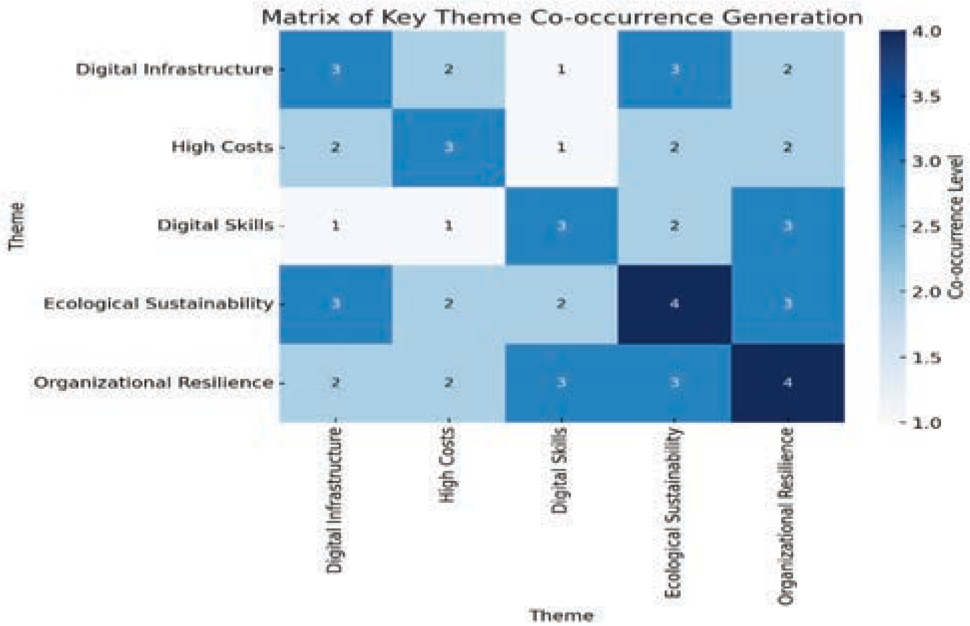
To provide a clear and structured synthesis of the previous findings, the table below brings together the main aspects analyzed in the literature on digitization in agriculture and its impact on sustainable rural development. Each aspect includes a description of the challenges and opportunities identified, along with their impact on rural sustainability. This format facilitates an overview of the technological, economic, social and ecological dimensions of digitization, also highlighting the relevant references that support these findings.

To provide a visual and structured representation of the central themes in the analysis of digitization in agriculture and the impact on sustainable rural development, a Word Cloud and a co-occurrence matrix were created.

Figure 1. *Matplotlib Chart – Word Cloud*

This matrix could help guide policy makers and stakeholders by indicating areas where investment and support are most needed. For instance, improving Digital Infrastructure and reducing High Costs could facilitate broader adoption of Digital Skills and Sustainable Practices, ultimately enhancing Organizational Resilience in the agriculture sector.

Figure 2. *Key theme co-occurrence generation matrix*



Reports generated by NVivo summarize observations for key nodes such as "Challenges," "Opportunities," "Public Policy Impact," and "Organizational Resilience." Each report will include a description of the topic, relevant quotations and a brief analysis.

Table 1. *NVivo Thematic Reports*

Theme	Description	Relevant Quotes	Analysis
Challenges in Agriculture Digitalization	Identification of the main obstacles in implementing digital technologies in agriculture, including access to infrastructure, costs, and digital skills.	"Access to digital infrastructure in rural areas is limited..." "Lack of digital skills among farmers..."	The challenges are varied – from inadequate infrastructure to high costs and limited skills among farmers.
Opportunities in Ecological Sustainability	Identification of the benefits of digital technologies for optimizing natural resources and reducing the environmental impact of agriculture.	"Technologies like 'digital twin' and 'smart farming' enable efficient management..." "Digitalization supports optimized use of water and pesticides..."	Advanced technologies can contribute to ecological sustainability, but their implementation depends on access and support.

Theme	Description	Relevant Quotes	Analysis
Impact of Public Policies and Public-Private Partnerships	Exploration of the role of government policies and public-private partnerships in facilitating agriculture digitalization.	“The success of digitalization depends on government support...” “Public policies are essential for investments in digital infrastructure...”	Public policies and public-private partnerships are essential for widespread adoption of digitalization in agriculture.
Organizational Resilience through Digitalization	Analysis of how automation and access to data enhance the capacity to adapt to climate and economic changes in agriculture.	“Digitalization supports rapid adaptation to climate change...” “Risk management capacity is improved...”	Digitalization enables farmers to better manage risks and adapt quickly to changes, strengthening long-term competitiveness.

The key theme co-occurrence generation matrix highlighted in figure 2 shows the frequency with which themes such as “Digital Infrastructure,” “High Costs,” “Digital Skills,” “Ecological Sustainability” and “Organizational Resilience” appear together in the analysis of the digitization of agriculture. This visualization highlights the close relationships between different aspects, providing a clear insight into the connections relevant to the sustainable development of the agricultural sector.

Reports generated by NVivo summarize observations for key nodes such as “Challenges,” “Opportunities,” “Public Policy Impact,” and “Organizational Resilience.” Each report will include a description of the topic, relevant quotations and a brief analysis.

Conclusions

Based on the research findings, we conclude that digitization in agriculture brings both challenges and important opportunities for sustainable rural development. The main challenges identified are related to poor access to digital infrastructure in rural areas and the high costs associated with modern technologies, which underlines the need for significant investment from the government and public-private partnerships.

Also, the lack of digital skills among farmers remains a major barrier to the adoption of advanced technologies, which highlights the importance of educational and specialized training programs. These measures are essential to facilitate the integration of modern technologies in agriculture and to increase the efficiency and competitiveness of farms.

Economically and socially, digitization can amplify inequalities between large and small farmers, and without adequate support, the risk of economic marginalization and urban migration increases. Therefore, initiatives to support small farmers are crucial to ensure equitable development in rural areas.

On the ecological sustainability side, digital technologies such as "digital twin" and "smart farming" offer effective solutions for monitoring and optimizing resources, reducing the impact on the environment. The implementation of these technologies supports an ecological, responsible agriculture adapted to the requirements of sustainability.

Finally, the success of digitization in agriculture is highly dependent on political support and an enabling legislative framework that supports public-private partnerships and large-scale adoption of innovative technologies. The contribution of digitization to the organizational resilience of farmers and rural businesses is another key finding, allowing better adaptation to market and climate changes, thus supporting long-term competitiveness.

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